Margit Gabriele Muller

Practical Handbook of Falcon Husbandry and Medicine



NOVA

PRACTICAL HANDBOOK OF FALCON HUSBANDRY AND MEDICINE

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Foreword

Falconers, from China through Central Asia down into the Middle East, up across Europe and on to the Americas, awake daily to begin a time honored management routine to prepare their birds for the field. The origins of the steps each falconer takes daily are often steeped in tradition, gleaned from experiences through centuries, learned from the falconers who preceded us. Yet we have changed more through the last 50 years with advancements in technology, methods of handling, conditioning and training our birds, and by dramatic new cures in raptor veterinary medicine, than any time in our long history.

Some falconers, by training and by diligent regimen led to some early cures and methods of management, which were the precursor to the health management of raptors that we have today. Dr. Robert M. "Doc" Stabler, a legendary, early American falconer, first introduced me to falconry in 1963. By profession, he was a zoologist and parasitologist. The scourge of falconry through those early years in American falconry was the disease commonly known as frounce (trichomoniasis) found in the pigeons we used to train and feed our birds. His painstaking work, in association with a drug company, gave us a cure with enheptin, the precursor to emtryl. Then I had the pivotal year of my falconry life with the renowned Spanish falconer, Dr. Félix Rodríguez de la Fuente, in the mid 1960s. As a doctor, albeit a dentist, he took raptor management to a new level by his scientific, medically oriented, disciplined approach to the daily management of his team of falcons. Because he was far more observant than the average falconer, he foresaw health issues that the rest of us did not recognize in their early stages. Yet both of these men could not have foreseen the level of veterinary practice and cures we know today.

Now, some forty years later, we are challenged daily by new diseases unknown to our predecessors, accidents, and other maladies that befall our birds. Some are the consequences of the global travel of organisms. All present an obstacle to achieving the goal that we have for each of our birds, to be a superb athlete in perfect health.

Often, I used to comment, perhaps naively and certainly arrogantly, that the falconer who knows and understands every raptor treatment is not managing his birds well enough to avoid medical problems. Yet in the last two years, I have had gyrfalcons perish from avian malaria. Several years ago I had to attempt to cure bumble foot on a peregrine that had the misfortune of landing on a cactus to be pierced in the foot by a cactus spine. And I have had two prairie falcon tiercels stoop so hard that they could not pull out in time to keep from slamming into the ground knocking themselves unconscious.

And once I had a young male gyrfalcon suffer a cardiac “explosion” while in flight to die in my hands several hours later. I was fortunate to have had veterinarians reasonably close to consult, but I did not have a veterinary manual in hand to take immediate steps that might have avoided the bumble foot infection or how to deal with an unconscious bird. All falconers can recount similar experiences.

A number of years ago, His Highness Sheikh Zayed bin Sultan al Nayhan, the visionary political leader and passionate falconer who founded the United Arab Emirates, conceived the idea of establishing a falcon hospital, to have a location where falconers in the UAE would have the opportunity to seek the finest treatment for their birds, now the envy of most falconers in the world. During my repeated visits to Abu Dhabi as a guest of the Environment Agency-Abu Dhabi, I have visited the Abu Dhabi Falcon Hospital every time. Under the management of Dr. Margit Muller, you find an assembly of people and equipment, which can treat virtually any disease or accident known to raptors. Dr. Muller and her staff see more birds monthly than most rehabilitation centers treat in a year. Dr. Muller is fortunate to have the equipment and support to diagnose and treat every raptor malady. Her experience and level of veterinary practice is beyond compare. Her approach is practical, based on enormous experience. In her hands, many birds that would otherwise perish make miraculous recoveries.

When Margit informed me about two years ago of her intention to write a veterinary handbook to treat raptor diseases, ailments, even accidents especially for birds used in falconry, I became an enthusiastic supporter of her practical approach to raptor treatment, because while there are many excellent, qualified falconer and raptor rehabilitation veterinarians, often we falconers and raptor keepers do not have time during a crisis to get our birds to one of them, or we find ourselves employing a veterinarian who has very little experience with birds. By their nature, raptors can be difficult to handle and treat. Because of Margit’s approach with this handbook, the treating veterinarian, even the falconer, can quickly assess the most visible problems to diagnose the causes to begin an effective treatment, be it is a disease, a broken bone, or a strained muscle. Medical problems become approachable and manageable if a cure is possible. Her goal is that treatment be practical and effective. And a properly instructed and equipped veterinarian can diagnose certain medical issues before they even become a problem. Margit’s handbook provides that needed special instruction.

And for the daily management of a raptor, she provides specific knowledge regarding what prophylactic steps can be taken to avoid future, even unforeseen, medical problems. Through this handbook we falconers and raptor keepers will have a better understanding of the changes in our birds through the annual life cycle.

Particularly we may be able to foresee stress as our young birds begin their first months of training, what must be done to avoid problems during training, and after a molt, how a bird’s health may be adversely affected by weight reduction.

Dr. Muller shares with us her incredible knowledge in a way as useful to falconers, raptor rehabilitators, and zoological parks as it is to the general practice veterinarian. In a practical sense, Margit's gift of her knowledge through this handbook to achieve the goal of the perfect athlete is commensurate with the advances made in telemetry, conditioning and training. Margit advances our useful knowledge on the health of raptors dramatically.

Frank M. Bond
President
International Association for Falconry and Conservation of Birds of Prey

Preface

Falcon medicine exists for centuries, but in the past 10-15 years tremendous progress and new development of diseases and treatment methods have been made. It has always been a challenge to treat these beautiful birds of prey and the challenge continues until now. Little did I know how difficult but also rewarding my professional life would become when I started working with falcons 15 years ago. I went a long way from being a student performing an externship with falcons to becoming the director of the Abu Dhabi Falcon Hospital. This was something I never expected and not even dreamt of. But sometimes our destiny guides us the way to live up to the challenge which is meant for us and let us pass all obstacles in our way. I am deeply grateful to have been given the opportunity to work in the Abu Dhabi Falcon Hospital and to develop it to a world-wide renowned institution. This would not have been possible without the trust and support of H.E. Mohammed Al Bowardi, a highly remarkable man who is gifted with a passion and love to falcons and for whom I would like to express my sincere gratitude. My thanks go to H.E. Majid Al Mansouri for his support during the past years.

The work with falcons is a virus that caught me and never let me go. The more I see of falcons, the more I feel and cherish what a great gift it is to have the feeling, instinct and understanding for those incredible characters. I was very fortunate to have met H.H. The Late Shk. Zayed bin Sultan Al Nahyan, the visionary founder and first president of the United Arab Emirates whose kind words have accompanied me ever since. A wonderful appreciation and recognition of my work with falcons was the winning of the prestigious Abu Dhabi Award in 2008 which I received from the Crown Prince of Abu Dhabi, H.H. Shk. Mohammed bin Zayed Al Nahyan. This also highlights the importance of falcons, falconry and falcon medicine in Abu Dhabi and the United Arab Emirates which can be regarded as the cradle of modern falcon medicine in the 21st century.

I am highly grateful to Amer Abu Aabed who encouraged and supported me to write this book. My special thanks go to Abdul Basith Kayakkandy, Kishore Kumar and Ancy George for their help. I would like to thank Frank Bond for his friendship and support and for writing the foreword to my book. My thanks go to the Mohammed Junaideen Nafeez and the staff of the Abu Dhabi Falcon Hospital. Special thanks go to Prof. Koesters and Karl Eckart for their help and support when I needed it most. Thanks go to all other people who I have met on my way and who have helped and supported me.

My special and deepest gratitude goes to my father Helmut, my mother Hertha and my sister Andrea. They have always supported me from childhood onwards when I knew already that I will become a doctor. They provided me with the foundation to become the person I am today.

Having treated more than 30,000 falcons over the past years, I feel that the time has come to share my outstanding experience with the veterinarians' and falconers' community for the sake of these incredible birds of prey – to enhance their living conditions and to improve medical falcon health care world-wide. This book is based on my experience of a large variety of different cases and is therefore very practical-oriented. It is intended to be a useful handbook for all interested people working with falcons such as veterinarians, veterinary students, falconers and raptor rehabilitation workers. The aim of this book is not to include all research that has ever been done on falcons, but to highlight those issues that are really working out in practice. It includes 17 chapters ranging from history of falcon medicine to different diseases up to first aid and intensive care medicine.

If this book saves the life of only one falcon (and hopefully many more), then it was worth all the time and efforts to write it.

Margit Gabriele Muller, Dr. Med. Vet., MRCVS, DVetHom MBA
Abu Dhabi, February 2009

Chapter I

Introduction

Abstract

The origins of falcon medicine can be traced back to the Arab-Persian region where the earliest written manuscripts have been written in the 8th century AD. During the crusades, those manuscripts found their way to various European countries where they were translated and served as framework for the European falconry literature. Falcon medicine was at its peak from the 12th to the 15th century. Different ingredients were used as remedies but the most successful discipline was surgery. In modern times, falcon medicine returned to the Arab region and Middle East. Specialized falcon hospitals were established in the United Arab Emirates making it to the leading center of falcon medicine world-wide.

1.1. Introduction

Since centuries, falcons have been regarded as the most precious, majestic and royal birds. Surrounded by legends, especially the most beautiful, huge white hunting falcons, the so-called gyrfalcons, were highly valued by the kings and emperors from ancient times until today. Those white gyrfalcons were always highly priced and were the pride and passion of their owners and the dream of falconers around the world. The hunting with these incredible birds of prey spans more than 4000 years and dates back to the year 2205 B.C. when Chinese princes of the Hia-dynasty gave falcons as gifts to each other [8]. The first known falconry scene is said to have been in the relief of Khorsabad that dates back 1700 BC but it remains under discussion if this can be regarded as sign of early falconry [20]. However, it is estimated that the earliest date for real hunting with falcons goes back to the 2nd century BC and is supposed to have originated in the south Asian steppe region [14].

The term hawking derives from the ancient Oriental manuscripts where the old Persian terms “bayzara” or “bazdara” meaning “hawking” are described. The related words “bazi” or “bazyar” can be found in the 3rd century already [18, 19].

1.2. History of Falconry

1.2.1. Historical Sources of Falconry

Among the earliest written sources about falcons used for hunting purposes is the historical source of Martial in the 1st century AD [29]. In Iraq, falconry was practiced in the 3rd century already [17, 20]. Arab sources, such as the manuscript of Abu Du'ad Al'Lyadi (480-550AD) mention the practice of falconry as common feature in the 5th century [17]. In Europe, falconry can be traced back to the 4th century AD [15]. Whereas in ancient times hunting with birds was performed by people of lower social classes [20], falconry has always been a sport of the kings and highest social classes only, but never of the common man in the medieval times [19]. In Medieval Germania falconry entered the Bavarian law, the so-called lex Baiuwariorum, already in 635 AD with the chapter "De accipitribus" [19].

1.2.2. Falconry in the Middle East

In the United Arab Emirates and most countries of the Middle East, falconry had and still has a different tradition compared to being regarded as pure sport and entertainment. In former times, the Arabs were Bedouins who lived in the desert. This life in the desert was a very difficult and harsh life. However, the Bedouins knew that in autumn wild falcons would be passing over the Arabian Peninsula and also the United Arab Emirates on the migration route from Europe to Africa to stay there over the winter time. The Bedouins went to those places and trapped the wild falcons. They returned to their tents in the desert and tamed the wild falcons because they were shy and afraid of humans in the beginning. Therefore the Bedouin carried them on their fist for 24 hours. If one Bedouin got tired, he gave the falcon to his brother or cousin to continue carrying the bird. After 2 weeks, the falcons got used to humans and could be used for hunting. Falcons used for hunting were mainly female birds due to their larger size although the gender was not known in former times.

The prey that the falcons of the Bedouins hunted was cooked as a meal for the Bedouin's family and provided an additional source of meat. Especially Great Bustards was regarded as the traditional prey for the Bedouins. Therefore falconry in the Arab countries was a necessity for the Bedouins to survive under the harsh conditions in the desert. This led also to a different view of falcons: they were not regarded as sports tools like in Europe, but as integral part of the Bedouins families.

In spring, when the climate got very hot and humid in the Middle East, the falcons would not have survived in the desert. Therefore the Bedouins released the falcons back to the wild where they joined the other migrating birds on their passage back to Europe. Here they returned to their original breeding grounds and could start breeding in the coming year. This can be considered as sustainable falconry and shows the deep love, passion and understanding of the falcons by the Bedouins (Figure 1.1). Until today, falcons are part of the families' hierarchy and are regarded as children of the family. Their value cannot be weighted in money terms and is the same like that of a son or daughter. Moreover, falcons are living in the living rooms of their families, have their own places in the falconers' cars, have special places in the offices and are even allowed to be carried to coffee shops or shopping malls.

Figure 1.1. Bedouin with falcon.

In 2002, the law changed in the United Arab Emirates when the country became a signatory of the CITES (Convention of International Trade of Endangered Species of Fauna and Flora). Complying with CITES regulations, it was not allowed anymore to keep any wild falcons or to hunt with them in the United Arab Emirates. Only captive-bred falcons are allowed to be used for falconry. Those captive-bred falcons are either bred in Abu Dhabi emirate, in Europe or America. They are brought to the United Arab Emirates and other Gulf countries to be sold to their new owners. As falcons are internationally classified as endangered species, high level documentation as well as closed foot rings are signs of the captive breeding origin of the falcons. Moreover, to facilitate traveling to other countries for hunting trips, the UAE falcon passport (Figure 1.2) has been introduced in 2003 being approved by CITES authorities and issued by the local CITES management authorities. This has opened a new chapter in the protection of falcons.

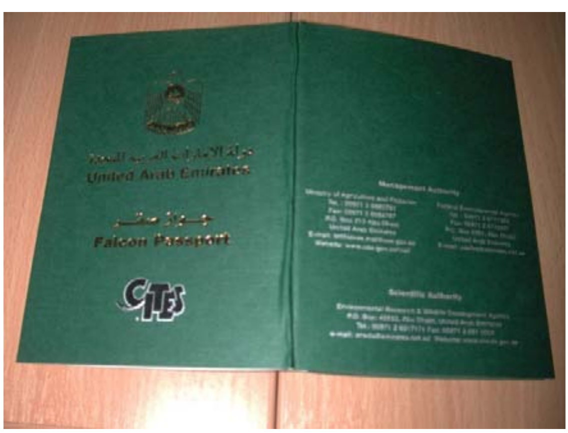

Figure 1.2. Falcon Passport.

1.3. Development of Falcon Medicine

1.3.1. Early Times of Falcon Medicine

The beginning of falcon medicine cannot be traced back completely due to lack of written sources. Falconry and falcon medicine has always been closely related. The earliest written manuscripts about falcon medicine can be traced back to the Arab-Persian region [29]. Already as early as in the 8th century AD, treatises about falcon medicine and treatment were written in the Arab-Persian region by Al Gitrif. Born around the turn of the 7th century as descendant of the monophysitic Christian tribe of Gassanides, Al Gitrif ibn Quadama al-Gassani held the position of Master of the chasse at the royal court of the caliph Hisam ibn Abd Al Malik (724-743AD). He gave Al Gitrif the order to write down the Persian, Turkish, Byzantine and Arabic treatises on falconry including falcon treatment. Al Gitrif based his most famous piece of work, the "Kitab Dawari At-Tayr" (Book of hawks and falcons) on the manuscripts that he and Adham had written together [18, 19].

Another famous treatise on falconry and falcon medicine is the "Moamin" tractate. Although it was not fully clear if Moamin was the name of the author [26] or the title of the book itself, research has identified Moamin as the title of one of the most important falcon treatises in the early ages [28]. Hunain ibn Ishaq (808-873 AD) has been identified as author of this tractate. He was the son of a Nestorian-Christian pharmacist family also being known under his Latin name Johannitius. Hunain received his education from the personal physician of the caliph of Baghdad and Samarra, Yuhanna ibn Masawaih. After traveling extensively and mastering perfectly the Greek language, Hunain translated the Greek medical literature of Hippocrates, Galen and other famous doctors of his time into Arabic and Syrian language. His own scientific work comprises the "kitab al-Mudhal fi-tibb" (Introduction into medicine), that became one of the leading education works of the Medieval Occident in its Latin translation "Isagoge Johannitii ad tegni galeni" [27].

1.3.2. Falcon Medicines Treatises in the Medieval Times

Falconry found its way to the Germanic region through Skytes and Sarmates and to the Gauls region along the river Rhône [15]. The high time of falconry in Europe came in the 13th century through contact with Arabs during the crusades. The early Arab-Persian manuscripts were brought to Europe and later translated in Latin language as the main language of the Medieval Times. They were then further translated into the different European languages [29].

One of the first treatises in the early Middles Ages was written by Adelardus (Æthelhard of Bath). The English philosopher, translator and scientist [21] managed to travel to places as far as Spain, North Africa, Greece and Asia Minor unlike many of his contemporaries. His knowledge of Greek and Arabic enabled him to translate the most diverse mathematical, astrological and astronomical tractates of this region. With regard to falcon medicine, the tractate "De Cura Accipitrum" has to be mentioned [23].

In the 13th century AD, the Greek doctor Demetrios Pepagomenos, also known under the name of Demetrius Constantinopolitanus, wrote a tractate about podagra [10] as well as a book about falconry. Podagra was a name for swollen feet of falcons, thus bumblefoot in our modern nomenclature. Both books were commissioned in the 13th century by the Byzantine Emperor Michael VII Palaeologos [12, 31]. 1588 the book about falconry was translated into Greek and Latin language by Morello in order to give the French readership access to this kind of literature [9].

The term “Tractate of Dankus” conceals one of the most famous and most quoted pieces of European Medieval hunting literature [11] that might have been written in the middle of the 12th century AD at the court of the Norman kings of Sicily [1]. The over 14 manuscripts remain in the libraries of Bologna, Chantilly, Florence, Heidelberg, Milan, Modena, New Haven, Oxford and Rome until today [24]. Therefore “Dankus” cannot be identified without doubt leading to speculations from Dankus being the King of India [32] up to an imaginative person [1].

In the middle of the 13th century, the German Albertus Magnus (1200-1289 AD) contributed to falcon medicine. Born in the Swabian town of Lauingen, he joined the preacher order after finishing his studies in Padua. In 1248 he was appointed head of the stadium general et solemne at Cologne [2] where Thomas of Aquin was one of his students. He wrote the important falconry and falcon medicine treatise “De falconibus”. This treatise based on elder manuscripts including the Dankus tractate, Gerardus tractate and unabridged transcript of Ptolemy letter [13].

In the 14th century AD, an important treatise about falconry and falcon medicine was written in France by Henri de Ferrières. Due to the fact that three different members of this famous Norman family Ferrières are documentary named with the first name Henri, the exact association of the masterpiece “Livre du Roy Modus et de la Reine Racio” is until now not possible beyond doubt [25]. King Modus and his wife Queen Ratio are mystic figures that have been sent to earth as personified Moderation and reason. They should help human being to live their live in unity with the order of god. Whereas Modus teaches humans about hunting, his wife Ratio makes comments on animals and birds especially [25]. This included falcons and falcon medicine [19].

Whereas in Germany the oldest German translations of falconry literature have been done by Wernherus Ernesti in 1404 and Heinrich Münsinger between 1434 and 1442 [2], the first original falconry literature without being based on Oriental transcripts was the so-called “Ältere Deutsche Habichtslehre” (Older German hawk treatise) written by an unknown author [29]. Detailed information about the anatomy of falcons can be found in the book “De Arte Venandi cum Avibus” (The art of hunting with birds) of Frederick II of Hohenstaufen. Several parts of his genial masterpiece have remained valid until today and were much ahead of his time.

In Medieval England, one of the first falconry treatises was “The Boke of St. Albans”. This book being one of the most famous pieces of hunting literature in Medieval England is said to have been written by the English prioress of Sopwell nunnery near St. Albans in Hertfordshire. It seems to be the first book about falconry and falcon medicine written by a woman. As nunnery registers and other sources were lost through the centuries only a few data on her life are available today. Dame Juliana Berners was possibly born in 1388 as daughter of Sir James Berners, a contemporary of King Henry IV. Dame Juliana's education is thought to have been that of any young lady of rank at her time. Therefore it is believed that Juliana Berners has gained a sound knowledge not only of the rules, behavior and life at the court, but also was highly competent in fishing, riding, hunting and falconry [30]. Her authorship of "The Boke of St. Albans" is still a discussion point in literary academic circles. However, apart from statements on hunting, falconry and medical treatment of falcon diseases, this book also became famous for its first-time use of colored wood cuts [7].

The Swiss botanist and doctor Conrad Gesner wrote the "Bibliotheca universalis" during his time as teacher. The diversity of Gesner's enormous knowledge cannot be better documented than in his zoological manuscripts "Thierbuch" (The book of animals), "Vogelbuch" (The book of birds) and "Fischbuch" (The book of fish) written in 1551 to 1555. His extraordinary language skills in Greek, Latin, Dutch, French, German and basic Arabic helped him to integrate original manuscripts in his literary career [16]. In his book of birds, he mentions falcon diseases and their cure [19].

Johann Wolff, a diplomat, translator and civil servant, was widely known at German Royal courts not only for his position as head of Mundelsheim district, but also for his excellent translation of hunting literature. Prince August of Saxony commissioned Johann Wolff to translate and revise the compendium on falconry in three parts that was published as "Falkenerybuch" (the book of falconry) in 1567 in Poitiers. In contains several veterinary chapters on falcon medicine [3].

Another famous English book was written by George Turberville (1540-1610 AD). Born in 1540 as descendant of an old established Dorset family, George Turberville, a prominent poet and publisher of the Elizabethan century, became the secretary of the English Ambassador Thomas Randolph after finishing his studies. In this role he was sent to the Royal Courts of Tsar Ivan the Terrible in Moscow. In the literary field, his name was well-known not only for its poetic content but also for the compendium "The Booke of Faulconerie or Hawking" which was first published in 1575 and the frequently reprinted. In his work, Turberville mixed research results of his predecessors and their work extracts to a unique standard work at his time [22].

In France, Charles d'Arcussia (1554-1628) was born in 1554 into a well-known aristocratic Provencal family. Following the family tradition he became a local politician and obtained a deputy seat as well as the position of procurator of Aix-en-Provence. Later he gained the seat of the first consul in his home town. His book "La Fauconnerie de Charles d'Arcussia" published in Aix-en-Provence made him a celebrity in the field of hunting [4].

In England, Simon Latham gained fame in the outgoing 16th and beginning 17th century AD at the Royal Court of Queen Elizabeth I.. Being a trained falconer, he wrote two treatises on falconry based on his own experience. From 1615 to 1618 both books were published in London as "Lathams Falconry or the Faulcons Lure and Cure into Bookes". The second volume on the medical treatment of falcons is even today regarded as an exceptional document of early modern medical methods [6].

In the 19th century, Husam d-Dawlah Taymur Mirza was born as one of 19 sons of the governor in the Persian province Fars. He gained great fame as legendary falconer and author of one of the most famous modern falconry tractates, the "Baz-Nama-Yi-Nasiri" written in

1868 [5]. This master piece has been translated and published in London by Lt.-Colonel Phillott in 1908.

In the same year 1868, Gah-I-Shaukati, the Indian falconer and descendant of the first ruler of Bophal wrote a tractate about falconry including falcon medicine. His tractate on falconry in the East was translated by Lt.-Colonel Harcourt from Urdu to English and published in London 1968 [5].

1.3.3. Falcon Treatment in the Medieval Times

Falcon medicine in the Medieval Times did not yet have any knowledge of avian physiology and subsequent metabolic diseases. Pathological changes were explained by humoral theory that included 4 humores. They were blood (sanguis), mucous (phlegma), yellow bile (chole) and black bile (melancholy). Bloodletting was one of the most prevalent therapeutic measures and was used for the treatment of all diseases as well as diseases prevention. Diseases were classified according to their symptoms which makes it difficult today to identify the real disease as the same symptom might be present in different diseases. The medieval falcon treatment consisted usually of several components originating from plant, chemicals, minerals and animals [29]. Moreover, superstition had an important place in the medieval falcon medicine. The so-called “snake rule” could be found in almost all medieval remedies for falcons. This “snake rule” meant that the middle part of a snake was fed to the falcons. Snakes were also fed to falcons to speed up the molting process. Surgical procedures had been described in the medieval falcon medical literature and might have been one of the most successful treatments procedures [29].

Chapters about feeding were important part of the medieval falcon medical literature. The knowledge of proper feeding and the importance of varied diets for falcons in captivity were highlighted. The falconers in the Middle Ages knew very well that one-sided feeding would lead to sick and tired falcons. Therefore, they controlled and observed the food intake and digestion of their falcons very closely [29].

1.3.4. Falcon Medicine in the 20th And 21st Century

Despite the fact that veterinary universities were established in Europe in the second half of the 18th century, the main emphasis of avian medicine was on domestic poultry. Falcon medicine became a forgotten part of avian medicine. Starting from the 1970s, falcon medicine returned as part of avian medicine in Europe [29] and America and started to blossom in the 1980s in the Middle East and herewith especially in the United Arab Emirates with the establishment of the first hospitals dedicated exclusively for falcons. In the United Arab Emirates, the Dubai Falcon Hospital was founded in 1983 as first private specialist falcon hospital. In 1985, the Abu Dhabi Falcon Research Hospital was opened in Abu Dhabi Emirate to treat the falcons of the first president of the United Arab Emirates, H.H. The Late Shk. Zayed bin Sultan Al Nahyan and existed until 2008. The Abu Dhabi Falcon Hospital was opened on October 3rd, 1999, as the first public falcon hospital worldwide (Figure 1.3).

Figure 1.3. Abu Dhabi Falcon Hospital.

Its original goal was to provide the best possible medical care for the falcons of the Abu Dhabi Emirate to enhance the living and health condition of those falcons. Moreover, it was supposed to raise awareness among the falconers community about falcon diseases and husbandry and prevention of diseases as well as to do research work. Over the years, the hospital has grown tremendously and has now a customer clientele from all emirates of the United Arab Emirates as well as the adjacent Gulf countries. With a yearly influx of more than 4,600 falcon patients, the Abu Dhabi Falcon Hospital has emerged as largest falcon hospital and leading falcon medicine facility world-wide. In the first nine years of its existence, 31,500 falcons were examined and treated in the Abu Dhabi Falcon Hospital. Through education programs and information material for the falconers about falcon husbandry and diseases, a turnaround from emergency and intensive care medicine to preventive medicine could be achieved. It has become a routine to bring falcons at least twice per year for health examinations without the prevalence of any clinical disease symptoms (Figure 1.4).

Figure 1.4. Examination room of Abu Dhabi Falcon Hospital.

In 2004, pre-purchase examinations have been introduced by the Abu Dhabi Falcon Hospital as first falcon hospital to provide an additional service for the customers. Moreover, a special internship program was established in 2007 to provide a training facility for veterinarians and veterinary students as well as veterinary technicians interested in falcon and falcon medicine. This program is accredited in several countries and universities world-wide. Research is another important part of the work of the Abu Dhabi Falcon Hospital.

Several research publications by falcon veterinarians from the Middle East and United Arab emirates have been published world-wide. The United Arab Emirates can be regarded as the center for falcon medicine in the late 20th century and the beginning 21st century.

1.4. Conclusion

The early beginning of falcon medicine originates from the Arab-Persian region. Through the crusades, those treatises came to the European countries where they were translated and integrated in the European hunting literature. The high time of falconry and falcon medical literature was in Germany, England and France during the 12th to the 15th century. In the 19th century, the Persian and Asian region returned to become the central point of falconry and falcon medicine literature. The circle closed completely in the late 20th and early 21st century when the high time of falcon medicine returned to the Arab region and dedicated falcon clinics and hospitals were established in the Middle East and especially in the United Arab Emirates. The first public falcon hospital, the Abu Dhabi Falcon Hospital, was opened in 1999 in Abu Dhabi, United Arab Emirates which has emerged as largest and leading falcon hospital world-wide.

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Chapter II

Species Information

Abstract

Major differences in anatomy, species specific feature and age specific features exist between different raptors species like falcons and hawks. Moreover, certain falcon species are used for falconry like peregrine falcons, saker falcons and gyrfalcons. Their special characteristic features for unique identification is explained in detail in this chapter. Moreover, distinct differences may exist between juvenile and adult falcons and are explained in detail. A quick reference table shows the most important visible anatomical differences between falcons and hawks to serve as easy reference guide. Furthermore, the most important raptor species used for falconry like hawks and golden eagles are explained in details to facilitate their identification.

2.1. Introduction

Several falcon and bird of prey species are more commonly used for falconry. Among them are *Falco peregrinus*, *Falco cherrug*, *Falco rusticolus*, *Accipiter gentilis* as well as hybrid falcons of the large hierofalcon species. In order to facilitate the identification of the different species, their main characteristics are listed. Moreover, some bird of prey species show special differences according to their age. However, certain species show considerable differences in color and plumage patterns despite being from the same species. This applies especially to falcon hybrid species where the identification might be especially difficult. The correct species identification may help also in diagnosing different diseases for which certain falcon species are more susceptible. Therefore this chapter offers a variety of valuable information for veterinarians, veterinary students and veterinary technicians who are not so deeply involved and experienced in falconry and raptors rehabilitation.

2.2. Raptor Anatomy

Falcons and hawks show some considerable differences in anatomy which makes identification relatively easy. Those differences can be found in size, weight, shape of the infraorbital bone, relation of wing tip to tail tips, nostril, cere and iris color. Moreover, other differences can be observed in the patterns of the scales, shape of the tomial tooth, presence of holding nods on the feet and talons. Moreover, malar stripes, wings and gender differences are visible in different raptor species.

Table 2.1. Differences in anatomical features in Falco spp. and Accipiter spp. [1,2,3,4]

Anatomical feature	Falco species	Accipiter species
Size	Between 35-64 cm	Between 47-62 cm
Weight	500-2100 g	600-1300 g
Prominent infraorbital bone	No	Yes, very prominent
Nostril	Round, with rods	Oval, without rods
Cere	Grey in juveniles	n/a
Iris color	Brown	Gold to red
Scales	Small	Large
Tomial tooth	Sharp (Falcon's tooth)	Rounded
Holding nods on feet	Yes	No
Talons	Thin	Longer and stronger than Falco spp.
Malar stripe	In some species prevalent	No
Tips of wings in relation to tip of tail	Wing tips do not reach tail tips	Wing tips do not reach tail tips, but almost reach middle of tail and are much shorter than in falcons
Wing	Long, pointed; second primary feather is the longest when the wings are extended	Round
Differences between females and males	Females have same coloring as males or slightly darker	Females might be more brownish colored

The size of most falcon species ranges from 35-64 cm whereas hawks are larger with 47-62 cm body size. The weight of falcons ranges from 500 to 2100 g. Hawks have an average weight of 600-1300 g. Prominent infraorbital bones can be found only in Accipiter species as this anatomical structure is absent in Falconiformes. Falcons have round nostrils with the typical rods located centrally in the nostril (Figure 2.1). In contrast, hawks and eagles have oval nostrils without rods (Figure 2.2). The cere of juvenile falcons is grey colored. Brown iris color can be seen in falcons of all ages compared to the gold to red iris color in hawks that depends on the age of the birds. Falcons feature a sharp tomial tooth, the so-called falcon's tooth, which exists in this form exclusively in falcons (Figure 2.3). Hawks possess round tomial teeth.

Figure 2.1. Round nostril with rod in peregrine falcon.

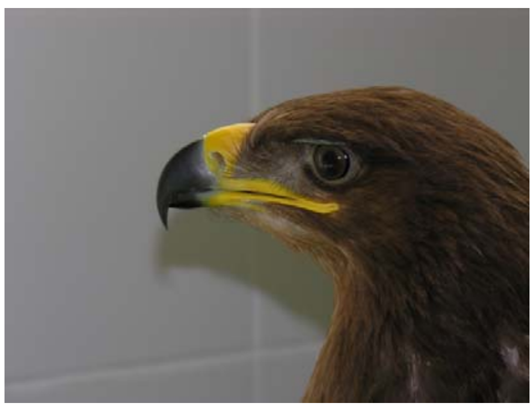

Figure 2.2. Nostril without rods of Golden Eagle.

Figure 2.3. Tomial tooth of falcon.

Another special anatomical feature in falcons is holding nods on the feet (Figure 2.4). These nods do not exist in Accipiter species. Thin talons can be found in falcons whereas hawks and eagles have longer and stronger talons than falcons. Falcons possess small scales in contrast to the large scales of hawks and eagles (Figure 2.5). In some falcon species like peregrine falcons prominent malar stripes are visible (Figure 2.6).

Figure 2.4. Holding nods of falcon's foot.

Figure 2.5. Feet of golden eagle.

Figure 2.6. Prominent malar strip of adult peregrine falcon.

In contrast, hawks do not possess malar stripes. In both, falcons and hawks, the wing tips do not reach the tail, but in hawks they are shorter than in falcons. However, in falcons, the wings are long and pointed and the second feather of the wings is the longest feather. Falcon females have the same color or are only slightly darker than males. However, they are larger than the males, in some species of up to one third (Figure 2.7).

Figure 2.7. Size difference in female and male falcon.

2.3. Species and Age Differences of Falcons

2.3.1 Lanner Falcon (*F. biarmicus*)

Size: The length of a lanner falcon ranges from 35-50 cm. The males (Figure 2.8) weigh between 500-600 g and the females are heavier with 700-900 g. The wing span in males is around 100 cm and in females approximately 110 cm [3].

Subspecies and range: Different subspecies of lanner falcons do exist. The European lanner falcon is the Feldegg's falcon or *F. b. feldeggii*. Moreover, in North Africa from Morocco to Tunisia the *F. b. erlangeri* can be identified which is the smallest lanner falcon species. The *F.b.tanypterus* lives in the region from Libya to Jordan [1]. *F.b. abyssynicus* and *F.b. biarmicus* can be found in Africa. In Europe lanner falcons prefer mountains and cliffs whereas they live in stony semi-desert and desert areas in the North African and Middle East region [1].

Figure 2.8. Lanner falcon male.

Special characteristics: Lanner falcons have longer tails than e.g. *F. peregrinus*.

Juveniles: Juvenile lanner falcons have mainly brown colour. Their back side is uniformly brown. In contrast their chest and abdomen is crème coloured with brown longitudinal dots that are similar to saker falcons [3].

Adults: Adult lanner falcons have a blue-grey back with light dark horizontal stripes. The plumage on their chest and abdomen is very light colored with only few dots. The head is sand colored up to fox-reddish color and they have dark thin malar stripes [3].

Similarities: Lanner falcons can be mistaken with saker falcons especially in those areas where both species can be found. However, lanner falcons are considerably smaller than saker falcons.

2.3.2. Peregrine Falcon (*F. peregrinus*)

Size: The size of peregrine falcons is 34-50 cm with a wing span of 90-105 cm. The weight of males is between 580-720 g with an average of 610 g. The females weigh 860-1090 g with an average weight of 940 g [3].

Subspecies and range: Peregrine falcons are globally distributed as *F. peregrinus* is the only falcon species that is cosmopolite and can be found on all continents, except Antarctica. Therefore 19 subspecies are internationally recognized. They are *F.p. calidus, F.P. anatum, F.p. tundrius, F.p. pealei, F.p. cassini, F.p. japonensis,F.p. fruitii, F.p. peregrinus, F.p. brookei, F.p. babylonicus, F.p. pelegrinoides, F.p. madens, F.p. minor, F.p. radama, F.p. peregrinator,F.p.nesiotes,F.p. ernesti, F.p. macropus and F.p. submelanogenys* [4].

Special characteristics: Peregrine falcons have long relatively sharp wings and a short tail. They have thick black malar stripes in sharp contrast with white cheek. In contrast to other falcon species, another special characteristic are long thin toes and very long middle toes that are almost double of other toes. Moreover, in peregrines a big size difference between male and female exists. Falcons of the subspecies *F. p. calidus* are bigger and their chest and abdomen is lighter coloured with smaller stripes. The subspecies *F. p. brookei* features smaller and darker falcons with reddish coloured nape and mild reddish coloured chest and abdomen.

Juveniles: Juvenile peregrine falcons have brown plumage on the back, wings and tail as well as head (Figure 2.9). Their chest and abdomen is light brown with thick longitudinal dots (Figure 2.10). Their feet are usually bluish colored.

Figure 2.9. Backside of juvenile peregrine falcon.

Figure 2.10. Frontside of juvenile peregrine falcon.

Adults: Adult peregrines have blue-grey back plumage, wings and tail (Figure 2.11). The chest is light colored and the abdomen is light colored with dark horizontal stripes. Some small dark drops that are sometimes heart shaped can be seen lateral of the chest and under the wings (Figure 2.12). The malar stripes of adult peregrines are sharper than in juveniles.

Similarities: Peregrine falcons look similar to *F.pelegrinoides*.

Figure 2.11. Backside of adult peregrine falcon.

Figure 2.12. Frontside of adult peregrine falcon.

2.3.3. Barbary Falcon (*F. pelegrinoides*)

Size: The size of the Barbary falcon (Figure 2.13) is 36-45 cm with a wing span of 85-112 cm. The average weight of a male Barbary falcon is 340-430 g whereas the female weighs 610-780 g [4].

Figure 2.13. Barbary falcon (F. pelegrinoides).

Subspecies and range: One subspecies is the *F. pelegrinoides pelegrinoides* which lives in the Atlas countries and ranges from the outskirts of the Sahara to the western Sudan. The so-called red-nape-shahin *F. pelegrinoides babylonicus* has a bigger size and can be found in Iran, western Mongolia and the north-western Himalaya [4]. They prefer stony semi-desert and desert as habitat.

Special characteristics: Barbary falcons have a black cap with wide malar stripe and look very similar to *F. peregrinus.*

Juveniles: Typical features for juvenile Barbary falcons are the brown back feathers that are darker than in *F. peregrinus* species. They have a lighter colored chest and abdomen with reddish head. Their malar stripe is smaller than in peregrine falcons.

Adults: Adult Barbary falcons have light blue-greyish back plumage and cap and their nape is reddish. The chest and abdomen appears to be only yellowish colored with only few dark dots and horizontal stripes.

Similarities: There are some distinct differences to *F. peregrinus*. The reddish color of cap and nape and its slimmer body is typical for the *F. pelegrinoides*. The chest and abdomen of the Barbary falcons is lighter yellowish colored and appears to be only one color. Their malar stripe is not as dark as *F. peregrinus.* Moreover, the *F. peregrinus* has a more prominent contrast on chest and abdomen.

2.3.4. Saker Falcons (*F.cherrug*)

Size: Saker falcons have a size of 46-58 cm. The wingspan is 105-128 cm. The male saker falcons weigh 700-900 g [3] and the females have a weight of 920-1300 g [4].

Subspecies and range: Saker falcons can be found in the desert areas and steppe areas of south east Europe and Central Asia up to China. Different saker species do exist among them *F.c.cherrug, F.c.milvipes, F.c.cyanopus, F.c.altaicus.* The largest subspecies is the Altai falcon [3].

Special characteristics: There are three color morphs of saker falcons and many intermediate forms. The underside of the saker's tail is striped whereas the backside of the tail shows light colored tail steps and oval dots on tail feathers. The two central feathers are sometimes without dots.

Asian species: Asian saker falcon species are darker and have more irregular longitudinal drops.

Mongolian and Russian species: The Mongolian and Russian species and especially the Altai falcons do often not have separate longitudinal drops but feature mainly a brown chest and abdomen. Moreover, they are larger in size.

Juveniles: Juvenile saker falcons have typical blue-colored feet. This typical bluish color is more prominent in wild saker falcons than in captive bred sakers. Their brown color is darker than in adult falcons. Moreover, their chest and abdominal plumage is darker and has longitudinal drops (Figure 2.14).

Figure 2.14. Saker falcon (F. cherrug).

Adults: In contrast to juvenile falcons, 2nd year old adult saker falcons have light yellow feet (Figure 2.15). Saker falcons that are older than 2 years have bright yellow feet. They have a brown backside and lighter colored head. Their chest and abdomen is lighter colored with dark longitudinal drops.

Figure 2.15. Adult saker falcon (F. cherrug).

Similarities: The wings of saker falcons are wider than and not as sharp as the wings of *F. peregrinus.* Moreover, they have a longer tail and are larger and more massive falcon than peregrine falcons. Saker falcons might look similar to the grey morph of *F. rusticolus* with their brown upper parts and white oval spots that can sometimes form bars.

2.3.5. Gyrfalcon (*F.rusticolus*)

Size: Gyrfalcons are 50-60 cm large with 110-130 cm wing span. The males weigh 960-1220 g [4] with an average of 1070 g [3]. The weight of the female gyrfalcon ranges from 1280-2100 g [4] with 1710 g [3] as average weight.

Subspecies and range: Gyrfalcons have their habitat in the arctic and subarctic regions of Northern Europe, North America and Asia. *F.r. rusticolus, F.r. obsoletus, F.r. candicans, F.r. islandus.*

Special characteristics: Gyrfalcons are the largest falcons. They have a very thin malar stripe. In white gyrfalcons the malar stripe is missing [3]. A massive body, big head with strong beak (Figure 2.16), long and wide wings are typical anatomical features for gyrfalcons. 3 main morphs exist in gyrfalcons:

Grey morph: F.r. islandus show the grey morph. Their head is streaked with white. The upper parts are grey and the lower parts white [1].

Black morph: The subspecies *F.r. obsoletus* or so-called Labrador gyrfalcon features the black morph [1]. The upper parts, head, and lower parts are predominantly dark brown. After about 2 years, the plumage will be replaced by typical grey morph plumage.

Figure 2.16. Head of adult male gyrfalcon (F. rusticolus).

White morph: Originating from Iceland, the white morph (Figure 2.17) can be found in the subspecies *F.r. candicans.* They have predominantly white upper parts, lower parts and head with some black markings [1,3].

Juveniles: In juvenile North European gyrfalcons a unified grey-brownish plumage can be observed. The chest and abdomen might show dark longitudinal spots on light-coloured plumage [3].

Adults: Adult North European gyrfalcons have a grey backside plumage with dark horizontal stripes. Their whitish plumage of chest and abdominal part is covered with darker spots [3].

Similarities: The grey morph might look similar to saker falcons.

Figure 2.17. Adult female gyrfalcon (F. rusticolus).

2.3.6. Hybrid Falcons

The creation of falcon hybrids using natural or artificial insemination to boost size, strength and speed is quite common in falconry nowadays. Hybrids are unpredictably variable; they can have a variety of characteristics. However, this mixture is not consistent as e.g. one *F. rusticolus* x *F. peregrinus* hybrid falcon can look very different from another. Hybrids may also be bred in genetic mixtures of 50%-50%, 62.5%-37.5%, 75%-25%, or in combinations of more than two species. ¾ or ⅞ hybrids may be mistaken for one parent or the other due to the higher content of genes of one parent. They may also feature a different variety of parental characteristics.

Falcons with white color derive this color from their white *F. rusticolus* parent. Prominent malar stripes in hybrid falcons are inherited from a *F. peregrinus* parent. Brownish feathers on the head are more indicative for the *F.cherrug* parent (Figure 2.18). 50%-50% *F.rusticolus* x *F. cherrug* falcons are often similar to saker falcons, but lighter colored and larger (Figure 2.19). 7/8 Gyr-Saker hybrid falcons (*F. rusticolus* x *F. cherrug)* hybrid might be barely distinguishable from the *F. rusticolus*. Although this kind of hybrid is smaller, the reason could be that it is a male. It is not necessarily an indicator that it is a hybrid falcon.

Dark spots and heart-like dots under the wing might be indication that the falcon is a gyr-peregrine hybrid falcon (*F. rusticolus* x *F. peregrinus)* (Figure 2.20). Another typical feature for gyr-peregrine hybrid falcons is a dark head color (Figure 2.21) which might derive from a black *F. rusticolus* that is crossed with *F. peregrinus* hybrid (Figure 2.22). It can also be an indication that the bird has genes of a dark peregrine falcon (Figure 2.23).

Moreover, it is likely that large sized falcons of more than 50 cm size have *F. cherrug* or *F. rusticolus* genes. Hybrids of species of different sizes will usually result in a size between the two. For example, a gyr-peregrine hybrid falcon (*F. peregrinus* x *F. rusticolus)* will almost always be larger than a peregrine falcon and smaller than a gyrfalcon.

Figure 2.18. Brown colored head of F. rusticolus x F. cherrug.

Figure 2.19. F. rusticolus x F. cherrug hybrid falcon.

Figure 2.20. F. rusticolus x F. peregrinus hybrid falcon.

Figure 2.21. Dark head of F. rusticolus x F. peregrinus hybrid falcon.

Figure 2.22. F. rusticolus x F. peregrinus hybrid falcon (dark F. rusticolus parent).

Figure 2.23. F. rusticolus x F. peregrinus hybrid falcon (dark F. peregrine parent).

List of Possible Hybrid Falcon Species

A large variety of hybrid falcons do exist and new hybrid falcons are bred, too. Some examples are given below to indicate this variety of hybridization in falcons.

Falco rusticolus x *Falco peregrinus*
Falco rusticolus x *Falco cherrug*
Falco rusticolus x *Falco biarmicus*
Falco rusticolus x *Falco pelegrinoides*
Falco rusticolus x *Falco columbarius*
Falco rusticolus x *Falco mexicanus*

Falco cherrug x *Falco peregrinus*
Falco cherrug x *Falco biarmicus*

Falco peregrinus x *Falco biarmicus*
Falco peregrinus x *Falco mexicanus*

2.3.7. Differentiation of *Falco spp*. Juveniles from Adults

In juvenile falcons, the cere, the ring around the eyes and also the legs are blue or grey. In contrast, cere, ring around eyes and the legs have a yellow color in adult falcons. Except for the white morph and black morph of *F. rusticolus*, all juvenile falcons have brown upper parts, pale under parts with varying degrees of brown spotting or streaking white forehead. Moreover, they might have a white eyebrow stripe and dark eye strip and malar stripe. The size differences may be useful in distinguishing the various species.

A mixture of brown and grey plumage on the backside and wings of the falcon, especially in *F. peregrinus* indicates that the specimen is the juvenile falcon in the process of replacing its brown, juvenile feathers with grey adult feathers.

2.4. Other Raptors Used for Falconry

2.4.1. Accipter Gentilis

Size: Hawks range in size from 47-62 cm. The male weighs between 600-870 g and the female between 900-1300 g [4].

Subspecies and range: A. gentilis can be differentiated in 10 subspecies*: A.g. gentilis, A.g. marginatus, A.g. arrigonii, A.g. buteoides, A.g. albidus, A.g. schvedowi, A.g. fujiyamae, A.g. atricapillus, A.g. laingi and A.g.apache.* dependaing on their subspecies, they can be found in Europe, North America, northern Asia and Japan [4].

Special characteristics: Hawks are used for falconry in Europe and America, but not in the Middle East. Typical for hawks is the prominent infraorbital bone and the strong beak. The upper parts of the plumage are grey. Female hawks may be browner with white eyebrow stripes. A distinct differentiation in the plumage similar to peregrine falcons gives clear information about the age of the hawks. Moreover, *A.gentilis* species feature relatively short and wide round wings and a long tail. The tail is much longer than the wings and has 4 typical wide dark horizontal stripes. The *A.gentilis albidus* is the white morph [4].

Juveniles: 1st year juveniles of the *A.gentilis* species possess yellow eyes with blue-grey iris. Their plumage on the backside is dark brown. They have the typical reddish-brown crème colored chest and abdomen with dark brown longitudinal dots [4].

Adults: After the first molting, adult hawks have a grey-brown up to grey-black backside feathers and wings. Their eyes change to orange colored eyes that get more orange-red when the birds get older. The chest and abdomen is whitish with very tight and fine horizontal band-like stripes. Moreover, adult hawks have a dark stripe from eyes to nape with light colored infraorbital stripe [4].

Similarities: The plumage of the 1st year hawks might resemble juvenile peregrine falcons or saker falcons, but the other differences between hawks and falcons are very distinct and should help in the differentiation of the species.

2.4.2. Harris Hawk (*Parabuteo unicinatus*)

Size: Harris hawks reach a size of 56 cm and wing span is 108-123 cm. The males have a weight of 600-840 g and females range from 820-1200 g [4].

Subspecies and range: Harris hawks have 3 subspecies that are distributed in south western America, Central America up to Paraguay and Argentina.

Special characteristics: Harris hawks are very good birds for new falconers that are lacking experience. They are famous for their bonding to their owners. Harris hawks possess a dark brown plumage with reddish wings and leg feathers. The iris is brown and they have a prominent beak.

Juveniles: Juvenile Harris Hawks feature a lighter colored brownish plumage and a brown striped tail.

Adults: Adult Harris Hawks have a typical black tail with white tail step [4].

Similarities: Harris hawks have a very prominent plumage and general look that cannot be easily mistaken with other falconry birds.

2.4.3. Golden Eagle (*Aquila chrysaëtos*)

Size: The golden eagles reach a size of 79-97 cm with a wing span of 190-235 cm. Male golden eagles weigh as an average 3800 g whereas females reach 5000 g as average weight [4].

Subspecies and range: 6 subspecies can be differentiated among golden eagles. They are *A.c.chrysaetos*, *A.c.homeyeri*, *A.c.daphanea*, *A.c.kamtschatica*, *A.c.canadensis* and *A.c.japonica*. Therefore they range from North Europe to Central Asia, Arabian Peninsula, America, Korea and Japan [4].

Special characteristics: Golden eagles have very long and wide wings with long tail. They have very characteristic prominent finger-like feathers [3].

Juveniles: Juvenile golden eagles can be differentiated through a characteristic white large feather area at the base of the inner side of the primaries (Figure 2.24). They also have a white tail with wide dark tail step [3].

Figure 2.24. Juvenile Golden eagle (Aquila chrysaëtos).

Adults: Adult birds reach their adult plumage at an age of 5-6 years. Their plumage is uniform dark brown with golden colored neck and head thus resulting in its name “golden eagle” [3].

2.5. Conclusion

The correct species identification of birds of prey provides valuable information not only about the different species, but also helps in diagnosing species-specific diseases. Therefore the information provided in this chapter will help to let non falconers understand the importance of the knowledge about different raptor species. Moreover, the differences in age are explained in order to avoid a wrong identification of the different age groups in raptors. This chapter is supposed to guide them to a faster recognition of the raptor species and thus indicate the prevalence of e.g. certain bacterial infection in some raptor species. Therefore valuable time can be saved that might lead to an earlier diagnosis and subsequent treatment. This chapter can be used as a quick reference guide to the most important raptor species used for falconry.

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Chapter III

Falcon Husbandry

Abstract

Good falcon husbandry helps to prevent diseases that can range from injuries over nutritional deficiencies to bacterial infections through contaminated falcon facilities. Housing has to be appropriate and falcon equipment must be well maintained. Varied diet is important to keep falcons healthy as otherwise vitamin deficiencies and related diseases can occur. Hygiene achieved through cleaning and disinfection plays an essential role for the well-being of the falcons. Regular screening of falcon facilities can be performed on monthly basis. It is highly beneficial because it detects hidden sources of bacterial and fungal contamination in the falcon's environment.

3.1. Introduction

Correct falcon husbandry is one of the essential parts in good management practice of falcons. It is the key to successfully keeping the falcon fit, healthy and in good hunting condition. Improper care for this fragile bird leads to management related diseases that could have been easily prevented.

This chapter provides an overview over the most important parts of falcon husbandry including housing, nutrition, hygiene and facility screening. It is not intended to provide a fully comprehensive manual about falcon husbandry as this topic has been covered extensively by specialized falconry books.

This chapter shall give the reader an outlook on the most important husbandry issues affecting falcon health. Moreover, it emphasizes the preventive tool of facility screening as a way to control the degree of contamination in falcon facilities. If remaining undetected, bacterial contamination may lead to serious consequences in falcons with often fatal results.

3.2 Housing and Equipments

3.2.1. Housing and Falcon Facilities

Falcons can be housed in rooms, enclosure and aviaries. The housing helps to protect the falcon from unwanted weather influences and disturbances. In several countries, legal requirement determine the size and space for falcon accommodations. The different housing types will not be explained in detail in this chapter as they have been covered extensively in falconry books. However, certain requirements are essential. Large rooms must have light and appropriate ventilation. Cages are preferably round-shaped as this reduces the number of injuries while flying. No wires should be pointed inside the cage as this can lead to severe damage of the falcon when hitting or getting entangled in the wire. Nets should be elastic but strong enough with small holes. In countries with hot climate or hot summer, air-condition is required. The falcon facilities should be in far distances of other animal housings as well as hey or manures which might be contaminated with *Aspergillus sps.* spores.

It is important to avoid overcrowding by placing not too many falcons in a small room. Good ventilation is essential to prevent dust and humidity causing respiratory problems in falcons. The area within reach of the falcon must be safe (no hooks, screws etc) to prevent injuries. The material of the place should be of good quality. It is advisable to keep a separate place or room for sick falcons to avoid spreading of diseases. Free flight in aviaries or larger rooms is an excellent way to ensure a good exercise outside the hunting season and to prevent bumblefoot in your falcon.

3.2.2. Equipment

Mangalahs (Arabic cotton muff) (Figure 3.1) and gloves should be used only for one particular falcon and not changed among several falcons in order to avoid the transmission of diseases. After feeding a falcon on the mangalah or glove, it should be cleaned and all pieces of meat have to be removed. If the falcon is used to be fed on the glove, one special glove should be reserved for feeding one falcon and used exclusively as feeding glove.

The hood (Figure 3.2) must properly fit in size around the eyes, mouth and beak to avoid damage to the falcon's eyes or pressure sores around the beak. Its purpose is to keep the bird quiet and calm but not to interfere in its well-being. Hoods should be controlled routinely from the inside. The inside of a hood can provide the falconer or veterinarian with highly valuable information about the falcon's health condition although this is frequently overlooked even by experienced falconers. Controlling the hood interior helps to detect any discharge from one or both eyes as well as pressure sores around the beak. If eye discharge happens, then either the hood is too small and touches the eyes or the falcon suffers from eye infections with watery or mucoid discharge. In both cases, the hood has to be replaced with a new and more suitably sized one. In case of eye infections, appropriate treatment has to be applied and the hood should be replaced by a new one and discarded. The hood should not be too tight around the beak region as this leads to pressure sores and can even result in abscesses.

Figure 3.1. Mangalah (Arabic cotton muff).

Figure 3.2. Falcon hood.

Ideally the hood is large enough to fit behind the angle of the mouth. It is advisable not to exchange the hoods between different falcons. Moreover, a good new hood in correct size should be bought for each new falcon [5].

Jesses should be of good and soft quality and fit the falcon's foot size properly no matter what material is used. In Western countries, leather jesses are used whereas in Arab countries jesses made of thread are favored (Figure 3.3). Old, porous and damaged jesses should be replaced immediately as otherwise the falcon will suffer abrasions or injuries around the feet [5]. Those injuries happen especially in the Arab jesses or so-called 'subuqs' as they have a much smaller diameter and can get entangled around toes very easily. This can lead to massive constriction of the toes, reduced blood circulation, cutting of the tendons, osteomyelitis and subsequently require amputation. Those injuries are explained in detail in chapter 14 and 15. Moreover, the falcon can easily escape if damaged or porous jesses tear.

Perches exist in different forms, diameters and material. It is good for falcons to have access to different size and diameter of perches. This will lead to changing pressure on the foot sole and thus help to prevent bumblefoot. Moreover, perches should be kept in good condition and cleaned on a daily basis [5]. A stainless steel stand can be covered with a wooden block that can be removed for cleaning on a daily basis. On top of the wooden block, astroturf can be fixed. Broken astroturf has to be replaced immediately to prevent bumblefoot in falcons as the damaged astroturf tips deeply penetrate the falcon's foot sole. Portable perches or so-called "wakirs" are widely used in Arab falconry due to their light weight and easy use in different areas while hunting (Figure 3.4). They usually have a softer cotton cover. However, falcons should not be tied to perches during the molting season and be placed in aviaries as detailed in chapter 4. Moreover, if the time does not allow the falconer to fly and exercise the falcon regularly, the bird should better be put in a free-flight cage and not be tied down for several days or weeks without exercise. Screen perches are not recommended for falcons as they may lead to their death when jumping and hanging downwards.

Figure 3.3. Typical Arab jesses.

Figure 3.4. Portable perch (Arab model).

3.2.3 Tethering

The falcons must be tethered properly with the falconer's knot (Figure 3.5, 3.6) to their perch to avoid their escape and also to prevent self-inflicted injuries by another falcon in the same room. It is advisable to check periodically the tethered and hooded falcons to ensure they are safe and comfortable [5]. It is advisable to control jesses and leash always when putting a falcon on the glove to ensure it is safely tied. Nothing is more embarrassing for a falconer and veterinarian alike as falcons that escape because jesses and leash were not checked and got loose due to negligence and carelessness.

Figure 3.5. Leash for tethering the falcon.

Figure 3.6. Falconer's knot.

3.2.4. Transport

The right transportation helps to prevents injuries and can be achieved by keeping in mind some simple guidelines. When placing the perch with the falcon into the transport vehicle, it should be positioned parallel to the line of motion. It is easier for a falcon to balance from side to side rather than back and forth when the vehicle stops and starts. Free-standing perches in a carrier during transport should not be used. Some special square perches exist also for transporting falcons in vehicles (Figure 3.7). They may shift or tip over thus resulting in injury to the falcon. No food or water should be left in a carrier during transport. Most falcons do not have to eat during travel and water tends to spill. Providing adequate ventilation and air-conditioning in the transport vehicle is essential. Therefore falcons should never be left inside a vehicle during summer time without air-condition [5].

Figure 3.7. Transporting falcons in vehicle.

3.3. Nutrition

3.3.1. Well-Balanced Diet for Falcons

Well-balanced food is one of the key success factors for good falcon management. It is never enough to feed just raw meat for a falcon. Captive raptors must be fed either whole animals, usually birds (e.g. quails, pigeons, day-old chicks, ducks) or mammals (mice, rats, gerbils, etc). In some countries, quail, pigeons, rats and mice are the most expensive food for falcons whereas chicken is less expensive. Often, rabbits and day-old chicks are cheap food [1]. The Abu Dhabi Falcon Hospital prefers feeding a whole–animal diet. However, beef meat is not an appropriate food for falcons [1]. Sheep meat leads to fattening of the falcons and frequently large yellow fat deposits in the airsacs can be observed during routine endoscopies. When feeding a natural diet, it is important to include the meat, organs (heart, liver), bones, and skin of the food animal. This ensures that the falcon is getting the proper balance of vitamins, minerals, and casting materials as well as the calories it needs to survive. Minerals and vitamins are an important part of the falcon's diet, and either deficiencies or imbalances can cause health problems. Their deficiencies can cause serious health problems. Normally, healthy falcons that are fed a proper diet do not need any other vitamin supplementation. However, if the falcon is thin, undergoing stress and molting or is temporarily unable to be fed on the proper diet, commercially available vitamin supplements may be added to its food [5]. It is good to feed fresh food of controlled origin as toxic residues might be present in uncontrolled fresh food. It is recommended to visit the farm where the food animals are coming from and to see how the food production is performed. If fresh food animals are not accessible, frozen food has to be used which has to be complimented with commercial vitamin supplements (Figure 3.8). Falconers using hunted prey for their falcon as food have to ensure that the prey has not been shot as otherwise a lead intoxication can result.

Figure 3.8. Vitamin supplements for frozen food.

3.3.2. Preparation of Fresh Food

Fresh food should be used only if the source of origin is known. Moreover, if fresh food is used that was bred in breeding farms like quails, it has to be ensured that no medicines, antibiotics or coccidiostats have been administered before at least 10 days. When feeding fresh food, it has to be ensured that the food has been killed immediately before feeding. The main parts of feathers, skin, head and feet should be removed. In pigeons additionally the crop and neck have to be removed and they should have been frozen at least two weeks before use [1] as they often suffer from diseases like trichomoniasis. After opening the body cavity it is useful to examine the body cavities and internal organs if there are e.g. spots in the liver, nodes in the intestines or the abdominal cavity or other abnormalities. In this case the food animal should not be feed to the falcon and the whole animal should be thrown. If everything looks normal, stomach, intestines and urogenital tract should be removed by leaving just the liver and heart inside the body of the food (Figure 3.9). The freshly prepared food can be given to the falcon as soon as possible. It is not problem to leave some feathers or skin for digestive purposes in healthy falcons.

3.3.3. Preparation of Frozen Food

Although fresh food is the best food for falcons, sometimes it is unavoidable to feed frozen food like quails from the supermarket. In this case, it has to be kept in mind that the freezing over a long period of time is reducing the vitamin content as storage has a negative impact on the vitamin level. Moreover, food for falcons should not be left outside in the sun for defrosting as this may lead to a bacterial infestation of the meat and subsequent danger of septicemia for the bird. It is better to defreeze the frozen food slowly in the fridge or quickly in hot water.

Figure 3.9. Fresh quail prepared to be fed to falcon.

3.3.4. Nutritional Values and Vitamin Content of Different Food

Falcons need certain basic nutrients to keep them healthy. If these essential nutrients are lacking, the falcon's body will not function properly. The falcon might become sick or exhibit poor skin color, feather condition, or beak and talon condition. Since a falcon's meat diet usually provides sufficient protein, carbohydrate and fat, most deficiency disorders originate from a lack of vitamins or minerals.

Vitamins act as catalysator for metabolic process in the body. The vitamins A, D, E and K are fat soluble and stored in the liver. If too many vitamins are given to the falcon, hypervitaminosis and related diseases may arise. In contrast, vitamin B and C are water soluble and not stored for a long time in the body. Another important vitamin that is not available to falcons through their diet is vitamin D. Vitamin D is essential for absorbing and using calcium and for laying calcium on bones. A diet consistently deficient in this vitamin leads to weakened bones thus leading to increased danger of fractures. Falcons normally acquire this essential vitamin when they are exposed to direct sunlight. Hence it is essential to expose falcons to direct sunlight for some time on a daily basis. Falcons housed indoors, without direct sunlight, require a regular vitamin D supplement in their diet [5].

Quails are rich in many minerals but if fed exclusively as frozen quails, additional vitamin supplement is needed. Pigeon is a high energy food, but often suffer from disease. They should be fed preferably when their origin is known and they are healthy. Mice are rich of vitamin A whereas rats contain higher vitamin E contents then mice [5].

Table 3.1. Deficiencies and effects of different vitamins [5]

Vitamin	Deficiency	Effect
Vitamin A	Lesions on beak and talons Eye problems Poor hatching of chicks High chick mortality Predisposing factor for visceral gout	Protection of mucous tissue of respiratory and alimentary tract Resistance against infections
Vitamin B group Vitamin B1 (Thiamine) Vitamin B2 (Riboflavin)	Biotin => feather and skin problems	Important for nerve system Biotin => necessary for good skin
Vitamin C	Level reduced in times of stess like training, transport Prolonged wound healing	Wound healing
Vitamin D, D_3	Weak bones, rickets	Balance of calcium and phosphorus Activated by sunlight => 45 min sunlight daily
Vitamin E	Low immune system, easier affected by diseases	Immune system, protective effect in stress
Vitamin K	Hemorrhages	Stored in liver => blood clotting factor

Vitamin A has the highest level in mice, followed by rats, quail chicken and the lowest level in day-old chicks. In contrast, vitamin E occurs mostly in whole day-old chicks, then rat followed by mice, chicken and quail. Among the minerals, there are different once, but calcium is one of the most important once. It is needed for metabolic activities of the body as well as the nerves and muscles, heart and the clothing of the blood. The normal ratio of calcium to phosphorus is 1,5:1. A deficiency leads among others also to fits in falcons.

3.3.5. Water

Falcons evaporate water from mouth and skin surface. Especially in times of stress and exercise they need additional water. It is very common in those situations to find falcons in very dehydrated condition. Dehydration can be detected by a soft pinch on the leg skin of the falcon. If the skin stays folded and does not return to normal immediately, it is dehydrated. If the skin fold still stands upright after 30-60 seconds, the bird is severely dehydrated (Figure 3.10). Such an advanced dehydration might result in kidney failure. In those cases the falcons must be rehydrated orally or by subcutaneous injections of fluid therapy. Therefore it is advisable to bring the falcon to a veterinarian to start full rehydration therapy and to examine for other underlying diseases causes. Rehydration therapy is explained in detail in chapter 16. Falcons must be offered water in a suitable bowl for drinking or bathing. Water supply can also be provided by spraying her with water or dipping the food for a very short time into fresh water. A good way to give water to falcons, who do not like to drink, is the pouring of water from a small water bottle through a hole in the bottle's cap over the food while feeding the falcon (Figure 3.11). Most of the falcons enjoy this very much and have a much higher water intake than normal. The water bowl or basin has to be cleaned daily and the water has to be changed once or twice daily.

Figure 3.10. Standing skin fold in severely dehydrated falcon after skin fold test.

Figure 3.11. Water poured over food.

3.3.6. Casting

Undigested bones, feathers and skin of prey or food animals are thrown up as the so-called "casting". This is a physiological feature in falcons. Before feeding new food to a falcon, the cast should have been thrown up completely. When the falcon still has a big cast, it is better to leave her without hood or only a very loose one. Sometimes falcons move the head up and down or to both sides when trying to bring up the cast. However, sick birds should not be fed any cast including bones as they are already very weak and therefore not able to digest and swallow the cast. If the cast stays too long inside the crop and the falcon is not passing it, bacterial septicemia may develop and in the worst case kill the falcon. Therefore it is essential to make sure that a falcon is never fed while still having cast or a crop full of food [5].

3.3.7. Rangles

In the Arab countries it is still common to feed ammonium chloride or “shenadra” to the falcon to clean its stomach. This may lead to a destruction of the stomach and kill the falcon. Ammonium chloride intoxications are explained in detail in chapter 17. Normally, cleaning of the stomach is not required. However, if it is done then it can be performed much better by the use 5-12 small stones, the so-called rangle. This is done naturally by wild falcons either once a week or once a month [1]. Their use is to remove the mucous in the stomach and excess cuticles and thus enhance the digestion.

These stones are given to the falcon in the evening after having a light meal without or very little casting. The stones clean the stomach overnight and in the morning they are casted. Usually it is only necessary to give these stones for a few times like for 7-10 days when the falcon has lost some body fat during training [1].

3.4. Hygiene and Disinfection

Every falcon facility should be cleaned daily, including removing old food and providing fresh water for drinking and bathing. A thorough disinfection of the equipments and facilities once or twice a week helps preventing falcons from bacterial diseases. Air-condition filters should not be forgotten while cleaning as they are a major source of spreading aspergillosis.

The cleaner falcons’ facilities are kept and the more often they get disinfected, the less chance will be of spreading diseases. A monthly facility screening of the falcon facility is an excellent way to control the hygiene status and to detect possible bacterial and fungal problems in an early stage.

Hygiene comprises all measures serving the perseverance of health both the animal’s and its keeper’s health as well as the prevention of diseases. The use of hygienic measures help to prevent the spreading of diseases, may they be contagious or not. However, unfortunately the use of facility screening is underestimated by falconers and veterinarians alike. Cleaning and disinfection should include:

- Regular cleaning of the floor and carpets
- Regular cleaning of gloves, jesses and perches

3.4.1. Falcon Facilities Screening

No matter how careful each falconer is with regards to the hygienic environment of falcons, sometimes hidden dangers in the falcon's facility may exist that cannot be detected by the bare eye. Yet, nevertheless these dangers have the potential to lead to disastrous results – namely the loss of the falcons, if action is taken too late.

Symptoms for falcons that got diseased in contaminated falcon facilities include:

- Reduced appetite
- Reduced flight performance
- Vomiting
- Diarrhea, including bloody diarrhea.
- Weight loss

The most common bacteria causing this dangerous chain reaction are:

- Escherichia coli
- Clostridium perfringens
- Chlamydophila sp.
- Klebsiella pneumonia
- Streptococcus sp.
- Staphylococcus sp.
- Fungal germs like Aspergillus. sp

Pathogenic microorganisms can spread by soil, water and air as well as direct contact [3]. Most of these bacteria are usually part of the normal soil flora only if they occur in small (means very small!) quantities. From the moment their number increases due to various reasons (temperature, decaying food, less thorough cleaning etc.) they become the health hazards [6]. It is well-known that unhygienic keeping of birds of prey on uncleaned perches, feeding places and floors lead to bacterial infections [4]. Those infectious agents can contaminate the environment of the falcons e.g. floor, perches, gloves where they can stay alive for weeks up to several months. This contamination may create a latent danger for all falcons in the facility. In falcons known to be suffering from bacterial and fungal diseases, pathogenic microorganisms can lead to substantial disease cases or even losses of birds. Therefore a regular control and examination of the hygiene status of the facility is advisable preferably on a monthly basis.

A facility screening is the regular health check-up of the falcon's environment by taking sterile samples from the:

- Falcon's room
    - Floor
    - Perch (Figure 3.12)
    - Water bath
    - Air-condition

- Falcon’s food
    - Food preparation area
    - Food animals, i.e. quails, chicken etc.
- Falcon’s equipment
    - Gloves
    - Falconer’s bag
- Falcon’s fecal

Figure 3.12. Sample taking from falcon’s perch for facility screening.

In a research study, samples of perches, floors and rooms of falcon facilities have been examined to determine a possible pathogenic contamination for falcons (Figure 3.13) [7]. Research results have shown that out of 107 samples from the perches for sitting and feeding, 53 samples showed a heavy bacterial growth of *Staphylococcus sps*., *E.coli*, *Bacillus* and *Proteus*. In 10 samples, moderate bacterial growth was isolated. Scanty growth was detected in 24 samples. Mixed bacterial growth was found in 16 samples, unidentified gram negative bacilli in 3 samples and fungal growth resulted in 1 sample. No anaerobic organisms were isolated [7]. The same research has identified out of 58 floor samples 40 samples with heavy growth of *Staphylococcus sps*., *E.coli*, *Bacillus*, *Micrococcus*, *Proteus sps* and unspecified bacteria (Figure 3.14). Mixed bacterial growth was isolated in 8 cases, moderate growth in 1 samples and scanty bacterial growth in 4 samples. 2 samples resulted in the isolation of fungus. No growth was detected in 3 samples. No anaerobic organisms were isolated [7].

Studies of 79 falcon rooms samples (Figure 3.15) resulted in 31 samples with heavy growth of *E. coli*, *Staphylococcus sp*., *Proteus sp.* and grampositive bacilli. 30 samples showed mixed bacterial growth and 13 samples were identified with moderate bacterial growth. Scanty growth was seen in 4 samples and one plate showed fungal growth. No anaerobic organisms were isolated [7].

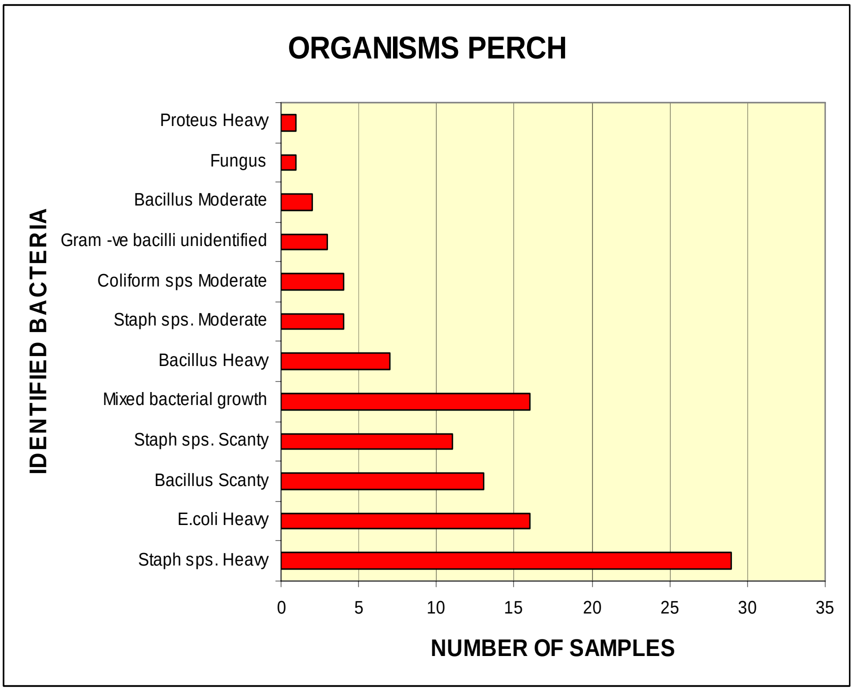

Figure 3.13. Organisms found in perch samples [7].

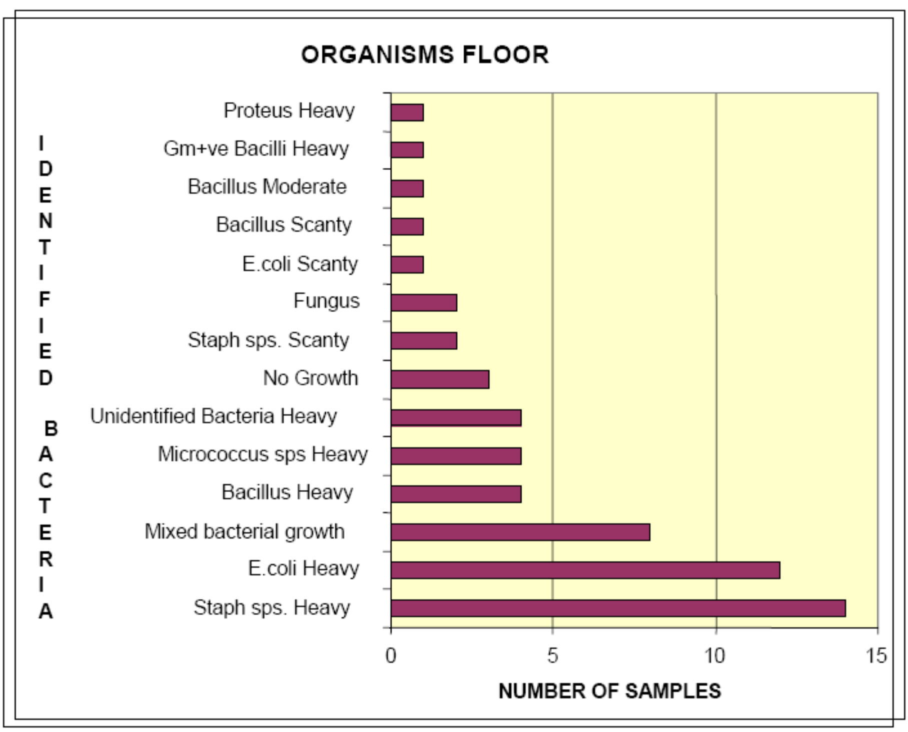

Figure 3.14. Organisms found in floor samples [7].

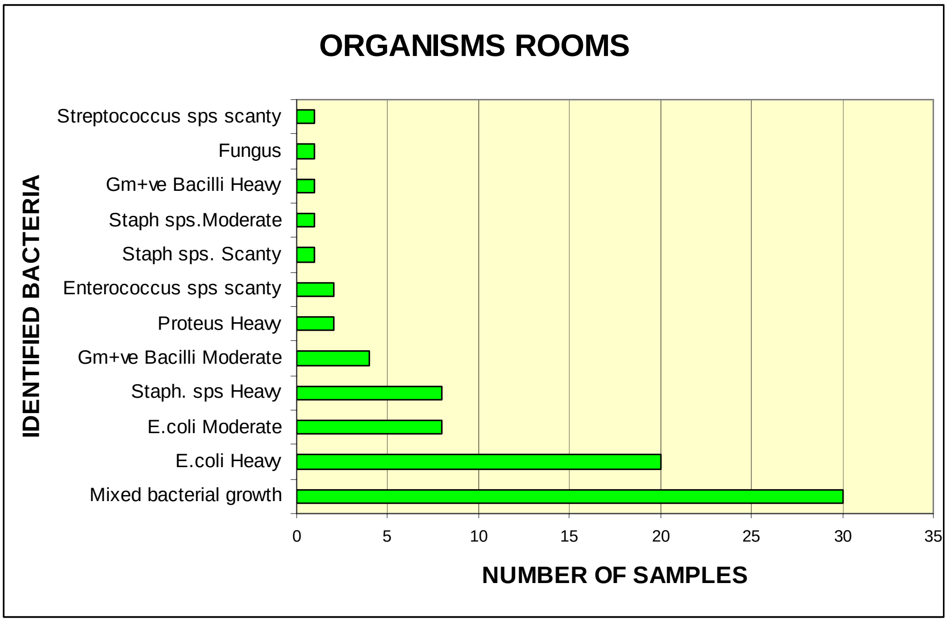

Figure 3.15. Organisms found in room samples [7].

Numerous samples of perches, rooms and floors resulted in *E. coli* and Coliform bacteria. *E. coli* can be linked to a potential colibacillosis which is both a contagious and infectious disease [9].

This colibacillosis or colisepticemia can be either acute or lead to the bird's death within 1-4 days or develop into a chronic systemic disease showing unspecific disease symptoms like inappetence, tiredness and weight loss [2]. *E.coli* has been found as one of the major pathogens for enteritis, hepatitis and nephritis as well as pneumonia and pericarditis in birds of prey [4]. The occurrence of *E. coli* can result in severe septicemia when the falcon eats contaminated food. If undetected, it can lead to death cases among the sick falcons [7]. More detailed information is provided in chapter 12.

Another major bacterium found in the study on perches and floors is *Staphylococcus sps*. The infections with cocci are common in husbandries with unhygienic maintenance [7]. They play a significant role as secondary pathogens in wound infections [4]. *Staphylococcus sps*. leads to abscessation and diarrhea [9] as well as bumblefoot [8]. One sample heavily infested with *Proteus sps*. of perch and floor was isolated [7]. This bacterium is known to cause unspecific general illness with considerable mortality in birds and psittaciformes [2]. The possible pathogenic impact of *Proteus sps*. in falcons is not yet fully clear [7].

3.4.2. Short Guidelines for Conducting Of Facility Screenings

- Screenings should be performed on a monthly (preferably), quarterly or half-yearly basis depending on the falconer's individual requirements and financial possibilities.
- Samples are processed in specialized veterinary laboratories

- Within the time span of 24 to 48 hours the complete results are available and compiled as facility screening report.
- Depending on the outcome of the screening which means the level of bacteria, fungal or other growth, the veterinarian should co-operate closely with the falconer in order to develop a bundle of measures to eliminate the contaminants. Where elimination is impossible due to financial, structural or other constraints and limitations, appropriate advice to contain and reduce the contaminants should be given.
- The facility screening report will be handed over to the falcon owner for his records.
- Regular consecutive screenings are useful to follow up the hygienic progress of falcon facilities

3.5. Conclusion

Falcon husbandry is essential in preserving falcons healthy. Suitable rooms or aviaries are essential as well as well-maintained equipment. Well-balanced diet is one of the key factors for successful falcon management. In case of feeding frozen food or in times of heavy stress or molting, vitamin supplements should be given to avoid nutritional deficiencies. Moreover, it is highly important to keep all falcon equipment and facilities clean. However, facility screening is an unfortunately often neglected and underestimated hygienic measure that can save the life of many falcons. Study results reveal that perches, floor and rooms of falcon facilities are often infected with heavy loads of pathogenic bacteria thus endangering the health of the falcon. In research studies, a high number of problem areas with heavy bacterial growth of especially *Staphylococcus sps.* and *E. coli* were detected [7]. Falcons suffering from tiny wounds e.g. in the foot areas are prone to the invasion of a large number of *Staphylococcus aureus* and *sps.* thus leading to massively infected bumblefoot. *E. coli* infections may result in considerable generalized infection and septicemia. In falcons known to be suffering from bacterial and fungal diseases, pathogenic micro-organisms may lead to substantial disease cases or even loss of birds. The research results show that regular control and examination of the hygiene status of the facility on e.g. monthly basis is necessary to trace pathogens on a routine basis and prevent diseases to develop [7]. The microbiological screening should be extended to food and water quality test as contaminated water or food may contribute to infection in falcons. Moreover, the control of the use of proper detergents and follow-up screening will reveal the improved hygiene conditions or the need of better and increased hygienic procedures. This routine facility screening will greatly contribute to the disease prevention and enhance falcon health of the individual falcon and the falcon collection.

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Chapter IV

Molting

Abstract

The yearly process of changing the feathers is called molting. It is induced by environmental and hormonal factors. Molting can be enhanced through a well-defined molting management including housing, feeding, day time length and special molting vitamins. The ideal way of molting is the use of free-flight aviaries which keeps falcons in good condition and continuous exercise. Falcons are molting in descendant and ascendant way starting from the 4^{th} feather. Disorders in feather growth can arise through stress as well as application of medicines and hormones. Falcons need to be observed during the molting time especially when molting in free-flight aviaries.

4.1. Introduction

The period of changing the feathers, the so-called molting is one of the most important times in the life cycle of falcons as only the successful molting paves the way to excellent hunting performance. The successful molting management includes a wide variety of different factors such as housing, feeding, timing of light, vitamin supplements and observation. A balanced diet of different food, clean and fresh water as well as water bath is essential to ensure a good molting. The molting can be very well supported by special vitamins which enhance the feather growth and structure like special composed vitamins, minerals and amino acids. However, even small disturbances during the molting time may result in molting disorders that can range from accidents to reduced feather quality. Unprofessional administration of medicines during this very sensitive time can lead to reduced feather growth or completely changed molting patterns and irregular molt. However, in case of necessary treatment of sick falcons, treatment has to be performed even in the molting time in order to prevent the birds from getting worse. Nevertheless, specialized falcon veterinarians know what kind of medicines can be administered to falcons during molting. Changes in the daylight time can enhance the speed of molting but it has to be performed in a highly controlled and careful way. Differences in the molting patterns do exist among the different falcon species and need to be taken into consideration for the judgment of the molting performance of falcons. This chapter enlightens the different aspects of molting management and highlights possible pitfalls during this time.

4.2. General Information about Molting in Falcons

The plumage of raptors consists of contour feathers, flight feathers like the primaries on the wing and tail feathers, down feathers and tiny hairlike filoplumes and small bristle feathers. The contour feathers cover the body surface whereas the flight feathers are positioned mainly on the wings and tail [3]. Those large plumes on the wings are also called remiges and are the most important feathers during the molting time. The tail feathers are called rectrices. The down feathers are used for insultation especially in small chicks. Moreover, gyrfalcons have a larger number of down feathers in the feather-free areas to increase insulation in their natural cold climate. They can be removed to some extent to acclimatize to warmer climate as this will reduce building up of heat and increased temperature [1]. The filoplumes are distributed over the body while the small bristle feathers are located around beak and nostrils [3].

The flight feathers have a feather shaft that is divided into two parts, the so-called rachis that forms the larger part of the feather shaft and the calamus being the hollow, cylindrical and translucent quill that ends in the bird's wing. Attached to the rachis, the vanes or web can be found on both sides. Those vanes are composed of barbs and barbules. Those distal barbules have hooklets with which they are attached to the barbules of the other flight feathers [3].

Molting in falcons takes place once per year on a gradual basis during the summer months. It is triggered by hormonal factors caused by the thyroid gland hormone and environmental factors like day light length. The length of the day light influences the pituitary gland which leads to increased molt. Delays in molt may arise in sick or emaciated birds. Differences in the molt can be observed in female and male falcons as well. Females molt heavier during the incubation period whereas males show delayed molt as they have to bring food for the females. They molt more when the female falcons is able to hunt again [1].

Molting in raptors follows different patterns. Whereas hawks and new world vultures have a descendant molt, falcons start to molt from the 4th feather as "molt center" (Figure 4.1) and molt in descendant and ascendant way (Figure 4.2, 4.3) [2]. The feather growth starts with a so-called blood feather which has strong vascularization (Figure 4.4).

4.3. Pre-Molting Examinations

Health examinations should be performed routinely before any falcon is put into molting in order to avoid that sick falcons are send for molting. This also rules out the possibility of transmitting infectious diseases to other falcons. Those health examinations include crop and fecal sample for parasitology and culture. This avoids parasitic contamination of the molting environment. Moreover, it rules out bacterial infestation of the falcons which might lead to severe health impacts of the affected falcons and other falcons in the same aviary alike if left undetected.

Figure 4.1. Molt center in falcons.

Figure 4.2. Ascendent and descendent molt.

Figure 4.3. Growth of new feather during molt.

Figure 4.4. Blood feather.

Blood samples for hematology and biochemistry reveal early signs of disease including liver and kidney problems. An endoscopic examination can be regarded as essential in the pre-molting examinations as it detects Aspergillosis and other organ diseases. It would be irresponsible to put falcons together in free-flight aviaries without having them endoscoped before. Moreover, it provides a good status report about the health condition of the falcons and can be used as comparison to the endoscopy in the post-molting examination which is described below in this chapter. Radiographs can be done but are not essential if the other examinations did not reveal pathological changes. However, if the falcon just returned from hunting and might have been fed with shot prey, a radiograph has to be taken in any case to determine the possible presence of lead bullets.

Coping of the beak and talons should be performed for all raptors before molting. They should be trimmed shorter than for normal coping. The vitamin and minerals administered during the molting time lead to strong growth not only of the feather keratin, but also the keratin of the beak and talons. This may result in extremely overgrown beaks and talons thus causing major difficulties for the falcon to eat or sit properly during molting. This is especially a problem in large free-flight aviaries where it is more difficult to observe and control the falcons.

4.4. Husbandry during Molting

4.4.1. Housing

In order to achieve a proper clean molting, it is important to keep the falcon in safe, quiet and stress free atmosphere. It depends on the financial and space-wise ability of each falconer which kind of molting facility he can provide his bird. In general, free-flight is recommended for falcons during the molting period as free-flight facilities give falcons the possibility for regular exercise and natural behavior. Free-flight can be performed in aviaries (Figure 4.5) or rooms. Although being practiced for a longtime in different countries, falcons should not be left tied down during molting as this will result in loss of muscle masses, reduced metabolism and bumblefoot [4]. Moreover, it is not ethical acceptable to keep birds tied down for half a year without any possibility to fly or to follow their natural behavioral instinct.

Figure 4.5. Molting aviary.

A large variety of different designs exist for molting aviaries and rooms [6]. The choice of the best suitable facility can be made according to the number of falcons, species, space and money of the falconer. For veterinarians who frequently treat raptors the construction of a free-flight aviary is useful and may provide an additional source of income. Special legal requirements determine in some countries the construction of aviaries and need to be closely followed. A suitable aviary consists of wire mesh covered completely with nets. This prevents that the birds get entangled in the wires and softens the landing of the falcons in the net. The net should not be too tight to allow air to go through. Moreover, it has to be strong enough to cover the outside wire fence of the aviary. Great care must be taken to remove all outstanding wire ends as they may lead to major puncture wounds in the falcons when they hit them by accident [6].

Perches are fixed in different height and form in the molting facility (Figure 4.6). This provides enough space for the birds and gives them a variety of landing areas. They can be covered with Astroturf. Before releasing the falcons in the cage, all perches have to be completely cleaned and disinfected. Those parts of astroturf that are damaged have to be replaced before the molting to prevent injuries of the falcon's foot sole and subsequent bumblefoot.

Water baths are essential and must be provided to any falcon. A special construction can be made with a central hole to remove the used water from the cage through pipes (Figure 4.7). Another pipe can be installed to fill the water basin with fresh water. It is advisable to be able to fix and open the tab for this pipe from outside the cage. The water baths can be designed in a way that an approximately 10 cm wide edge with astroturf is surrounding the water baths and thus provides the falcon with a good sitting area. The water basin should be only deep enough that the falcon can stand in the water to take the bath. The minimum diameter of the water basin should be at least 60-110 cm to ensure enough space for taking bath without breaking the feathers at the basin edges. Moreover, the water has to be changed daily.

Figure 4.6. Different height of perches in molting aviary.

Cleaning of the water basin should be done daily if possible. It is better to clean it directly before feeding to minimize the stress for the falcons by entering the aviary only once per day. In the last stage of molting (when the first feather is molted), cleaning can be performed every 2-3 days but the water must be changed daily.

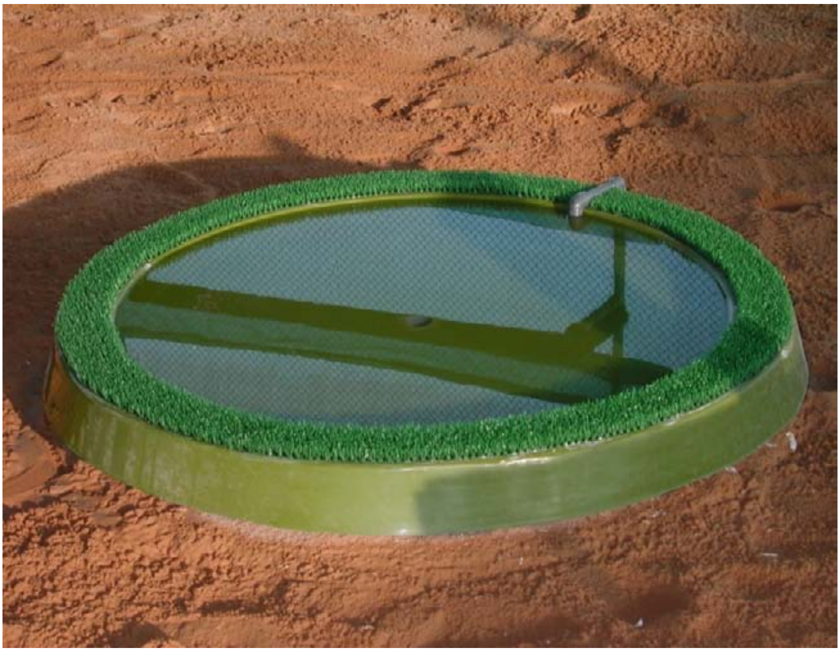

Figure 4.7. Waterbath in molting aviary.

4.4.2. Feeding

The feeding regime is one of the key pillars to successful molt. The diet has to be varied to include as many different nutritious components as possible. Suitable food during the molting time is quails, mice, rats and day-old chicks. Rabbits and pigeons might be used as well. Further information on food can be found in more detail in chapter 3.

The falcons should be fed at the same time every day according to their special feeding schedule. Those feeding schedules can be made on monthly basis.

4.4.3. Vitamin Supplements

Vitamins and amino acids are essential to ensure a good support for falcons during molting. Special molting vitamins are composed to enhance feather growths and increase the strengths of keratin. A plan for administering those products to the food should be established and closely followed as mentioned above.

4.4.4. Light Management

The photoperiod has an important influence on the molting in birds as the right timing has a beneficial influence on the molting. It is advisable to place a light timer outside of the room to control the length of the light. Moreover, the length of daylight has to be changed during the molting period. Experiments have shown that drastic increase of day length to 24 hours per day followed by 8 hours per day after the first feathers are molted result in dropping of all primaries at the same time. This leads to flight inability in the affected falcons [1]. However, it is highly questionable if such a photoperiod regime should be applied to falcons only for the sake of reducing the molting period for one month. The negative impact in the falcons' biological rhythm, hormonal cycle and metabolism may be considerable and long-term side effects cannot be ruled out. Moreover, falcons in free-flight aviaries should always have flight ability as otherwise other falcons may attack and kill them.

4.4.5. Control of the Molting Process

It is very important to control the molting process and therefore to know which feathers have been molted already. In case of releasing a group of falcons in aviaries, it might be difficult to allocate the dropped feather to the individual falcon. Therefore each falcon should be individually marked. This can be done by painting the inside of the feather shaft of primaries and tail feathers with colored marker pens. Each falcon gets a different color which will help to identify the appropriate feather. It is good practice to set up special documentation forms for molting falcons. They state the individual identification as well as photo of the birds. Moreover, the primary and tail feathers are documented separately in this form and the marker color for this falcon is recorded. This allows entering the date when the individual feather has been dropped. All feathers should be collected from the aviary on a weekly basis and then sorted according to the different colors. Then the date can be entered in the form. This allows full control of the molting process and detection of any molting disorders or delays.

4.5. Successful Release of Groups in Molting Aviaries

It is very much advisable to give the falcon the chance to fly freely in aviaries during the molting period. Nevertheless, some important precautions have to be taken to avoid attacks between the falcons. When deciding to put more than one falcon in one aviary, care must be taken during the selection process of those falcons.

It is always better to choose birds of the same size as otherwise a male peregrine falcon might be a nice lunch for a big female gyrfalcon or hybrid falcon. After having a group of falcons, they need to get used to each other. This can be done by keeping them tied on a perch without hood. The distance between the individual tied falcons should be large enough that they cannot grab each other. A minimum distance is 2 m. Feeding of the birds should be performed in the same time once per day. The minimum time period for getting used to each other is 1-2 weeks. It is very well possible that some falcons in this group do not get used to each other and try to scream or jump on the other falcons. This is a clear sign that this falcon is not suitable for the group and it has to be removed and put either in another group or kept separate. Only those falcons being definitely not aggressive towards others and not attacking other falcons can be safely kept together. Falcons with known records of killing other falcons should never be released in groups and must be always kept alone. Once all falcons are comfortable in their group, the release in the free-flight aviary takes place. The release in the aviary should be performed only after having fed a full crop to all falcons as they will be in much more peaceful mood and will not fly too much on their first day in the aviary. In contrast, if they are hungry they will start to attack the other falcons. Moreover, jesses should be checked carefully before release as too tight jesses might cause horrible injuries. Due to the reduced control over a free flying falcon, most of these cases are detected too late.

All falcons are always released at the same time as otherwise the falcons have already their territories and newly arrived falcons will be most likely attacked. This can be done by seating the falcons with hood on perches, while having the leash removed. Only the jesses are left on the falcon. This helps to remove the hood quickly and thus to release all falcons in the same time. In some cases it is also possible to remove the jesses completely.

Great care has to be taken that not too many falcons are released in one aviary as otherwise overcrowding may lead to attacks among the falcons and can lead to death cases or less dominant birds. Moreover, stress and fighting for food may lead to severe damage of feathers. Before falcons are released together in the cage, all necessary arrangements for feeding, water supply and perches have to be taken. When putting the falcons in closed rooms being used as free-flight aviary, it has to be ensured that the air-condition is working properly during hot climate.

The falcons should be observed on a regular basis preferably daily with binoculars to ensure that they are in good condition.

4.6. Post-Molting Examination

The same examinations as pre-molting examinations mentioned above in this chapter should be undertaken when catching the falcon after molting is finished. The previous pre-molting endoscopic recording can be reviewed before performing the post-molting endoscopy. This will show any slight changes or new diseases. However, if falcons have been molted in dusty or sandy environment, the airsacs might appear mildly cloudy which is physiological in those cases. Veterinarians need to take those changes into consideration. They must be able to differentiate them from new diseases e.g. newly acquired airsacculitis requiring treatment. The vitamin and mineral supplements during the molting period lead usually to overgrown beaks and talons. Therefore, coping of beak and talons as described in chapter 8 has to be performed for every falcon after molting as part of the routine post-molting examination. Apart from the medical examinations, all feathers have to be checked for their correct growth, strength of keratin and possible molting disorders. In some falcons which molted for the first time, not all body feathers are fully molted (Figure 4.8, 4.9). This happens frequently and does not pose any problem for the falcon. If any feather or growth disorders have happened during the molting time, the reason for these problems needs to be searched and identified. In such cases, the molting management for the coming year needs to be changed and corrected accordingly.

Figure 4.8. Second year falcon with partly molted body feathers.

Figure 4.9. First and second year plumage in shoulder area after molt.

4.7. Molting Disorders

The time of molting in falcons is also the time to be extremely careful with the bird and to take precaution against avoidable injuries and accidents. Although it is a favorite time to administer drugs to the falcon to speed up the molting process, a lot of even irreparable damage might be done to the falcon.

Administration of Thyroid Gland Hormones

Medicines containing thyroid glands hormones do not influence the beginning of the molting as often believed by inexperienced falconers but they are supposed to speed up the molting time. The normal dosage for thyroxin is not enough to induce faster molting. Oral intake of the thyroid gland of cattle seems to be more effective than tablets [2]. However, the intake of such drugs may lead to disastrous results such as hormonal disorders and even to lifelong hormonal imbalances. Falcons that have been given these medicines show a completely irregular molting and plenty of feathers are thrown at the same time. The even more severe consequence of administering thyroid gland hormones is a massive increase in burnt energy thus leading to an increase of required calorie intake. If the falcon does not get an additional amount of food, it may even starve to death [2]. In peregrine falcons, thyroxin administration leads to complete irregular molt that often can be observed in the next molting season. In some cases, the feathers do not fully grow again or show damage of the feather itself. In any way, medicines containing thyroxin should not be used in falcons as this massive impact in the hormonal status of the falcons is not justified.

Medicine Administration

Another problem during molting for some falcons might be special antibiotics like enrofloxacin and chloramphenicol. The administration of these antibiotics may result in feather growth disorders as well as in a complete throwing of the feathers. In some exceptional cases these feathers do not grow again during lifetime [2,5].

Stress and Fear

During the molting period, the falcons should not suffer from stress or fear and should be kept in a relaxing stress free environment [5]. Stress or fear in birds leads to an increase of adrenalin. This results in a vasoconstriction and therefore reduced blood supply even in the feather follicles. This malnutrition of the feather leads to so-called “hunger traces” (Figure 4.10). They often can be recognized as white-colored part of the feather. No major impact will result in case of only a small number of affected feathers. Moreover, the feather is losing strength in this area and can break much easier than in non affected parts (Figure 4.11, 4.12) [2].

Damage to the Feather Follicle

Feathers might be injured at the follicle during the growth time. This can result in an abnormal feather growth like twisted feathers (Figure 4.13, 4.14). In some cases, the tail mount blocks the development of the new feather. The new feather grows inside the tail mount, gets damaged and does not grow to full size (Figure 4.15).

Figure 4.10. “Hunger traces” of feathers.

Figure 4.11. Breaking of feathers due to stress marks.

Figure 4.12. Breaking of feathers due to stress marks (close view).

Figure 4.13. Abnormal feather growth.

Figure 4.14. Damaged feathers due to feather growth disorder.

Figure 4.15. Feather damage due to tail mount.

Figure 4.16. Feather cyst.

Other problems are feathers that do not emerge properly out of the feather sheath. Therefore they may get stuck inside the follicle and develop into feather cysts [2]. This may cause irritations for the falcons and consequently lead to picking of the cyst. Inflammation of the skin and rupture of the cyst results from it (Figure 4.16).

During molting, feathers are very much in danger of breaking in the growth zone at the follicle. This leads to severe consequences for the further feather growth as normally no further growth is taking place in that area. The sand clock like change of the feather becomes visible and the already developed part of the feather is dying [5].

In rare cases, falcons can get curly feathers (Figure 4.17) which might be caused by a feather growth disorder or even genetic disposition although this feature has not been observed in directly related falcons [2].

Figure 4.17. Feather disorder “curly feather”.

Parasites

Endoparasites like trematodes, coccidia or other worms are found in the gastrointestinal tract of falcons. In high numbers, they can cause severe dehydration, inflammation in the intestines and enteritis. Sometimes even bleeding of the intestines can be observed. Other endoparasites live in the crop thus leading to crop inflammation, vomiting and loss of appetite. Therefore it is necessary to carefully check the falcons for parasites before the molting period. Undetected parasitic infestations might lead to heavy parasite burden of falcons in the molting and subsequent deterioration of their health conditions. This might negatively impact the molting process through delayed molting and reduced feather quality [5]. Further information about parasites can be found in chapter 10.

Ectoparasites live on the outside on feathers and skin of falcons. The most commonly found ectoparasites are lice and feather mites. Lice are usually mallophaga species (*Laemobothrion spp.*) and might contribute to a weakening of the bird’s health condition. Feather mites start eating the feather vane and affect in some cases all primaries. This leads to instability of the affected feathers which might break much easier (Figure 4.18). This can cause problems for the new growing feather due to lack of support.

Figure 4.18. Damaged feathers due to mallophaga infestation.

4.8. Conclusion

Molting is a highly critical physiological process in the falcon's life. Influenced by hormonal and environmental factors great care has to be taken to support the falcon during this time through suitable and stress free environment. Diverse feeding and nutritional supplements with special molting vitamins are important to support the falcon's metabolism during molting. This enhances not only feather growth and strengths, but also help to speed up the complete molting process. Moreover, it is highly essential to conduct pre-molting examinations to identify sick falcons. They need to be treated before being released into free-flight aviaries for molting. A comprehensive molting management comprising all important factors like husbandry, feeding, nutritional supplements, pre-molting examinations is the key for a successful molting time.

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Chapter V

First Aid

Abstract

Basic knowledge in First Aid should be essential for falconers, bird owners, raptor rehabilitators and veterinary staff as well. Those important basic measures have to be learnt well to be applied correctly in stress situation when a bird of prey gets injured. Moreover, it is critical to understand the right prioritization in emergency cases. The use of a First Aid box can become an essential equipment in cars of falconers to be ready in case of an emergency. Emergencies do not necessarily have to be only injuries or fractures, but can also be heatstrokes, reduced body temperature, burns and electric accidents. Through those basic measures, the life of many birds of prey can be saved.

5.1. Introduction

Falconers all over the world are usually very well aware about diseases in falcons and are often able even to give medication to their birds. However, they are often not well prepared to cope with frequently happening injuries or accidents during the training or hunting time in the field. This lack of information, experience and equipment has had fatal consequences for many falcons which could have been saved if an at least basic first aid knowledge and equipment would be known by falconers and bird of prey lovers in general. In order to improve this unsatisfying situation and to give necessary equipment and tools to falconers and people interested in birds of prey, the content of a First Aid Box for Falcons is explained in details. This chapter focuses on a large variety of major incidents and accidents that can happen anytime and in any situation to falcons, birds or prey and other birds. It gives clear guidelines about emergency behavior and prioritization of emergencies. Moreover, this chapter covers wound management, correct bandaging techniques, fracture management, heatstroke, eye injuries, dehydration, reduced body temperature, frostbites, burns and insect bites. However, it has to be understood that first aid and emergency care does not replace the visit to a veterinarian and poses just the first step in the treatment process of the bird of prey in order to save its life or to stabilize its condition. Therefore all first aid cases should be presented to a veterinarian as soon as possible to continue the medical treatment in professional way.

5.2. General Information about Emergencies in Falcons

Emergencies can happen anytime and anywhere. All emergencies require *immediate,* but well-thought and careful help. It is highly important to be fully confident in what has to be done and to follow procedures step by step to avoid time loss or more stress for the falcon. The more quiet and calm the handler performs the first aid during an emergency situation, the less additional stress is put on the falcon in this exceptional situation. Therefore it is highly recommended to train the first aid and emergency procedures during normal times. It is very advisable to learn how to handle the first aid kit and how to use its content as this will save precious time and might save the life of the falcon or bird of prey.

Falcons are especially prone to injuries during the training and hunting season whereas the danger of catching wounds is less apparent during the molting season. Wounds can be observed predominantly in the chest, legs and wings of the falcons. As falcons are sensitive animals, great care and attention should be drawn to the first aid wound management.

It is important to note that in any case of emergency, the falcon should never be fed as this might aggravate the already difficult situation. In some cases, feeding of falcons in emergency situation has cost the life of the falcons as they were too injured and weak to digest the food and thus died from the feeding, not from the emergency!

Always remember:

1. A falcon in an emergency situation is always under shock!
2. It is important to stabilize the falcon as first step and then perform first aid treatment.
3. It is important to set clear priorities in emergencies like first to treat the shock, stop bleedings and then perform other first aid measures.
4. It is highly recommended to seek the help of an experienced avian veterinarian as soon as possible, especially in critical cases.

5.2.1. Priorities in First Aid Management

The main priorities in first aid management are life-threatening conditions that have to be immediately treated with first aid measures. Those can be heavy bleeding or blood loss mainly of large open wounds. Another life-threatening condition can be circulatory breakdown. It is highly recommended to visit the next veterinarian’s practice soonest.

The next priority is the treatment of not life-threatening injuries, but injuries causing massive pain to the raptor. Those include fractures, vomiting, and diarrhea. First aid is used in these cases to control an aggravation of the falcon’s condition and then to bring the bird into veterinary care.

The last priorities are not life-threatening and less painful conditions like small cuts and abrasions. They can be treated according to the first aid protocols and might not require immediate veterinary care [2].

5.2.2. First Aid Kit

The First Aid Kit Box is the essential equipment which includes necessary tools, medicines and consumables for unexpected emergency situations (Figure 5. 1). The First Aid Box has been designed in a portable way in order to be kept inside the car. It contains the most important materials and medicines to cope with injuries and accidents as well as lost tailmounts. Each falconer can put additional items inside which he might require. This First Aid Box has to be checked at least every six months to ensure that all items are in good condition and the medicines are not expired yet.

Table 5.1. Content of the First Aid Box

Medical Consumables	Medicines	Tools
Sterile gauze	Sterile Saline	Scissors
Gauze bandages	Cooling gel against swellings	Forceps
Self-adhesive Bandages	Antibiotic Wound powder	Torch
Cotton balls	Iodine Ointment	Superglue
Cotton Buds	Antibiotic Wound Ointment	Tailmount
Gloves	Surgical spirit/Disinfectant	Plier
Syringes	Iodine Pads	Bamboo Sticks
Non Adhesive Wound dressing	Eye cleaning Lotion	
Silver Nitrate Stick	Antibiotic Eye Drops	
	Foot cream	

Figure 5.1. First Aid box for falcons.

Medical Consumables

The First Aid Box contains several medical consumables, medicines and tools. The medical consumables contain sterile gauze of 2.5 cm or/and 5 cm size. Soft conforming gauze bandages should be cut to a size of 1 cm. The same applies to self-adhesive bandages. Cotton balls are very useful for wound management and can be used as pressure bandages in cases of heavily bleeding wounds. Moreover, cotton buds are extremely useful in cleaning and disinfecting small wounds. They can be used as well to apply medicines like ointments. Gloves are part of the First Aid Box to protect the skin of the handler's and the falcon from possible contamination. Syringes can be added in different size like 1ml, 10ml and 20ml. Sterile Saline is very useful to give birds fluids and to flush dirty wounds. Non adhesive wound dressing e.g. Melolin® is added to the First Aid Box to cover wounds after application of iodine cream or wound powder. Melolin shall be put with its shiny surface facing the top of the iodine cream or wound powder. The silvernitrate stick is very useful to stop bleeding of the beak or talons [6].

Medicines

Disinfectants or surgical spirit is helpful in wetting the feathers and disinfect a wound area. The iodine pads are usually available as single packed pads. This packing makes it easier to keep them in the First Aid Box. They can be used to clean and disinfect dirty wounds. Sterile saline is used to flush dirt or sand out of wounds and therefore are helpful in cleaning dirty contaminated wounds. Iodine cream can be applied on clean, not too deep wounds that should be covered with a non-adhesive wound dressing afterwards. Antibiotic wound powder can be applied to wet wounds. Special cooling gels are useful to reduce the swelling in case of for sudden swelling of the feet e.g. due to too tight jesses. However, care should be taken not to apply them on or close to any open or infected wound. Foot creams are helpful on longer hunting trips for the daily massage of the falcon's feet and to prevent reddening or inflammation of the foot skin. In cases of eye problems, special eye cleaning lotion and eye drops are advisable to be added to the First Aid Box. The eye cleaning lotion is used to wash out dirt or foreign bodies from the eye. Moreover, antibiotic eye drops are helpful for eye inflammation e.g. due to sand or windy weather conditions. Drops are preferred in such cases as they do not disturb the bird as eye ointment might do [6].

Tools

Sharp scissors are part of the First Aid Box to cut bandage material or bamboo sticks for imping. A forceps is used to remove foreign bodies e.g. thorns or split tree branch pieces. As accidents often occur to the most untimely parts of the day, it is very helpful to include a torch in the First Aid Box. This torch is essential to deal with emergencies that happen in the evening or night. Superglue and tail mount are other useful items of the First Aid Box, especially during the training of falcons or hunting trips.

The superglue helps to fix the tail mount at the falcon's tail feather in order to attach the tracking antenna. The plier helps to bring the tail mount in the correct position and shape before and after gluing. Bamboo sticks are helpful items for first aid as well [6]. They can be put into the shaft of broken feathers for imping. After measuring the bamboo stick, it will be covered with superglue. Then the bamboo stick gets re-inserted in the feather to attach the new feather. This will ensure a proper balancing of the falcon during flight and improved hunting abilities.

5.3. Emergency Situation Requiring First Aid Treatment

5.3.1. Shock

Shock has always to be regarded as severe emergency as many emergency situations lead to shock additional to the injury. The shock symptoms include fluffed feathers, not moving, rapid shallow breathing and the head may be turned with eyes partly closed. Often the falcons have problems to sit properly on a perch (Figure 5.2). It is highly important to keep those shock symptoms in mind as the best first aid treatment does give successful results if the falcon gets deeper in the shock condition which might be fatal in the end.

Figure 5.2. Falcon in shock condition.

As first step, the falcon should be kept in a quiet, warm, secluded and dark environment. If the falcon is not able to stand anymore, it is advisable to use a towel or any kind of soft cloth to keep the falcon in comfortable position. In this laying position, the head of the bird has to be kept a little bit higher than the body to prevent it from inhaling vomited food, blood or mucous. If the falcon is inhaling vomited food, blood or mucous, it might result in suffocation and death. If the shock situation is accompanied by life threatening injuries like massive bleeding, then those life threatening injuries have to be treated immediately and with highest priority. On the other hand, if life threatening injuries are not visible, it is better to leave the falcon undisturbed [6].

5.3.2. Management of Wounds and Injuries

5.3.2.1. Wounds

Wound Bandaging

For many people, the instinctive reaction to the sight of bleeding wounds is – to apply a bandage. This is perfectly alright, however, when dealing with falcons, great care has to be taken for bandaging wounds. If the falcon gets bandaged too tight, it may lead to severe injuries. Bandages that are applied without previous cleaning of a dirty or infected wound may even result in life threatening infections. Therefore it is important never to bandage a dirty wound!

The first step is to clean the wound with ready-to-use iodine pads. Then the cleaned wound has to be dried with the help of sterile gauze. Afterwards, antibiotic creams, wound powder or iodine cream can be applied on the wound. Then the wound should be covered with non-adhesive wound dressings. This wound dressing has to be fixed with a small gauze bandage. Great care has to be taken that the bandage is not wrapped too tight as otherwise swelling will be provoked. A self-adhesive bandage gets wrapped around the gauze bandage as last step in the bandaging process. It is highly recommended to take the falcon to a veterinarian to further examination and treatment against a beginning infection and professional wound management.

Bleeding wounds

In many severe accidents, damage of skin and major blood vessels is involved. Whenever an accidental injury in a well-vascularized area like skin, talons, growing feathers etc. occurs, the blood loss might be considerable. In contrast to mammals, birds including falcons do not have a large quantity of blood available. Therefore the loss of a minor quantity as a few milliliters of blood may lead to serious health consequences for the falcon.

Therefore it has to be given high priority to stop heavy bleeding of wounds (Figure 5.3). This can be done by firmly pressing a folded sterile gauze (Figure 5.4) or cotton bud (in case of bleeding talons) onto the wound for at least 30 to 60 seconds (Figure 5.5). Then the bleeding should have stopped. If this is not the case, one of the major arteries or veins has been damaged. In this case, it is better to apply pressure for two to three minutes. If this remains unsuccessful, a pressure bandage is required. Hereby, a cotton ball can be pressed on top of the sterile gauze and then tightly bandaged (Figure 5.6, 5.7).

In all cases of heavy bleedings and great blood loss, veterinary care must be sought as soon as possible as the blood loss may require substitution of special blood-like fluids. It is best to give first an intravenous bolus of plasma expander or 0.9% saline with 5% glucose.

Figure 5.3. Bleeding wound on leg.

Figure 5.4. Sterile gauze for pressing on bleeding wound.

Figure 5.5. Sterile gauze firmly pressed on bleeding wound.

Figure 5.6. Start of bandaging the wound.

Figure 5.7. Finished bandage of wound.

Further fluid substitution can be given by administering e.g. up to 60 ml Sodium lactate Ringers subcutaneously. In cases of huge blood loss, an intravenous catheter can be placed to continue the fluid substitution over a longer period of time. After the fluid substitution and stabilizing of the falcons the wound will be properly and professionally cleaned and bandaged so that the risk of secondary infection is reduced ands the healing process speed up considerably.

Bleeding Wounds, Cuts or Abrasions (Small Wounds up to 0.5 cm Length)

Under normal circumstances small wounds heal very well as the avian skin has the ability to recover extraordinarily fast.

As first step in the first aid treatment, the bleeding has to be stopped as explained in detail above in this chapter. Then the wound cleaning has to be performed. This can be done by cleaning the injured area gently with iodine pads. Then antibiotic wound cream mixed with iodine cream can be applied in cases or open wounds. For cuts and abrasions, antibiotic wound powder is helpful, after applying a non-adhesive dressing, the bandage will be applied. If the cut is on leg or feet, the bandage has to be loosely done to avoid swelling of the leg or feet [6].

Larger Wounds (More Than 0.5 cm Length) or Infected Wounds

Large wounds often have a traumatic origin such as if the falcon hits a stone, tree or prey. They can also arise during a fight between the falcon and its prey or two falcons attacking each other. Depending on the position of the impact some of these serious wounds do not necessarily bleed too much. This may result in the fact that the wound gets underestimated and are regarded as minor wound. This is especially the case in the keel region or injuries in the crop and neck region. Moreover, some puncture wound might lead to arterial or venous rupture and serious bleeding as well as opening of crop or body cavities. As often the skin closes above those wounds, they might remain undetected until the falcon shows a deteriorating general condition. Even veterinarians need to be very careful in detecting those hidden wounds. Hidden wounds are often not taken seriously as they do not bleed heavily. However, they may cause serious and sometimes life-threatening infections which then take a long time to heal.

After the bleeding has been stopped, the wound area should be gently cleaned with iodine pads. Sterile gauze is used to dry the wound. The application of antibiotic wound powder can be useful as it has a drying effect [6]. In such cases, it is highly recommended to search veterinary help as soon as possible in order to check whether there are further serious injuries. They usually require professional veterinary care like suturing. In those cases only by professional veterinary care and treatment, a fast and proper healing process can be started.

Bleeding from Mouth, Ears or Nostrils

Bleedings from mouth, ears or nostril (Figure 5.8) are indicative for trauma and injury of the head and have to be taken very seriously. These are real emergencies that should be attended by a veterinarian immediately.

Figure 5.8. Bleeding through nostril following trauma.

Until the falcon can be brought to the veterinarian, it is advisable to keep bird in quiet and dark place. Moreover, it is highly important not to move the falcon too much. As the trauma to the head might involve either fractures of the skull, ruptures of vital arteries and veins in the head regions or intracerebral hemorrhages, an X-ray must be taken soonest to locate the damage [3].

5.3.2.2. Injuries

Hitting of obstacles

Falcons and other raptors often do not recognize obstacles when they are chasing a prey. Therefore, they frequently hit trees, cars and even house walls as they only focus on their prey. When hitting the obstacle hard, the bird of prey can fall down without any obvious external signs of trauma. Sometimes they continue to fly, but start to show reduced general condition later on.

Symptoms for commotio cerebri or head injuries can be apathy, imbalance, holding the head to one side, weakness or fits. In those cases, the bird has to be kept in a warm, very quiet place to prevent shock conditions. If the falcon is not able to stand anymore, a towel can be placed under it. In these cases, the falcons should be brought to a veterinary practice immediately to professionally assess further trauma to the head and brain.

Attacked by another Raptor, Canines and Felines

Falcons and birds of prey can be attacked by birds of the same species or other raptors. Those attacks frequently result in severe injuries, mainly in the neck, crop, shoulder and chest area. Dogs may bite falcons, but the more serious bites are done by felines like cats. Their bite goes very deep due to their extremely sharp canine teeth. Often those wounds are not very well visible as the skin closes over this puncture wound. In all those cases, the wound management as described in detail above in this chapter should be performed as first aid measures.

Injuries Caused by Jesses

Injuries caused by too tight jesses or jesses entangling the toes or legs are frequently seen. As the jesses might constrict the toe or leg very tightly, the blood supply gets massively reduced. In the worst case, the blood supply might be reduced to such an extent that necrosis occurs. This is explained in detail in chapter 15.

As first procedure, the falcon has to be restraint to catch the injured toe or leg without danger for the handler. Then the jesses should be removed from the injured led or toe. The wound has to be cleaned with iodine pads. Then antibiotic cream can be applied. The wound is covered with sterile gauze or non-adhesive wound dressing and fixed with adhesive bandage. If the injury has damaged the blood vessels or tendons, the falcon might require surgical treatment by a veterinarian.

Broken Blood Feathers

Feathers during the molting time have an enhanced vascularization at the feather base and growth area. If the feather breaks in this area, a quite considerable hemorrhage might arise and might lead to strong blood loss (Figure 5.9).

Figure 5.9. Broken blood feather.

The first step in the first aid measures is to try to keep bird quiet because flapping of the wings will increase the hemorrhage. In case of minor bleeding, the bleeding can be left to stop on its own. If this is not possible, the bleeding feather shaft can be firmly grasped with pliers at its base close to the skin (Figure 5.10). It is possible to put a gauze piece between feather and plier. The wing should be held firmly during this procedure. If the feather is broken in the feather follicle, it is better to apply pressure for one or two minutes with thumb and index finger. After the bleeding has stopped, wound powder can be packed into broken feather shaft (Figure 5.11). It is advisable not to pull the feather shaft as this may lead to damage to the feather follicle or heavier bleeding [5].

Figure 5.10. Pliers to stop bleeding of broken blood feather.

Figure 5.11. Wound powder on broken blood feather.

5.3.2.3. Fractures

In most cases of fractures, the falcons are in shock due to the massive pain. Therefore it is very important to perform the shock measures as mentioned above in this chapter. Special care should be taken to place the falcon in a small enclosure in dark area and to keep it warm. Moreover, it is highly advisable to bring the falcon as soon as possible in veterinary care as the fracture will require urgent surgical intervention [4].

Fractured Wing

In case of an open fracture of the wing, the wound should be cleaned and disinfected. This can be undertaken if it is clear that it will take some time until veterinary treatment can be received. Otherwise it is more advisable to let the veterinarian clean the wound professionally. Then the broken bones should be covered with sterile gauze. The wing is wrapped carefully and gently with a figure-of-eight bandage (Figure 5.12, 5.13). While fixing the bandage, care should be taken to keep the wing in the normal physiological position (Figure 5.14) [3,5,6]. In case of closed wing fractures, the figure-of-eight bandage will be fixed directly on the wing.

Figure 5.12. Start of bandaging a broken wing.

Figure 5.13. Wrapping of figure-of-eight bandage.

Fractured Leg

In case of an open leg fracture, the wound should be cleaned and disinfected if the veterinarian cannot be reached immediately. If veterinary help can be received soon, the veterinarian will clean and disinfect the wound. As next step, the broken leg has to be covered with sterile gauze. It is helpful to stabilize the leg with sticks. If the accident happens in a forest, small branches of a tree or bush can be used and broken down in suitable sticks (Figure 5.15). These sticks can be wrapped with thin cotton layers made out of cotton balls (Figure 5.16). Then they are placed on both sides of the leg (Figure 5.17) and fixed with a bandage (Figure 5.18, 5.19). It is helpful to provide towels for transport to the veterinarian which should be done as soon as possible [3,5,6].

Figure 5.14. Position of wing bandage.

Figure 5.15. Tree branches and bandaging material for fixation of leg fractures.

Figure 5.16. Soft covering the branches with cotton.

Figure 5.17. Positioning of soft covered branches to the leg.

Figure 5.18. Start of fixation of branches with bandage.

Figure 5.19. Fixation of branches with bandage.

Broken Toes

Toes can break when the falcon is fighting with its prey. Moreover, there had been cases of broken toes while landing. In those cases the falcon was not able to reduce the speed properly before landing and crushed on the ground with high speed.

As first step in the first aid measures for fractured toes, gauze gets wrapped into ball. Then the toes are put around ball in a way that it looks as if the foot grabs the ball-shaped gauze. Finally the foot gets fixed to gauze ball with a self-adhesive bandage [3].

Broken Talon or Beak

Talons or beak can break if the falcon hits a hard surface or gets trapped and tries to get free again. The first emergency measure is to restrain the bird and to hold sterile gauze on the bleeding area until the bleeding gets reduced. If just the tip of beak or talons is broken, a cauterizing product like the silvernitrate stick can be pressed on top of the broken beak or talon until the bleeding is under control [3]. In severe cases, the complete talon sheath might come off (Figure 5.20). This happens especially when falcons fly in a net or get trapped and try to free themselves. This leads to hemorrhage. Moreover, due to the loss of the talon sheath, the bone gets exposed thus being very painful for the falcon. In this case, no silvernitrate stick should be pressed on the wounded area as this will damage the remaining soft tissue. Sterile gauze is put around the bone without damaging the soft tissue on the tip of the bone. After the hemorrhage has stopped, antibiotic wound ointment and iodine ointment can be both applied on the wound area. A non-adhesive dressing is wrapped around and covered with bandaging material. It is advisable to keep the talon sheath if it can be found as it can be later fixed again. This will be explained in detail in chapter 8.

Figure 5.20. Broken talon with hemorrhage and loss of talon sheath.

5.3.2.4. Miscellaneous Emergencies

Heat Stroke

In summertime or regions with hot climate, heat strokes are not uncommon features. If the heatstroke does prevail, the bird of prey can get unconscious. Damage to the brain arises often with irreversible outcome and the heatstroke might end lethal to the bird. Symptoms of heatstroke are an open beak and heavy breathing through the open beak. The falcon might try to hold the wings away from the body. Birds with heatstroke often seem nervous, restless and have problems to control their movements. In a more advanced stage, the falcon cannot sit upright anymore and might lay down with heavy breathing.

As this can be a life-threatening emergency, the falcon has to be cooled immediately through spraying of the feathers with cold water (Figure 5.21). It is also helpful to put the bird’s feet in cold water. If it is possible, the falcon should be placed in a cold room or car with air-condition to reduce the outside temperature. Moreover, it is highly important to observe the falcon for signs of shock. After cooling down, the falcon should be wrapped loosely in a towel to prevent chill. However, great care and attention has to be taken when applying cool water. It has to be kept in mind not to put cool water for a too long time as otherwise the falcon will cool out completely. This may lead to further severe problems. Heat strokes can be easily avoided by not letting birds of prey in hot cars without sufficient cooling. Often the temperature inside cars is underestimated or the driver just wants to get something quickly and lets the falcon inside the car. However, this may become a trap for the bird in relatively fast time. Moreover, they should not be kept outside in the sun during midday heat or used for training during hot temperatures. Shade has to be always available for them [3,6].

Figure 5.21. Spraying of overheated falcons with water.

Reduced Body Temperature and Frostbites

Body temperatures below the normal level of 40° and 42° C can arise in cold winters or in weak and immune suppressed birds or chicks. Affected birds show ruffled feathers and shivering. Sometimes they do not want to sit on the perch and prefer to sit down.

In those cases, it is important to warm up the falcon slowly. This can be achieved by keeping the bird next to a heat source like car heating or room central heating. Warm undergrounds like heating pads, warm water bottles and warm light can be effective, too. However, it is important to keep in mind that dry heat caused e.g. by heating can lead to dehydration. Therefore it is advisable to keep a bowl of water in the room.

In severe cases, frostbites can lead to dry gangrene of toes, feet and legs. If a dry gangrene has already affected those body parts, those parts cannot be saved anymore and need to be amputated [1].

Eye Injuries

About one third of all falcon used to hunting suffer from eye injuries or eye problems. Often those injuries are caused during fights with the prey or while flying through bushes and branches of trees.

The first aid gets started by keeping the falcon away from intense light. If sand or dirt can be found inside the eye, the eye should be flushed with eye cleansing lotion (Figure 5.22) or sterile saline in a syringe without needle. Then ophthalmic eye drops can be applied to the eye. In case of foreign bodies in the eye which are not puncturing the eye, they can be floated out with eye cleansing lotion, sterile saline in a syringe without needle or ophthalmic drops. If a foreign body like a thorn has punctured the eye, it is advisable to leave it in place as you can cause more damage by removing it. In this case the falcon should be sent to the veterinarian as soon as possible. If the falcon is a quiet bird, it should be left without hood as otherwise the foreign body might be pushed further into the eye through the pressure of the hood [3,5,6].

Figure 5.22. Cleaning eye with eye cleansing lotion.

Burns Caused by Electricity, Heat and Chemicals

Burns can be caused by electricity, heat and chemicals. They can affect only small skin or feather areas, but larger burns up to the deeper skin layers can be found as well. Those larger burns are often caused by birds flying into electric wires during hunting. Larger burns can lead to severe shock and dehydration. Great care has to be taken by the person who tries to free the bird of prey as electric wires might also cause injuries to the person itself. It might be more advisable to call the civil defense to free the bird instead of risking its own life. Moreover, chemicals might have acid effects which can damage the skin completely.

First aid starts with spraying or flushing of the affected skin area with cold water. In case of burns caused by chemicals, the skin can then be gently rinsed with warm soap water. In the case of larger and deeper burns, only the affected skin area should be flushed with cold water. The other body parts of the falcon should be kept warm to prevent a shock or in case of already present shock to prevent overcooling. The bird should not be rubbed dry, but to be dried in gently way by just slightly touching the skin with a tissue or cloth. Burns can be glazed twice daily with small amounts of antibiotic ointment [2]. In case of acid burns, a thin coat of baking soda paste can be applied. However, it is inevitable to present the falcon to the veterinarian especially in case of large and deep burn wounds.

Dehydration and Hypoglycemia

Dehydration and hypoglycemia can be frequently found in cases of overtraining and starvation. This can be especially often observed in hunting falcons in summertime or in warmer countries like in the Middle East. Undetected severe dehydration can lead to reduced flight performance and in an advanced stage to kidney failure. Another reason for dehydration and hypoglycemia are crop inflammations, vomiting and diarrhea.

Figure 5.23. Dehydrated falcon.

It is easily possible to test the degree of dehydration in the falcon by pulling the skin up and thus making a skin fold on the foot. Dehydrated falcons show a prolonged time until the skin returns in its normal position (Figure 5.23). In order to rehydrate the bird, water can be mixed with special vitamins containing glucose or fructose orally or over the food [4]. It is possible to dilute one teaspoon of fructose in 100 ml water and give it orally to the birds [2]. Another possibility is to spray water over the falcon's body and in the mouth [5,6]. Moreover, when feeding the falcon, water can be poured over the meat while the falcon is eating. This also increases the fluid intake of the bird.

In cases of crop inflammations, vomiting and diarrhea, the falcon should be presented to the veterinarian as soon as possible as this might have other underlying causes like bacterial infections.

Insect Bites

Falcons suffer sometimes from ant bites on the unfeathered feet and toe area. Although not dangerous, they might disturb sensitive birds.

In those cases, antibiotic wound ointment can be applied and the falcons positioned in another place without insects on the ground. In rare cases, falcons can suffer from bee or wasp bites. In those cases, the bite area should be cooled and anti-insect gel can be applied. They usually contain antihistamines which lead to reduction of the swelling. However, in cases of oversensitive reaction of the falcon, it should be taken to the next veterinary practice immediately as especially bites in the mouth and tongue might lead to breathing problems.

5.4. Conclusion

First aid is a neglected topic in falcon medicine. Although highly valuable, many falconers and persons dealing with birds of prey do not have proper knowledge and training to cover the first and most important time of an emergency until veterinary help can be sought. With the advice and recommendations in this chapter, this inacceptable situation shall be resolved. Falconers and raptor handlers are very interested in such knowledge, but often simply do not have access to proper information on first aid and emergency topics. It is highly advisable to practice all first aid measures explained to be confident during any kind of emergency situation. The First Aid Box for Falcons can be amended upon the falconers' special requirements. It provides guidelines of important equipment, medicines and tools. However, it might be increased or amended anytime to suit the needs for training, hunting trips or special occasions. It is hoped that through this chapter the life of many falcons and raptors can be saved through the correct and confident use of emergency procedures and the presence of first aid boxes. Moreover, the emergency and first aid measures and procedures can be applied to a large extent to other avian species as well.

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Chapter VI

Clinical Examination, Sampling and Medical Procedures

Abstract

The clinical examination is the most important step in the diagnosis of diseases. This comprises the complete case history as well as the physical examination of the falcon. Sample taking is another vital part of the examination and has to be performed proficiently to avoid wrong results. Apart from basic examination procedures, advanced procedures like radiography and endoscopy provide valuable information about the falcon's condition. The pre-purchase examination is an excellent tool to assess the health condition of a falcon for purchase. Moreover, medicine applications via various administration routes are important medical procedures.

6.1. Introduction

Before starting with the clinical examination, all necessary information about the owner, the patient and its husbandry and feeding has to be gathered. The clinical history can provide valuable hints for diagnosis and therapy. The clinical examination and sample taking of raptors pose an essential part in the process of correct diagnosing. The physical examination should be performed without any restraint by observing the falcon in its current position. However, for advanced examinations restraint is inevitable to take the samples. The different methods of manual restraint and anesthesia are explained.

A large variety of samples can be taken from falcons like crop, fecal and blood samples, samples for virology and microbiology. Radiography and endoscopy are very helpful diagnostic tools in assessing the bird's condition and can be used as routine examination. The endoscopic examination is explained in detail to make its use easier for the practicing veterinarian. This chapter also explains in detail pre-purchase examinations that have been introduced by the Abu Dhabi Falcon Hospital to provide assistance to the falconer when purchasing a new hunting falcon.

Furthermore, clinical procedures like the intravenous, intramuscular, subcutaneous and oral administration of medicines provide the basis for correct and successful treatment. Apart from them, flushing of the stomach with tubes is another basic procedure mentioned in this chapter.

6.2. Clinical History

Before examining the falcon patient, the clinical history has to be gathered from the falconer. To compile full data about the patient's clinical history, information of various parts have to be established. This includes in-depth information about the owner, falcon's patient data, husbandry and housing, feeding, general clinical information, previous clinical records and current clinical problems.

At the first visit, the following information about the owner and the falcon patient should be gathered [10].

Owner data:

- Name [10]
- Address
  - Contact number [10]
  - Mobile/cell-phone[10]
  - Home phone number
  - Office phone number
  - Fax
  - Email
- Friend's or family member's contact details (in case that the owner is unavailable)

Patient data

- Species [10]
- Gender [10]
- Age [10]
- Name [10]
- Individual identification [10]
  - Ring (left/right leg)
  - PIT (Passive induced transponder)
  - Tattoo
- Country of Origin
- Breeding center
- Change of ownership
- Duration of current ownership

Husbandry and housing

- Type of housing
- Size, height and length of room/aviary
- Air-condition
- Kind of perches

- Surface material of perches
- Surface material of floor
- Separate gloves for each falcon
- Special glove for feeding
- Single keeping
- Keeping with other falcons/birds (kind/number/sex)
- Times of exercise per day/week
- Duration of one exercise cycle
- Trained to hunt special prey
- Access to water bath
- Molting in aviary or tied down
- Hygiene, cleaning and disinfection
    - Frequency of cleaning
    - Kind of detergents

Feeding
- Type of food
- Live/fresh/frozen
- Origin of food
- Times of feeding per day (e.g.1x, 2x)
- Vitamin/mineral supplements
- Food storage
- Amount eaten per day
- Access to drinking water and consumption

General clinical information
- Weight
- Regular deworming
- Regular routine examination
- Normal behavior
- Character (quiet bird, active, aggressive)
- Use of falcon for falconry or breeding
- Molting

Previous clinical records
- Previous diseases
- Previous accidents/injuries
- Inconsistent flight performance
- Previous eating habits
- Poor molting

Current clinical problems
- Loss of appetite/vomiting/delayed passing of crop
- Weight loss

- Reduced flight performance
- Breathing problems
- Clinical symptoms
- Apathy, lethargy
- Changes in fecal consistency and color
- Problems in molting
- Changes in perching
- Duration of clinical symptoms
- Other birds affected with the same clinical symptoms
- Current medicine application

These questions are the most important ones that a veterinarian should keep in mind when performing the initial examination of a falcon. Not all points might be relevant in each case, but this list provides a guideline for the veterinarian. However, in emergency cases, only the most important questions relevant to the critical condition of the bird should be asked in order not to loose valuable time to start immediate examination and treatment.

6.3. Restraint

6.3.1. Manual Restraint

Manual restraint is necessary to reduce the stress for the falcon during handling, examination and sample taking. Moreover, the fixation of a raptor prevents the veterinary staff from being grabbed, bitten and eventually injured. Nevertheless, before any restraint, the falcon should be observed in its physiological position and behavior.

Restraint can be performed by grabbing the falcon. One person stands behind the falcon and holds his hands next to the wings. The thumbs point towards the backbone of the falcon and the second and third finger point upright. The other two fingers are held towards the ventral side of the bird (Figure 6.1). Grabbing has to be done careful but energetic enough that the falcon cannot escape the hands. The second finger points upright to the wing tips. The center of the hand palm of the handler is positioned over the joint of humerus and radius and ulna. The last two fingers hold the falcon’s feet (Figure 6.2).

Another fixation method is the wrapping method as falcons can be restraint with a towel as well. The towel is wrapped around the wings and then closed on the ventral side. This method of restraint can also be used for falcons when waking them up. This wrapping method should be used only for a few minutes.

Wrong handling can lead to fractured wings or legs. Moreover, too tight catching of the falcon can result in respiratory arrest if too much pressure is put on the lung and airsac region. Pressure on the abdominal part can result in liver damage. Furthermore, falcons should never be transported while being restraint as this will lead to maximum stress for the bird, hyperventilation and in the worst case death of the falcon.

Figure 6.1. Positioning of hands to grab the falcon.

Figure 6.2. Restraint of falcon.

Following the manual restraint, the falcon can be put in anesthesia to conduct further examination and sample taking.

6.3.2. Chemical Restraint

General Information about Anesthesia

The anesthetic management of raptors has made huge progress in recent years. Although before 15 years injectable anesthesia with preferable ketamine/xylazine combination was state-of-the-art, nowadays gas-induced anesthesia methods have become the gold standard. The choice of the anesthetic gas has also modernized and moved from halothane to isoflurane. Isoflurane has major advantages compared to halothane like very good muscular relaxation, little respiratory depression, only slight cardiac depression and high safety margin

[6]. Recently, sevoflurane has been introduced as new anesthetic for birds, but the high price and special vaporizers have so far prevented it from being a routinely used anesthesia gas. However, it has to be remembered that the falcon must have an empty crop with a preferably starvation of 12 hours to prevent unfavorable anesthesia events. A bird should not be put in anesthesia with food in the crop as it might vomit and die of suffocation.

Anesthesia with Volatile Gas

Anesthesia with volatile gas can be performed through face masks that are put over the falcon's head. Commercially face masks are available for dogs. The small and medium size face masks are suitable for smaller and larger falcons.

After putting the face mask (Figure 6.3), the falcon is anaesthetized with isoflurane with initial flow rate of 4.5-5% isoflurane combined with oxygen at 2-3 l/min. per min. It gets reduced to the maintenance rate of 2.5-3% isoflurane combined with oxygen at 2-3 l/min. per min. It is useful to control the anesthesia with surveillance monitors. The maintenance rate of the anesthesia should be administered according to the degree of pain during the medical procedure or surgical intervention. This means that in case of fracture repairs the anesthesia depth should be increased when painful procedures are carried out. Moreover, it is important to monitor the temperature with a temperature probe or digital thermometer. Moreover, the temperature can be stabilized either through a heated table or heating pad under the falcon [8].

It is also possible to intubate the falcon for procedures on the head or eyes where face masks would be disturbing. It is important to choose a suitable size for the endotracheal tube. After inducing the anesthesia with isoflurane through the face mask, the endotracheal tube can be inserted into the glottis at the end of the tongue and then pushed gently forward. In some cases, the irritation of the trachea might lead to coughing reflexes. After the tube has been put correctly in place, it can be fixed to the tongue and beak through masking tape or tesa tape. The endotracheal tube should be uncuffed as the falcon's trachea consists of cartilage rings as cuffed endotracheal tubes can lead to ruptures of those tracheal rings.

Figure 6.3. Putting falcon in face mask for anesthesia.

Another possibility for anesthesia is the airsac intubation anesthesia. Hereby a hole through the body wall into the caudal thoracic airsac serves as entry for the airsac tube. The advantage of the anesthesia is that the head, face, mouth and eyes are accessible without any disturbing tubes or face masks. However, the main disadvantage of this method is the respiratory apnea that can last for several minutes [5].

Injectable Anesthesia

Injectable anesthetics can be used on hunting trips in absence of a small clinic with portable gas anesthesia machine. They are indicated for emergencies and routine cases like imping and stitching of small wounds. In such cases, the combination of ketamine/xylazine has been administered successfully as intramuscular injection in the pectoral muscle. The falcon will be narcotized for an average of 20-30 minutes. However, this combination is not advisable for major surgeries as the analgesic effect is not strong enough.

Local Anesthesia

Local anesthetics can be administered to the eye for special ophthalmologic examinations and surgeries. 1 drop of special lidocain used for eye anesthesia has a satisfying effect already. Diluted lidocain can be injected locally around skin wounds

Anesthesia Surveillance

Every anesthetic intervention has to be monitored closely to avoid cardiac and respiratory arrests. Auscultation with the stethoscope is very useful to assess the heart rate and any possible abnormalities. This should be performed before starting any surgical intervention. It is critical to control the temperature as hypothermia can lead to a severe anesthetic interference. The temperature can be controlled by special temperature probes that are attached to surveillance monitors. Moreover, digital thermometers fulfill the purpose, too. A heated surgery table might be useful equipment if the veterinary practice treats avian patients to a larger extent. The heart rate, pO_2, pCO_2 and pulse frequency can be monitored in complex anesthesia surveillance monitors. Especially equipment from neonatal medicine has proved to be very useful for avians.

Special apnea alert machines can be used for the surveillance of short-term anesthesia.

Positioning of Anesthetized Falcon on the Examination Table

During the anesthetic induction, the falcon is held by the handling person in ventral position with closely attached wings and its head inside the face mask. After being anesthetized, the falcon is turned and placed in dorsal recumbency on a table to allow easy access for medical examination and sampling. It is advisable not to place the falcon on the table without anything underneath. Therefore the table should be covered with a soft bath towel. On top of the towel, it is useful to place a blue paper from a blue paper roll which consists of a absorbing and a plastic part. This helps to keep the falcon warm, softly padded and to absorb fluids or blood through the blue paper. If required, the falcon can then be turned in ventral or lateral recumbency.

6.4 Routine Examinations and Sample Taking

6.4.1. General Examination

Physical Examination

The physical condition of falcons had been examined first by observation without restraining the bird. The first look on the falcon should be from a distance of approximately 1 m to assess the posture and behavior. It is important to notice how the falcon sits and holds its wings. Moreover other information can be gathered by head, beak, eyes, nostrils and ears for any abnormalities and discharge. The feathers and skin can be watched for ectoparasites, broken feathers, skin abrasions as well as skin color. Cyanotic skin color is an indication for bacterial septicemias. The feet and talons might show abnormalities like bumblefoot, swelling, lesions, pox lesions and overgrown talons. The condition of the pectoral muscle gives a clear statement about the nutritional status of the bird. A well-muscled pectoral muscle can be found in well kept falcons whereas a prominent sternum with highly reduced pectoral muscle reveals emaciation and malnutrition of the falcon. The mouth, tongue, choana and crop entrance can be examined for lesions, swellings or injuries [8]. Any other unusual behavior or feature has to be noticed as well. Weight taking of the falcon is essential to assess its nutritional status. If food is present in the crop, the amount of the food has to be estimated and deducted from the total falcon's weight.

Assessment of Respiratory Rate (Stress Test)

The respiratory rate is a measurement tool to assess the frequency, type and possible abnormalities of respiration before and after stress. The hooded falcons are then allowed to rest for 10-15 minutes and then the respiratory frequency per minute is counted. Then the falcon is stressed for maximum one minute by flying while being tied to the glove. After this exercise the falcon rests for 2 minutes before the respiratory frequency is recounted. If the falcon returns to the respiratory frequency before stress, it will be regarded as normal breathing frequency. However, if an increase in the respiratory frequency is detected, the falcon might suffer from respiratory problems or underlying diseases [8]. A heavy breathing or so-called double pump (heavy breathing in the abdominal area) is highly indicative for aspergillosis or ascites and requires endoscopic or radiographic examination.

Assessment of Dehydration

In order to assess the degree of dehydration in falcons, a skin fold is made from the dorsal side of the foot (Figure 6.4). If the skin fold dissolves immediately, the bird is in good hydration. If the skin fold stands more than 5 seconds, the falcon is mildly dehydrated. In the case of not dissolving the skin fold within 30-60 seconds, the falcon is strongly dehydrated. In some cases, the skin fold does not dissolve anymore at all. This is an alarm sign for severe renal disorders as described in chapter 17.

Fecal Examination and Sampling

The droppings of falcons have different parts. Apart from the dark solid fecal part, the urates are normally white-colored (Figure 6.5). A greenish discoloration of urates can give hints for possible diseases like hepatopathies, aspergillosis or malnutrition (Figure 6.6, 6.7). Bloody feces can be caused by clostridiosis (Figure 6.8).

Figure 6.4. Assessment of dehydration status by skin pinch test.

Figure 6.5. Normal feces with white urate part.

Figure 6.6. Green colored feces.

Figure 6.7. Green colored urates.

Figure 6.8. Bloody feces.

Mucous in the feces is indicative for enteritis and can be combined with blood (Figure 6.9). Several medicines like multivitamins or red colored antibiotic tablets can lead to a discoloration of the feces that is not pathologic. Watery feces can be indicative for coccidiosis (Figure 6.10) whereas diarrhea can be caused by bacterial infections. Sometimes sand can be found in feces as well (Figure 6.11). The dark fecal part is required for the parasitological examination.

Falcons that are not doing feces can be motivated in different ways to defecate. One way is to show them a quail and to excite them to such an extent that they make droppings. Moreover, they can be sprayed with water as another way of getting fecal.

Figure 6.9. Mucous and blood in feces.

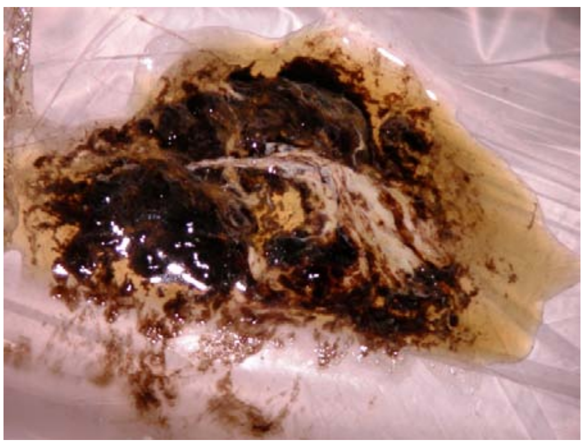

Figure 6.10. Feces of falcon with coccidiosis.

Figure 6.11. Feces with sand.

Crop Examination and Sampling

The tip of a sterile cotton swab has to be dipped with a warm drop of sterile saline. The falcon has to be caught and restrained by one person. The other person removes the hood, and opens the mouth with the backside of the hood. Then the left thumb is placed in the falcon's right corner of the mouth (from the handler's view left side) to keep it open. This provides the veterinarian with a good chance to review the oropharynx of the bird for the presence of any lesions, injuries, swelling or other pathological signs. Then the wet swab is inserted in the falcon's right side of the mouth and moved down to the crop (Figure 6.12). The swab is then rolled inside the crop a few times in a gentle way. After removal the swab is put back into the swab cover.

Figure 6.12. Crop sampling.

The parasitological examination of feces and crop as well as urate testing is explained in detail in chapter 7.

Skin Scrapings

Ectoparasites can be detected by skin scrapings. The feathers are moved to the side. With a sterile scalpel blade, scraping of the skin until it bleeds lightly is performed. The scraped material is then placed on a microscope slide. The examination of skin scrapings is explained in chapter 7.

Cloaca Sampling

Samples from the cloaca can be taken by gently inserting a sterile metal swab or ENT swab in the cloaca after wiping the feather to the side (Figure 6.13). The swab should not be inserted more than maximum 1cm in the cloaca in order to not damage the mucosa of rectum and coprodeum (Figure 6.14).

Aspirates

Aspirates from pathologically enlarged masses or joints can be taken for cytology and culture examinations as very important part of avian cytodiagnostics [4]. The area from where the aspirate is selected to be taken is disinfected. A fine-needle aspirate can be taken by gently inserting a thin needle, preferably 25G in the mass or joint. The aspirate is then processed for cytology as detailed in chapter 7.

Figure 6.13. Preparing for cloaca sampling.

Figure 6.14. Insertion of swab in cloaca for sampling.

Conjunctival Swab

In cases of eye infections or conjunctivitis, a conjunctival swab can be taken for cytology, bacteriology and Chlamydia test. This is only useful in the untreated eye as otherwise false negative results may arise. A small sterile swab e.g. ENT swab is gently wiped in the conjunctival area and then put sent and processed in the laboratory as detailed in chapter 7.

Blood Sampling

For blood sampling, it is essential that the falcon is properly restraint as unwanted movements can lead to perforation of the veins [5] and subsequent hematoma. In order to prevent any perforation of the vein, the direct contact of the hand that holds the syringe with the avian patient is inevitable [5]. It is also possible to take blood under general anesthesia while performing other clinical examinations.

Due to the high viscosity of avian blood due to the nucleated erythrocytes, the lumen of the needles have to be larger compared to mammals [5]. In falcons, a 25 G needle is suitable for blood taking. Different syringes like 1ml or 2.5ml can be used. The 1ml syringe is useful for blood taking of smaller quantities. The 2.5ml syringe is shorter than a 1ml syringe and therefore often easier to handle during blood taking. All needles and syringes should be of reputed brands.

Sites for blood sampling are preferably the left or right basilic vein (*Vena cutanea ulnaris superficialis*) or the right or left caudal tibial vein (*Vena metatarsalis plantaris superficialis*). The jugular vein can be used, too. The falcon is positioned in dorsal recumbency. The feathers are moved to the side to provide a free skin surface and clear visibility of the basilic vein. The area is disinfected with surgical spirit. The left index finger and thumb are used to put pressure on the vein (Figure 6.15).

The needle is bent at a 30-45° angle (Figure 6.16, 6.17) and gently inserted in the vein above the elbow joint in the underarm region (Figure 6.18). In this position the vein is undermined by the M.humerotriceps. The blood taking directly in the vein at the elbow joint may lead to massive hemorrhages and hematoma [5]. Therefore it is more advisable to take the blood above the elbow joint (Figure 6.19). It is helpful to place the right hand on the left thumb to prevent shaking of the hand while taking 1 ml blood. After removing the needle, the vein has to be immediately compressed with a cotton ball to avoid further bleeding or development of hematoma (Figure 6.20).

In birds, blood amounts of maximum of 1% of the body mass can be taken for blood sampling [5]. For a full blood count including hematology and biochemistry, 1ml blood is sufficient. For hematology, 0.5 ml blood is collected in a 1.0 ml EDTA tube and 0.5 ml blood is stored in a 2.5 ml Li-Heparin tube for blood biochemistry.

Figure 6.15. Preparation of V. cutanea ulnaris spf. for blood sampling.

Figure 6.16. Bending of needle in syringe cap.

Figure 6.17. Bent needle.

Figure 6.18. Insertion of needle in V. cutanea ulnaris spf.

Figure 6.19. Blood taking.

Figure 6.20. Removal of needle and pressing of cotton ball on vein.

The complete blood count (CBC) is performed directly after blood taking preferably with as less time delay as possible. A full range of hematological parameters should be measured including red blood cell count (RBC), hemoglobin (Hb), hematocrit (Hct), white blood cell count (WBC), count of heterophils, lymphocytes, monocytes, eosinophils and basophils.

The blood samples are examined for biochemistry in a fully automated biochemical analyzer or with semi-automated machines. The following parameters are routinely performed: GGT, AST, ALT, TP, ALB, CK, LDH, CHOL, UA, UREA, GLU.

Other tests for the blood include the blood gas test. For this, blood can either be taken by special syringes or in capillary tubes. More detailed information on processing of blood samples and blood tests is provided in chapter 7.

Blood can also be sampled in special samples tubes without diluents for ELISA or PCR testing (Figure 6.21).

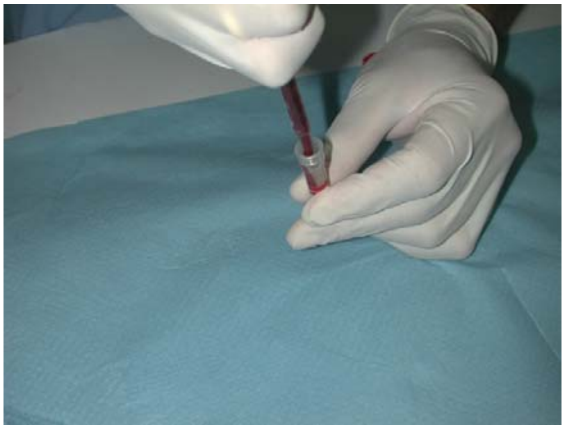

Figure 6.21. Inserting blood in special samples tubes for ELISA and PCR tests.

6.5. Advanced Examination

6.5.1. Radiography

Further investigation is required to assess conditions like hepatomegaly, foreign bodies, lead bullets and skeletal problems. It is advisable to get more detailed information through diagnostic imaging like radiography or other diagnostic imaging like C-bow imaging.

X-Rays can be performed conventionally or digitally. For each radiograph, the date, name of clinic and patient identification number should be set up to ensure the clear identification of the X-ray. The left and right side of the bird should be always clearly marked.

The X-ray should always be taken in 2 positions, ventro-dorsal and latero-lateral position. Hereby the cassette is divided in two halves. The bird is positioned one the right half with the full body, extended wings and fully pulled legs (Figure 6.22). When performing a full body radiograph, the sternum has to be positioned exactly above the vertebral column to achieve a straight line and full symmetrical position of the bird's body. The legs have to be pulled caudally. If the position is not fully symmetrical, positioning artefacts might be mistaken as pathological changes. The second latero-lateral position is on the left side of the radiograph with the falcon in lateral recumbency. The wings are folded behind the bird's body and pulled to the left side of the cassette out of the radiograph (Figure 6.23).

A full body X-Ray on a 30x40cm cassette is recommended to get a full overview of the complete skeleton of the falcon and to assess the internal organs for the presence of any damage, enlargement or pathological form. It is also the correct size for large falcons like gyrfalcons or larger raptors.

For wing injuries or fractures a special X-ray on a 30x40 cm cassette of the different wing position is helpful to review the wing and shoulder girdle. Hereby, the cassette gets split in three parts, two for the injured or fractured wing and one for the healthy wing.

For leg fractures, the injured and non injured limb should be radiographed together. For this purpose a 24x30 cm cassette can be used. Moreover, it is useful to fix the legs or wings in correct physiological position with a masking tape to avoid any movement during radiography.

Figure 6.22. Positioning of falcon on right half of cassette for radiography.

Figure 6.23. Latero-lateral positioning for radiography.

Radiographs of toes can be done by taping the toes in two positions, dorso-plantar and latero-lateral, on a divided cassette. Masking tape has proved to be useful for this purpose. Moreover, it is very important to put the toes of both feet next to each other to enable better comparison of the phalanges. Pathological changes in this area might be so tiny that they can be easily overlooked.

6.5.2 Endoscopy

General Information about Endoscopy

Endoscopy is a visual method to inspect body cavities and to view and assess the internal organs via an endoscope. Developed in the 1940s and 1950s, the endoscopy has become a routine tool for diagnostic and sexing in avians during the last 15 years [11]. Various forms of endoscopy exist as all body cavities can be used for endoscopic examinations. They include the endoscopy of the external auditory canal (otoscopy or auriscopy), cranial sinuses (rhinoscopy), oropharynx (pharyngoscopy), trachea (tracheoscopy), crop (ingluvioscopy), esophagus (esophagoscopy), celomic cavity (laparascopy/celoscopy) and cloaca (cloacoscopy) [11]. In this chapter, the endoscopy of celomic cavity, trachea as well as esophagus and crop are explained in detail due to their major importance for the practicing clinician.

Endoscopy does not only help as routine diagnostic tool but also to take biopsies or remove lesions in the airsacs and/or trachea like *Serratospiculum seurati* worms, *Aspergillus sp*. or *Pseudomonas aeruginosa* lesions. Due to the development of highly sophisticated endoscopic examinations, the falcon recovers fast from the procedure and can be used for training and hunting again in the same or following day. It has been stated in literature that the endoscopy of the left airsac is sufficient for sexing and routine endoscopy [7]. In the author's experience it is an absolute must for correct diagnosis to routinely endoscope the left and right airsac as often pathological findings can be found on only one, either left or right, side. This applies even for sexing purposes as nothing is more embarrassing for the veterinary surgeon as if the sex has been correctly diagnosed but the aspergillosis on the right side has been overlooked! The best way is to first endoscope the left and then the right airsac as a routine procedure and to perform the endoscopy always in exactly the same way. This helps to visualize all anatomical structures and not to forget anything.

An experienced avian veterinarian is able to conduct a celoscopy of left and right airsac within 6-8 minutes thus greatly reducing the anesthesia time for the falcon. The maximum number of celoscopies that had been performed by the author in the Abu Dhabi Falcon Hospital is 64 celoscopies in one day thus showing the integration of this diagnostic procedure as part of routine examinations. As helpful tool, the endoscopy should always be conducted while performing pre-purchase examinations. Research has shown that in more than 37.8% of first year captive-bred falcons diseases of the lungs and airsac including aspergillosis and airsacculitis as well as organ diseases of liver and kidneys were detected during routine endoscopic examination [8].

Endoscopy Equipment

Avian practitioners should set up at least basic endoscopic equipment (Figure 6.24). This basic equipment includes one small forceps, sterile scalpel blade No.15, absorbable suture material like Vicryl 3-0, cannula, trocar, rigid endoscope of 2.7mm diameter and 0° viewing angle, xenon or halogen light source and rigid biopsy forceps for endoscope 2.7 mm diameter (Figure 6.25). A special working sheath can be used for crop endoscopy. The trocar is usually commercially available with a sharp end that should be filed manually to become blunt. Sharp trocar edges increase the potential danger of punctures and hemorrhages. It is highly recommended to perform endoscopies always with attached camera and video monitor (Figure 6.26). This has several advantages like storage of the videos, printing of the endoscopic picture to enhance client satisfaction and review of older record when the falcon is presented again. In disputed cases, the endoscopic recordings can serve as proof.

Figure 6.24. Endoscopy room.

Figure 6.25. Endoscopy equipment.

Figure 6.26. Endoscopy with camera view in monitor.

Moreover, one of the greatest advantages is that only with the attached camera correct celoscopies can be performed as it is possible to visualize the lung ostium and bronchi. This is extremely difficult if the endoscopy is done by looking through the endoscope with the practitioner's own eye only as the endoscope has to be positioned below the bird's median line to enter in the ostium. This position makes it almost impossible to look through the endoscope with direct view. It has been suggested in literature that although cameras are vital for endoscopy-guided surgeries direct view endoscopy is acceptable for routine endoscopies in small animals practice [7]. In the author's experience wrong diagnosis are frequently posed when the camera is not used as the lung ostium is not visualized. Sometimes new *Aspergillus* lesions can be found only inside the ostium and the rest of the airsac looks perfectly fine. With direct view endoscopy, the aspergilloma is simply overlooked and left undiagnosed. Therefore avian practitioners should invest in one basic endoscopy set with camera and video equipment.

For avian practitioners with large avian clientele, two identical endoscopy equipment sets are useful that can be used alternating thus reducing waiting time during disinfection.

Laparascopy/Celoscopy

The endoscopy of the airsacs and assessment of the celomic cavity and its internal organs is called laparascopy or celoscopy. Following an isoflurane anesthesia with inhalation mask, the anaesthetized falcon is placed in left lateral recumbency. The wings are positioned behind the falcon's body and extended dorsocranially (Figure 6.27). Literature suggests keeping the wings in normal anatomical position [11] but in the author's experience the extended wing position provides a better position for the falcon and the veterinary surgeon. Then the wings and body feathers are taped with masking tape that is placed above the thorax of the falcon and attached to the surgery table (Figure 6.28). Both legs are pulled caudally and tied to the surgery table. The feathers are plucked in the area of the last ribs. Skin disinfection is performed by iodine solution followed by surgical spirit. This can be repeated 3 times. The wet skin surface is dried with sterile gauze that is wiped once over this area. A sterile window drape is placed over the bird.

Different entry points have been suggested [7, 11]. In the author's experience the entry point is best chosen between the last two ribs at medium height of the falcon's body. If the entry point is chosen too much dorsally, the lungs or kidneys can be punctured while entering. If it is chosen too much ventrally, the internal organs like liver, proventriculus or intestines can be punctured. Puncturing of organs like kidneys and liver can lead to severe bleeding.

Between the last two ribs, a small skin cut of approximately 2-3 mm length is made with a sterile scalpel blade. A hole is gently punched with a curved hemostatic forceps through the muscles into the caudal thoracical airsac. The tips of the forceps are opened along the rib curvature and not against it to avoid fracturing the ribs. The cannula with retracted blunt trocar is inserted into this hole. The trocar is retracted up to the end of the cannula and held in this position with one hand. The trocar should not be used for punching and serves only to cover the cannula that no tissue or liquid material can enter inside. After inserting the cannula in the caudal thoracical airsac, the trocar is removed. The inserted cannula is held with thumb and forefinger of the left hand directly in the place where the cannula exists from the falcon's body. The fingers are left is this position throughout the endoscopy to control the depth of the inserted endoscope. The 2,7 mm rigid endoscope is attached with the light source by an assistant and held with the thumb and one or two fingers of the right hand.

Figure 6.27. Positioning of falcon in lateral recumbency.

Figure 6.28. Positioning of falcon for endoscopy.

Figure 6.29. Use of camera for endoscopy.

It is gently inserted in the cannula without bending. After attaching a camera (Figure 6.29), the endoscopic picture can be visualized on the adjunct monitor.

The endoscopy of the left caudal thoracical airsac starts at the blood vessels between lung and liver. This is a good starting point for the veterinary surgeon for orientation in the airsac. The ostium and bronchi are visualized and then the endoscope is rotated in an outer circle from lung to airsac body wall, liver with partly covered proventriculus to get a distant view of the complete airsac. The endoscope has to be held in a flat and downwards oriented position very close to the falcon's body to see all distant structure and to get an overview. The circling of the endoscope in this position poses frequently problems for beginners as they are not used to hold the hand and the endoscope in such a downwards oriented position. The second round circle is the inner one where all internal organs are closely visualized and assessed. Hereby the endoscope is held in a position that is much higher up than the bird's body.

The second circle starts with the assessment of the heart and cranial thoracical airsac by gently pushing the endoscope to the airsac membrane. The circle continues to the kidneys and the gonade at its left caudal pole as well as the ureter, uterus or vas deferens. Gently touching of the airsac membrane provides the veterinary surgeon with a good view to the abdominal airsac to assess spleen, proventriculus and intestines. The endoscopic view of the right caudal thoracical airsac provides a much larger visualization of the liver and therefore easier assessment of this organ. After viewing all structures the endoscope and then the cannula are removed.

One single suture with absorbable 3-0 suture material closes the skin cut in the middle of the cut. Wound powder is applied on the suture. This procedure is repeated on the right side.

It cannot be stressed enough that it is highly recommended to perform endoscopy on left and right side as in many cases one airsac is clear and pathological changes can be found on the other side. In some cases the endoscopic examination was verified by a biopsy sample for the cytological examination taken by a rigid biopsy forceps. A single antibiotic injection intramuscularly with e.g. marbofloxacin is recommended as preventive measure against infections.

Tracheoscopy

Tracheal endoscopy or tracheoscopy can be performed in cases of sound or voice changes as this might be indicative for syringeal aspergilloma, tracheal stenosis caused by pseudomonas lesions or other pathological problems. The falcon has to be put very deeply in anesthesia for this procedure due to the irritation of the trachea. When performing tracheal endoscopy, the falcon has to be held upright in a very straight position with straight extended head and neck. It is advisable to apply non-fogging drops on the 2.7mm Ø endoscope tip to prevent fogging after entering the trachea. The rigid endoscope is inserted gently in the glottis by holding it in straight direction. It is then gently pushed forward up to the bifurcatio. It is essential not to bend the endoscope or to push to the sides of the trachea. This will lead to danger of puncturing the cartilaginous tracheal rings and endangering the falcon's life. Lesions can be grabbed and removed with a rigid biopsy forceps of 2.7mm Ø that is attached to the endoscope. However, it is possible to enter maximum 2-3 times as otherwise the trachea gets irritated. If the lesion could be only partly removed, another try can be done on the following day. Great care has to be taken to avoid grabbing and puncture of the tracheal cartilage rings with the biopsy forceps and subsequent hemorrhages. Literature suggests performing tracheostomy to remove tracheal or syringeal lesions [3] but in the author's experience such an invasive procedure is not indicated as in all cases the lesion can be removed with a biopsy forceps.

Ingluvioscopy

Ingluvioscopy or crop endoscopy is indicated as standard procedure in cases of falcons that stopped eating, are not eating well, vomiting or flicking food. The falcon is held in straight position for crop endoscopy. A special working channel sheath is used for this procedure. A plastic tube or pipe is attached at this sheath to blow air into the crop. This makes it possible to create enough space in the crop that the crop mucosa can be completely assessed up to the entrance of the proventriculus. This endoscopic method reveals lesions, vascular hyperemia as well as undigested old food or bones that are stuck in the crop. The insertion of a flexible biopsy forceps in the working channel makes it possible to remove foreign bodies, undigested meat or lesions.

Sexing

Endoscopy of the airsacs can be used also to determine the bird's sex and to assess the reproductive status and functionality of the gonads. They are located on the anterior base of the cranial kidney lobe and form a triangle with the adrenal gland [11]. They can be visualized by gently pushing the endoscope to the airsac membrane if the airsacs are very clear. However, in case of cloudy airsacs the membrane between caudal thoracical airsac and abdominal airsac has to be punctured gently. This will provide free view of the gonads. In female falcons like in most birds the left ovary is better developed than the right one. In some cases the right ovary can also be developed to a certain extent but not as much as the left ovary. In first or second year female falcons, the ovary is not mature yet and only immature ovary tissue or stroma with tiny follicles is visible. In older females, the number of follicles increases and can grow to considerable size when the female is examined in the breeding time.

The testis is not well developed in young males, but can grow to considerable size in the breeding season. They can be easily visualized by their shiny whitish surface. In older males that are in breeding condition an increased vascularization might be observed in the testis.

For questions of the breeding status the airsac has to be punctured to follow the suspensory ligament of the ovary which is located on the cranial kidney pole. In some cases a sterilization might have been performed before with removal of this suspensory ligament.

6.6. Pre-Purchase Examination

Every year, a large number of captive-bred first-year falcons, especially hybrid falcons are sold in the United Arab Emirates for falconry purposes. Nevertheless, the feature of pre-purchase examinations has not been executed in those sensitive birds and has been virtually unknown in falcons before 2003. Usually after-sales examinations have been performed with partly disappointing results for the buyer of any sick falcon. In the hunting season 2003, the Abu Dhabi Falcon Hospital introduced for the first time ever the service of a complete pre-purchase check-up in order to evaluate the health status of those falcons. In cases of health problems, the falcons were returned to their breeder without payment of the purchase fee. The purpose of this important service is not only to detect diseases in newly arrived falcons in the United Arab Emirates, but also to maintain the health status of the already existing falcon population of the owners. A study was conducted by the Abu Dhabi Falcon Hospital for the first time to assess the health status of newly bought falcons [8].

This research study has shown that in routine pre-purchase examinations several diseases are detected. The parasitological fecal examination revealed 73.6% healthy falcons and 18.2% falcons suffering from *Caryospora* burden. 5% falcons were infected with tapeworms and 2.5% with *Serratospiculum sp.* 0.5% falcons were diagnosed with inflammatory cells in the feces. In the crop examination, 88.6% falcons were negative. 5% falcons suffered from a Candida sp. infection and 3.2% were diagnosed with the occurrence of inflammatory cells. 1.4% falcons had a *Trichomonas* infection and 0.9% falcons a *Serratospiculum sp*. infection [8].

The blood hematology examination revealed that 81.0% falcons had not any changes in the hematology picture. However, in 19.0% falcons, elevated WBC, Hb, PCVand heterophils and *Hemoproteus* infection was diagnosed. The blood biochemistry examination led to 62.0% healthy falcons. In 33.7% cases, the LDH was elevated and in 21.0% cases the CK was increased. 14.6% falcons showed an increase of urea levels mainly due to dehydration. An increase in the one or more of the liver parameters (GGT, AST, ALT) was observed in 8.8% falcons [8].

The research revealed in the endoscopic examination 62.3% healthy falcons. 20.0% falcons were diagnosed with aspergillosis and 7.3% suffered from different forms of airsacculitis. 3.2% falcons had a *Serratospiculum sp*. infection and 2.7% were diagnosed with hepatomegaly [8].

Although the research covered exclusively first year captive-bred falcons which were around 6 months old at the time of the pre-purchase examination, the results are alarming. Only 25.9% of all falcons were perfectly healthy.

The statistical percentage reveals that in the total percentage a big difference between gyr-saker and gyr-peregrine hybrid falcons could not be found. Interestingly, gyr-peregrine hybrid falcons were diagnosed with less pathological changes with regard to blood hematology and biochemistry as well as endoscopy. These overall results justify and encourage the examination of falcons before purchase.

The pre-purchase examination does not only ensure the purchase of healthy falcons for the new owners, but also reduces the risk of sick falcons joining a healthy flock of falcons in large falcon collections. Therefore it is a highly important disease prevention feature which should not be only limited to falcons, but extended to other animal species, too. An extension of the examination for viral diseases, *Chlamydophila* and *Mycoplasma* can be routinely undertaken. These results of first year captive falcons lead to questions regarding the health status of older falcons available for purchase or moving to new collections where a higher number of undetected diseases might be possible [8].

6.7. Application of Medicines

Medicines can be applied in various forms such as per oral, subcutaneous, intramuscular, and intravenous. Other possibilities are medicine applications through inhalation, intratracheal and intraosseus. In birds of prey, several techniques can help to reduce the stress for the birds while giving medicines. However, no matter how medicines are applied, it is highly important to use correct application methods. In the worst case, incorrect application of medicines can lead to the death of the patient. In falcons, oral medication is useful as they are big enough for even larger tablets or capsules. Drinking water medication should not be given as the medication intake cannot be controlled fully and not every falcon drinks enough water [5]. Intramuscular injections lead to faster effects of the pharmacological content. This is extremely helpful especially as avian diseases have a rapid progress due to the high metabolic rate in birds [5].

Oral Application of Medicines

The application of medicines through the mouth e.g. in form of tables, capsules or liquids is one of the most common ways to give medicines to birds. After the required dosage of the medicine has been determined according to the body weight of the bird, the medicine has to be prepared before touching the bird. It is very helpful to use pill cutters to cut tablets in the portion required. Moreover, pill givers are a helpful tool especially for less experienced persons as they can reach deep into the crop and thus position the tablet in the correct place. Some medicines come in form of powder or little bits in capsules. They have to be measured according to the required dosage and then are placed into new capsules. In falcons, the smallest size of capsules is most useful as the larger ones are difficult to swallow for the birds and might be stuck in the upper part of the esophagus. In some cases, the gelatine capsules can get dissolved in the oropharynx if they are too big to be easily pushed down the crop.

In order to give the medicine perorally, one person has to grab the perched falcon and hold it in a 30° angle. The person who applies the medicine is positioned in front of the bird and holds the bird's head with the left hand. When catching the head, the thumb is under the chin and the first two or three finder hold the central part of the head. It is very important to avoid touching the eye as this may lead to serious eye damage. With the right hand, the hood gets removed. Then the side part of the hood is placed in the bird's beak to keep it open. The thumb of the left hand is correctly positioned in the bird's right (the handler's left) side of the mouth between the upper and lower beak or maxilla and mandible. It is very helpful to turn the bird's head approximately 30° angle downwards to the bird's right side (the handler's left side). This little trick helps to prevent that the tablet is misplaced in the trachea by mistake. The tablet or capsule can then be pushed carefully with one finger to the outer side of the mouth to the esophagus and the crop. This also helps to prevent a misplacement of the tablet or capsule. The falcon's mouth then should be closed carefully and the hood can be put back in position.

Liquid medication can be put in 1 ml syringes and given orally by probes. The outer surface of the syringe shall be wiped to remove any medicine content. On top of the syringe, a crop needle with rounded edge is attached. These are preferably of metal content with rounded tip and can be straight or curved. This crop needle can reach deep into the crop without puncturing or injuring the crop mucosa.

Before fixing the falcon, the crop needle should be attached to the syringe with the liquid medicine already. A similar procedure can be done for application of liquid medicines. The falcon is held in straight position by a second person. The left hand holds the bird's head and the left thumb is fixing the falcon's right (the handler's left) side of the mouth in open position. The handler's right hand holds the probe. The probe is then inserted in the right side of the esophagus (the handler's left side) far behind the glottis opening and pushed gently down the crop. In other birds, the oral medication can be given in the left side of the oropharynx [5] but in falcon it is easier to use the right side of the oropharynx due to the way of fixing the head.

Tube Placement in Esophagus or Proventriculus

Feeding of critically sick falcons has to be performed by a tube that is inserted either in the esophagus or preferably direct in the proventriculus (Figure 6.30). This is helpful also in falcons with large lesions in the crop that are caused by *Trichomonas*, *E.coli* etc. These lesions can lead to constriction of the esophagus and thus inability of the falcon to pass the crop. Falcons with surgeries in the crop region can be fed in the same way. The liquid food preparation should not exceed a maximum of 25-30 ml per application and is described in detail in chapter 16. A maximum of feeding 3-4 times per day should not be exceeded as the food has to be digested and passed. The amount of excreted feces has to be controlled.

The positioning of the falcon is the same as described above for oral medication. The tube should not be a metal one as for the oral application of liquid medicines, but instead with an elastic plastic tube. The tip of the tube has to be round and should not be cut off as the sharp edges might lead to massive damage of the esophageal mucosa. The tube is attached with a 60ml syringe as this can be easier attached to the tube and the pressure while emptying is better distributed. The tube is gently pushed forward in the esophagus until a mild resistance can be felt.

Figure 6.30. Tube placement in esophagus or proventriculus.

This resistance poses the entrance of the proventriculus. While pushing down the tube along the crop, the tube tip can be felt when touching the crop region. After passing the resistance of the proventricular entrance, the tube is pushed just a little bit further down and the syringe content is emptied in the proventriculus. After emptying the syringe content, the tube is gently removed again.

It has described in literature that the tube should be placed permanently for up to several weeks [3]. The advantage of the here described method is that the falcon is not put under anesthesia and is not an invasive measures as it is the case of esophagostomy or ingluviostomy. Moreover, it is a temporary measure that does not disturb the falcon. The risk of infection is less, too.

Subcutaneous Application of Medicines

It is better to warm up subcutaneous fluid to body temperature. In some cases, where this might not be possible the injection should at least not be administered after taking it out of the fridge. It is a possibility to roll the syringe with the medicine in the hand as the temperature rises automatically through rubbing.

Injections can be given under the skin. Preferred application places are the inside of the thighs, on the chest or in the neck-shoulder region. Due to the fact that the avian skin is highly elastic, even injections of up to 30ml can be injected subcutaneously without any side effects. The fluid gets absorbed by the falcon's body within 10-15 minutes. However, it is important to correctly inject the liquid medicines or fluids. The injection into the muscles can lead to abscesses, lifting up of the legs and in extreme cases to muscle necrosis or reduced flight ability if the pectoral muscles are affected. Before giving any subcutaneous injection, the feathers should be moved to the side (but not plucked) to get a feather-free skin area. The skin has to be disinfected e.g. with gauze soaked in surgical spirit.

For subcutaneous injection in the precrural fold of the thigh, the thigh can be held in the distal third of the leg with one hand. The other hand is used to inject under the skin (Figure 6.31). In order to prevent that the injection needle is misplaced when the falcon is moving, a simple trick is very helpful. The fingers of the hand that is holding the thigh can be used to hold the syringe as well. This can only be done if the syringe is held exactly parallel to the thigh itself. Moreover, the needle should be held in flat position when inserted under the skin as otherwise the danger to puncture the muscle is increased. The skin in the precrural fold is so elastic that even the amount of 40ml can be easily administered (Figure 6.32).

For subcutaneous injections in the chest region, only small amount of liquid medicines or fluids can be given as the skin in this region is not elastic enough for larger fluid amounts. This part of the body is usually used for injections of vaccines. In this case, the needle is inserted from the cranial side. If inserted from the caudal side some fluid might drop downwards through the hole.

Subcutaneous injections in the neck and shoulder region can be used to apply larger amounts of medicines and fluids. The falcon is held by another person in a position that is parallel to the floor. This position makes the entrance angle of the needle easier as syringe and needle can be held in horizontal position to the bird's back. The injection is performed in a distance of approximately 1cm parallel to the vertebral column. Care needs to be taken not to inject in one of the blood vessels.

Figure 6.31. Insertion of needle for s.c. injection.

Figure 6.32. Subcutaneous injection in precrural fold

Intramuscular Application of Medicines

The intramuscular application of medicines is one of the most stress-free medicine application forms for birds of prey as they do not need to be restraint. The intramuscular application can be easily done in the pectoral muscle [2]. The sternum should be measured into two halves. The injection can be performed in the middle of the sternum and on its lateral side. It is useful to hold the syringe and needle in a 45° angle to the sternum. In order to avoid a backward move of the bird, the other hand can be placed behind the bird's back without touching it. In case that the falcon moves backwards, this hand will pose a natural barrier for it and thus prevents the falcon from escaping the injection.

It is important to only use medicines that do not produce necrosis of the pectoral muscle in order to avoid reduced flight performance.

Intravenous Application of Medicines

The intravenous application of medicines is a limited medical procedure as not many medicines are administered intravenously. Intravenously applied fluids should be warmed up to body temperature. They are mainly 0.9% sodium chloride and 5% glucose or plasma expanders. The former is given in case of strong dehydration whereas the latter is administered in case of strong blood loss caused by hemorrhages. Both intravenous fluids are injected very slowly with the amount of maximum 10ml per falcon in the vein. The location of the vein and preparation for intravenous injection is the same method as described above for blood sampling. Certain antibiotics like piperacillin can be administered intravenously as well, especially to provide an initial bolus in cases of septicemia. Intravenous injections can be done with the use of needles or winged vein catheter (Figure 6.33).

Figure 6.33. Intravenous injection with use of winged vein catheter.

Inhalation of Medicines

Application of medicines through inhalation is commonly used as treatment of the upper respiratory tract especially in aspergillosis cases. The equipment required is a nebulisation chamber, nebulizer, oxygen and air compressor. The falcon is put on a perch that is placed in the middle of the nebulisation chamber. The nebulisation chamber that is used for falcons in the Abu Dhabi Falcon Hospital has measures of 76 cm height x 51 cm length x 51 cm width. This size is sufficient even for large falcons.

Medicines like enilconazole or Amphotericin B can be used for nebulisation in aspergillosis cases. 1ml enilconazole is diluted in 20 ml sterile saline or 0.5ml Amphotericin B is mixed with 10ml saline. The dilution is then added in the nebulisation vaporizer. They have to be under the size of 3πm diameter in order to pass the airsacs and lungs [9]. The mixture of medicine-saline is then inhaled by the patient in form of tiny drops. The nebulisation can be performed between 1 to 4 times per day for the duration of up 20-30 minutes. A positive effect on the treatment progress can be observed with nebulisation as additional therapy component.

Intratracheal Application of Medicines

The intratracheal application of medicines is very rare and only indicated in the case of tracheal stenosis or syringeal aspergilloma. Lesions caused by *Aspergillus sp.* and *Pseudomonas aeruginosa* can lead to constriction of the tracheal lumen resulting in massive breathing difficulties and sound change of the falcon. The intratracheal treatment can be performed only after mechanical removal of the lesion with a rigid biopsy forceps as detailed above in this chapter as otherwise the danger of suffocation is given. On the next day following the removal of the lesion, the first intratracheal application of e.g. Amphotericin B can be given. The medicine is prepared in a 1ml syringe and should not exceed 0.2-0.3 ml. The syringe is placed directly above the glottis, but not inside the glottis itself. Then the liquid medicine content is carefully and slowly dripped in the glottis where it rinses down to the bifurcation. This treatment is performed for a maximum of 3 consecutive days. It should only be applied by experienced medical personnel as in cases of wrong administration the falcon can suffer from asphyxation pneumonia und in the worst case of suffocation. However, this treatment has proved to be extremely efficient in the described cases.

Intraosseus Application of Medicines

Intraosseus application of medicines in the ulna and tibiotarsus has been described in literature as bolus or continuous fluid therapy as alternative method to intravenous fluid application [1]. However, in the author's experience intraosseus medication does not have advantages compared to intravenous injection of fluids but the impact on the bird and the risks of iatrogenic fractures and osteomyelitis are considered as too high. Therefore this method is not described in detail in this chapter.

6.8. Conclusion

The correct clinical examination including complete case history is vital for diagnosing diseases. The comprehensive examination includes general examinations and advanced examination techniques. It depends on the case history, disease symptoms and general condition of the falcon which examination techniques are chosen by the veterinarian. Moreover, it is essential to be proficient in the application of medicines and to be able to judge the best administration method.

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Chapter VII

Laboratory Examinations

Abstract

Laboratory examinations posed an inevitable part of falcon medicine. Apart from common diagnostic methods like flotation or smear tests, blood smears and staining, more sophisticated diagnostic methods like ELISA and molecular analysis have found their way into modern veterinary parasitological diagnostics. Blood tests for hematology, biochemistry and blood gas have become integral part of avian medicine. Other laboratory tests like microbiology, virology and cytology are standard examinations of modern avian medicine. Laboratory methods have to be conducted in standardized and correct way as otherwise false positive or negative results may arise. Reference parameters are nowadays available for the different falcon species thus enabling the practicing veterinarians to correctly interpret laboratory results.

7.1. Introduction

Avian and falcon medicine relies to a great extent on correctly performed and accurate laboratory results. They have to be done as fast as possible as every hour counts for birds. Fast laboratory results can make the difference between survival and death of the avian patient. Several tests like parasitology and blood examination can be easily conducted in the general veterinary practice without investing too much in equipments. In contrast, more advanced tests like virology, ELISA and molecular analysis often have to be sent to specialized laboratory facilities. More laboratories world-wide have nowadays avian profiles and disease testing readily available thus facilitating good avian and falcon medicine for the avian practitioner. Most falconers are able to conduct parasitological tests for feces and sometimes crop by themselves which helps them in monitoring the overall condition of their falcons on a regular basis especially in those cases where specialized avian practitioners are not situated around the corner.

This chapter emphasizes the most important laboratory examinations that are relevant for avian practitioners. It also provides reference values for the most important blood parameters for 5 falcon species that are commonly used for hunting. They are gyr-saker hybrid falcons, gyr-peregrine hybrid falcons, peregrine falcons, saker falcons and gyrfalcons. Advanced methods like virology, molecular analysis or ELISA (enzyme linked immunosorbent assay) are mentioned but not explained in detail in this chapter as they can only be conducted professionally by highly specialized laboratories and do not form part of the routine avian practice.

7.2. Parasitological Examinations

Parasitology is one of the most important laboratory examinations for birds. Several different methods can be used for detection of parasites, their eggs and intermediate stages. However, not all routine methods show the same sensitivity for different parasites.

The most common routine method, the direct flotation, is commonly used for detection of avian helminths in feces. The slide for the parasitology examination has to be labeled (Figure 7.1) and the flotation solution (Figure 7.2). The feces material is put on the slide (Figure 7.3) and mixed (Figure 7.4). The prepared slide (Figure 7.5) is then examined under the microscope (Figure 7.6). Different flotation solutions do exist with the most common one being saturated saline nitrate. Hereby, 568 g sodium nitrate is mixed with 1000ml water. This flotation solution is used to detect nematodes, cestodes and acanthocephala. Another solution is saturated zinc sulfate solution of 336g zinc diluted with 1000ml water which is most suitable for the detection of *Giardia* cysts and spiruoid eggs [4]. Trematodes or flukes can often not be detected through flotation methods. For them, sedimentation with soap-in-water solution is the method of choice [4].

The size of the different *Cryptosporidium* stages is very small and range from 4-6 µm [1]. Due to their small size and the ability to float in a higher pane, the likelihood to miss them in the routine fecal examination is relatively high. However, they can be concentrated in sugar flotation where they appear in pinkish color.

Figure 7.1. Labeling the slide for fecal test.

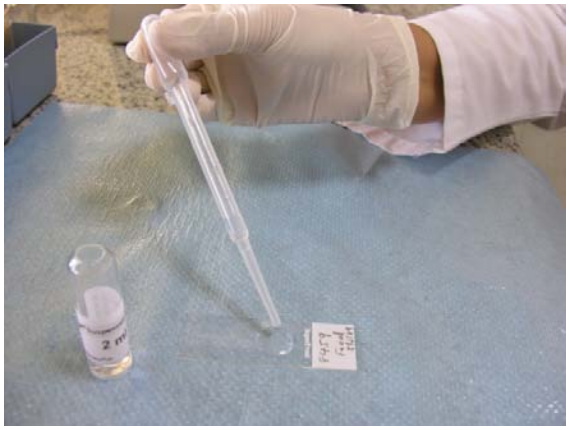

Figure 7.2. Pipetting flotation solution on the labeled slide.

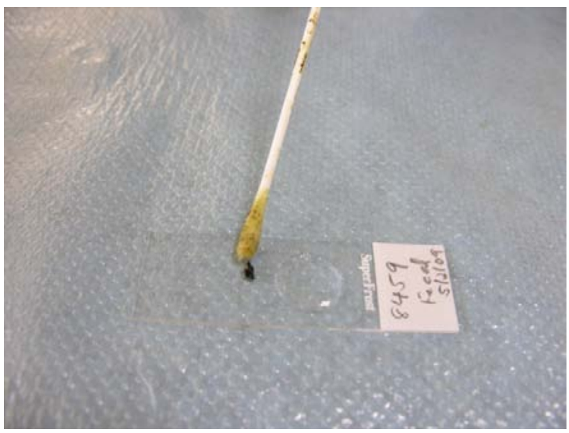

Figure 7.3. Putting feces material on prepared slide.

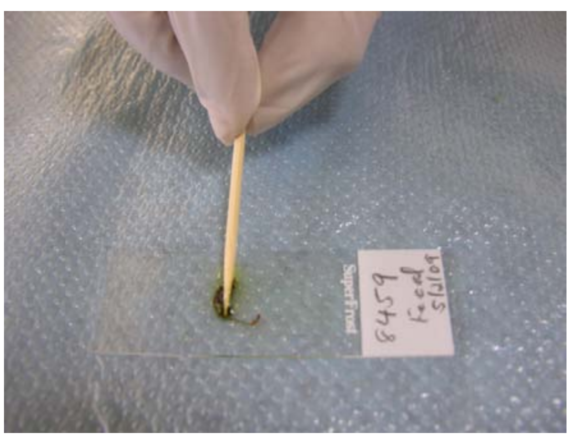

Figure 7.4. Mixing of feces material with flotation solution.

Figure 7.5. Slide prepared for microscopic examination.

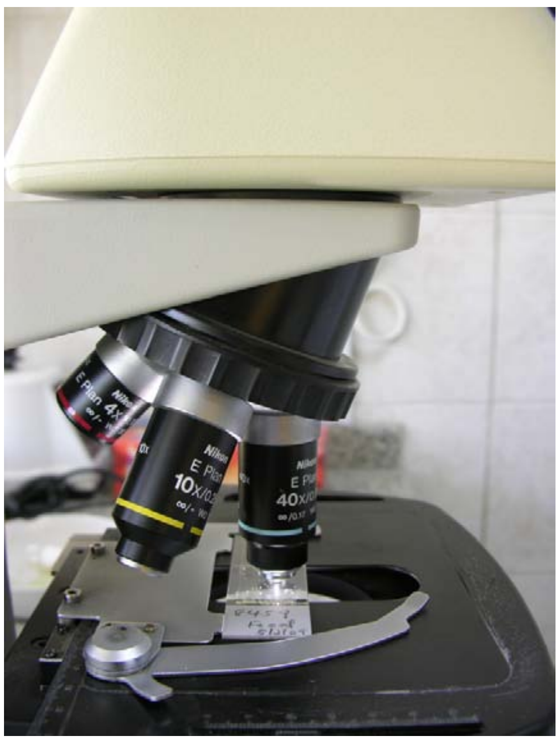

Figure 7.6. Microscopy of slide for parasitology.

The sugar flotation makes oocysts visible. It can be easily made of 454g (1lb) cane or beet sugar mixed with 335ml boiled water. 6ml of 10%formalin helps to preserve the solution [10]. Another possibility for the Sheather's sugar solution is the dilution of 500g table sugar in 320ml water and 6.5g phenol crystals which is helpful to identify coccidian oocysts [4]. Although *Cryptosporidium spp.* can be identified through acid-fast staining methods, but precise examinations are required because the staining material might be mistaken as cryptosporidium and the real parasite might be overlooked. ELISA and immunofluorescent assays can be performed, but do not seem to be as useful in avians as in mammals [10]. Advanced diagnostic methods like molecular analysis give more precise results [12].

Motile protozoan trophozoites like *Giardia*, *Hexamita* and *Trichomonas* can be identified in direct smears. For *Giardia* and *Hexamita*, the feces material is mixed with Lactated Ringer's Solution or normal saline. Another possibility to detect *Giardia* is the staining of fresh feces material with carbol fuchsin or iodine. Sterile tissue swabs are soaked with warm saline or warm Lactated Ringer's Solution and must be examined under the microcope within ten minutes after sample taking in order to detect *Trichomonas sp.* [4].

Enzyme-linked immunosorbent assays (ELISA) methods have found their way in avian parasite diagnostics. The ELISA tests detect an antigen of the parasite through a parasite-specific coated antibody membrane. Especially for detection of *Giardia* and *Cryptosporidium* ELISA methods have proved to be helpful although they are not especially developed for avian parasite testing [10]. Furthermore, immunofluorescent antibody (IFA) tests have been added to avian parasite diagnostics. They are used mainly for testing of *Giardia* and *Cryptosporidium spp*. [10].

Polymerase-chain-reaction methods have also been used for the detection of avian parasites like *Enterocytozoon bieneusi* [9]. However, the PCR might not be used as a routine diagnostic tool due to cost and time consideration, but is extremely helpful for detection of uncommon or new parasitic diseases.

Avian hematozoa can be identified in blood smears on microscope slides. It is helpful to cover the microscope slides with cover slips to keep the parasites in place. The smears can be stained with Wright/Giemsa or Giemsa stain [4].

7.3. Laboratory Blood Examination

7.3.1 Hematology

Blood hematology has become one of the most common laboratory examinations in avian practice. A full blood count should be routinely performed either to ensure the health of the bird or to identity pathological changes.

Red Blood Cell Count (RBC)

The working solution consists of 10 ml 40% formaldehyde, 31.3 g trisodium citrate and 1000 ml distilled water. 4 ml of this solution has been mixed in a plain sample tube with 20µl of the falcon blood stored in the EDTA tube. This diluted sample has been filled via a capillary tube in the improved Neubauer haemocytometer [11]. After 5 minutes waiting time, the cells of 5x16 squares have been counted in the center of the counting grid. The counted cells had been calculated as follows [7]:

N=Number of cells counted, then: $\frac{N}{100} = \text{RBC} \times 10^{12} / 1$

White Blood Cell Count (WBC)

1.9 ml of a 1% ammonium oxalate solution had been mixed with 100 µl of the falcon blood sample and kept on a tube roller for 3 minutes [11]. A small amount of the diluted samples has been filled via a capillary tube in the improved Neubauer haemocytometer. After 5 minutes waiting time, the cells of 4 outer large squares have been counted in the center of the counting grid. The counted cells had been calculated as follows [7]:

N=Number of cells counted, then: $\frac{N}{20} = \text{WBC} \times 10^9 / l$

Packed cell Volume (PCV)/ Hematocrit (Hct)

The PCV [11] is measured by the used of microhaematocrit capillary tubes and centrifuge. However, the hematocrit is often used as this might be the more accurate than the PCV [3, 7]:

Mean cell volume: $\frac{\text{PCV} \times 10}{\text{RBC}} = \text{MCV(fl)}$

Mean cell hemoglobin: $\frac{\text{Hb} \times 10}{\text{RBC}} = \text{MCH (pg)}$

Mean cell hemoglobin concentration: $\frac{\text{Hb} \times 100}{\text{PCV}} = \text{MCHC (g/l)}$

Hemoglobin

The hemoglobin is measured by capillary, venous or arterial blood used in EDTA. The optical eye of the Hemocue Microcuvette contains reagents deposited on its inner wall and the blood sample is drawn in to the cavity by capillary action spontaneously mixed with the reagents. The HemoCue photometer system provides a direct reading of the concentration of hemoglobin in a blood sample [7].

Preparation of Blood Smear

A slide is labeled in preparation for the blood smear (Figure 7.7). One small drop of blood sample is put on a clean microscopic slide (Figure 7.8, 7.9). A spreader slide is positioned in front of the drop of blood at an angle of about 45°. The spreader is moved backwards and the drop of blood is touched gently to run across the edge of the slide (Figure 7.10). The spreader is pushed with a steady forward movement to create a blood smear (Figure 7.11) [7].

Staining method. The HEMAstain test is for the rapid, differential staining of hematological smears that yields qualitative results similar to Wright-Giemsa stain. It can be used very well for routine staining. The slide is dipped in fixative solution for 5 seconds, than in solution 1 for 5 seconds and than in solution 11 for 5 seconds. The excess solution is allowed to drain. The slide is rinsed with distilled or deionized water, then allowed to dry and examined under oil immersion lens. The examination of the blood smear for the shape of the blood cells and avian blood parasites is routinely performed for each blood smear (Figure 7.12, 7.13, 7.14) [7].

Figure 7.7. Labeling of slide for blood smear.

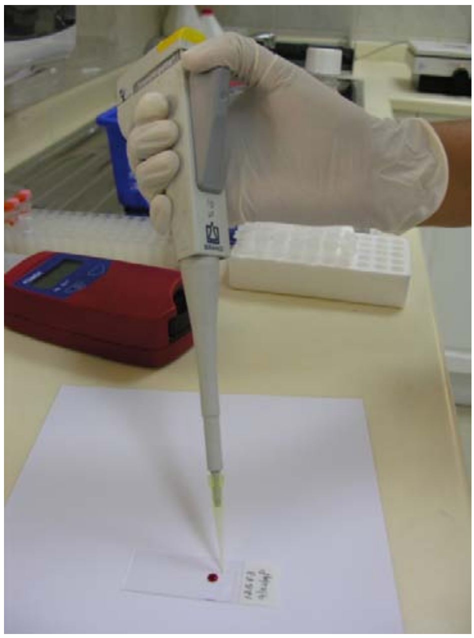

Figure 7.8. Putting a blood drop on a slide.

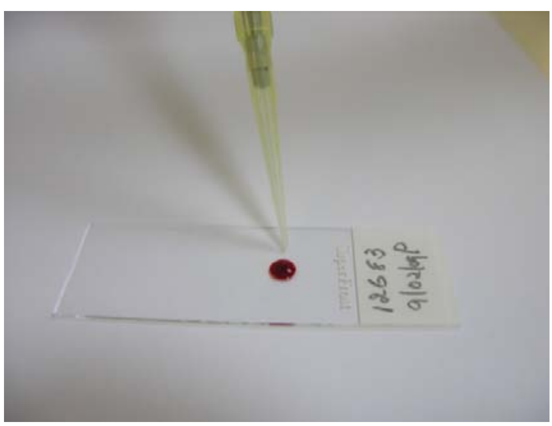

Figure 7.9. Putting a blood drop on a slide (close up view).

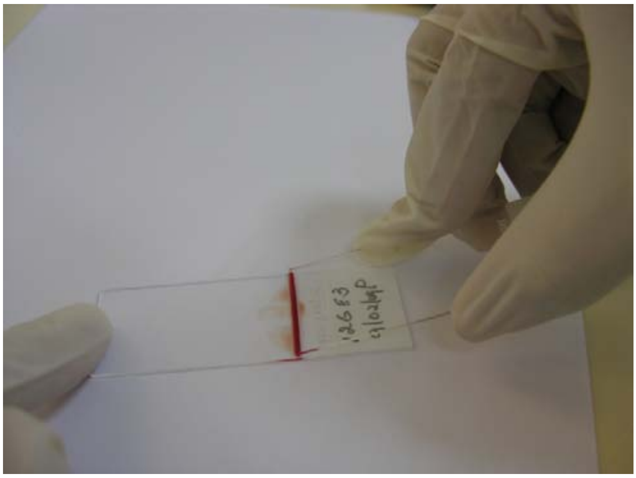

Figure 7.10. Pushing the spreader slide backwards of the blood drop.

Figure 7.11. Blood smear ready for examination.

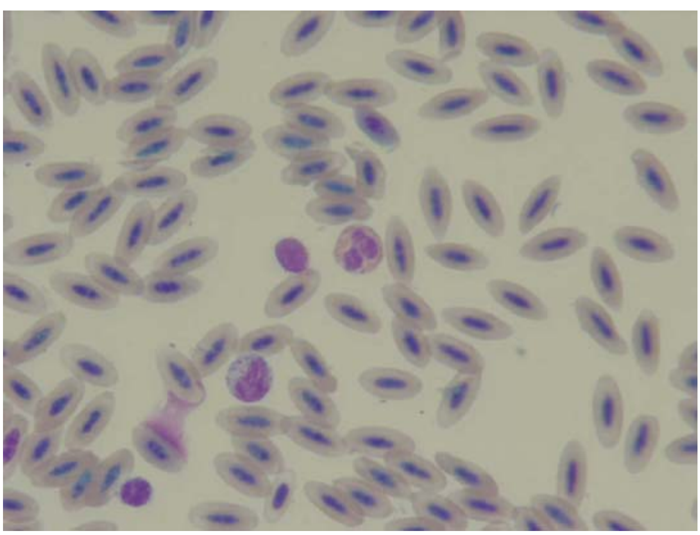

Figure 7.12. Normal hematological picture.

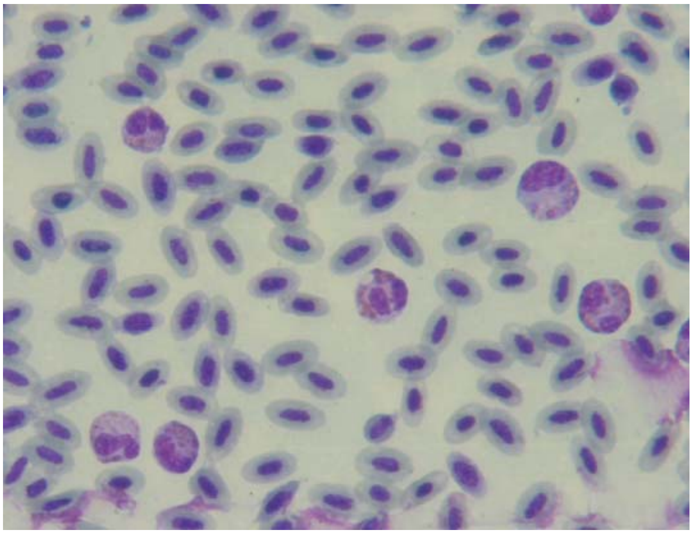

Figure 7.13. Abnormal hematological picture.

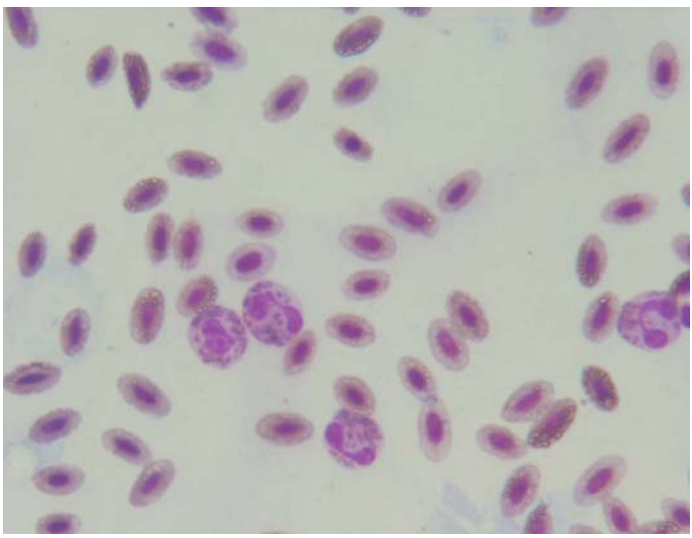

Figure 7.14. Toxic heterophils.

Reference Values for Hematological Parameters for Different Falcon Species

Different falcon species show varieties in their reference values for blood hematological parameters. The table below provides the most important reference values for the 5 most common falcons species used for hunting that have been established by the Abu Dhabi Falcon Hospital.

Table 7.1. Reference values for hematological parameters for gyrfalcon, peregrine falcon, saker falcon, gyr-saker hybrid falcons (*Falco rusticolus x Falco cherrug*) [7], gyr-peregrine hybrid falcons (*Falco rusticolus x Falco peregrinus*) [7]

Parameters	Gyr falcon (n = 100)	Peregrine falcon (n = 100)	Saker falcon (n = 100)	Gyr-Peregrine falcon (n = 320)	Gyr-Saker falcon (n = 369)
RBC ($\times 10^{12}$/l)	2.73–3.24	2.50 – 3.22	2.61– 3.29	2.13–2.65	2.18-2.48
Hb (g/dl)	14.09–17.89	14.58 – 19.07	14.28– 18.48	16.33–19.47	16.23-19.23
Hct (l/l)	40.04–49.36	39.73 – 51.49	40.25– 51.18	47.25– 56.75	46.91-56.23
MCV (fl)	136.71–163.29	144.84–174.8	142.8–167.5	194.32–245.08	200.29-243.49
MCH (pg)	48.17–59.25	52.61–65.37	49.7– 61.6	67.14 -84.04	69.41-83.07
MCHC (g/dl)	33.10–38.56	34.0–39.88	33.24–38.54	32.95-35.91	32.85-35.99
WBC (x10^9/l)	5.68–8.62	5.68– 9.42	5.8– 9.0	5.28–9.82	5.28-9.72
Heterophils %	47.00–55.00	48.43– 55.07	49.3–55.85	46.41– 53.41	46.02-53.78
Lymphocytes %	41.00–47.00	40.45–47.19	39.4 –47.4	40.82–47.54	41.20-47.02
Monocytes %	1-4	1-3	1-4	2.77-6.03	2.84-6.00
Eosinophils %	0-1	0-1	0-1	0.29-2.45	0.37-2.21
Basophils %	0-1	0-1	1-3	0-0	0.25-0.55

7.3.2. Biochemistry

Blood biochemistry can be performed in fully automated machines which are used in the Abu Dhabi Falcon Hospital. A fully automated machine is only useful if larger numbers of samples are processed. For smaller veterinary practices with limited number of blood samples, it is also possible to use semi-automated machines. They usually work with platelets or strips for each parameter. The following biochemical parameters can be performed routinely:

Table 7.2. Blood biochemical parameters

Parameters (abbreviation)	Parameters	Elevation	Decrease
GGT	γ-glutamyl transferase	Hepatic problems [13]	
AST	Aspartate Aminotransferase	Skeletal muscle damage, hepatopathy (often acute), viral hepatitis [13]	
ALT	Alanine aminotransferase	Hepatopathy (incl. toxic liver damage, hepatitis, hepatic necrosis), myocarditis, skeletal muscle disease [13]	
TP	Total protein	Dehydration, acute and chronic inflammation [13]	Blood loss, emaciation, maldigestion, enteropathy, hepatopathy, anemia [13] hemoparasites, tumors [5]
ALB	Albumin	Dehydration, haemoconcentration [13]	Hepatopathy, protein loosing enteropathy (e.g. salmonellosis, parasitosis, chronic malabsorption) [13]
LDH	Lactate dehydrogenase	Muscle damage, hepatocellular damage [13], tumors, intoxications [5]	
CK	Creatine kinase	Muscle damage, stress, excessive exercise, intramuscular injections, nutritional myopathies (e.g. Vit.E and Selenium deficiencies) [13]	
UA	Uric acid	Advanced renal damage, nephritis, gout, high protein diet, severe tissue necrosis, lead intoxication, urinary obstruction, A hypovitaminosis, [13]	
UREA	Urea nitrogen	Dehydration, vomiting, diarrhea, hemorrhage [13]	
GLUC	Glucose	Starvation [5]	
CHOL	Cholesterol	Hepatopathy, renal disease, high fat content of food [5]	
BA	Bile acid	Hepatopathy	

Reference Values for Blood Biochemical Parameters for Different Falcon Species

The different falcon species show differences in the blood chemistry values. Therefore the table below lists the blood biochemical reference values of 5 main falcon species used for hunting that have been established by the Abu Dhabi Falcon Hospital.

Table 7.3. Reference values for biochemical parameters for gyrfalcon, peregrine falcon, saker falcon, gyr-saker hybrid falcons (*Falco rusticolus x Falco cherrug*) and gyr-peregrine hybrid falcons (*Falco rusticolus x Falco peregrinus*)

Para-meters	Gyr falcon (n = 62)	Peregrine falcon (n = 50)	Saker falcon (n = 75)	Gyr-peregrine falcon (n = 400)	Gyr-saker falcon (n = 570)
GGT	4.00–11.00	2.00–8.69	3.00–10.00	6.00–12.00	5.50–11.55
AST	41.60–123.30	26.51–96.17	40.85–116.75	47.70–110.00	45.07–122.33
ALT	20.26–56.26	20.68–54.20	32.30–85.13	44.94–73.50	37.28 – 91.00
TP	2.32–3.24	2.40–3.40	2.35–3.00	2.15–3.35	2.22–3.40
Alb	0.99–1.30	0.77–1.56	0.99–1.23	0.73–1.35	0.90–1.26
CK	236.80–618.67	236.80– 618.67	253.56–632.16	341.00–668.75	312.30– 681.37
LDH	707.00–1305.00	662.00–1300.00	703.00–1299.00	802.00–1457.00	788.87–1493.3.9
UA	3.48–7.58	2.96– 7.74	2.87–8.49	3.60–7.00	3.48 – 7.58
Urea	7.19–17.00	6.6–17.00	7.70–16.10	7.00–17.00	6.46 – 20.14
Chol	160.00–250.78	164.00–250.70	167.00– 232.00	167.00–272.00	159.00– 267.00

7.3.3. Blood Gas

Blood gas values have great importance in critically ill birds. They give information on the status of acidosis or alkalosis being present in the bird. Blood gas values can be easily and rapidly measured with blood gas machines or portable analyzers. Changes in blood gas values may derive from medical conditions like bacterial septicemia, diarrhea, vomiting and dehydration. Other factors impacting the balance of blood gas values are management related and include overtraining, stress and starvation. It is useful to measure pH, partial pressure of oxygen (pO_2) and partial pressure of carbon dioxide (pCO_2). The fluid administration for critically sick falcons can be determined from the blood gas results. Depending on the blood gas results, the decision regarding the administration of the most suitable fluids like 0.9% saline and 5% glucose, Lactated Ringers solution, dextrose or Hartmann's solution can be taken.

Table 7.4. Reference values for selected blood gas parameters for gyr-saker hybrid falcons (Falco rusticolus x Falco cherrug) and gyr-peregrine hybrid falcons (Falco rusticolus x Falco peregrinus)

Blood gas Parameters	Gyr-Peregrine falcon (n = 100)	Gyr-Saker falcon (n = 70)
pH	6.91-7.69	7.35-7.76
pCO_2 (mmHg)	26.4-52.2	27.0- 49.5
pO_2 (mmHg)	60.0-13.0	64.2-110.5
Na^+ (mmol/l)	135-166	132-157
K^+ (mmol/l)	2.92-4.84	3.05-4.83
Cl^- (mmol/l)	101-125	100-127

7.4. Cytology

Cytology of avian samples is a very useful and rapid diagnostic tool. This technique provides information about cells that are examined under the microscope. Samples can be taken from various tissues of the avian body like organ samples, crop, airsac and feces samples as well as different aspirates of masses of unknown origin, joints and ascites. Different kinds of stain are available and used in avian diagnostics. They include Wright's stain, Giemsa stain and Gram stain that are routinely used in avian cytodiagnostics. Gram stain also helps to differentiate bacteria and is frequently used in avian medicine. Acid-Fast stains are preferred for the detection of mycobacteria. New Methylene Blue solution and fecal trichrome stain are other common stain for avian cytology [3].

Fine-needle aspiration is commonly performed for any kind of abnormal growth like lumps, masse or swellings of joints. The aspirate contains different kind of cells that provide information if an acute inflammation, non-inflammatory reaction or neoplasia is present [3]. Biopsies of airsacs performed during laparoscopy reveal the presence of e.g. fungal hyphae, bacteria, heterophils or *Serratospiculum seurati* eggs.

7.5. Microbiology

General Microbiology

Routine samples for bacterial examination include samples of crop, feces, blood, tissue, aspirates and biopsies. Microbiology is an inevitable part of avian medicine and can make a difference for the survival of the bird in critical situation. Crop samples are taken by sterile cotton soaked in a drop of sterile saline. The fecal samples are taken from fresh fecal and either streaked directly on the plate (Figure 7.15, 7.16, 7.17) or kept in charcoal media for up to 24 hours. Special agar media is required for identification of the different bacteria. They are explained for the most common bacteria in falcons in chapter 12 [6].

Figure 7.15. Preparation for streaking on agar plate.

Facility Screening

Environmental microbiology is the discipline which studies natural as well as pathogenic microorganisms in natural or artificial environment. Pathogenic microorganisms can spread by soil, water and air as well as direct contact [6].

Unhygienic keeping of birds of prey on uncleaned perches, feeding places and floors leads to bacterial infections. Those infectious agents can contaminate the environment of the falcons e.g. floor, perches, gloves where they can stay alive for weeks up to several months. This contamination may create a latent danger for all falcons in the facility. In falcons known to be suffering from bacterial and fungal diseases, pathogenic microorganisms can lead to substantial disease cases or even losses of birds. Therefore a regular control and examination of the hygiene status of the facility is advisable e.g. on a monthly basis as explained in detail in chapter 3 [4].

Method

For air and environmental contamination, settle plates can be used for facility screening. 90 mm diameter settle plates used were pre-incubated to check the sterility prier to use. The plates with the media are exposed for a period of 20min. The blood agar plates were incubated at 37°c for 24 hrs and Sabouraud-Chloramphenicol-Agar plates for at least 7 days at 22-28°C. The colonies were counted and expressed as bacteria carrying particles (BCP) [4].

Figure 7.16. Start of streaking on the agar plate.

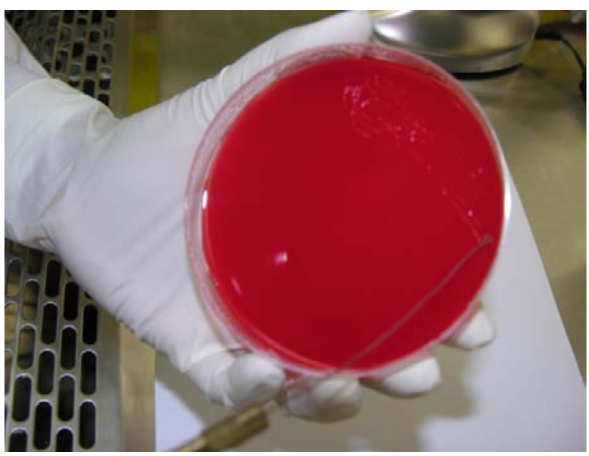

Figure 7.17. Streaking on the agar plate.

For sampling of equipment, rooms, perches, floors, air-conditions and other special places, samples can be taken with sterile swabs soaked with a drop of sterile saline that are stored in charcoal media. The swab samples are put on blood agar (aerobic and anaerobic), Mac Conkey agar and Sabouraud-Chloramphenicol-Agar. The plates for anaerobic incubation are kept in anaerobic jars. The other plates are incubated at 37°C for 18-24 hrs. The plates are read on the next day by colony characteristics. Final identification test can be performed with e.g. API Kits [4].

7.6. Conclusion

Avian medicine cannot get satisfying results without the use of laboratory samples. However, it is inevitable that those samples are taken correctly and processed in the fastest time. This will ensure reliable results that support the medical examination and diagnostics. For veterinary practitioners with larger amount of avian clientele, the setting up of at least basic laboratory facilities might be very helpful. This can include testing for parasitology and blood examination (hematology, semi-automated biochemistry, blood gas) as this is less costly and even individual samples can be examined. Moreover, this set up can be used for other animal species alike.

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Chapter VIII

Imping and Coping

Abstract

Perfect feathers are essential for falcons to fly well-balanced and to catch prey. Broken feathers are frequent problems in falcons as they can easily break when fighting with the prey or landing with high speed on hard ground. Feather repair is therefore an essential work for falconers, veterinarians and veterinary technicians and requires special equipment and techniques. Good technique is required for feather repair as incorrectly fixed feather will not last until the next molting season. Overgrown beak and talons can lead to severe health problems like starvation, self-inflicted injuries or bumblefoot. Correct cutting and filing are required to avoid cracking of the keratin and to ensure the full functionality of beak and talons again.

8.1. Introduction

The flight performance of falcons depends greatly on their ability to use their primary and tail feathers to full extent. This ensures proper balancing to be able to catch the prey in the best possible way. However, damage to the feathers may arise while catching and fighting with the prey [4] or hitting obstacles. Moreover, flying in unsuitable aviaries, jumping on perches or wrong handling or transportation procedures or hard landing on the ground [4] with high speed may lead to bending or breaking of mainly primary or tail feathers. As falcons require intact feathers to be able to catch prey and to be used for falconry, it cannot be waited until the next molting season when the feather is naturally thrown and grows again [5]. Furthermore, the feathers adjacent to the bent or broken feathers tend to break faster as they do not have a good stronghold anymore if the damaged feather is not repaired in time. Therefore, a special art of repairing bent or broken primary and tail feathers has developed among falconers and specialist raptor veterinarians and veterinary technicians.

Repair of broken feathers or so-called "imping" is one of the most important falconry procedures to keep falcons in good condition for flight and hunting. Known for ages among the falconer's community, these procedures have to be performed up to perfection which poses an art.

"Splinting" is a technique where bent feathers are stabilized through special splints. This prevents breaking of the feather and can be regarded as one technical step before imping. Different techniques and equipment exist to fix either bent or fully broken feathers. They range from bamboo sticks and sewing needles to special imping needles. Light weight, elasticity and easy accessibility are among the main attributes that material for feather repair requires. The choice of material for imping depends on the diameter of the fractured feather shaft as well on the personal preference and technical ability and experience of the falconer, veterinarian or veterinary technician.

"Coping" is the trimming of talons and beak. In the wild, falcons keep their talons and beak automatically in correct lengths and shape due to different kinds of prey and large variety of seating places and surfaces. This does not happen in falcons in captivity as they do not wear their talons or beaks sufficiently. They require normally coping two times per year, before and after the molting season. Correct coping procedures are essential as otherwise great damage might be done to the falcon.

Beak repair is another important technique for falcons. Often, falcons suffer from damage to the beak due to various reasons like malformation, damage of the keratin, or underlying diseases like poxvirus infections or sinusitis. This beak damage may become so extensive that it may negatively impact the eating and catching ability and behavior of the falcon.

8.2. Preparation for Feather Repair

8.2.1. Equipment

For falconers, veterinarians and veterinary technicians who work frequently with raptors, it is advisable to set up special equipment for imping and splinting as these are common procedures. Moreover, all equipment has to be prepared before the falcon is touched to reduce the time for the feather repair. It is useful to keep all equipments and instruments in one tool box that is used for imping and splinting. This equipment includes the following:

- Scissors (small, fine-pointed, 13mm)
- Guillotine Nail cutter (for dogs)
- Pliers (straight, 130mm)
- Metal file (flat, 150mm long)
- Surgical blade (No. 11)
- Knife
- Dremel Minimite
- Nail files (with fine and rough surface)
- Superglue (cyanoacrylate glue, 2g)
- Epoxy glue and hardener (2 tubes, 4,2g)
- Talcum powder (fine)
- Splints (1-2mm wide and 3-4 cm long) from feather shafts
- Bamboo skewers for barbecue

- Sewing needles (different sizes)
- Paper pieces (4x4cm)
- Cotton buds
- Masking tape

8.2.2. Feathers

Feathers are usually taken from molting falcons or dead falcons. Artificial feathers are not used for this purpose. It is highly essential to replace the broken feather by exactly the same feather with regard to number of the feather in the wing or tail, species, size, length and color. Therefore feathers that are kept for feather repair should be kept assorted e.g. in drawers or boxes according to the following:

- Falcon species
- Female or male falcon
- Primary feathers No 1-10 of left wing
- Primary feathers No 1-10 of right wing
- Tail feathers
- Color (if possible)
- Complete wings/tails or dead falcons (if several broken feathers of wing or tail have to be replaced)

Only healthy feathers should be used for imping. Feathers with pathological condition like stress marks and parasites or already imped feathers should not be used to imping. Before including feathers of dead falcons in the feather collection, they should be disinfected and then dried e.g. in the sun. After they have dried completely, they can be assorted and put in the feather collection. This helps to ensure that only dry and clean feathers are used for imping. Moreover, it is important to clean the drawers or boxes of the feather collection on a regular basis to avoid entry of dirt and parasites that could negatively impact the quality of the stored feathers.

Before starting any feather repair procedure, suitable feathers should have been selected and kept ready for use on the table as otherwise the anesthesia for the falcon might unnecessarily take too long.

8.2.3. Preparation of the Falcon

For all splinting or imping procedures it is the best method to place the falcon under general anesthesia as described in chapter 6. This helps to reduce stress for the bird and in the same time enables the falconer, veterinarian or veterinary technician to conduct the splinting or imping without interruption through unwanted movement of the falcon. For imping, the falcon is normally placed in dorsal recumbency as detailed in chapter 6. Splinting of tail feathers might be performed also in ventral recumbency.

Masking tape can be used to tape those feathers that are covering the feathers that need to be splinted or imped. This allows free access to the damaged feather without disturbance.

8.3. Splinting

Bent feather can be repaired in two ways: with hot water or splints. The choice depends on the extent of the feather damage. If the feather is only bent mildly without damage to the feather shaft, then 60-80° hot water can be used [5]. In very mild cases, the steam of the hot water can be used to straighten up the damaged feather [4]. Moreover, the hot water can be poured over the feather or be put in a bucket. Then the falcon is held tightly and its tail is dipped into the hot water for at least one minute [5]. The feather keratin puffs up and returns quickly to its normal position [2]. The bent feather can then be straightened up with the fingers.

Another possibility to straighten up the bent and non broken feather is the use of a "Pirotta" clamp. This clamp looks like a forceps and has flat plates as tips. It gets heated by a fire lighter and then pressed quickly on the bent feather shaft to straighten it [5].

In case of a damaged feather shaft of a bent feather or strong bending, the feather requires additional stabilization through a splint. Splints are made from feathers that are left over from imping and would otherwise be thrown away. They can be recycled by cutting their feather shaft in fine pieces of 1-2 mm width and 3-4 cm length. Kept in a box, they form the ideal material for splinting.

The bent feather shaft is straightened with the pliers on the dorso-ventral and laterolateral axis [4]. A thin piece of paper is put under the damaged feather in the bend area. The ventral side of the bent feather shaft is inserted with the scalpel blade up to 1 cm and then filed with the nail file or the Dremel Minimite to roughen the outer shaft layer. In case of more severe damage, a cut sewing needle piece is inserted in the feather shaft. A suitable splint is selected and cut in size that it covers the bent shaft area and extends on both sides. Cyanoacrylate glue is applied into the inserted feather shaft area. The splint is attached to it (Figure 8.1) and tied strongly with pliers in ventro-dorsal axis.

On both splint ends, cyanoacrylate glue is put up along the feather shaft. Talcum powder is applied on the wet glue and mixed with it (Figure 8.2). After hardening, the talcum glue mixture and splint is gently filed with Dremel Minimite (Figure 8.3) to remove all rough edges. The splint provides now a strong additional stabilization of the bent feather and the feather will not break in this area. This procedure can be performed on the ventral and dorsal side of the feathers. The repaired feather will be molted in the next molting season.

Figure 8.1. Splint on feather shaft.

Figure 8.2. Talcum powder applied on splint.

Figure 8.3. Splint after filing with e.g. Dremel Minimite.

8.4. Imping

Imping can be performed with bamboo skewers or sewing needles. Moreover, specially designed needles for imping do exist. It is less stressful for the falcon to be put in anesthesia for imping. Although it is possible to repair one feather without anesthesia, the use of anesthesia provides better chances for perfect results. If the broken feather part is still available, a partial feather repair can be performed. This applies for distal feather fractures. For feather broken proximally or lost feather parts, a complete feather repair can be done.

8.4.1. Mid-Shaft or Distal Feather Repair

Feathers can break in the mid-shaft (Figure 8.4) or distal part (Figure 8.5) where the feather shaft has a small diameter. The broken feather part can either be missing or still be available. If it is missing, a suitable feather of the same number from the feather collection has to be chosen and cut in exactly the same size. This can be done by measuring the feather size of the other side of the wing or tail.

If the broken feather fragment is still available, is has to be reattached. Before reattaching, the feather fragment has to be cut with a scissor to create a perfect fit for the remaining feather part. A suitably sized sewing needle is selected and cut in size. The needle edges and the edges of the remaining feather and feather fragment are filed with the Dremel Minimite to smoothen the surfaces. A piece of paper is placed under the remaining feather fragment. The needle is covered with cyanoacrylate and inserted 2-3 times in the remaining feather shaft (Figure 8.6) to fill the glue inside. The needle is then glued into the distal feather fragment and hardened. After putting glue around the outstanding needle tip, the needle is inserted into the remaining feather part and tied to it with pliers by applying pressure. The excess glue can be filed to smoothen the repaired feather shaft.

Figure 8.4. Feather broken in midshaft region.

Figure 8.5. Broken tail feathers.

Figure 8.6. Broken tail feathers.

8.4.2. Proximal Feather Repair

Feathers that are broken at the proximal part have a wide shaft diameter. Therefore bamboo sticks or skewers are suitable material for fixation. They have advantages like light weight, elasticity and low price. A suitable feather is selected from the feather collection and measured with the same feather of the intact other side. Masking tape is used to tape the small cover feathers. This provides free access to the broken feather. The remaining feather part is cut with a scissor to achieve a perfect joint surface. A piece of paper is placed under the feather that needs to be fixed to avoid gluing the other feathers. A bamboo skewer is selected and shaped with the knife to fit perfectly into the feather shaft. Epoxy glue and hardener are mixed according to manufacturer's instructions. It is ready when it is starting to get solid and then put around one half of the bamboo skewer piece. The glued bamboo piece is inserted into the replacement feather.

Figure 8.7. Tail feathers to repair broken tail.

Figure 8.8. Completely repaired broken tail feathers.

Figure 8.9. Completely repaired broken tail feathers (close up view).

The outstanding bamboo piece is covered with the epoxy glue and attached with the remaining feather shaft. Care has to be taken to achieve a perfect joint between both feather parts and to keep the feather in the same direction like the other feathers. If more than two or three feathers are broken in the proximal feather part, feathers of a complete wing or tail (Figure 8.7) of a dead falcon should be selected to have enough suitable feather material to replace all broken feathers (Figure 8.8, 8.9).

8.4.3. Broken Blood Feathers

During the molting period, feathers have a strong blood supply at the feather base to nourish the growing feather. They may break in this area of the increased vascularization thus leading to considerable hemorrhages. If more adjacent feathers break, a simultaneous growth of more than one feather may arise. The protective function of the feather for its adjacent feathers is therefore lacking. This leads to highly increased danger that the adjacent feathers break [2]. Moreover, it is possible that feather growth disorders may develop in damaged blood feathers. They may range from sand clock like constrictions of the damaged blood feather, dry out and break in this place. The remaining feather follicle might even come off and a new feather follicle may develop [2].

It is highly important to first stop the hemorrhage. This can be done by pressing pliers on the feather shaft or by applying hemostatic substances. It has been recommended that the feather should be removed while the bird is conscious [1]. In the author's view and practice in the Abu Dhabi Falcon Hospital, the broken feather part should be left in place. Moreover, it causes unnecessary and unjustified pain to remove the feather follicle without putting the falcon in anesthesia. In the Abu Dhabi Falcon Hospital, the feather follicle is left to dry completely. After being dried out, the feather can be imped again.

The best prevention for broken blood feathers is to minimize the handling of falcons during the molting time.

8.5. Coping

Overgrown talons or beak (Figure 8.10) is caused by changed metabolic conditions like administration of molting vitamins during the molting time. Moreover, the talons or beak do not wear if the same meat is fed. This happens especially in case of feeding meat without bones or small one day old chicks. Moreover, another cause is the use of the same perch surfaces without any change.

Figure 8.10. Overgrown beak.

These underlying root causes lead to an increased growth of the beak and talon keratin and thus overgrowth in this area. Overgrown beaks can be so prominent that the falcon is not able to eat anymore [5]. Those falcons are then presented in veterinary practice with the complaint of “not eating well”. It is mandatory to control the length of the beak in such cases as it has been observed that overgrown beaks were overlooked during clinical examination. Overgrown talons can lead to self-inflicted injuries and therefore puncture wounds of the foot sole. Bacterial invasion can result in pododermatitis with severe swelling as mentioned in detail in chapter 9. Moreover, overgrown talons may result in difficulties to catch or kill prey as the circle of the talon is too large to penetrate the prey [5].

In few cases, talons are not sharp enough due to rough perch surfaces. This makes catching the prey more difficult [5]. Therefore coping is required to restore the physiological sharp form of the talons.

Coping of the beak is performed by cutting the tip of the beak with a nail clipper in distal to proximal direction (Figure 8.11). Great care has to be taken not to cut too much as otherwise hemorrhage may occur. After cutting the tip, the side part of the beak can be slightly cut. The remaining beak is filed in correct shape and length with e.g. Dremel Minimite. The filing has to include only the distal part of the beak, but not the proximal one as here vital keratin structure might get damaged. Moreover, the falcon’s tomial tooth has to be shaped again with first clipping. It is shaped by filing with e.g. Dremel Minimite (Figure

8.12). The correct length of the beak tip is in a straight line from the mandibular part of the beak. At the end, the beak can be polished with vitamin E cream.

Coping of talons needs to be performed with care as otherwise hemorrhage may occur. First, the tip of the talon is clipped with a nail cutter from the inside in distal to proximal direction (Figure 8.13). Talons should not be clipped from the outside of the talon and from proximal to distal direction. Then a sharp knife is used to remove dead keratin under the talon layer by layer.

Figure 8.11. Cutting of overgrown beak.

Figure 8.12. Filing of cut beak.

Figure 8.13. Cutting of overgrown talon.

The keratin on the outer side of the talon should not be removed with the knife. After all dead keratin layers have been removed and the shape is restored, the talon gets filed with e.g. Dremel Minimite in the distal part from all sides (Figure 8.14). Polishing is performed with vitamin E cream. The proper length of the talon is the direct line from the underside of the last distal toe pad to the talon tip.

Figure 8.14. Filing of cut talon.

8.6. Beak Repair

The anatomical beak structure can get damaged through too porous beak keratin (Figure 8.15) caused by vitamin and mineral deficiencies. Genetic defects like mandibular deformation might exist as well (Figure 8.16). Disease like poxvirus infection and sinusitis can also result in damage or grooves in the beak.

Figure 8.15. Damaged beak keratin.

Those grooves can be usually found on one or both lateral sides of the beak and often start in the nostril area (Figure 8.17). They can be caused by old age, too. Too porous keratin material and deep grooves may first result in cracks and then in fractures of beak parts. In order to avoid cracked or broken beaks, damage to the beak should be repaired as soon as possible.

Beak repair includes filling of the grooves. This can be performed by using light hardening polymers that are used in dentistry. If they are not available, material like polymethylmethacrylate (Technovit™) can be used, too (Figure 8.18). The damaged beak is filed with a hand file. Special epoxy glue and hardener are mixed and then applied in the groove (Figure 8.19). Polymethylmethacrylate is applied on the epoxy mixture and mixed. After complete hardening (Figure 8.20), the excess epoxy-polymethylmethacrylate layer is filed gently to achieve a perfect shape.

Figure 8.16. Mandibular deformation.

Figure 8.17. Groove in deformed beak.

Figure 8.18. Use of polymethylmethacrylate as filling material for groove.

Figure 8.19. Glue and hardening material applied on groove.

Figure 8.20. Hardened beak filling material before filing.

8.7. Conclusion

Feather repair, trimming of beak and talons are essential parts of the falconer's, veterinarian's and veterinary technician's work. The use of right equipment as well as correct techniques is important for the successful coping and imping. The correct anatomical features have to be known to understand abnormal changes and to be able to rectify them. Practicing of coping and imping can be performed by beginners on dead birds until the skills are improved to professional standards. Unprofessional coping may lead to damage and hemorrhages of beak and talons whereas unprofessional imping leads to loss of the repaired feather and poor flight performance.

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Chapter IX

Feather and Skin Problems

Abstract

Feather and skin problems are commonly found in falcons. Feather and skin problems can be manifold including bacterial, fungal and parasitic origin. Cutaneous eczema caused by E. coli infections can be found under the winds. Skin diseases can be also caused by mycobacteria and thus lead to cutaneous tuberculosis. For the first time in falcons, the bacteria Acinetobacter baumannii was isolated in the tuberculosis granuloma. Foot problems can be caused by different endogenous and exogenous factors. A new classification has been developed for foot conditions. They can range from pressure sores, hyperkeratosis up to pododermatitis and bumblefoot of metabolic origin. Different treatment methods can be chosen depending on the foot condition but prevention is essential.

9.1. Introduction

Feather and skin problems are frequently encountered problems in falcons. They can range from bacterial to fungal infections. Moreover, parasitic infestation can lead to severe damage of the feathers. Skin problems may include bacterial and fungal infections of the skin, pododermatitis but also cutaneous tuberculosis. In the cutaneous tuberculosis granuloma the bacteria Acinetobacter baumannii was identified and poses a new pathogenic agent in falcons that can be classified as emerging disease. Due to close contact of falcons with their owners, infectious agents causing feather and skin problems have to be identified and treated as soon as possible to avoid any cross contamination. Feather problems occurring during the molting season or caused by molting disorders are mentioned in chapter 4. Moreover, this chapter covers foot problems like pododermatitis. A new classification for pododermatitis has been developed and explained in details with the respective therapy.

9.2. Feather Problems

Feather problems are frequent problems in falcons. Apart from bent and broken feathers which are featured in chapter 8 several other feather problems may be present. They can include bacterial and fungal infections of feathers as well as ectoparasites. Moreover, external influences like malnutrition, diseases and stress have influence on the feathers especially during the feather growth period.

9.2.1. Bacterial Infections of Feathers

Bacterial infections of feather can damage feathers especially in the abdominal and wing region. The feather damage can become so severe that parts of the skin are featherless. Microbiological cultures of affected feathers reveal often *E.coli* or *Staphylococcus sps.* infections. Antibiotic sensitivity provides information about suitable antibiotics. However, in most cases, systemic antibiosis is inevitable.

9.2.2. Fungal Infections of Feathers

Mycotic contamination of feathers can lead to similar feather damage caused by feather lice. The edges of the feather vane look like “eaten up”. Sometimes feathers covering the falcon’s body can be affected, too. Feather samples are examined in the laboratory and cultured. In most cases, *Aspergillus sp*. or *Candida sp*. (Figure 9.1, 9.2) can be identified. Topical treatment of the feathers with diluted ketoconazole is usually successful. In advanced cases, systemic treatment with antifungals like itraconazole is required.

Figure 9.1. Candida sp. infection of feathers.

9.2.3. Feather Lice

Feather lice or *Mallophaga sp*. are frequently encountered in falcons especially in immune suppressed conditions. They are explained in detail in chapter 4 and 10.

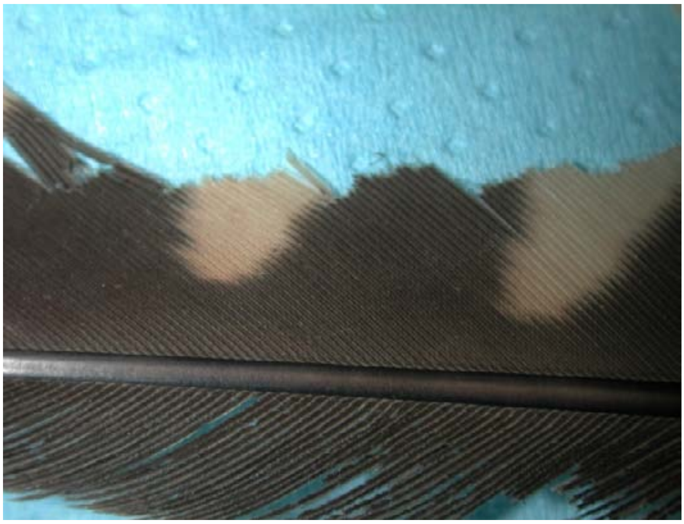

Figure 9.2. Damaged feather vanes due to Candida sp. infection.

9.2.4. Vitamin Deficiencies

Vitamin deficiencies especially hypovitaminosis A and E lead to weak feathers that break easily and frequently. The feather shaft is not strong enough to resist pressure or trauma. This problem can happen when malnutrition and insufficient vitamin supplies leads to hypovitaminosis. Special molting vitamins can help to rectify this hypovitaminosis as detailed in chapter 4.

9.3. Skin Problems and Diseases

9.3.1. Fungal Skin Infections

Fungal infections of the skin are mainly caused by either environmental contamination or secondary infections. Those fungal skin eczemas can be round or irregular shaped. Frequently *Aspergillus sp.* or *Candida sp*. can be identified from skin scrapings and skin swabs. Skin scrapings should be taken from the edge of the lesion to achieve best results. Treatment includes topical antifungal ointments or diluted ketoconazole. In severe cases, systemic therapy with antifungals might be required. In cases of mixed infections of fungal and bacterial origin, an additional antibiotic therapy following antibiotic sensitivity is recommended. Other fungal agents might be possible but are rarely encountered.

9.3.2. Bacterial Skin Infections

Bacterial skin infections are frequently seen in falcons with traumatic origin in most cases. These traumatic injuries can be caused by talons of fighting prey that are contaminated with bacteria or by hitting the ground where abrasions or skin wounds get contaminated by dirty soil or water. More information on bacterial skin infections can be found in chapter 12.

9.3.3. Wing Eczemas

Falcons can suffer from wing eczemas that are located on the medial side of the wing and (Figure 9.3) that can extend up to the shoulders (Figure 9.4). Through folding the infected wing area to the body wall, the eczema can extend to the lateral thoracic body wall in more advanced cases (Figure 9.5).

Figure 9.3. Bilateral cutaneous E.coli infection on wings.

Figure 9.4. Bilateral cutaneous E.coli infection on wings and under shoulders.

Figure 9.5. Bilateral cutaneous E. coli infection of wings reaching to lateral thorax side.

Often, those eczemas are wet and change the skin color to either reddish or yellowish (Figure 9.6). Those eczemas can be very itching and painful thus causing a considerable negative impact on the falcon, sometimes up to changed behavioral patterns. In some cases, the bird tries to pick on the affected areas thus leading to an aggravation of the already damaged skin condition.

In many cases, those eczemas are mistaken by fungal infection and treated wrongly. It is highly important to take skin scrapings and swabs for bacterial and fungal culture. The most common causative agent is *E.coli.* Moreover, it is recommended to take blood samples as often major changes in the hematological blood picture like elevated white blood cell counts and heterophilia are present.

The affected falcon has to be isolated from other birds and treatment has to be started immediately. The therapy requires both, topical and systemic antibiosis according to the antibiotic sensitivity tests. Systemic antibiosis has to be performed until the bacterial load is wiped out and the infection is controlled which may take at least 10-14 days in most cases. In severe cases especially where the infection has spread to the body walls already, it might take even longer. Topical antibiotic ointments have to be applied at least once per day. Moreover, it is helpful to gently curette the damaged skin to allow new and healthy skin to grow. During the course of treatment, the infected skin gets hardened (Figure 9.7) and can easier be removed step-by-step. In those cases, the dried lesions of *E. coli* infections start to detach and can be removed carefully with help of a forceps (Figure 9.8).

Healthy skin granulates under the detaching skin layer (Figure 9.9). Topical ointments are applied and work much more efficiently as on top of the damaged skin. Skin granulating ointments like the homeopathic Traumeel® cream are very useful to enhance skin granulation and normalization of the skin quality.

Figure 9.6. Yellowish coloration and wet consistency of skin under wings.

Figure 9.7. Drying of the E.coli infected skin after treatment.

Figure 9.8. Removal of detaching infected skin layer with forceps.

Figure 9.9. Granulation of healthy skin under the detaching skin layer.

Vitamin A and E or multivitamin injections are helpful to enhance the skin quality as well. It is recommended to attach a beak protection on the falcon’s hood to prevent it from picking the infected skin area. Feather loss may be observed in many cases, but after treatment the feathers grow back in short time.

9.3.4. Cutaneous Tuberculosis and Actinetobacter Baumannii Infections

Cutaneous tuberculosis can be found in different kind of birds and are caused by different *Mycobacterium sp.* like *M. avium* and *M.avium tuberculosis.*

In falcons, a massive thickening of the skin especially in the thigh region can be observed (Figure 9.10). In some cases nodule like lesion develop (Figure 9.11). Under the skin, large yellowish caseous material starts to harden and can reach up to several centimeters length (Figure 9.12, 9.13). The leg cannot be pulled anymore and the falcon has problems to stand properly on the leg. Those tuberculosis lesions can be observed unilateral or bilateral. They can reach up to the abdominal and thoracic body wall. Following observations in the Abu Dhabi Falcon Hospital, cases of cutaneous tuberculosis have not been found until before two years. In those past two years, those cases are on the rise in falcons of different origin, different owners and different living places. From May 2007 to May 2008, 20 falcons, among them 12 gyr-peregrine falcons and 8 gyr-saker falcons, were diagnosed with cutaneous tuberculosis. All falcons showed unspecific symptoms like not eating well, not flying well, weight loss or were presented only for general examination. Out of those 20 falcons, in 9 gyr-peregrine falcons and 6 gyr-saker falcons *Acinetobacter baumannii* was isolated in the tuberculosis granuloma. This is the first time that the multi-drug resistant *A. baumannii* was isolated from falcons and is a new infectious agent in falcons. This is even more important as this bacterium causes severe and even lethal infections in humans as it happened to soldiers in the Iraq war. Further research is currently under processing.

Figure 9.10. Cutaneous tuberculosis with A.baumannii infection on right thigh and abdomen.

Figure 9.11. Elevated tuberculosis granuloma mixed with A.baumannii infection in thigh region.

Figure 9.12. Removal of cutaneous tuberculosis granuloma mixed with A.baumannii infection.

Figure 9.13. Tuberculosis granuloma mixed with A.baumannii infections after removal.

Acid-fast stain of feces material is usually negative. Only in the end stage of the disease, shedding of the mycobacteria in the feces can be observed (Figure 9.14).

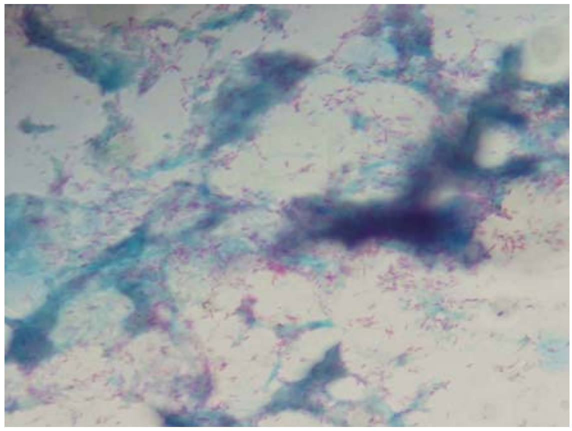

Figure 9.14. Positive acid-fast stain of tissue in advanced stage of cutaneous tuberculosis.

Table 9.1. Hematological values for falcons with tuberculosis infections and combined tuberculosis and A. baumannii infections

Parameters	Gyr-Saker TB + A.baumannii	Gyr-Saker TB only	Gyr-Saker Normal Range	Gyr-Peregrine TB + A.baumannii	Gyr-Peregrine TB only	Gyr-Peregrine Normal Range
	n=6	n=8		n=9	n=11	
RBC(x 10^{12}/l)	2.25	1.57	2.18-2.48	2.14	2.11	2.13-2.65
Hb (g/dl)	14.05	10.01	16.23-19.23	13.93	13.7	16.33-19.47
Hct %	39.58	28.1	46.91-56.23	38.26	37.9	47.25-56.75
MCV (fl)	174.98	129.69	200.29-243.49	178.27	180.08	194.32-245.08
MCH (pg)	62.43	46.39	69.41-83.07	64.7	64.81	67.14-84.04
MCHC (g/dl)	35.76	26.05	32.85-35.99	36.29	36.01	32.95-35.91
WBC(x 10^9/l)	29.03	21.38	5.28-9.72	29.28	29.92	5.28-9.82
Heterophils %	72.67	52.8	46.02-53.78	70.57	72.03	46.41-53.41
Lymphocytes %	19.75	14.9	41.20-47.02	24.17	22.67	40.82-47.54
Monocytes%	4.08	2.81	2.84-6.00	3.44	3.38	2.77-6.03
Eosinophils%	1.08	0.79	0.37-2.21	1.2	1.27	0.29-2.45
Basophils%	0.83	0.63	0.25-0.55	0.83	0.86	0-0

Radiography shows the lesion as radio-dense soft tissue thickening and large masses in the thigh region that might reach up to the abdominal and thoracic body wall. In endoscopic examinations, the liver and other organs are normally not affected by the diseases and are inconclusive for tuberculosis diagnosis. PCR testing of caseous material leads to positive results whereas blood and feces material does not reveal the presence of mycobacteria in the PCR method. Moreover, the hematological blood picture shows highly typical patterns with massive anemia and highly elevated WBCs of up to 45 x 10^9/l. Hematological reference values are explained in details in chapter 7.

In advanced stages, the diseased falcons show severe emaciation although they are eating well. The disease may take at least 2-5 months to develop real clinical symptoms and the typical subcutaneous lesions. It can last up to one year until the end stage of the diseases commences where massive weight loss, massive anemia, highly elevated WBCs, extension of the lesion, uni- or bilateral lameness and shedding of mycobacteria in the feces are present. This stage leads inevitably to the death of the affected falcons. Contamination of other falcons or even hospital environment with *A.baumannii* is a major danger and poses a high risk and threat even to human personnel and falconers alike.

Treatment for birds with mycobacteriosis is not recommended. Those birds should be euthanized. In case of a therapeutic approach, rifampicin can be administered over at least 3-6 month daily and the falcons must be fully isolated from any other bird in a quarantined area.

9.4. Pododermatitits

Pododermatitis, commonly called by falconers "bumblefoot" has been known for centuries to falconers. It can be traced back to the 8th century AD where this disease was mentioned as "swollen feet" by Al Gitrif [40]. Over centuries, this foot problem of falcons can be found in various manuscripts and different reasons like rough jesses and harsh snow [36] were made responsible for its occurrence. In the 16th century, for the first time a differentiation in exogenous and endogenous factors was made for swollen feet [66]. Exogenous pathogenic factors included extensive hunting and training as well as old or newly acquired injuries caused by prey and thorns. Moreover, it was stated that swollen feet can be found in saker falcons more often than other falcons due to their heavy weight and large feet [66]. Too tight jesses were also seen as reason for swollen feet [13]. Other descriptions for bumblefoot were 'podagra', warts, holes and furuncles as well as fluids in the feet [63]. Furthermore, tumors [41], and pins [66] were also used to describe this pathological foot condition. Therapeutic recommendations included changes in the husbandry, steam therapy, foot baths, ointments, poultices, powders, liquid drug preparations as well as cauterization, blood-letting and surgery [41, 43, 44].

9.4.1. Bumblefoot Research in the 20th Century

Several attempts to unify this disease were made in the 20th century with setting up of different definition models for bumblefoot.

Definition Models

Astonishingly, a homogenous, universal and precise definition of bumblefoot does not exist until today. This can also be said regarding its etiology, progress and therapy. Scientists agree that certain symptoms can be related to this disease. However, these symptoms have not been specified within the framework of a universal classification. For that reason the differentiation of bumblefoot contains three [10, 12] as well as four stages [24]. This foot disease has also been differentiated into five main classes with a further division into up to three subclasses [48, 54]. Contrary to this, another definition model describes seven grades of this foot disease [14]. For reason of completeness, the differentiation of chicken bumblefoot into a traumatic and nutritional one [49] has to be mentioned.

In the author's opinion, those above-mentioned different classification models lead to a major confusion of falconers and veterinarians as e.g. a scab or corn is classified as type 1[10.12], class IIB [48, 54], type 3 [52, 53] and type 3A [24]. According to the different definition models, the functional loss of the digit is defined as bumblefoot stage 2 [29], type 3 [52], class 5 [48, 54] and grade 6 [14]. Moreover, it remains questionable that all etiologically and pathologically different foot problems are put together in one single disease called "bumblefoot" which does neither reflect the causes of the different disease picture nor the different treatment approach. It seems to be more clear and useful to differentiate the disease with regard to their different pathologies like wounds, injuries, pressure sores and to name them accordingly as it is done in other parts of the body. Metabolic problems leading to swollen feet due to lack of exercise or inactivity of wild falcons in captivity should be regarded as real "bumblefoot".

9.4.2. Etiology

The different causes for this multi factorial avian foot disease can be differentiated into various groups. The usually strict division into predisposing factors and etiology does not occur on bumblefoot in the veterinary literature. For this reason in this chapter both aspects are covered under the headline etiology.

9.4.2.1. Exogenous Factors

An acute or chronic trauma of various forms and strength is caused by external infliction on the bird's foot. The trauma's severity is determined by the nature, duration and intensity of these exogenous causes.

Mechanical Factors

Mechanical factors comprises injuries caused by foreign bodies, preys as well as ipsilateral bandaging of a leg or foot.

Foreign Bodies

The skin of the foot soles is pierced by vegetal foreign bodies like thorns (i.e. cactus) or industrial manufactured foreign bodies like nails, glass or plastic splinters. They create an ideal portal of entry for a following bacterial colonization [11, 15, 17, 58]. This problem can also occur in self-inflicted injuries caused by piercing the prey with the raptor's claws. When trying to catch wild falcons in their natural habitat in many countries forbidden traps are used. This leads to injuries and lesions of the foot [9, 14, 51] or bruises of the plantar foot surface [15]. According to research trapping injuries result in about 21% of the total bumblefoot cases [5].

Preys

Especially squirrels and other rodents fight against being caught by the falcon and therefore bite mainly into the dorsal toe surface of the raptor leading to localized lesions [14, 19].

Asymmetric Weight Load

In case of orthopedic and soft tissue injuries falcons tend to protect their injured leg by concentrating the body weight on the healthy leg and therefore overstraining it. This extreme and relatively long lasting pressure on the foot of the healthy leg causes bumblefoot lesions [15, 51].

Husbandry

The health of the wild falcon kept in captivity has to be seen in close connection with its husbandry. Improper equipped cages and aviaries, malnutrition and behavior disorders can lead to the development of bumblefoot at the falcon foot [41].

Wild Falcons

A highly trained organism and a good condition - not to be mistaken for the falconer's term "condition" meaning the body weight of the falcon – is guaranteed by frequent unsuccessful hunting flights of the wild falcon. One successful catch is accompanied by five unsuccessful attempts [64, 65]. Behavioral disorders like hanging with the head down may lead in singularly cases to cutaneous abrasions. Research shows that the wild falcons tested respond to the conditions of captivity in a different way than their captive-bred counterparts and suffer more frequently from feet problems [41, 42].

Captive-Bred Falcons

The situation of captive-bred falcons shows a different picture. Although possessing the same genetic disposition as long distance hunters like wild falcons captive-bred falcons do not make full use of this ability. To what extent this genetic potential can be utilized depends very much on the training and hunting frequency as well as on the quality, experience and time of falconer. The captive-bred falcons are permitted to fly freely during training and hunting. As the prey tries to escape his hunter with the highest possible speed in order to save its live, the captive-bred falcon has to achieve the same hunting and flight performance as wild falcons. Only in exceptional cases the breeders allow their young birds a period of hacking. This means that 5-6 weeks old falcons are abandoned in the wild for about four weeks to learn the natural hunting behavior. The hacking secures that metabolism, condition he overall organism of the falcon is in accordance with the species specific development level [37, 41].

Husbandry in Cages and Aviaries

Aviaries and cages are usually built with a surrounding netting wire. Sharp edges, extremely small cage or aviary areas as well as the quality of the wire-netting (hard metal or plastic safety coating) may lead to manifold injuries of all body parts and hereby especially of the feet [24, 41, 56]. Whenever the bird is flying against the netting wire wall of its cage being too small or tries to break with the help of its feet while landing at the wire-netting enclosure, lesions, bruises and raptures often resulting in bumblefoot are in many cases the consequences [24]. Raptures of the flexor tendons are frequently to be observed when falcons repeatedly jump against the wire and get hooked [15]. The wire-netting enclosure of aviaries especially becomes a source of danger when lacking any screen installation [41].

Block Perches

In contrast to the bow perches of accipiters block perches are used as a transportable seating for falcons using hunting and training. Stationary block perches can be found not only in cages but also sometimes in aviaries. In contrast to European countries, falcons on the Arabian Peninsula are often seated on transportable block perches within falconer's houses or gardens during the hunting season. The reason given in literature for using block perches is preference of flattened rocks and cliffs by falcons in their natural habitat [18]. The surface of block perches consists of so manifold materials such as cork, concrete, wood, padded cloth, sisal and in recent years of plastic grass, the so-called 'Astroturf'. Moreover perches with empty spaces for sand, sisal or other fillings are in use.

Defects of block perches are usually termed as e.g. improper [2, 50, 53] without further precision available in veterinary publications. Those defects are as manifold as the surfaces materials used [41].

Height of Block Perches

The impact of excessive bating on the falcon feet is only determined by the total height of the block perch but also by the size and body weight of the jumping falcon thus determining the quality of injuries. Hereby a proportional correlation between the height of the block perch, the floor surface, the weight of the jumping falcon and the pressure impact on the falcon's feet can be established. The injuries resulting from bating are metatarsal pads traumata [5], bruises and excoriation of the plantar foot area [14] which can be regarded as predisposing factors of bumblefoot [41].

Seating Area Surface

A diameter size of the block perch being too large results in digital hyperextension. If this unnatural seating position is kept for a considerable time, the pressure on metatarsophalangeal joints as well as on digital pads will be increased by this digital hyperextension [16, 21] leading to pressure sores. As soon as the diameter size of the block perch is too small, the toes automatically clutch around the edge of the block perch leading to an abrasion of the plantar foot pad or to self-inflicted stitching injuries caused by sharp claws. Micro lesions and epithelial abrasions are caused by a much too rough perch surface whereas the danger of micro-organism like pyogenic bacteria invasion caused by pressure surface [16]. “Pressure sore and hyperkeratosis” are caused by hard and smooth perching surfaces [55]. An extremely soft surface prevents the necessary epithelial abrasion and thus leads to the development of a horny skin change comparable to the human corn [15]. The latter is a disorder of the epithelial regeneration [41].

Lack of Hygiene

Seating and floor areas contaminated with feces causes the invasion of microorganism in already damaged epithelium [6, 24, 38]. Egg yolk of one day old chicks as well as already putrefying fodder remain [18] support a germ friendly culture medium as soon as the perch surface and its surrounding are not cleaned regularly and properly. In the wild this problem is prevented by a frequent change of seating areas [41].

Lack of Sunlight

Birds being kept in boxes without or only with little sunshine during molting are more in danger of a bacterial invasion. The reason for that lies in the reduced damage of the bacteria by missing exposure to UV light [33, 69]. It has been described that the light spectrum of most birds is between 320 and 700nm [32]. In contrast to human beings birds are able to absorb ultraviolet light. Electric bulbs and neon light tubes that do not radiate to their surrounding possess a flicker fusion frequency of 70/min (on/off switch gear) which is invisible for human beings. In falcons this frequency ranges from 120/min to 150/min [30]. This flickering may possibly result in behavior disorders which can be prevented by the change from alternating current (A/C) to direct current (D/C) of the use of bio lights which radiate ultraviolet light [32, 41].

Talon Length

Falcons kept in captivity are rarely offered surfaces with a variety of textures (i.e. sand, stone, rock, tree branches). The sharp talons cannot sharpen in a natural way. This is leading to “overgrown talons” [62] resulting in an unphysiological weight distribution, digital hyperextension as well as disproportionate pressure on the metatarsal pads [52]. Overgrown talons have severe consequences for the raptor. When grabbing the hunted prey or food pieces [34] the falcon closes its toes during the grabbing process. Hereby overgrown, long and sharp talons may lead to self-inflicted puncture injuries at the plantar area of the metatarsal pad mainly by the hind claw. This is especially the case when the falcon misses its prey [64]. These puncture injuries are predisposed portals of entry for a bacterial colonization. Apart from ubiquitous germs, bacteria are an infection source that cannot be underestimated [1, 33, 41].

Jesses or Identification Rings

Any falcons is tethered by jesses made of leather or ropes which loosely surrounds the legs. While continuously bating the skin of a nervous falcon may be abraded or gazed underneath the jesses [29]. This leads to the invasion of bacteria like staphylococci followed by a wound infection that can spread up to the foot pads [8]. Identification rings [29] and jesses which are too tight lead to a constriction of the tibiotarsus and therefore to a reduced blood circulation in the pedal area [41].

Lack of Exercise

Predisposing factors for bumblefoot like circulatory disturbances, overweight and immune suppression caused by lack of exercise are rarely seen in the wild [21]. In captivity, however, falcons spend almost the whole day tethered on their block perches as only few of them have the opportunity of flying free in aviaries. Their exercise consists of the training sessions during the hunting period. Many captive falcons react to this lack of exercise with circulatory disturbances and reduced blood-circulation [3, 29] as well as a subsequent decrease in blood supply of the lower extremities [62]. There is a possibility that the inactivity of tethered falcons further aggravates the tissue fibrosis [7]. Furthermore, this supports the development of pressure sores [34] and the damage of the tissue laying underneath [15] both being the prerequisites of bumblefoot [41].

Nutrition

The regular excessive food supply in captivity directly influences the quality of food intake lying way above the average food intake level in the wild. Consequently, the caloric intake is increased and in conjunction with lack of exercise leads to overweight falcons [65]. Furthermore, the permanent pressure on the weight bearing pedal areas are increased considerably [21], thus supporting a subsequent infection [16]. Low-energy food like quail led to an increased bumblefoot morbidity rate of wild falcons kept in captivity [42]. In contrast to falcons living in the wild, falcons kept in captivity are supplied excessively with one-sided food [21]. The habit of feeding one day-old chicks is a suitable example to be found in many countries. Although rich of vitamins, the one day-old chicks suffer from iron deficiency leading to an oxygen reduction in the falcon’s blood as well as microcirculatory disorders based on a hypochrome normocytic anaemia [35, 39]. One day-old chicks absorb iron only when eating soil.

The nutrient and vitamin deficiency increases the probability of developing bumblefoot [24]. Vitamin A deficiency may lead to a damage of the epithelium and thus supporting bumblefoot [24, 61, 69]. Biotin and pantothenic acid deficiencies may support an inflammation of the pedal skin in connection with tethering the falcons on block perches and in addition to a lack of vitamin A [29]. Food like egg yolk, duck and chicken contains high vitamin A level [27].

9.4.2.2. Endogenous Factors

Relating to bumblefoot endogenous factors comprise a pedal temperature below normal, a reduced digital blood supply, disorders of the circulatory and immune system as well as the molting process and wing loading. Whether genetics play a decisive role in this context cannot be determined yet further research will be needed. However, the current stage of research does not imply genetic involvement in the development of bumblefoot [42].

Digital Blood Supply and Pedal Temperature below Normal

The blood supply of the avian toes is regarded as relatively low [5, 61] although the cutaneous vascular system at the foot sole area shows a larger density than at the scale carrying part [67]. Arteriovenous anastomoses [67] and rete mirabile possess a thermoregulatory function in the pedal area based on the counter-current principle. Therefore the lower temperature in the acrae of the avian foot is physiological determined [68]. This fact results n a reduced resistance against infection caused by foot injuries [10, 61].

Circulatory System

Disorders in the circulatory system and their consequences [14, 69] can always be traced to a lack of exercise [33] as well as absolute inactivity after the hunting season [25]. In contrast, wild falcons are in a better circulatory situation due to the high number of their daily flights for finding food [18]. Falcons living in captivity but being flown by their falconers show a distinctive warming of their feet after landing. This leads to the assumption that the blood circulation has been stimulated up to the toes [41].

Immune System

Immune suppression can be caused by stress through captivity [5, 38, 48], disease e.g. parasitoses and aspergillosis [48], reduced immune resistance [33], faulty husbandry and nutrition [14, 16]. In case of micro-organism invasion a reduced immunological response and the spreading of the infection are the result, thus supporting both the development and the course of bumblefoot [41].

Molting Disorders

During molting both the bird’s feathers and the epithelium of its featherless skin are renewed. If the epithelial scales do not “slough off” completely in the lower extremities, hyperkeratotic formations of necrotic material comparable to the human corn will occur [24]. The new growing skin layers are covered by necrotic cells during molting leading to the development described above. Via a reduced blood circulation and immune resistance this pathological dermal change supports the invasion of invasive micro-organisms into the epithelium tissue where a locally limited process of micro-destruction is already under way [15].

Wingloading

The importance of the wing loading as significant predisposing factor for the development bumblefoot has been stated [56] when the falcon flaps its wings or jumps.

9.4.2.3. Infectious Factors

Bacteria, fungi and yeast invade the foot tissue as infectious agents. Birds of prey show a strong affinity to fibrin clots being an ideal culture medium for bacterial colonization [30]. Yeasts like *Candida albicans* can be found as well.

Bacteria

In microbiological research the bacteria staphylococci, streptococci, coliform bacteria, *Pseudomonas sp.*, *Proteus*, *Clostridium sp.*, *Corynebacterium*, *Mycoplasma* and *Mycobacterium sp.* were found in connection with bumblefoot. They occur in this cases either in pure or often in mixed culture.

Staphylococcus Aureus

In 80-90% of all cases [24, 60, 61] *Staphylococcus aureus* has been proved to be isolated in pure culture [17, 20, 46]. In experiments on the foot skin of raptors only a small number of *Staphylococcus aureus* were found [9]. In bacteriological experiments [45] a contamination of *Staphylococcus aureus* was proved in the bacterial flora of the foot skin of 33% healthy hawk living in the wild.

Streptococci

In connection with bumblefoot *Streptococcus faecalis* was isolated in pure and mixed culture. *Streptococcus faecalis* can usually be found in the intestinal flora [19, 46, 58] and leads as well as *Streptococcus pyogenes* to unspecific infections in animals [10, 46]. This germ shows an only minor pathogenicity in animals. *Streptococcus epidermidis* has also appeared in connection with bumblefoot [10, 46].

Coliform Bacteria

In the group of coliform bacteria *E.coli*, appearing in pure or mixed culture, plays an important role in the development of bumblefoot [19, 61] hereby causing septicemia in ill and weak birds [6]. Because of its localization in the intestines *E.coli* is excreted by the falcons with their feces. It serves as an indicator for fecal contamination [10] of water and food. Its high level of tenacity enables this germ to survive outside the body for many months with its capability of reproduction [57]. However, *E.coli* does not belong to the normal bacterial flora in birds [35].

Pseudomonas

Belonging to gram-negative rod-shaped bacteria and appearing in mixed culture in connection with bumblefoot, *Pseudomonas* [4, 58] can be found mainly in soil, sea-water and freshwater. It has been stated that *Pseudomonas spp*. colonization develops as a consequence of either lacking hygiene during surgeries or in the aftermath of extensive antibiosis [10].

Proteus

Proteus sp., a gram-negative rod, has been established in connection with bumblefoot in mixed form [4, 6, 19]. This ubiquitos germ serves as indicator for fecal contamination [10]. *Proteus* has its special meaning as putrefactive agent not only because of its ‘proteolytic activity”, but also of its difficult treatment due to its resistance to most antibiotics [57].

Clostridia

In connection with bumblefoot research has shown [10] the identification of the sporiparous bacterium *Clostridium tetani* in anaerobic culture of bumblefoot. In contrast, the existence of *Clostridium tetani* in a saker falcon suffering from tetanus and bumblefoot could not be proved [48]. *Clostridium spp*. which can be found in the soil was isolated in several bumblefoot cases [4, 19, 58].

Corynebacterium

Although *Corynebacterium sp*. has been defined as one of the bumblefoot pathogens in the publicized microbiological results [46, 55], there has not been any further species specification.

Mycobacteria

In the group of gram-positive sporiparous rods mycobacteria causing tuberculosis were found in bumblefoot cases [26, 46]. Furthermore, during histological examinations *Mycobacterium avium* serotype 2 was isolated in a buzzard [46]. This germ which can be found in the feces of infected animals contaminates both drinking water and food of birds in connection with a lack of hygiene and is therefore orally taken in.

Fungi

Candida

In connection with bumblefoot *Candida albicans* belonging to yeast or Blastomycetes is mentioned in literature [14, 58]. The pathogenicity of Candida sp. becomes also visible by the formation of pseudo-mycelia [28]. In addition, a synergism between *Candida sp.* (*C. albicans*) and *Staphylococcus aureus* [59] does exist.

Apergillosis

Aspergillosis sp. and especially *Aspergillosis fumigatus* has been proven in bumblefoot cases [46, 55, 58].

9.4.2.4. Climatic Factors

Falcons living in the wild are exposed to the most different climatic influences. Usually these conditions do not affect the health of the animal. Only extreme temperature changes in the hot or cold climate range may lead to trauma like burns [14, 53] or congelations [14, 15]. This situation occurs as soon as a bird is sitting on extremely cool surfaces like ice, frost and snow or very hot surface like sand or concrete. Clinical signs are soft tissue damages of different degrees that may lead to bumblefoot after dermal ablation and secondary bacterial invasion. In the worst case the loss of the affected toe could be the result [15].

9.4.3. Diagnosis of Different Foot Conditions

Foot problems of falcons can be diagnosed by clinical, microbiological, radiological and, if necessary, histological examinations. The clinical symptoms comprise changes of the foot skin up to massive swelling of the metatarsal pad, the toes and the whole pedal area. Changes of the horny layer of the pad epithelium are clearly visible right from the beginning of the disease. Other symptoms are reduced performance and lifting of legs. The existence of foot problems is further indicated by pain, unusual resting of the affected extremities in the case of unilateral and lying down in the case of bilateral bumblefoot. As the existing classifications do not differentiate between the reasons for foot problems and thus lack specific treatment methods, this chapter takes a different approach to foot problems by combining the different specific foot diseases with the respective treatment. In the author's experience, this approach is more practical and leads to clearer way for treatment methods for the practicing veterinarian.

9.4.3.1. Pressure Sores

Pressure sores are usually found in falcons with problems on one or both feet. These problems can be caused by e.g. fractures, swollen joints and trauma of limbs. The pressure sores are therefore frequently observed on the contralateral leg. Due to the increased pressure, the pedal skin gets ischemic which is visible by a pale discoloration of the foot sole skin. These pressures sores can cover the metatarsal pad or extend to the digits, too. The papillae of the skin flatten and can fully disappear in case of severe pressure sores (Figure 9.15). Those advanced pressure sores can even reach the tendons (Figure 9.16).

Figure 9.15. Advanced pressure sores due to one-sided pressure.

Figure 9.16. Advanced pressure sore up to tendon.

In those cases, the blood circulation of the foot area and skin has to be enhanced through gentle daily massage and skin granulating ointments. Falcons may be kept in sand as this removes the pressure from the feet as often artificial grass like astroturf is too hard. The underlying reason especially of the other leg has to be identified and treated accordingly as otherwise the ischemia will increase and lead to open wounds. Protective bandages with skin granulating ointments, non adhesive wound dressings and cotton are indicated in case of larger pressure sores. Special "shoes" made of foam material are useful to remove the pressure of the skin. Vitamin injections can be given. Surgery is not indicated in those cases.

9.4.3.2. Hyperkeratosis

Excessive skin granulation that dries in several layers leads to hyperkeratosis of the feet. The hyperkeratosis can be small (Figure 9.17) or larger (Figure 9.18).

This can be frequently observed when falcons are perching on rough surfaces. Foot baths with gently scrubbing with a soft toothbrush help to exfoliate the excessive skin. Often the cutaneous papillae are well intact under the hyperkeratotic layer and the skin has a strong quality. Massage with herbal or vitamin E creams are helpful as prevention of hyperkeratotic skin. Moreover, perch surfaces have to be examined and changed if required.

9.4.3.3. Reddening of the Foot Sole

Flattening of the foot papillae and reddening of the skin is one sign of a weakening skin structure. The reddish discoloration of the skin is sign of increased pressure on the feet and starting inflammation of the skin in this area (Figure 9.19). It can be an early stage of pododermatitis. Treatment occurs with mild foot baths, skin granulating ointments and gentle massage. If the skin is already very weak, bandages with skin granulating ointments are indicated. The surface of the perches has to be examined and softer perch surface material can be used to prevent further infections of the foot sole. Vitamin injections and homeopathic remedies are helpful in those cases.

9.4.3.4. Scab

Frequently a small hard central scab can be found at the metatarsalpad. The surrounding skin is usually still intact with well developed papillae. This scab is only superficial in the beginning but can grow deeper into the skin layers. This development is in most cases accompanied by abscessation.

The abscess can grow directly under the scab but may also extend in the whole foot area. Superficial scabs can be removed relatively easily and the feet can be bandaged with skin granulating ointments in combination with antibiotic ointments to prevent further infection of the affected region. Deep scabs should be removed when they are mature enough for removal (Figure 9.20, 9.21) as otherwise massive hemorrhages may arise.

Often the yellowish or greenish colored abscess is firmly attached to the scab. Abscess material should be sent for microbiological culture to identify the causative bacteria. If possible, the complete abscess including abscess capsule should be removed. If this is not possible, the necrotic tissue can be gently removed as much as possible. Care has to be taken not to damage vital foot structures like tendons.

Enzymatic cleansing of the wound is useful to remove necrotic debris and fibrin material. Antibiotic creams depending on the antibiotic sensitivity tests are applied. Bandaging with antibiotic ointments and “shoes” are useful.

Surgical closure of wounds with abscesses is not indicated as following wound closure the not fully treated abscess may continue to grow in the depth of the wound. This can lead to opening of the suture line.

However, the skin can be closed surgically after the antibiosis has led to a control of the injection and the abscess has been removed. The surgery should be attempted only if the surrounding skin quality is good with clearly visible papillae. In such cases, surgery can be a successful treatment method.

Figure 9.17. Small hyperkeratosis.

Figure 9.18. Larger hyperkeratosis.

Figure 9.19. Reddening of foot sole.

Figure 9.20. Advanced scab with massive abscessation.

Figure 9.21. Pododermatitis with starting abscessation.

9.4.3.5. Pododermatitis

Infection of the foot skin through puncture wounds, injuries or trauma can lead to massive swellings, increased temperature in the foot region as well as abscessation. The infected area can be puffy and fluctuation can be palpated under the skin (Figure 9.22). This is usually a more advanced stage of the previously described scab. The treatment approach has to be on one hand to control the infection and thus to reduce the swelling and on the other hand to remove the abscess. For this purpose, systemic antibiosis as well as local antibiotic therapy has to be combined. Conservative treatment with granulation of the skin tissue is possible. In most cases, surgical intervention is not indicated due to the poor skin quality and extensive damage or loss of the skin in the foot area. Special “shoes” are extremely helpful in those cases to reduce pressure and pain. In an advanced stage, osteomyelitis, tendinitis and deformed toes (Figure 9.23) can occur. Falcons suffering from such a condition are not able to stand on their feet due to deformation of foot and toes as well as massive pain. In this stage, treatment will not be successful anymore and the falcon should be euthanized.

Figure 9.22. Advanced Pododermatitis.

Figure 9.23. End stage of pododermatitis with tendinitis and deformed toes.

9.4.3.6 .Bumblefoot Due to Metabolic Problems

Metabolic problems leading to swollen feet (Figure 9.24) can be found especially in wild falcons that are kept in captivity and suffer from reduced exercise. In regard to exercise and training, wild falcons need a higher training frequency per day than captive-bred falcons [42]. This need may derive from the fact that falcons in the wild need more flights for catching their prey and therefore have more exercise leading to a high level in their circulatory condition. Wild falcons that live in captivity have only a very limited amount of daily training time, which inevitably leads to a reduced circulatory condition. Therefore, wild falcons in a research study reacted sensitively to reduced exercise opportunities and were significantly more prone to bumblefoot because this disease is due to microcirculatory disorders caused by captivity-related inactivity and lack of exercise [42]. Therapy includes daily massage of the feet, foot baths, daily exercise and change in diet.

Figure 9.24. Bumblefoot due to metabolic disorders.

9.4.4. Therapy

Therapy of foot problems is performed either as conservative and operative treatment. Which of these methods or their combination will be chosen depends on the severity of the foot problem, the request of the patient's owner as well as the therapeutic methods and experience of the veterinarian in charge. The hospitalization possibility enhances range and choice of different treatment methods as well as control practicability and decision flexibility by far. Raising the owner's and veterinarian's awareness with regard to the important role of after-care will improve decisively the treatment success and reduce the danger of bumblefoot reoccurrence. The duration of the medicine application period is determined by the stage of the foot disease, the reaction of the patient and the type of medication used.

9.4.4.1. Conservative Treatment

In addition to foot baths, ointment therapies and enzyme therapy, the conservative bumblefoot treatment also comprises the topical and systemic application of chemotherapeutics and antibiotics.

Foot Baths

Foot baths are not only used in the early stages of bumblefoot without any bacterial colonization [25] but also in beginning light lesions [61] and superficial epithelial defects. In many cases an infection in this area is treated with the help of iodic, disinfectant betadine-solution [18, 58, 61]. Tea baths are mostly composed of natural substances like chamomile [18, 22, 62] and oak-bark [22]. Foot baths with water and hibiscrub can be used in early cases of hyperkeratosis where the foot sole can be gently scrubbed with a soft tooth brush.

Ointments

Ointments are applied in various stages of foot problems. Positive results are achieved by softening, enzymatic, antiphlogistic, anti-inflammatory and antibiotic ointments [15, 16, 21, 25, 58]. Application of dimethylsulfoxide (DMSO) has been [4, 19] also applied. However, according to the author's experience, DMSO should not be applied as it weakens the skin quality and can result in severe skin damage. Ointments containing amoxicillin/clavulanic acid, chloramphenicol and gentamycin are useful and should be applied following antibiotic sensitivity. Homeopathic and herbal ointments are extremely useful in enhancing skin granulation and quality.

Antibiotics and Chemotherapeutics

A systematic antibiosis of the avian patient should be applied in an early stage of the disease as this will restrain septicemic spreading of bacteria. In advanced cases antibiosis is inevitable in any way.

Enzyme Therapy

The local application of the enzyme preparations like leukase has been very effective. Especially in infected wounds with purulent discharge enzyme preparations are very helpful. Those enzymatic bits can be placed in the curetted wound to remove necrotic tissue and fibrin debris. They can be used as well in operation wounds to prevent the formation of purulent plugs [34].

Bandaging

Bandages should be changed every 2-3 days depending on the condition of the feet. Different bandages can be made. This includes small protective bandages with only few layers of bandaging material. Ball bandages are bandages with several bandage layers especially around the toes. Cotton bandages include cotton to pad the toes and foot sole. Special "shoes" made of foam material and cut individually for each falcon are extremely useful in the treatment process of foot problems (Figure 9.25). Foam material of children's swimming boards. Cotton is placed between toes and shoe (Figure 9.26) to provide a softly padded shoe and to avoid pressure sores and necrosis of the toes (Figure 9.27).

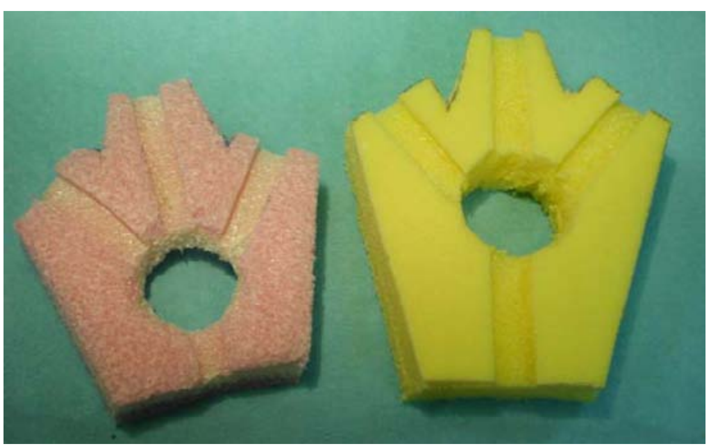

Figure 9.25. Foam shoes.

Figure 9.26. Cotton layers for polstering the shoes.

Figure 9.27. Shoes placed above cotton layer.

Figure 9.28. Bandaging of the shoes with adhesive bandaging material.

Figure 9.29. Falcon with shoes.

The shoe is bandaged with adhesive bandaging material (Figure 9.28, 9.29). Apart from shoe bandage, the tips of the toes should always be free and not bandaged. This helps to easily identify any swellings of the toes.

9.4.4.2. Surgical Treatment

Surgical treatment can be performed in suitable cases. They are pododermatitis cases where the skin and papillae structure are intact. Surgery on feet with poor skin quality like flattened or non existing papillae or on still infected feet will not lead to the desired outcome.

The falcon has to be placed in dorsal recumbency on the surgery table. A tourniquet is placed around the leg. The foot can either be fixed in a special rack or held by an assistant. The skin of the foot is disinfected and covered with sterile cotton or plastic transparent drape. An elliptical cut is made with sharp edges to the lateral side of the foot sole. The cut has to reach healthy skin tissue. The skin gets gently and carefully undermined. The wound is flushed with antibiotics and dried. It is important to reduce the pressure on the suture line as much as possible. Moreover, the skin has to be correctly attached and the sutures with non absorbable suture 4-0 in single sutures are placed in the middle part of the skin layer. This will lead to perfect alignment of the two skin sides. After wound closure, antibiotic wound powder is applied and non adhesive dressing is put on the foot sole. The foot is bandaged with a special shoe made of foam material. This shoe helps to reduce the pressure on the foot and thus leads to faster and enhanced wound healing and reduced pain.

9.4.4.3. Prevention of Foot Problems

The best prevention of feet problems is daily examination of the feet by the owner (Figure 9.30). This is a good way to identify reddening, abrasions or small injuries of the foot area. Research shows that massage of the feet plays an extremely important role in preventing foot problems. This physical measure improves the blood circulation, increases the removal of metabolic products and prevents also the formation of edemas. Tissues are penetrated faster by healing substances contained in ointments with the help of foot massage. A significant direct relation exists between daily massage as preventive measure and the occurrence of pododermatitis. However, massage being performed after advanced foot problems have occurred does not seem to be sufficient or can be regarded as even counterproductive due to the distribution of infectious agents in the tissue [42].

Moreover, according to research results captive-bred falcons seem to adjust much better to the circumstances of limited exercise and training time and frequency. Although these living conditions do not seem to affect the captive-bred falcons to such an extent as they affect wild falcons, exercise twice a day should be regarded as a necessary tool in the fight against bumblefoot.

Figure 9.30.Falconer controls his falcon's feet

In the molting season, during which no training flights are performed, free flight in aviaries resulted in significantly less bumblefoot cases. Therefore, it cannot be stressed enough that spending the molting season in free-flight aviaries in a very important prophylactic measure to prevent the occurrence of bumblefoot both in captive-bred falcons and especially in wild falcons living in captivity [42].

Additionally, diet shows a significant influence on the occurrence of bumblefoot. Especially wild falcons showed in a research study a reduced morbidity rate when fed pigeons, bustards, and ducks, which resemble their usual prey. Therefore, this high-energy diet is part of the natural nutrition of wild-living falcons. Low-energy food like quail leads to an increased bumblefoot morbidity rate. In contrast to this, captive-bred falcons are often fed with low-energy food like beef as part of their nutrition plan, resulting in a significant decrease of bumblefoot cases. This discrepancy in metabolizing low-energy food by captive-bred falcons and wild falcons possess a much higher turnover of energy because of an increased exercise and circulation level than their captive-bred counterparts. It also indicates that the high metabolism of wild falcons living in captivity cannot adjust to the much lower metabolic turnover that a sudden and prolonging reduction of natural exercise would require. Captive-bred falcons do not show this demand for high-energy food, indicating an originally lower metabolism in raptors [42].

9.5. Conclusion

Feather and skin problems are frequently encountered in falcons. Common problems of the feathers are feather parasites. Skin problems can be caused by bacteria especially *E.coli* infections that can start under the wind and extend to the body walls as well. Cutaneous tuberculosis seems to be a disease that should not be underestimated as more cases are detected nowadays. Moreover, the detection of A.baumanii for the first time in falcons can be regarded as a severe new emerging disease with possible zoonotic impact.

Foot problems still form a common disease in falcons although they occur less frequently than before a decade. This chapter highlights a new approach to foot problems taking into consideration the origin of the foot problem without generalizing the foot conditions as done in the existing bumblefoot classifications. Treatment methods are mentioned for each foot condition individually and then explained in more detail at the end of this chapter. It is hoped that this new and different approach to foot problems will enable the practicing veterinarian and falconers alike to identify foot problems correctly and to apply appropriate treatment. Moreover, it has to be kept in mind that prevention is better than cure and many foot problems can be avoided by proper management and preventive measures.

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Chapter X

Parasitic Diseases

Abstract

Avian parasites have been detected in raptors and other avians for a longtime and form a major part of avian diseases. This chapter includes information about the most common falcon and raptor parasites, transmission routes and distribution. It also focuses on clinical symptoms and therapeutic approaches. Moreover, it highlights the new emerging parasitic diseases in falcons and birds of prey. Moreover, parasitic diseases are among the most common infections in birds. They may serve as predisposing factors and pave the way for other secondary infections due to immunosuppression if being unrecognized or left untreated.

Among the most common avian parasites are ectoparasites like arthropods, but also endoparasites including protozoa and the large groups of helminths. Helminths can be differentiated into the classes trematodas (flukes), cestodas (tapeworms) and nematodas (roundworms). Moreover, blood parasites like *Plasmodium sp* or *Haemoproteus sp*. are present in birds and can cause considerable problems for them. However, several parasites are host specific like *Serratospiculum seurati* or *Caryospora sp*. being found in falconiformes. Other parasites have very low species susceptibility like trematodes or roundworms.

However, apart from the common avian parasites, new parasitic diseases are emerging like microsporidiosis caused by *Enterocytozoon bieneusi* infections. Moreover, parasites like mosquitos may even transmit zoonotic viruses like West Nile Virus to birds. Due to their possible implications on human health and a possible transmission of avians to humans, those new emerging parasitic diseases may pose a considerable and highly underestimated threat to both, human and avian health.

10.1. Introduction

Parasites are a common feature in birds of prey. They can be differentiated according to their location as ectoparasites and endoparasites as well as their life cycle and hosts. Their size may also vary considerably, from intracellular organisms to blood parasites and larger visible helminths or arthropods. Regional differences as well as seasonal changes may be observed in several parasites. Immune suppression in case of overcrowding, poor hygienic conditions, contaminated soil or litter and contact between wild birds and captive birds can serve as predisposing factors for parasite invasion. The damage they cause to their avian host depends largely on the amount of parasites. In case of only few parasites being present, the damage to the host may be of minor importance. However, large parasite burdens may cause considerable damage and thus pave the way to secondary infections either by bacteria or viruses. Moreover, the clinical picture shows changes in the lumen of affected organs and can cause anemia in case of blood sucking endoparasites and ectoparasites [39].

10.2. Ectoparasites

Ectoparasites are frequently found on the feathers and integument of birds. In small numbers, they do not cause major problems whereas in large quantities, they may lead to major disturbance of the affected birds and might result in anaemia in case of blood sucking ectoparasites. Moreover, ectoparasites can become vectors for the transmission of infectious diseases. Therefore only the most clinically relevant ectoparasites are mentioned in this chapter.

10.2.1. Mallophaga

Mallophaga can be found very frequently in birds and raptors alike (Figure 10.1). Those chewing lice can be differentiated in two subspecies, *Ischnocera* and *Amblycera*. Both are strictly host specific and can be isolated in a large number of avian species [23].

Figure 10.1. Feather damage due to mallophaga.

Some mallophaga species feed on blood whereas others use feathers, skin and skin products as their nutrition source. They have a typical only few millimeters large dorsoventrally flattened body without wings. Moreover, they have a large head, short antennae, and short legs with hooks in the end as well as very strong mandibles and masticatory system [11].

The development cycle takes six weeks [23] and takes place entirely on the host bird. The female lays her eggs on the feathers of the invaded raptor [11]. The parasites life takes up to 2-3 months, but their life duration is reduced if they are forced to live outside the host. Disease transmission takes place through contact and contaminated litter. In ducks, death cases through mallophaga infestation have been observed [23]. Mallophaga can be frequently found in raptors with reduced immune system [38]. Moreover, it is interesting to note that in cases of dying falcons, the mallophaga lice leave the dying body by jumping from the body. This can be regarded as a clear sign that the falcon is in a life-threatening condition.

10.2.2. Diptera

Culicoideae (Mosquitos)

The mosquito females are the blood-sucking insects. They can cause irritation and through the sucking of the blood even lead to anemia. Moreover, mosquitos may transmit serious diseases like avian malaria, viral diseases and trypanosomiasis [66].

Hippoboscidae (Louse flies)

Louse flies or Hippoboscids are frequently found in wild birds, psittacines and raptors [23] which are kept in open-air aviaries [21]. The main hippoboscid species affecting for those birds are *Ornithomyia*, *Lynchia* and *Pseudolynchia*. They have a characteristic dorsoventrally flattened body [20]. It is relatively difficult to detect louse flies as they move very quickly between the feather and stick to them. Adult louse flies are sucking blood and can lead to anemia and death of juvenile birds. Moreover, they may serve as vectors for the transmission of viruses, bacteria and *Haemoproteus* sp [23]. The disease can be controlled by removing the potential source of transmission, the wild birds, and cleaning as well as disinfection of the aviary [22, 39].

Calliphoridae (Blow flies)

In birds with injuries and traumas causing open wounds myiasis can be found. The larvae of blow flies and flesh flies can invade those open wounds [22].

10.3. Endoparasites

10.3.1. Protozoa

Common avian protozoa or single celled parasites are a varied group of coccidians (e.g. *Eimeria, Isospora, Caryospora*), Microsporidians (*Enterocytozoon*) as well as flagellates (*Trichomonas, Giardia*). Moreover, protozoa include blood parasites like *Plasmodium* and *Haemoproteus.*

10.3.1.2. Trichomoniasis

Trichomonads are transmitted through direct contact through contaminated food or water. They are also present as commensal species. The most common pathogenic trichomonad species is *Trichomonas gallinae.* It has several strains ranging from avirulent to highly virulent [21]. *T. gallinae* affects mainly pigeons, either free-ranging or captive, as well as Passeriformes, Psittaciformes, Falconiformes and Phasianiformes [23]. Moreover, *Trichomonas* infections have been reported in budgerigars, cockatiels and blue-fronted amazon parrots. Often parental birds transmit the protozoa to their chicks with the crop milk of regurgitated food or while feeding [19]. In raptors, infected prey like doves and pigeons [21] play an important role in the disease transmission [23] of the so-called “frounce” in falcons.

Trichomonads are found as motile trophozoites with four free anterior flagellates and one undulating membrane. Its size ranges from 8 to 14 µm length [19] and cannot survive longtime in the environment. Latent carriers are often found among adult birds and especially pigeons. Waterbowls as well as small lakes can serve as reservoir of the pathogen [23].

Clinical symptoms are weight loss, caseous lesions up to ulcera in the tongue (Figure 10.2), mouth, oropharynx (Figure 10.3), esophagus and crop where they can reach walnut size. *Trichomonas* lesion may also be found in the choana. Birds have problems to eat, show ruffled feathers and get emaciated in more advanced stages. The disease might be acute or chronic [21, 23]. Spreading of *Trichomonas* lesions up to the sinuses and conjunctivae is possible [21]. In such severe cases, *Trichomonas* lesions might be found in the infraorbital area which leads to large swellings above the eye (Figure 10.4). Those lesions can go up to the middle of the head. Their surgical treatment is explained in details in chapter 15.

In raptors, feeding of pigeons infected with *Trichomonas gallinae* may transmit the contagious disease. Often trichomonads can be found in the crop of the pigeons that are fed to falcons. As prevention, pigeons should always be fed to raptors without head, neck and intestines.

Figure 10.2. Trichomonas lesions in tongue.

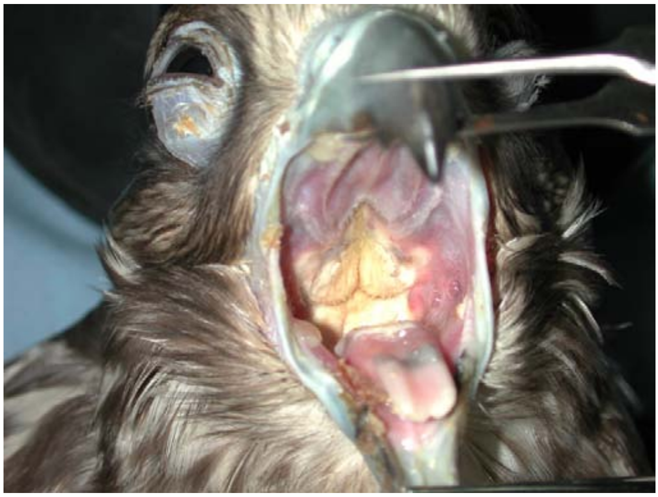

Figure 10.3. Massive trichomonas lesion in oropharynx.

Figure 10.4. Infraorbital trichomonas lesion.

Trichomonas infection might be associated with *Pseudomonas aeruginosa* infections [47]. Often, trichomonads pave the way for *Pseudomonas* infections and cannot be detected clinically in smears anymore. In such cases, raptors often suffer from swollen tongues, sometimes with caseous whitish lesions inside the tongue. Cheesy lesions can be found in the mouth, oropharynx, choana and up to the esophagus and crop. The lesions can be disinfected with chlorhexidine or iodine povidone solution [47]. Moreover, it is very helpful to dry out the lesions in the oral cavity and tongue through application of a thin layer of mercurochrome. Great care should be taken not remove lesions that are still fully attached as they can lead to a considerable bleeding. After metronidazole application, the lesions start to dry and detach slowly. It is always better to wait for a few days until the lesions get well detached. The detaching lesions can then be carefully removed with forceps or curettes. In the oral cavity, a good healing process can be observed. However, large masses in the mouth or choana may lead to large holes after removal which might require surgical closure. This can be performed with thin absorbable sutures 4-0 or 5-0 in order to reduce the artificial trauma in the highly vascularized oral cavity [39]. Metronidazole application for a minimum of 5 consecutive is useful as treatment of trichomoniasis. In severe cases, the dosage can be doubled and given for up to 10 days. However, not all available brands seem to have the same effects. The *P. aeruginosa* infection can be treated with piperacillin as first drug of choice until an antibiotic sensitivity test is available [36].

10.3.1.2. Giardia

Giardia are protozoa which can be found in many bird species although the major clinical problems are caused in psittacines [21]. They are characterized by a motile trophozoite and a cyst stage [19] which invades the lumen of the small intestines [20]. The cysts can be transmitted directly when the host digests food with contaminated feces. Moreover, the cysts can stay alive in the environment thus serving as potential source of reinfection for birds. This protozoal disease can be found in various psittacine species like budgerigars, cockatiels, lovebirds, parakeets [19] as well as in herons, toucans, raptors and Anseriformes [66].

Predisposing factors for giardiasis are stress, molting, poor ventilation of the rooms and malnutrition. Some disease signs affect the integument with dry skin and feather plucking especially in cockatiels. They pluck their feathers up to a stage of self-mutilation. In juvenile and neonate birds of those species, *Giardia* infestation can lead to weakness, poor plumage, skin contamination with feces [21], reduced growth and high mortality of up to 50% [19]. Other disease symptoms in psittacines are watery, whitish diarrhea, enteritis, anorexia, depression, yeast infection and changes in the blood patterns like eosinophilia and hypoproteinemia [19, 21]. Malabsorption is likely to cause hypoproteinemia as well as diarrhea. Birds that enter newly into bird groups may serve as subclinical carriers [21].

In post mortem examinations, scrapings of the small intestine mucosa may lead to the detection of *Giardia sp*. being located in the mucous between the villi. Often dilatation and milky-whitish mucous can be found in the small intestine [21].

Giardia is not only limited to avians, but transmission of avian *Giardia* isolates to mammals like mice was successfully performed. This may have serious implications for contamination of watersheds [54], especially as the presence of *Giardia* in infected feces and contaminated drinking water causes important implications for human health as it is regarded as the most important cause for protozoan diarrhea worldwide [13]. Treatment with metronidazole or nitrofurazone for a minimum of 5 days can be done with drinking water. Even after successful treatment diarrhea can persist for another one or two weeks as it takes time for the mucosa to heal completely [21]. Probiotics can be helpful in restoring the intestinal flora.

10.3.1.3. Coccidia

Eimeria and Isospora

Eimeria and *Isospora* are part of the coccidian species and are distributed worldwide [66]. The maturation of *Coccidia sp*. goes through three phases. The first one is the schizogony followed by the second one the gamogony. Both phases develop in the host cells. The third stage develops in the environment and is called sporogony [23]. The infectious stage of the coccida is during the maturation process when the sporulated oocysts get divided into sporocysts with sporozoites [19].

The strictly host specific [23] *Eimeria sp.* are commonly found in poultry, Galliformes and Columbiformes and can be regarded as one of the most important protozoal pathogens in poultry industry [64]. Severe infections with *Eimeria sp.* can be diagnosed in juveniles Anatiformes [23]. Moreover, two *Eimeria* species have been reported in psittacines [19]. Oocysts have a size of 10-45 µm [64] and direct life cycle. In *Eimeria sp.*, sporulated oocysts have four sporocysts with two sporozoites each [19].

Isospora sp. can be diagnosed in psittacines, passerines and Piciformes [64]. In *Isospora sp.*, four sporozoites are located in two sporocysts [19].

Both coccidian species can be either asymptomatic in birds or cause melena, depression or diarrhea [19]. Typical signs for coccidiosis are also soiled vents, distended intestines and swollen abdomen, fluffed feathers and emaciation [21]. Advanced disease stages lead to anorexia and death [19], usually 1 week after the beginning of the coccidial infection [21]. Nervous symptoms have been reported although not being a common feature of coccidiosis. These nervous symptoms are caused by electrolyte imbalance, hypoglycemia and debilitation [21]. Coccidiosis can be treated with the coccidiostat toltazuril orally. It is advisable to give supplementary multivitamins [21]. Moreover, special avian probiotics can be helpful to restore the intestinal bacterial flora after finishing the antiparasitic therapy.

Caryospora

Caryospora sp. can be isolated from raptors and hereby mainly Falconiformes (Figure 10.5).

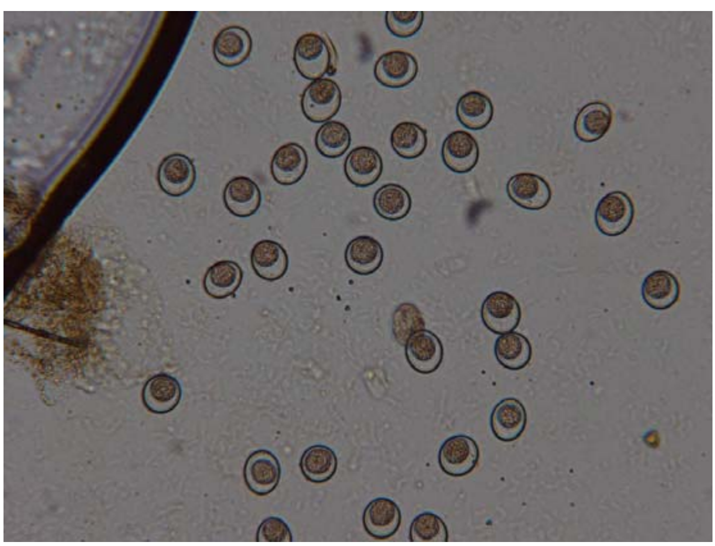

Figure 10.5. Massive Caryospora sp. in fecal sample.

It is regarded as one of the main causes for enteric problems in falcons. Although being described as a disease affecting mainly juveniles and sub-adult birds [66], this coccidia can be identified as well in older falcons. More than seven different *Caryospora* species have been described [26], among them *C. falconis*, *C. neofalconis*, *C. megafalconis* and *C. kutzeri*. Those are mainly found in the Middle East [66]. *C. neofalconis* has been reported in juvenile merlins and a snowy owl in the UK [14].

In falcons with heavy *Caryospora* burden, clinical symptoms like changes in the fecal consistence and weight loss can be observed. Moreover, in those severe cases, enteritis with thickened intestinal walls can be visualized in the X-ray [39]. A heavy *Caryospora* infestation also leads to a suppressed immune system and can pave the way for secondary infections like clostridiosis and microsporidiosis with *Enterocytozoon bieneusi*. Toltazuril has been used effectively against *Caryospora sp.*. Moreover, in case of heavy *Caryospora sp.* infestation, the application of probiotics after the anticoccidia treatment is recommended to restore the intestinal flora [38].

10.4. Helminths

10.4.1. Trematoda (flukes)

Trematoda (Figure 10.6, 10.7) or flukes belong to the *Platyhelminthes* and can live either in the liver of the blood vasculature of Psittaciformes [19], Passeriformes, Anseriformes and poultry [66]. In raptors, different trematodes like *Strigea falconis*, can be isolated [66]. The flukes in the blood are called *Schistosomatidae*. All flukes possess a simple digestive system and are hermaphroditic apart from the *Schistosomatidae* [65]. The liver flukes are part of the family *Dicrocoelidae*. The life cycle of flukes contains one or two intermediate hosts [66], the first one usually a snail [27] and the second one an arthropod [19], dragonfly or dragonfly larvae [27]. The transmission of flukes happens via a second intermediate host which is eaten by the bird. Due to its intermediate host range, infections arise more frequently in aquatic bird species or Anseriformes [65].

Fluke infection affecting the liver can lead to major clinical symptoms like hepatomegaly, hepatic necrosis, elevated liver enzymes, anorexia, and diarrhea as well as weight loss. In the advanced stage, the liver fluke infection may be lethal for the infected bird. In cockatoos, the liver and bile ducts can get infected by flukes. This leads to major clinical signs like hepatomegaly. In histopathology, fibrotic changes of the liver as well as bile duct hyperplasia can be seen [19].

Treatment with anthelmintics like fenbendazole or praziquantel may not lead to clinical improvement but might reduce the number of fluke eggs [19]. The use of praziquantel, albendazole, flubendazole, fenbendazole has been suggested [27]. In raptors, rafoxanide can be used [65].

10.4.2. Cestoda (tapeworms)

Different species of tapeworms (Figure 10.8) like *Cladotaenia globifera* can be found in raptors [66].

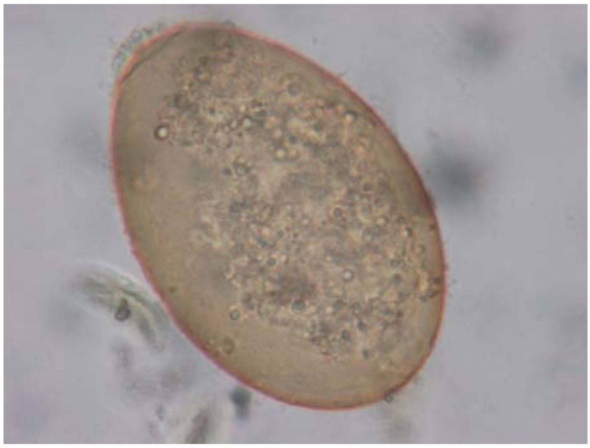

Figure 10.6. Trematoda egg.

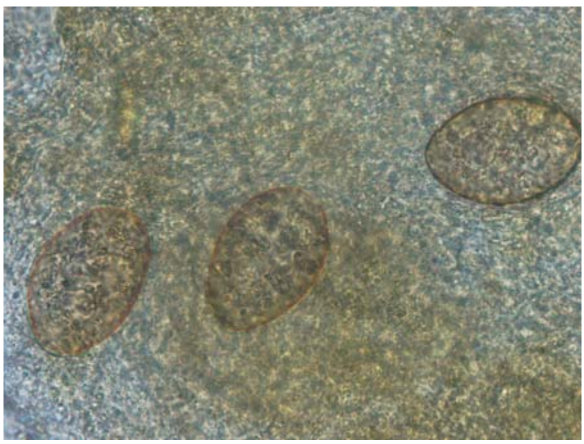

Figure 10.7. Strong infestation with trematode eggs.

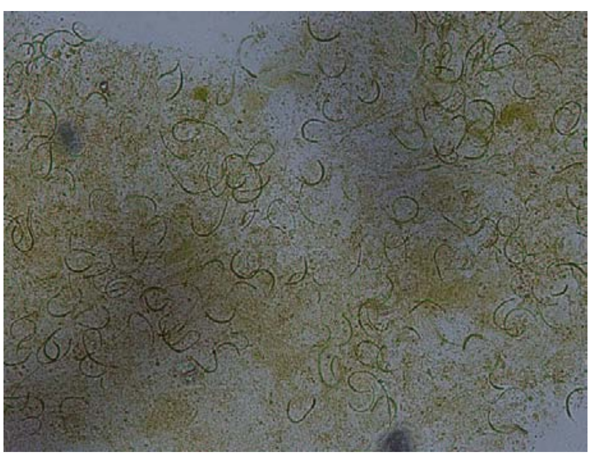

Figure 10.8. Cestode egg (tapeworm).

Intermediate hosts are required for the infection with tapeworms which leads to infection of mainly birds with contact to the ground. Water and land arthropods as well as molluscs can serve as intermediate hosts [23] and containing the cysticercus [66]. The tapeworm eggs have a hexacanth larvae and six hooks on oncosphere [19]. They can be found in the small intestines [20]. Tapeworm eggs or proglottis can be identified in the feces during parasitological examinations [66].

The infection can remain asymptomatic, but can also show clinical signs like diarrhea, weight loss and death in the case of heavy parasite burden. A possible eosinophilia might be present but does not reflect a direct relationship with the parasite infection [19]. Other symptoms for heavy tapeworm infections can be enteritis, hemorrhagic enteritis and intestinal obstruction [66]. Compared to the relatively low infection rate in companion birds, tapeworms can be frequently observed in raptors in the Middle East living in captivity.

Cestode infections can be treated with praziquantel, niclosamide, rafoxanide [66]. In falcons, repeated treatment after 1 week to 10 days is indicated in cases of heavier tapeworm burden.

10.4.3. Nematoda (roundworms)

10.4.3.1. Ascaridia

The roundworms of the species *Ascaridia* can be frequently found in birds [20]. In falcons, *Ascaridia* can be found mainly in wild peregrine falcons (Figure 10.9). The difference between females and males is the large precloacal sucker in the male worms [33]. *Porrocaecum sp*., especially *Porrocaecum ensicaudatum* can be found in passerine birds [21]. *Ascaridia* have a direct life cycle. The infective larvae need 2-3 weeks to develop in the egg. After hatching, the larvae migrate in the mucosa of the small intestine and then to the lumen to mature [21]. They can also develop in the oral cavity, esophagus and proventriculus where they might get attached to the proventricular mucosa.

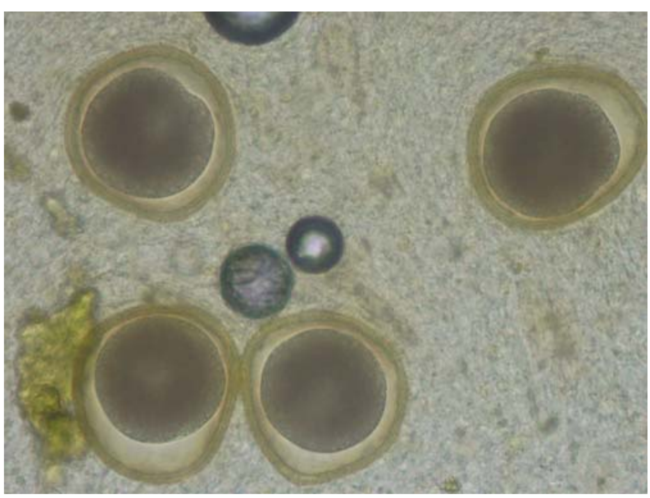

Figure 10.9. Ascarida eggs.

Ascaridia spp. eggs are ellipsoidal with smooth and colorless whereas *Porrocaeacum spp.* are more round-shaped with pitted and brown shell. The eggs can survive in the environment for several months [21].

In necropsies, ascarids can be easily identified with female worms reaching up to 40 mm size and smaller males [22].

Ascarid infections can be treated with levamisole, fenbendazole, mebendazole, ivermectin and pyrantel tartrate. However, fenbendazole should not be used in molting birds as they affect the feather formation. [21].

10.4.3.2. Capillaria

Capillaria sp. are trichuroid nematodes [20]. They are very small thread-like nematode with the typical two poles of the eggs. *Capillaria sp*. are located in the gastrointestinal tract and especially in crop, esophagus and small intestine [19, 66]. This nematode can be found in raptors like gyrfalcons, peregrine falcons (Figure 10.10), American kestrel as well as poultry and psittacines like budgerigars, macaws and canaries as well as in [53], Gyr-peregrine hybrid falcons and Gyr-Saker hybrid falcons. In pigeons, *Capillaria columbae* can be isolated [20].

Having a direct life cycle, it takes approximately two weeks to develop adult *Capillaria* larvae. The eggs show the very characteristic pattern of bipolar eggs [19].The eggs can survive up to several months in the environment especially in very humid conditions and moderate temperature [66]. The adult *Capillaria* worms have a beaded esophagus [20]. They can invade the crop and esophagus mucosa as well as the intestinal mucosa [19] mainly of the small intestines [20]. This results in clinical symptoms like regurgitation, dysphagia, weight loss, diarrhea and melena. In cases of heavy *Capillaria* burden, hemorrhages may arise in the upper intestinal tract [19]. *Capillaria* infestation in raptors may also lead to vomiting and reduced appetite [39].

Figure 10.10. Two Capillaria sp. eggs.

Whereas in poultry severe infections in the upper digestive tract can be observed, the clinical pattern in other avian species is not unified [23].

Hygienic measures have to be strictly enforced to avoid recontamination. Treatment with fenbendazole, levamisole, mebendazole, ivermectin and moxidectin is usually successful [66]. A repeated treatment is to be done in case of heavy *Capillaria* burden [23]. In raptors, treatment with fenbendazole for 5 consecutive days is advisable.

10.4.3.3. Serratospiculum

Being a diplotriaenoid nematode of the respiratory tract, *Serratospiculum spp.* can be identified in air sacs (Figure 10.11). Its adult filaroid worms can be found in connective tissue, meninges, heart, blood vessels and under the skin [20]. *Serratospiculum sp*. can be frequently found in Falconiformes. It has been detected in North America, some European countries and tropical and subtropical countries [66]. Moreover, the *Serratospiculum* infection associated with bronchopneumonia and airsacculitis was identified in New Zealand falcons [18]. *Serratospiculum seurati* is frequently found in the Middle Eastern countries [48].

Serratospiculum seurati has an indirect life cycle. The larvae stages of *S. seurati* can be found in 7 intermediate hosts, namely beetles and the wood louse. Falcons in captivity eat the infected intermediate hosts. The L3 larvae move out from their capsule, penetrate the proventriculus and ventriculus walls and migrate directly to the airsacs. Inside the airsacs, the L3 larvae undergo direct mold for two times. The resulting L5 larvae are regarded as the immature adult filarial worms. The adult worms can breed and produce large numbers of embryonated eggs (Figure 10.12). Those ova can be coughed up through the trachea, swallowed in the digestive tract and then shed with the feces. Histopathological changes include the different *S. seurati* stages like larvae, adult worms and eggs, but also mild focal hemorrhages, focal necrosis and macrophage infiltration. *S. seurati* infections are associated with airsacculitis, pneumonia and early Aspergillosis lesions [48].

Figure 10.11. Serratospiculum worms in airsac detected during endoscopy.

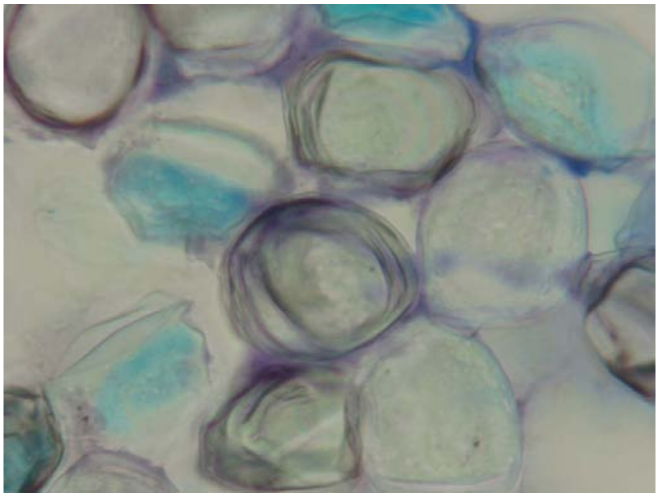

Figure 10.12. Serratospiculum eggs in cytology sample of airsac of Gyr-Peregrine falcon.

Figure 10.13. Serratospiculum eggs in fecal sample.

In prairie falcons, the heavy *Serratospiculum* burden of more than 100 worms has led to the acute respiratory problems and subsequent death [58]. In the same falcon species, another fatal infection due to *Serratospiculum amaculata* was reported [28].

However, *S. seurati* infections can be present even though no embryonated worm eggs might be detected in the feces. On the other hand, *S. seurati* eggs can be present in the feces examination (Figure 10.13), but no eggs, larvae or adult worm stages might be visible in the air sacs when performing endoscopic examinations [39]. Other features of the endoscopic examination are yellowish colored egg clutches that can be easily mistaken with fat deposits. The air sac membrane might show for *Serratospiculum seurati* typically whitish spotty discoloration which is usually produced by larvae or worm stages even if they are not present anymore[39]. Discussions among avian veterinarians are on-going if the *S. seurati* worms should be removed during endoscopy before or after treatment with anthelmintics or if the worms should not be removed at all. If the worms have not been treated yet, but are detected during routine endoscopy, it is more advisable to remove them carefully with the help of a biopsy forceps (Figure 10.14). They can reach a maximum length of approximately 20 cm (Figure 10.15). Often 10-30 worms can be removed (Figure 10.16). However, it is not indicated to remove adult *S. seurati* worms if they are fully covered with large numbers of blood vessels as the subsequent hemorrhage would be more problematic for the falcon. Large numbers of *S. seurati* can be frequently found in older saker falcons (Falco cherrug) [39]. However, serratospiculosis can be detected in gyr-hybrid falcons and peregrine falcons as well. Ivermectin and moxidectin can be used to treat serratospiculosis [48].

Figure 10.14. Starting removal of Serratospiculum worms during endoscopy.

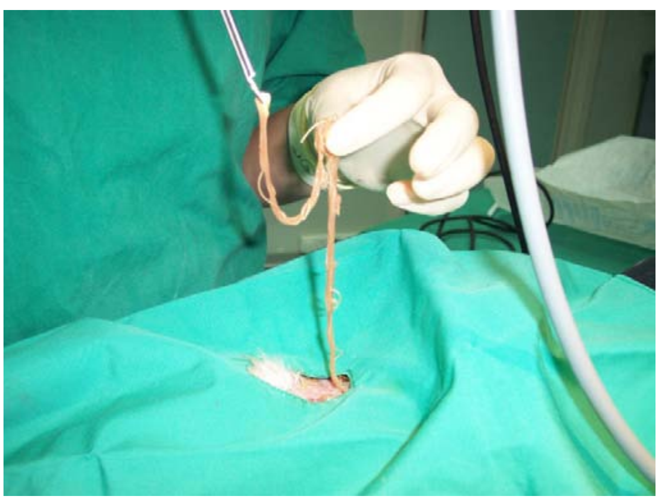

Figure 10.15. Removal of adult Serratospiculum worms during endoscopy.

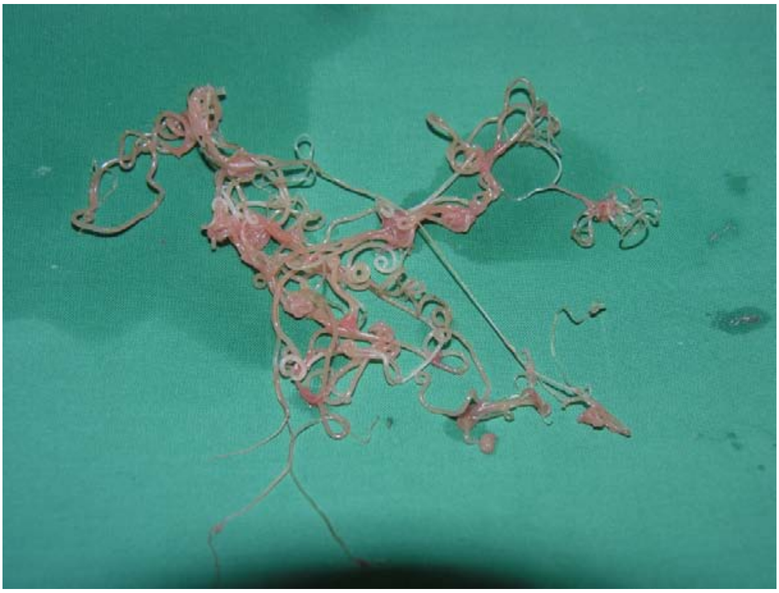

Figure 10.16. Numerous Serratospiculum worms removed during endoscopy.

10.4.3.4. Syngamus Trachea

The nematode *Syngamus trachea* belongs to the genus *Strongyloidea* and family *Syngamidae*. This bright red-colored gapeworm can be found in the respiratory tract of birds like in the trachea, bronchi and bronchioles. Bird species that are commonly affected are chicken, quails, turkeys, guinea fowl, geese, peafowl and pheasants [45]. Other avian species susceptible to *Syngamus trachea* infections are raptors, Columbiformes, Psittaciformes and especially cockatoos, Passeriformes and mainly Corvidae and starlings [23]. Typically *S. trachea* worms are found in pairs. The females and males are attached on a permanent basis through copula [20] in a Y-form position [44].

Disease transmission can arise through shedding of thin-shelled *Syngamus* eggs in the feces of infected older birds. Eggs can remain infectious for up to four years in cages or pens. Wild birds are also a source of infections. Eggs develop in the moist warm environment and can mature up to larva stages. The eggs or larvae are eaten by birds either direct or through an intermediate host like earthworms, snails or insect larvae. *Syngamus trachea* larvae migrate through the blood to the trachea. Disease symptoms are severe respiratory diseases with dyspnea, coughing, opening of the beak, respiratory sound and clotted blood around the beak. The general conditions of the infected birds declines and the death arrives through asphyxiation [23, 66]. Post mortem changes may be bronchitis, lung congestion, tracheitis and mucous [66].

Treatment can be performed with manual removal of the gapeworms through endoscopy. Medication combines application of Ivermectin as well as antibiotics to cover up the tracheal damage [44] and to prevent secondary infections. Moreover, fenbendazole, mebendazole and thiabendazole can be used as antiparasitic treatment [66].

10.5. Blood Parasites

Haemosporidian parasites are distributed worldwide. 3 main species are isolated in birds, *Haemoproteus*, *Plasmodium* and *Leukocytozoon* [3]. Other hemosporidians with pathogenic effects in falcons are the piroplasms *Babesia sp*. [41]. *Haemoproteus* is the most commonly found blood parasite and along with Leukocytozoon host specific. In contrast, *Plasmodium* has a wide host spectrum and can be isolated in several avian species [3]. The occurrence of blood parasites in avians are known to have an impact on the flight performance by reducing the flight distance. Moreover, the number and species of blood parasites are also determining components for the reduced flight distance. Therefore birds infected with haemoparasites get more vulnerable to fall prey to raptors [34]. Furthermore, acute *Plasmodium* infections lead to reduced oxygen transport and impact the thermoregulation [25].

10.5.1. Plasmodium

More than 34 *Plasmodium spp.* grouped in five subgenera have been detected in birds [4]. *Plasmodium* infections can be found in raptors, canaries, small passerine birds, pigeons, waterfowl, penguins and poultry. In those species, the infection with *Plasmodium* can result in major clinical problems which can lead to increased morbidity and mortality. Passeriformes and Psittaciformes are often asymptomatic carriers. Mainly *P. relictum* and *P. ellongatum* have been isolated in the peripheral erythrocytes, thrombocytes, leucocytes and in the cells of the endothelium. The disease is usually transmitted through sporozoites that are located in the saliva of blood sucking mosquitos [23] like culicine mosquitoes [41]. Golden or black colored refractile pigment granules in the schizonts and gametocytes can be identified in the cytoplasm of *Plasmodium sp.* [20].

First schizonts stages can be found in the reticulo-endothelial cells of visceral organs and bone marrow [23]. Schizogony occurs in the peripheral blood where gametocytes and schizonts are visible [55]. However, extra-erythrocytic stages were detected in the endothelial cells of brain and lung capillaries of hiking throttles (*Merula migratoria*). Schizonts and gametocytes develop at later stages. Gametocytes located in the erythrocytes are transmitted to blood sucking insects which pose the intermediate host for the further *Plasmodium* development [23].

The infection e.g. to passerines can be transmitted through mosquitos. This leads to a seasonal occurrence of Plasmodium infections especially in spring and autumn in North America [16]. Such a seasonal infection distribution patterns can also be found in blue tits *Cyanistes caeruleus* with bimodal occurrence in spring and autumn peaks, especially in *Plasmodium circumflexum* infections. However, in winter, no infection could be observed. In contrast, infections with *Plasmodium relictum* showed reduced seasonal patterns. The age also might play a role in the seasonal occurrence of the infection as in the blue tits the seasonal infection was found only in one year old birds. Older birds did not show the seasonal *Plasmodium* infection patterns [8].

Newly infected birds show more clinical symptoms. Clinical symptoms may not correlate with the number of parasites in the peripheral blood [55]. Anaemia can occur as disorders of erythrocytes including intravascular hemolysis in passerines and penguins. In the latter, *P. relictum* can cause a relative lymphocytosis, anorexia, vomiting and cramps with mortality especially in the months of July and August [23]. In gyrfalcons, a high parasitemia can be seen associated with lethargy, anorexia and jade-green fecal [55]. Moreover, prominent poikilocytosis can be diagnosed in the avian bloods smear. Intraerythrocytic gametocytes with nuclear displacement can be identified in the blood smears [16]. Other disease symptoms especially in Falconiformes are ballooning of the erythrocytes and eosinophils as well as jaundice and elevated AST parameters. Moreover, dyspnea, vomiting and cramps especially in gyr falcons have a more severe manifestation than e.g. in peregrine falcons [23]. Canaries and finches show dyspnea, lethargy and anorexia with high parasitaemia. Sudden death cases have been observed in those species. In other species, death may arise immediately or within 1 to 2 days after occurrence of clinical symptoms [55]. Post mortem reveals often hepatosplenomegaly, pulmonary edema and pericardial diffusion [55].

Despite being host specific haemoparasites, *Plasmodium sp.* can also affect other birds species e.g. *Plasmodium sp.* of passerines was detected in birds or prey and owls in Europe. This leads to the conclusion that a much broader and nonhost specific presence of *Plasmodium sp.* exists which is not confined to one avian species only [29].

As therapeutic agents, most human antimalarial medications like chloroquinine and primaquine are effective in birds. Supportive therapy with fluids is helpful [55].

10.5.2. Haemoproteus

Haemoproteus spp. can be frequently found in Falconiformes (Figure 10.17), Accipitriformes, Strigiformes and Psittaciformes [23] as well as in wild-caught birds like white cockatoos, green-winged macaws (*Ara chloroptera*) and halfmoon conures [16]. It is the most common haemoparasite in birds [55] with more than 128 species and five morphological forms [41]. Pigmented gametocytes are visible in erythrocytes and can be used as differentiation to the other haemoparasites [20]. Blue staining is characteristic for macrogametocytes whereas pale blue and pink staining is indicative for microgametocytes [55]. They have been regarded to be the least pathogenic of all haemoparasites [3]. However, if more than 10% of the erythrocytes are affected, severe disease symptoms like inappetence, apathy, anemia might arise and might be lethal, especially in pigeons and quails [23]. In falcons, similar symptoms might be observed. Moreover, *Haemoproteus* infections can be more frequently found in gyrfalcons and gyr-hybrid falcons from American breeding centers.

The *Haemoproteus sp*. life cycle is similar to the life cycle of *Plasmodium sp*. and *Leukocytozoon sp*.. However, the schizonts develop exclusively in the endothelium of the different visceral organs whereas the gametocytes mature in the circulating erythrocytes [23]. Intermediate hosts can be mainly *Culicoides spp*. or *Hippoboscidae spp*. The acute parasitemia is usually 7 to 10 days after infection and can remain up to several weeks. Recurrence of the disease is caused by stress and in spring time [23].

Although being usually host specific [3], *Haemoproteus sp.* switches not only between the same species, but also between species of different families [5]. Moreover, a host switching in a familial level has been observed in a promiscuous genotype of *Haemoproteus* *sp*. in six different exotic passerine birds in California. The infection led to severe morbidity and high mortality although clinical sign were either few or not observed. The blood smears did not reveal any *Haemoproteus* parasites. However, the pathological picture included hemocoelom, hemorrhages and hepatocellular necrosis. Various stages of degenerated protozoal megaschizonts were isolated in the affected liver areas. Moreover, peripheral nonsuppurative inflammation was present. The molecular analysis resulted in avian malarial mitochondrial cytochrome B. Its sequencing identified the close relation to *Haemoproteus sp*. of North American passerine birds that were asymptomatic [10].

Treatment can be done with chloroquine and mefloquine as combination treatment.

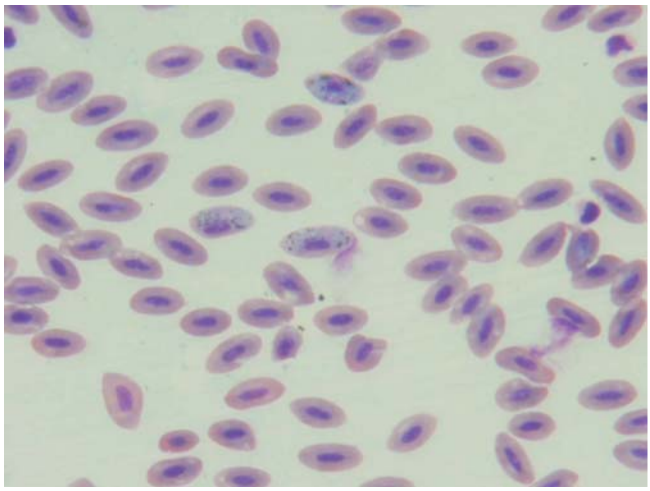

Figure 10.17. Haemoproteus sp. in blood smear.

10.5.3. Leukozytozoon

Malaria caused by *Leukocytozoon sp*. can be found in poultry as well as 100 other wild-living avian species. More than 70 species can be isolated mainly in juvenile birds [23]. In poultry and waterfowl, malaria caused by *Leukocytozoon sp*. is known as reason for serious diseases. In other avian species, the pathogenicity is not fully researched yet [3]. *Leukocytozoon* is the largest haemoparasite in birds [55].

Transmission occurs through the black flies of the family *Simulidae*. The schizogony happens in the liver parenchyma whereas the merozoites develop in erythrocytes to gametocytes. In contrast to *Plasmodium* and *Haemoproteus*, pigments are not produced by *Leukocytozoon sp*. [23]. Syncytia of the liver parenchyma gets released and ingested through phagocytosis in liver, spleen, heart, kidneys and brain. In these organs, megaloschizonts develop of up to 200µm and can contain millions of merozoites. The megaloschizonts get encapsulated through fibrotic tissue and macrophages, heterophils, plasma cells and red blood cells as host inflammatory response. Necrosis and calcification of megaloschizonts can happen. A direct correlation between the presence of megaloschizonts and the pathogenicity of *Leukocytozoon sp*. is present [3].

Leukocytozoon sp. infections cause severe anaemia [3]. Young raptors, turkeys, and waterfowl suffer from hemolytic anemia and hemogluburinemia [55]. In turkeys, pneumonia, lung congestion and blockage of alveolar capillaries can arise [55]. Other disease symptoms are inappetence, dyspnea, cough, diarrhea, infertility and high mortality [23]. Furthermore, necrosis of the liver, spleen enlargement, lymphocytic infiltration of liver and heart as well as haemosiderosis can be present [3].

10.5.4. Babesia

The piroplasm *Babesia* has 14 species. By invading the erythrocytes, trophozoites multiply by binary fission and form pairs or tetrads through schizogony. In Falconiformes and hereby especially saker falcons, *Babesia shortii* is considered as pathogenic *Babesia* species [46]. The transmission route is not fully clarified yet, but ticks like ixodid ticks are assumed to be the causative agents. Disease symptoms are cell destruction, jaundice and death. Through control of tick infestation, the disease can be prevented [41].

Differential diagnosis to *Plasmodium* and *Haemoproteus* shows that *Babesia* does not contain melanin pigment granules and a very distinctive white vacuole [41].

10.6. Emerging Diseases

10.6.1. Microsporidiosis Caused by Enterocytozoon Bieneusi

The divers groups of Microsporidians are eukaryotic, single-cell organisms closely related to fungi [52]. Microsporidians are intracellular parasites of vertebrates and invertebrates [58], but have been isolated from birds as well.

Enterocytozoon bieneusi has been reported in Germany in 2 out of 8 chicken examined. The genome sequencing revealed the genotype J [42]. Moreover, this microsporidian parasite was identified in 17 of 124 (13%) healthy pigeons examined in Spain, but the genotype was not identified [24]. Furthermore, in Portugal, *E. bieneusi* was recently detected in 24 of 83 (28.9%) faecal droppings from birds of the orders Columbiformes, Passeriformes and Psittaciformes [30]. A large microsporidian outbreak in falconiformes has been reported in the United Arab Emirates where 70 falcons were infected by *E. bieneusi* [38]. The pathological picture of the infected falcons revealed multiple yellowish 3-5 mm large plaques that were found mainly on the small intestine and colon (Figure 10.18, 10.19, 10.20, 10.21). On the liver (Figure 10.22, 10.23, 10.24) and kidneys (Figure 10.25), several yellowish foci of 1-5 mm diameter were identified. Lesions also occurred on pancreas and spleen. In an advanced stage, the infection leads to high mortality. The epidemiology indicates the lymphatic spreading of spore-infected macrophages from the gallbladder reservoir inducing proliferative serositis. No significant changes in hematological and biochemical blood parameters are symptomatic for this disease except that elevated white blood cell counts were detected in the majority of infected falcons. Underlying diseases like coccidiosis, aspergillosis and hepatopathy pave the way for microsporidian infections [38].

Figure 10.18. Early stage of intestinal E. bieneusi abscess.

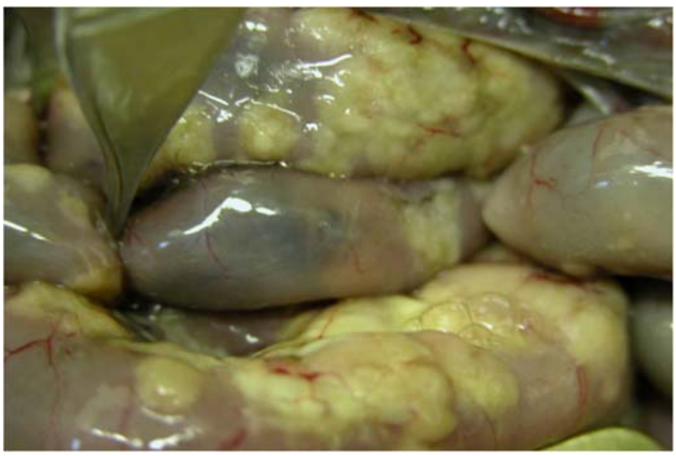

Figure 10.19. Advanced stage of intestinal E. bieneusi abscesses.

Figure 10.20. Advanced stage of intestinal E. bieneusi abscesses up to 3cm.

Figure 10.21. End stage of intestinal E. bieneusi abscesses

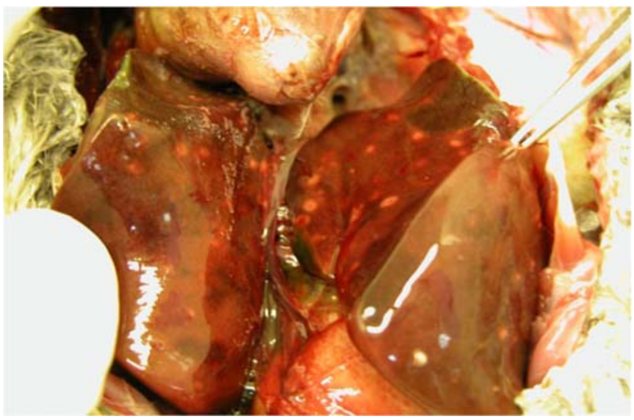

Figure 10.22. Early stage of E. bieneusi abscesses in liver.

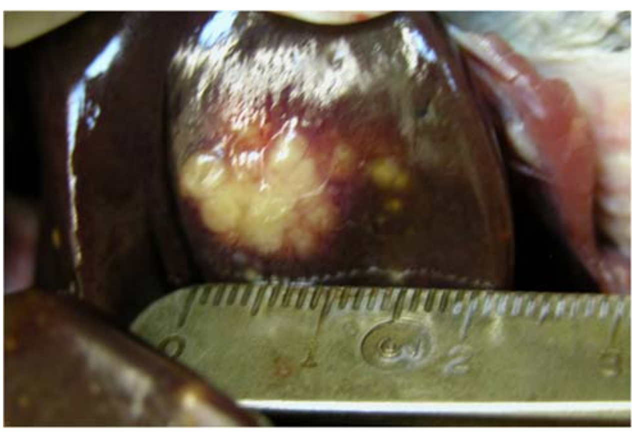

Figure 10.23. Advanced stage of E. bieneusi abscesses in liver.

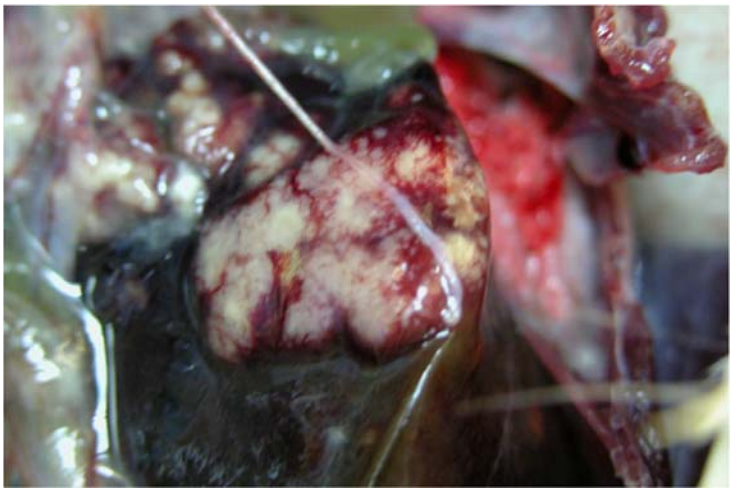

Figure 10.24. End stage of E. bieneusi abscesses in liver.

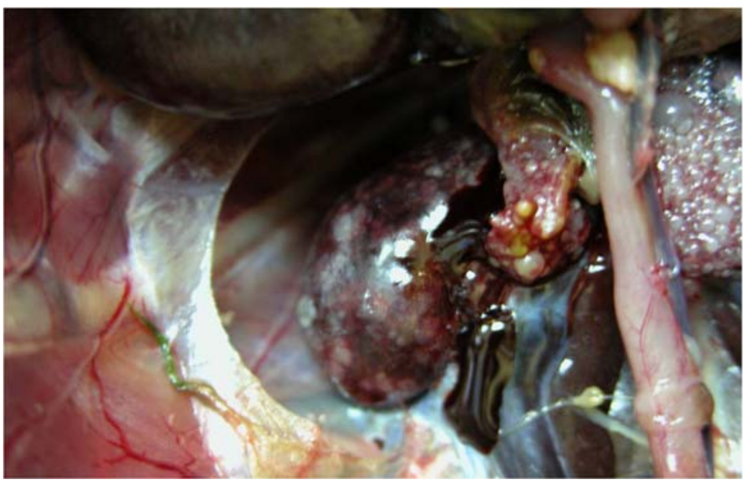

Figure 10.25. Advanced stage of E. bieneusi abscesses in kidney.

The histopathology findings included extensive thickening of the intestinal serosal surfaces. They were characterized by proliferation of mesothelial cells and nonsuppurative inflammatory cell infiltrate which involves all intestinal layers from the serosa to the mucosa. The liver lesions showed large areas with foamy hepatocytes and bile duct proliferation, fresh necrosis and microabscesses in the adjacent areas. On pancreas and kidneys, multifocal severe diffuse degeneration with pyogranulomatous inflammation, with most renal tubuli containing protein cylinders were found. Immunohistochemistry is another laboratory examination that can be performed for *E. bieneusi.* The examined liver, kidney and intestinal lesions were tested positive for microsporidian antigen in the immunohistochemistry. Microsporidian antigen was identified as brownish stained material in the cytoplasm of numerous cells in and around necrotic areas [38].

Detection of microsporidian stages in fecal samples might be difficult due to the small size (1-2 μm) in some species [6] which can make a reliable visualization by light microscopy difficult [17]. Fecal identification methods include simple salt flotation followed by cytospin and Giemsa staining [56] and PAS stain [6]. Another fecal staining method is Weber's chromotrope stain as well as Gram chromotrope-based stains [35, 60]. In recent years, microsporidia were detected through use of monoclonal antibody-based fluorescence assays [50] and multiplexed fluorescence in situ hybridisation (FISH) assay [15]. Other laboratory methods are transmission electron microscopy (TEM) [15] as well as in situ hybridization (ISH) on formalin-fixed, paraffin-embedded tissues [7]. Furthermore, molecular analysis through PCR has gained increasing importance in recent years for the detection of microsporidia as diagnostic method for in clinical samples and different protocols have been published [15]. The *E. bieneusi* specific PCR showed the typical 607 bp fragment for falcons being identical to the AF023245 strain isolated from a macaque and to the INDRE01, the AF024657 and the L16868 strain, all three isolated from AIDS patients [38]. Moreover, the typical abscesses can be seen during the endoscopic examination (Figure 10.27, 10.28, 10.29).

The route of microsporidian and *E. bieneusi* transmission is still not fully researched yet. Transmission is possible through contaminated chicken meat or water [42]. The spores can also contaminate water in areas with infected pigeons. This possibility of an air- and waterborne transmission route though infected pigeon faeces can cause infections in falcons as well [38]. However, the zoonotic potential of *E. bieneusi* is well-known [32]. *E. bieneusi* spores of infected urban pigeons' faeces can be aerosoled which might lead to an airborne transmission of humans. This infection of humans might arise through inhalation of 4 times higher *E. bieneusi* spores concentrations than potentially viable as well as by direct contact through oral mucosa and ingestion of the microsporidial spores [17, 24]. Moreover, a possible transmission from infected humans to birds could not be ruled out [38].

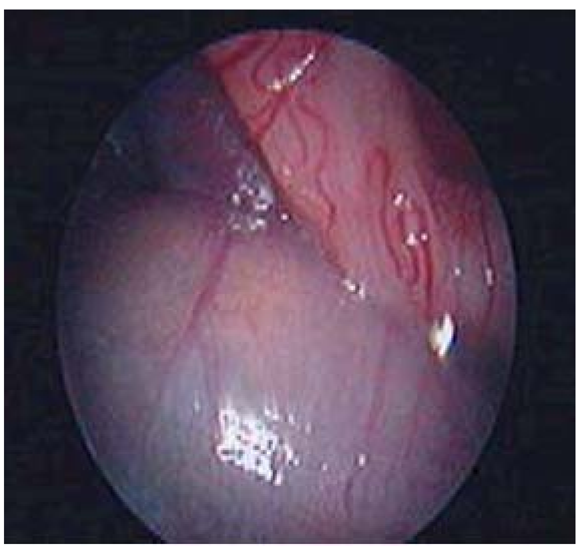

Figure 10.26. Endoscopic view of early intestinal E. bieneusi abscess before treatment.

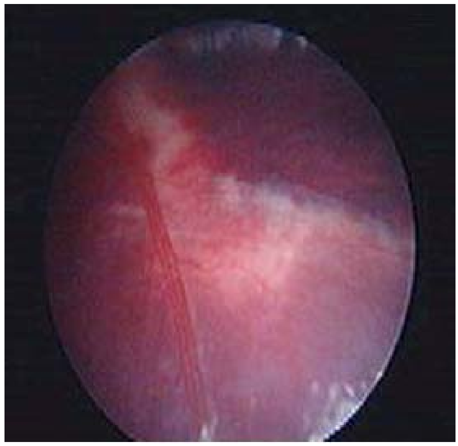

Figure 10.27. Endoscopic view of E. bieneusi abscess in liver before treatment.

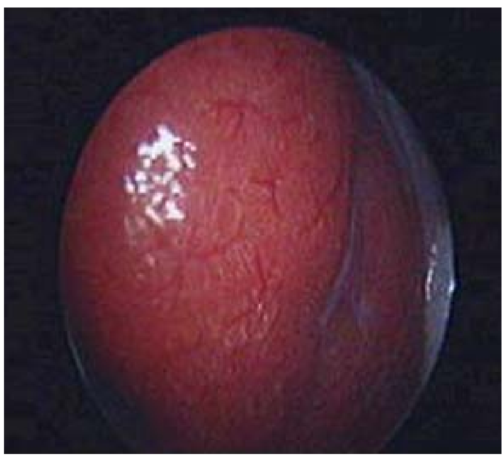

Figure 10.28. Endoscopic view of E. bieneusi abscess in kidney before treatment.

Figure 10.29. Endoscopic view of intestinal E. bieneusi abscess after treatment.

Treatment of E. bieneusi in falcons was performed with dimetronidazole 50mg/kg p.o. once daily for 10 days. Falcons with intestinal abscesses were treated after one week rest again with dimetronidazole in the same dosage for another 10 days. The abscesses showed a gradual regression following the treatment course until complete disappearance (Figure 10.29, 10.30, 10.31). The application of probiotics after the end of the treatment period helps to restore the damaged intestinal flora. Underlying diseases have to be treated as appropriate. The complete treatment protocol for *E. bieneusi* infections in falcons is as follows (table 10.1) [37].

Figure 10.30. Endoscopic view of E. bieneusi abscess in liver after treatment

Figure 10.31. Endoscopic view of E. bieneusi abscess in kidney after treatment.

Table 10.1. Medication for Enterocytozoon bieneusi infections in falcons [37]

Drugs	Application mode and frequency	Day 1-10	Day 11-17	Day 18-27	>Day 27
Emtryl®	50mg/kg p.o. 1 x d AM	Yes	No	yes	If required, after 7 days break another 10 days treatment
Nux vomica®	1.0ml sc 1 x d AM	Yes	Yes	yes	Yes if required
Mucosa compositum®	1.0ml sc 1 x d AM	Yes	Yes	yes	Yes if required
Hepar compositum®	1.0ml sc 1 x d AM	Yes	Yes, if required	Yes, if required	Yes if required
Legalon®	1 tabl 5 x d AM, PM	Yes	No	no	no
Berberis compositum®	1.0ml sc 1 x d AM	Yes	Yes, if required	Yes, if required	Yes if required
Cantharis compositum®	1.0ml sc 1 x d AM	Yes	Yes, if required	Yes, if required	Yes if required
Hartmann's solution®	40-60 ml sc 1 x d AM	Yes	Yes	Yes, if required	Yes if required
NaCl and Glucose®	10 ml iv 1 x d AM	3-5 days	No	no	no
Baycox®	0.7ml/1kg BW, 1 x d AM	3 consecutive days	If Caryospora still present, another 3 d	no	no
Spark®	1 spoon over the food 1 x d	Yes	Yes	yes	no
Probiotics®	1 spoon over the food 1 x d	No	No	no	yes

10.6.2. Cryptosporidia

Cryptosporidiosis is a parasitic protozoan disease of the phylum *Apicomplexa* that is regarded as one of the most prevalent infections in more than 30 species of domestic, wild, cage and pet birds [13, 51]. In gyr-saker hybrid falcons, cryptosporidiosis with *C. baileyi* has been reported [57]. Moreover, a case of cryptosporidiosis with *C. parvum* in juvenile gyrfalcons has been observed [43]. Chicken, quails, ducks, turkeys, geese, pheasant as well as ostriches and swans are among the species that can be affected. Finches, cockatiels, macaws, budgerigars and canaries had reported case of cryptosporidiosis [13]. In avians, three main species can be found, namely *C. baileyi*, *C. meleagridis* and *C. galli*. Their life cycle develops from unsporulated oocysts, young schizonts, mature schizonts to sporulated schizonts. This leads to longtime survival of the oocysts [13]. In contrast to other coccidian species, the *Cryptosporidium* oocysts are immediately infective [40].

Although cryptosporidiosis infects mainly the intestinal tract, renal and respiratory *Cryptosporidium* infections have been diagnosed. The main clinical symptoms for enteric cryptosporidiosis are diarrhea and enteritis. Respiratory infections show unspecific signs like coughing, sneezing and even dyspnea whereas renal cryptosporidiosis leads to enlarged and pale discolored kidneys [13]. In gyr-saker falcons, respiratory symptoms like laryngeal stridor, epiglottal swelling, nasal discharge and sneezing had been observed. Moreover, in a gyrfalcon, anorexia, respiratory problems and bilateral ocular discharge and conjunctivitis has been reported [43]. However, no enteric signs were found in those falcons [57].

The treatment of cryptosporidiosis in avians poses considerable challenges as most anticoccidial medicines are not very effective especially against enteric and renal infections [13]. The treatment in falcons seems to be still not unified. In a juvenile gyrfalcon, paromomycin was administered successfully [43]. However, in gyr-saker falcons, paromomycin and azithromycin had been tried as medicines against cryptosporidiosis, but this treatment approach failed [57]. This treatment outcome might be due to the different *Cryptosporidium* species.

Moreover, another *Cryptosporidium*, *C. parvum*, is commonly found in humans with special significance in immunosuppressed humans, but it has been detected in immunocompetent humans as well [61]. The genome structure of *C. parvum* differs from other eukaryotes as its sequencing revealed that the mitochondria do not seem to contain DNA [2]. Being the most important contaminant in drinking water in the USA, its oocysts contaminate 90% of the surface water in the U.S. [13]. Cryptosporidiosis can cause massive lethal outbreaks like in Milwaukee with 403,000 deaths [31]. It was also possible in clinical studies to inoculate Peking ducks (*Anas platyrhynchos*) where the parasite was shed in infective stages. This raises concerns about the epidemiological potential of this parasite in human hosts as well as its zoonotic potential [17]. These concerns are supported by the finding that waterfowl is able to act as mechanical carriers of *C. parvum* by disseminating infectious oocysts in the environment [13]. Another avian specific *Cryptosporidium* species, *C. meleagridis*, has also zoonotic potential and is known to infect humans [63]. Furthermore, one case of an AIDS patient infected with *C. baileyi* has been reported [9]. As both species, *C. meleagridis* and *C. baileyi*, have been isolated in cockatiels, it raises even more concerns of possible avian-to-human disease transmission due to the close relationship between pet birds and their owners [1].

However, it seems to be highly likely that a much larger diversity of *Cryptosporidium spp*. exist in humans, mammals and avians [62]. This raises the questions to what extent further zoonotic potential exists and what further epidemiological interactions might not have been identified yet.

10.6.3. Mosquito-Borne Parasitoses

West-Nile Virus

An arthropod borne virus (arbovirus) is the West-Nile Virus (WNV) which belongs to the genus Flavivirus and family Flaviviridae. Its first detection was in the eastern part of the United States in 1999 from where it spread quickly to the western regions. Transmitted mainly by mosquitos the WNV has been reported to affect more than 325 avian species, among them magpies, jays, crows, birds of prey as well as psittacines [49].

Clinical symptoms of the West-Nile Virus infection in psittacines include general symptoms like ruffled feathers, lethargy, anorexia, depression, weight loss and sudden death. The gross post necropsy results only revealed atrophy of the pectoral muscles as well as mild to moderate liver and spleen enlargement. However, the histopathological changes are more obvious with myocarditis, nonsuppurative interstitial nephritis, hepatitis, spenitis, enteritis, pancreatitis and in few cases encephalitis [49].

10.7. Conclusion

Parasitic diseases have been known in avian medicine since longtime. Causing major symptoms in debilitated, immuno suppressed and weak birds, it is highly important to keep birds healthy and enhance the immune system. Moreover, new parasitic diseases have recently emerged that had not been identified in birds before. This leads to the assumption that a wider range of parasitic diseases of other animal species or even humans might have to be taken into consideration as causative parasitic agents in birds from now on. It can be expected that new parasitic diseases will be detected in the coming years due by enhanced diagnostic methods like molecular diagnostics and sequencing.

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Chapter XI

Fungal Diseases

Abstract

Fungal diseases like aspergillosis and candidiasis are among the most common infectious diseases in falcons. Especially the fungal disease aspergillosis has been a nightmare for falconers and falcon owners for decades. As in some cases aspergillosis can develop very rapidly, great care has to be taken to seek early diagnosis. Several predisposing factors contribute to the development of this fungal disease. A new aspergillosis classification has been developed and the respective treatment has been explained in detail.

11.1. Introduction

Fungal diseases like aspergillosis have been frequently found in wild birds that were kept in captivity, but also other captive-bred species. Gyrfalcons and gyr-hybrid falcons are very susceptible to aspergillosis. Wild birds are not affected by this disease to a great extent. However, they may get infected in cases of poor general condition or anorexia. This chapter gives an overview about the etiology and disease transmissions.

A strong emphasis was laid on the identification and diagnostic tools for aspergillosis. This chapter takes a critical outlook on the current classifications of aspergillosis and on medicines currently used for aspergillosis. Moreover, a new classification derived from the endoscopic examination results have been developed and is explained in details. This new classification covers new, active, old and syringeal aspergillosis.

According to this new classification, the treatment approaches have been developed according to each new class. General information about aspergillosis prevention has been included in this chapter. Moreover, other fungal diseases like candidiasis have been covered in this chapter as well.

11.2. Aspergillosis

11.2.1. Etiology, Distribution and Transmission

Aspergillosis is one of the most common and feared infectious diseases in Falconiformes. The main susceptible species are gyrfalcons [6], gyr-saker falcons and gyr-peregrine falcons. Saker and peregrine falcons can be affected as well, but to a far lesser extent. Apart from falcons, other raptors can get infected as well, but there are major species differences regarding the susceptibility to aspergillosis. Highly susceptible raptors species are rough-legged buzzard (*Buteo lagopus*), golden eagle (*Aquila chrysaetus*), osprey (*Pandion haliaetus*) [4]. Lesser susceptible are prairie falcons (*Hierofalco mexicanus*) [4], immature red-tailed hawks (*Buteo jamaicensis*), snowy owls (*Nyctea scnadiacea*) and goshawks (*Accipiter gentilis*) can get infected by aspergillosis as well [6]. A higher susceptibility to aspergillosis can be observed in falcons from colder arctic regions [7] like gyrfalcons due to their low immune status and reduced ability to fight against external germs.

Aspergillosis can be caused by a wide variety of *Aspergillus spp*. However, the most common causative agent is *A. fumigatus* (Figure 11.1). Other species are *A. terreus*, *A. flavus* (Figure 11.2) [7] and *A. niger* (Figure 11.3, 11.4).

Aspergillosis can be detected either as system mycosis (Figure 11.5) [3] or localized mycosis especially in the syrinx (Figure 11.6) [7]. Its transmission route is orally though inhalation of fungal spores. Those fungal spores can be found widely distributed in the environment. However, if the avian organism has a good immune system, the infection may not occur. In cases of heavy spore load, the bird can get infected through the high number of spores. Moreover, aspergillosis may arise in cases of reduced immune system through predisposing factors even if lower numbers of spores are prevalent [7].

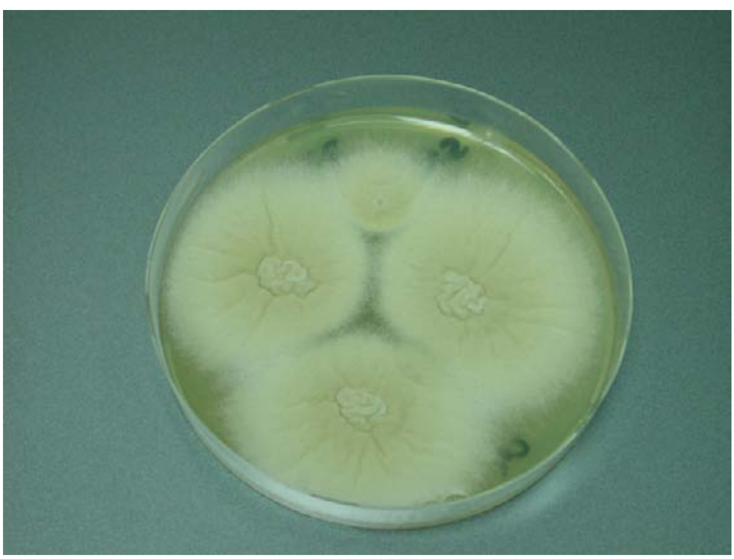

Figure 11.1. Aspergillus fumigatus.

Figure 11.2. Aspergillus flavus.

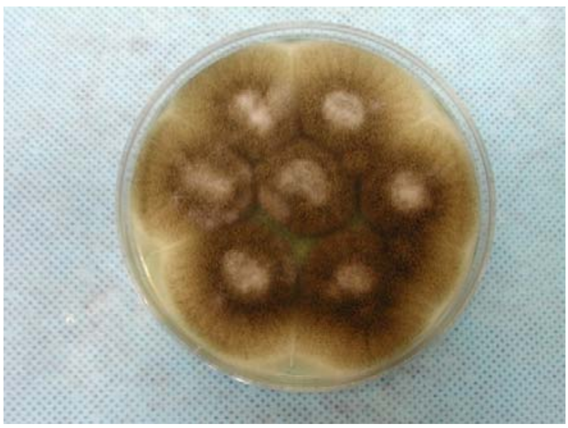

Figure 11.3. Aspergillus niger.

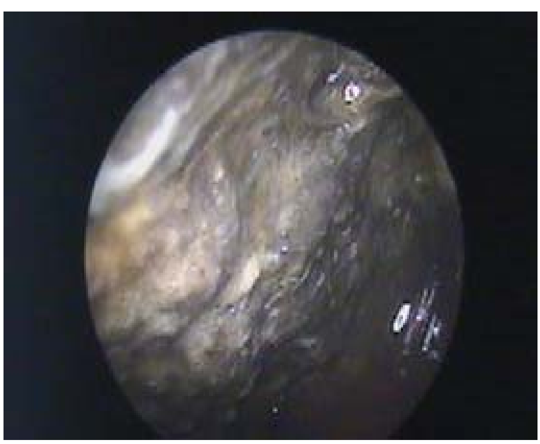

Figure 11.4. Aspergillus niger covering complete lateral thoracical airsac (endoscopic view).

Figure 11.5. End stage Aspergillosis caused by A. fumigatus covering complete airsacs (Post mortem).

Figure 11.6. Syringeal Aspergillosis leading to tracheal stenosis (Post mortem).

Predisposing factors include recent capture, change of ownership [7], stress, extensive training and exercise, long travels and change of environment, poor ventilation [7] as well as not properly cleaned and disinfected air-conditions can also pave the way to *Aspergillus* infections. *Aspergillus* spores accumulate in air-condition ducts and outlets from where they get distributed all over the rooms or pens of birds. Falcons with previous long-term treatment with antibiotics can get easier infected with aspergillosis, too.

Other predisposing factors might be lead intoxications, neonatal and geriatric conditions [7]. Furthermore, falcons also can get infected if an *Aspergillus* contaminated environment exists close by to the falcon cages. These can be farms with *Aspergillus* spores on their premises that get distributed through the wind to adjacent outside located falcon cages. Those falcons then get exposed to the high number of *Aspergillus* spores. Moreover, climatic conditions like very rainy, humid and very hot weather can be predisposing factors for the development of aspergillosis. In the Abu Dhabi Falcon Hospital, a sharp rise in aspergillosis cases of newly imported first year falcons have been observed during routine pre-purchase examination when the summer in Europe has been either very rainy or extremely hot.

11.2.2. Identification

Different ways to identify aspergillosis have been described. They range from clinical symptoms, ELISA antibody tests, tracheal cultures or washes on Sabouraud's dextrose agar, airsac washes, blood hematology to endoscopy and radiography [7]. However, the most useful diagnostic tool is the endoscopic examination due to various reasons. Firstly, clinical symptoms will not show in the beginning stages of the infection. They will only get manifest in a more advanced stage of the disease and should therefore be taken seriously with immediate endoscopic examination and subsequent treatment. Secondly, the ELISA testing method is not species-specific for falcons and should not be used as independent diagnostic tool. The danger of false positive or negative results cannot be ruled out as well. Moreover, even the positive ELISA test will not indicate the stage of the disease thus making appropriate treatment regimes difficult. Thirdly, cultures of airsac or tracheal samples do not give information about the extent and distribution of the disease and valuable time might get lost until the culture is grown. Blood hematology does not correlate with the actual stage of the disease in most cases. Despite the fact that in literature frequently elevated white blood cell counts, heterophilia and monocytosis are regarded as main indication for aspergillosis [7], the observation in the Abu Dhabi Falcon Hospital does not support these findings. In many cases of active and more advanced *Aspergillus* granulomas, no changes in the hematological picture can be observed. Moreover, highly elevated white blood cell counts and heterophilia can be indicative for bacterial infections like *Pseudomonas aeruginosa* infections or *E. coli* septicemias, too. Those differential diagnoses should be always taken into consideration. Therefore, hematology should not be regarded as diagnostic tool for aspergillosis. Radiographs do not give any information about early disease stages and should be regarded with caution as diagnostic tool for aspergillosis. They do not provide information about treatment progress and success as well. However, radiography is a helpful tool to assess more advanced diseases stages due to the visualization of the extent of aspergillomas in the airsac.

Endoscopy can be regarded as gold standard in the diagnostics of aspergillosis. However, the endoscopic examination should ideally be performed as soon as possible after the first disease symptoms may arise and not be proceeded by general screening, ELISA, culture and hematology [7]. Any time delay in diagnosing aspergillosis may result in a massive spreading of the disease and thus make treatment more difficult. Routine endoscopic examination as part of pre-purchase examination [5] revealed that in new first year falcons that came directly from the breeders, 20% suffered from aspergillosis without showing any clinical symptoms. Those results are alarming as if they had not been examined in an early stage of the disease with excellent treatment prospects, those falcons would have remained undetected until the appearance of clinical symptoms and therefore reduced treatment chances. Moreover, it is highly important to use a camera when performing endoscopy as without camera, both lung ostia and bronchi cannot be seen and evaluated correctly. As *Aspergillus* lesions can be found in the lung ostium without any other *Aspergillus* lesions in the airsacs, the use of endoscopy without camera might lead to false negative results of the examination. Tracheal endoscopy plays an important part in diagnosis as well, although it is not part of a routine examination. In any case of either sound change, breathing difficulties or large and invasive *Aspergillus* infections, the trachea should be examined with the endoscope. Other diagnostic tool like hematology or radiography can be used as additional information after performing endoscopy.

11.2.3. Symptoms and Clinical Manifestation

Well-known to every falconer, the most prominent symptoms of aspergillosis are heavy breathing, reduced flight ability, inappentence, anorexia and green fecal. However, those symptoms describe the advanced stage of the disease as often early aspergillus infections remain unnoticed. Both, the upper respiratory and lower respiratory tract can be affected by aspergillosis. The lower respiratory infection of airsacs and lungs is regarded as location of more serious infection [7].

Different classifications for aspergillosis had been established. 4 different *Aspergillus* forms have been described in literature [6]. The first form is an acute aspergillosis with miliary infections in the lung parenchyma. This form is caused by high number of spores and reduced immune system. The second form is a chronic aspergillosis form A where the fungus grows in the body cavities. This form derives from moderate number of spores, but entirely suppressed immune system. The other chronic form, form B, leads to massive aspergillomas in the lung parenchyma and airsacs caused by moderate environmental contamination but hypersensitivity of B-and T-cells. The fourth form is a localized form in skin, esophagus and trachea. This form develops in a moderately contaminated environment and functioning immune system, but reduced local immune resistance.

Another classification of four aspergillosis classes goes in line with the disease prognosis and therapeutic perspectives [7]. The first class shows vague unspecific disease symptoms with either no endoscopic examination performed or inconclusive endoscopic results. The prognosis in this class I is excellent. Class II states the presence of clinical signs like respiratory difficulties and endoscopic visible lesions or vascularized airsacs. Full treatment results in fair to good prognosis. Severe clinical symptoms like dyspnea, vomiting, anorexia, weight loss lead to class III. Hereby, the endoscopic and radiographic examination reveals clearly visible lesions and prognosis is poor. Syringeal aspergilloma is classified as class IV with excellent prognosis in case of removal of the aspergilloma.

11.2.4. New Aspergillosis Classification

The author believes that a classification of aspergillosis makes sense, but should be derived from the development stage of the aspergillus lesions and granulomas themselves under integration of disease symptoms. This will lead to specific treatment approaches and subsequently to prognosis.

Aspergillosis can be divided into new aspergillosis, active aspergillosis and old aspergillosis. The active stage can be subdivided into early stage, advanced stage and end stage of the disease. Syringeal aspergilloma forms a special form of the disease.

11.2.4.1. New Aspergillosis

The endoscopic examination reveals the earliest stage of aspergillosis with small, mucoid *Aspergillus* lesions without visible hyphae which are just a few days old (Figure 11.7). They can be localized e.g. in the lung ostium or lung parenchyma or more widely distributed on the lungs, airsacs and the body wall. Increased vasculaization of airsacs might still be absent or might be already localized or covering larger parts of the airsacs. The liver has not been affected yet. Radiography is negative in this stage.

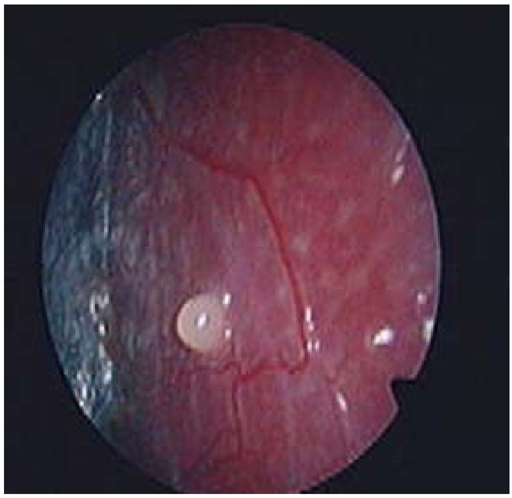

Figure 11.7. New Aspergillosis – mucoid Aspergillus lesion.

11.2.4.2. Active Aspergillosis

Active Aspergillosis – Early Stage

The endoscopy shows clearly visible whitish *Aspergillus* lesions on airsacs, lungs and/or body wall. Cytology of the lesions can be performed during endoscopy to verify fungal hyphae under the microscope (Figure 11.8). The lung ostia can be partly affected, but not fully blocked yet. Those lesions might be present with clearly visible hyphae thus showing the typical "cottonball" picture. However, they are still small in size (Figure 11.9). Increased vascularization of airsacs might be already visible in localized form or covering larger parts of the airsacs. The liver has not been affected yet. Radiography does not show these lesions yet. No disease signs or mild unspecific disease symptoms like reduced flight ability or reduced appetite might be present.

Active Aspergillosis – Advanced Stage

Larger aspergillomas can be found in the airsacs during endoscopic examination. They might still show the typical "cottonball" appearance with hyphae or are more advanced already (Figure 11.10). Aspergillomas can be found blocking the lung ostia either to more than 2/3 (Figure 11.11) or fully, sometimes associated with yellowish mucous (Figure 11.12).

The liver shows brownish or dark discoloration, sometimes with blackish discolored interstitial tissues and might be enlarged.

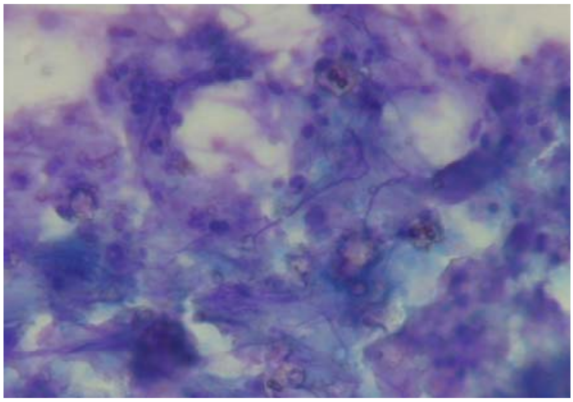

Figure 11.8. Fungal hyphae in cytology sample.

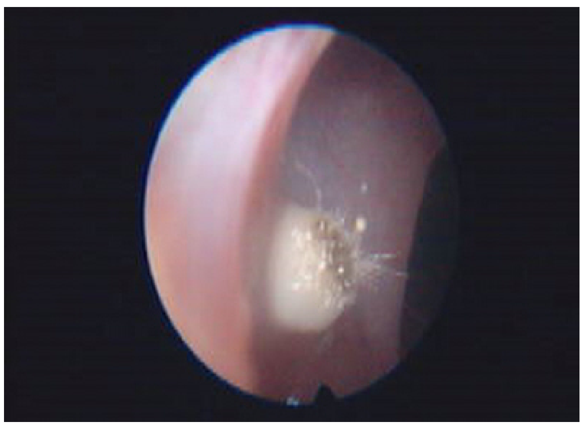

Figure 11.9. Active Aspergillosis – early stage.

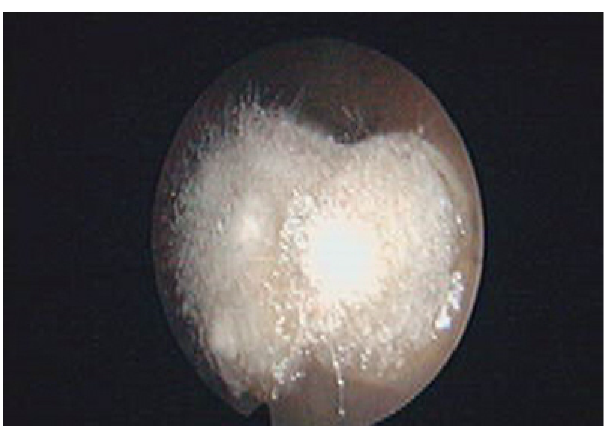

Figure 11.10. Active Aspergillosis – advanced stage.

Figure 11.11. Aspergillosis in lung ostium and bronchi.

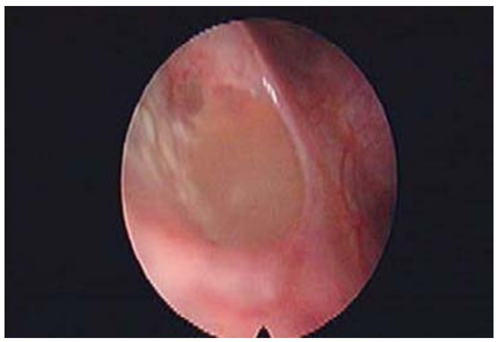

Figure 11.12. Lung ostium blocked with aspergillosis associated with yellow mucous.

Figure 11.13. Radiography active Aspergillosis advanced stage.

Radiographic results show clear shadows or granulomas in the airsacs (Figure 11.13) and hepatomegaly if present. The airsacs might be cloudy or highly vascularized. Clinical signs include breathing difficulties, sometimes abdominal pumping while breathing, poor flight performance, reduced appetite, weight loss, inactivity and green colored urates.

Active Aspergillosis – End Stage

In the final stage of Aspergillosis, the endoscopic results show that large parts of the airsacs, lungs and body wall are covered with large whitish or yellowish *Aspergillus* lesions (Figure 11.14). The liver may not be visible anymore as it might be covered with *Aspergillus* lesions. In those cases, where the liver is still visible, very dark to blackish discoloration as well as hepatomegaly can be present. Radiography reveals the blocking of the airsacs and possible hepatomegaly (Figure 11.15). Clinical symptoms include heavy breathing, considerable anorexia, vomiting and dark green urates. The falcon is unable to eat and fly.

Figure 11.14. Active Aspergillosis – end stage.

Figure 11.15. Radiography Active Aspergillosis end stage.

11.2.4.3. Old Aspergillosis

Aspergillomas can get vascularized and encapsulated following successful treatment. Moreover, in the case of untreated vascularized and encapsulated aspergillomas (Figure 11.16), the avian immune system was strong enough to fight against the *Aspergillus* infection by itself without treatment. In the endoscopic examination, often old vascularized and encapsulated *Aspergillus* lesions with transparent adhesions (Figure 11.17) and spidernet-like looking lesions (Figure 11.18) in airsac and on body wall are visible. The same can be found in the lung ostia. Those old aspergillomas do not cause problems for falcons and may remain in the same form for years. In this case, the falcons can be used for hunting for many years. In many cases, no new aspergillus infections arise later on. However, if predisposing factors are present, the infection with a new aspergillosis might be possible.

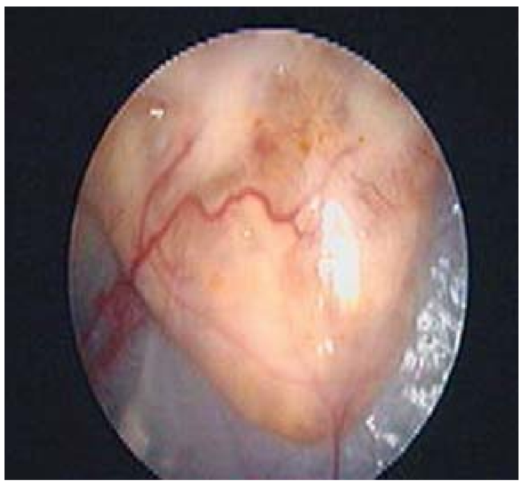

Figure 11.16. Old Aspergillosis untreated.

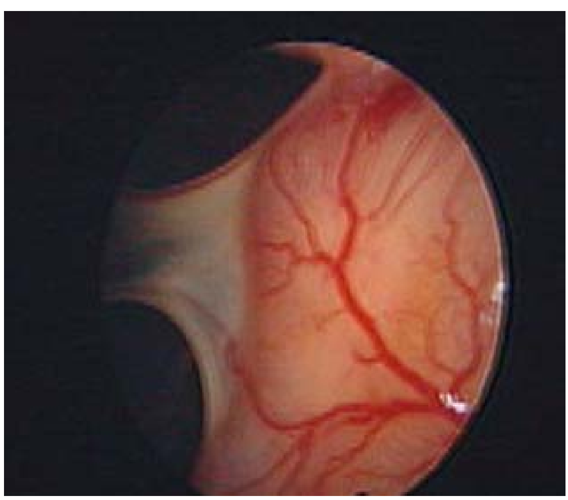

Figure 11.17. Old Aspergillosis with transparent adhesions.

Figure 11.18. Old Aspergillosis with spidernet lesions.

Therefore it is advisable to control the extent of the old aspergillomas twice per year as a part of a routine examination. Moreover, it is highly recommended not to remove those old *Aspergillus* lesions. While grabbing those aspergillomas with a biopsy forceps, it can happen that during this removal process the capsule gets damaged and still active *Aspergillus* spores may be found in the inside of the lesion. Those active spores can than re-infect the falcon.

11.2.4.4. Syringeal Aspergillosis

Syringeal aspergillosis can be found either unilateral or bilateral at the *Bifurcatio tracheae*. This is the place where the trachea divides into the main bronchi and the so-called *Pessulus* of the syrinx, the avian voice apparatus, can be found (Figure 11.19). The main bronchi can be either partly or completely closed. This leads to symptoms like changes in the voice, massive breathing problems, whistling sound from the trachea and opening of the beak to inhale more air. In very rare cases, *Aspergillus* lesions can be found after the trachea opening and glottis or in the cranial third of the trachea.

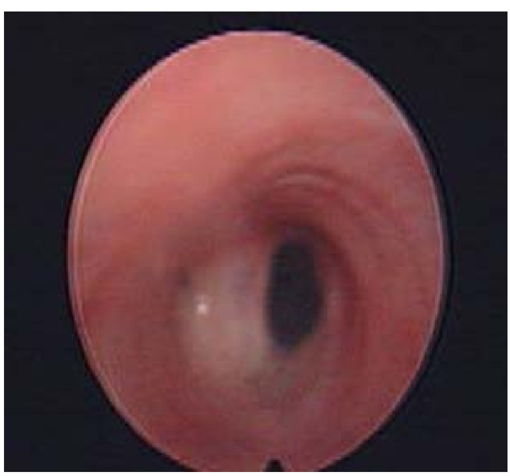

Figure 11.19. Aspergilloma in bifurcatio tracheae.

11.2.4.5. Cutaneous Aspergillosis

Mycotic infections with *Aspergillus sp.* of the avian skin will be discussed in detail in chapter 9.

11.2.5. Therapy

The treatment of aspergillosis depends largely on the extent of the disease and its location. Moreover, in most recommended literature about therapeutic approaches of aspergillosis, the treatment focuses exclusively on the aspergillosis itself without taking into consideration the hepatotoxicity of antifungal medicines and the damage of the liver in more advanced disease stages due to the *Aspergillus* toxins. The treatment of aspergillosis has to be considered as complete therapeutic protocol including liver protection therapy and if required kidney protection. Other underlying diseases like e.g. coccidiosis, dehydration, have to be treated accordingly.

A routine endoscopy to review the treatment progress should be undertaken every 2-3 weeks until the treatment is finished. Moreover, in cases of increased blood parameters, the initial blood sample should be repeated after one week. In those cases without any major changes in the blood hematology and biochemistry, routine blood sampling should be performed every two weeks as a routine. This helps not only to monitor the white blood cell counts and heterophil counts, but also to evaluate the liver and kidney parameters. This is highly essential as during the prolonged treatment, increases in those parameters might be observed and then the medicines have to be adjusted accordingly.

A large variety of different aspergillosis treatment protocols have been described with itraconazole, fluconazole, clotrimazole, enilconazole, ketoconazole, 5-flourocytosine, amphotericin B [7] and voriconazole [2]. Voriconazole has recently found its way into avian aspergillosis treatment. Despite the fact that it is recommended as application once daily [2], recent research suggest that one dose per day is not sufficient to maintain the pharmaceutical concentration and repeated doses have to be administered [8]. Moreover, it is very well-known in humans that voriconazole is hepatotoxic [1]. Cases of falcons that developed advanced hepatomegaly following voriconazole treatment were observed in the Abu Dhabi Falcon Hospital. Moreover, treatment duration is not shorter than treatment with other antifungals, but more expensive due to the high costs of voriconazole.

Itraconazole is still a widely used treatment and well accepted by falcons. The therapeutic regime has to be established according to the stage of the disease. A general treatment approach is the use of itraconazole orally for 3-6 (8) weeks supported by antibiotics in the first 1-2 weeks. Inhalation therapy through nebulisation with enilconazole is enhancing the therapeutic success and recommended (Figure 11.20, 11.21). In cases of syringeal aspergilloma or very fast growing active aspergillosis, amphotericin B is highly useful as it has fungicidal effects. Unfortunately, it is not available anymore in all countries and there is no equally effective replacement for it. Liver protection therapy is given throughout the treatment period.

Often forgotten, but essential part of the aspergillosis treatment and prevention treatment is the proper cleaning and disinfection of the rooms or cages where the falcons are kept.

Figure 11.20. Nebulisation box for inhalation therapy.

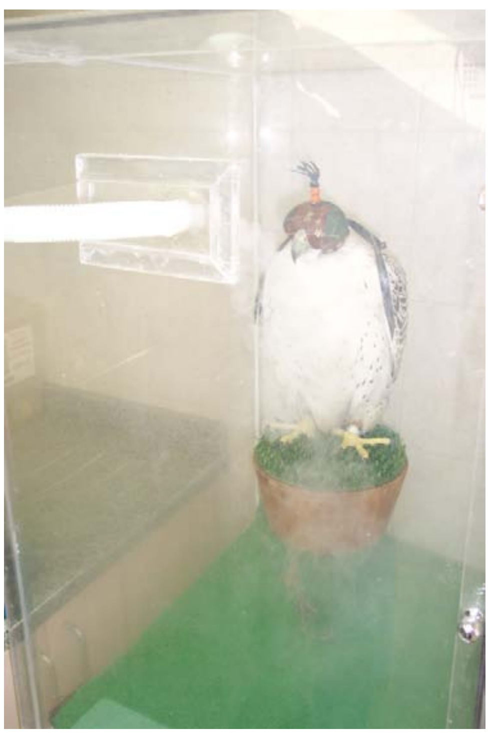

Figure 11.21. Falcon during inhalation therapy.

This has to include air-condition or ventilation outlets and ducts *Aspergillus* spores can get easily distributed by being blown out of air-conditions or ventilations. Moreover, a routine facility screening for fungal organisms and not only bacterial organisms is a helpful control measure to assess the spore load of the facility. Furthermore, possible contaminants should be searched in the falcon's facility and closer environment of the rooms and cages as the best treatment will not help if the source of the infection is not eradicated.

Falcons suffering from aspergillosis should be kept separately from other birds during the complete treatment period to avoid any possible contamination among the birds.

Good food with vitamins and fresh water is helpful to support the overall conditions of the falcon. The daily weight taking is a must for falcons suffering from aspergillosis to assess their condition and to readjust the medicine dosage if necessary.

11.2.5.1. Treatment of New Aspergillosis

Removal of mucoid lesions with the biopsy forceps during the endoscopic examination is useful and reduces the treatment duration.

Cases of new aspergillosis can be treated with itraconazole for 2-3 weeks. Antibiotics can be given if a vascularization of the airsacs has increased already. Antibiotic coverage with marbofloxacin can be administered intramuscularly for 8-10 days. If the falcon is treated in a hospital or clinic, inhalation therapy with enilconazole can be applied once per day for 20 minutes. Moreover, fluid substitution with lactated Ringer's Solution or Hartmann's Solution subcutaneously per day can be performed.

The prognosis in these cases is very good to excellent.

11.2.5.2. Treatment of Active Aspergillosis

Active Aspergillosis – Early Stage

In cases of single active Aspergillomas, removal with the biopsy forceps during the endoscopic examination is a helpful tool to reduce the treatment duration and to reduce the spore burden inside the lungs and airsacs (Figure 11.22). It is also helpful to remove *Aspergillus* lesions inside the lung ostia, if present, as they usually grow very fast and may lead to a blockage of the ostia. However, great care should be taken not to damage the lung tissue and not to enter to deep into the bronchi.

Moreover, cases of active aspergillosis in an early stage can be treated with itraconazole for 3-4 weeks. Antibiotics like marbofloxacin for 8-14 days intramuscularly support the antifungal therapy and clear up the airsacculitis. If the falcon is treated in a hospital or clinic, inhalation therapy with enilconazole is applied 2-3 times per day for 20 minutes. Liver protection therapy is useful. Moreover, fluid substitution with sodium lactate solution subcutaneously per day can be performed. In cases of dehydration, the kidney function can be supported. This can be administered until a satisfying rehydration has been achieved and Urea and UA levels in the blood chemistry have returned to normal values. Moreover, it is helpful to support the avian immune system with immune stimulants. A good recovering of the damaged airsac and lung tissue can be achieved with special homeopathic remedies acting on the airsac mucosa.

The prognosis for the early stage of active Aspergillosis is good.

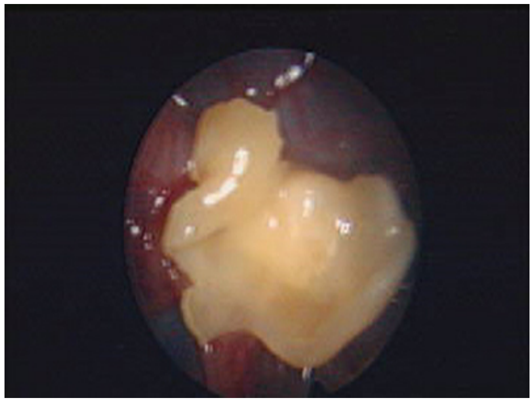

Figure 11.22. Active Aspergillosis – early stage for endoscopic removal.

Active Aspergillosis – Advanced Stage

In cases of the advanced stage of an active aspergillomas, removal with the biopsy forceps during the endoscopic examination might not be possible anymore. However, a partial removal especially in lung ostium and of "cottonball" lesions can be regarded as useful to support the treatment. Surgical debulking of the aspergillomas through explanatory surgery has been described in literature [7], but remains questionable as being too invasive in the author's view.

Treatment of cases of active aspergillosis in an advanced stage includes the administration of itraconazole for 4-6 weeks. In some cases, the therapy has to be prolonged to 8 weeks. In severe cases, initial treatment with amphotericin B can be started intravenously for up to 3 consecutive days. Antibiotics like marbofloxacin for 10-14 days i.m. support the antifungal therapy and clear up the airsacculitis. Inhalation therapy with enilconazole is applied 3 times per day for 20 minutes. Routine endoscopy after 2 weeks usually reveals yellowish colored aspergillus lesion. If routine endoscopy after 2 weeks reveals that no major improvement has taken place, the nebulisation with enilconazole can be replaced with amphotericin B. However, due to the renal and hepatic toxicity of amphotericin B, the falcon has to be monitored closely regarding its blood biochemistry values and dehydration status. Liver and kidney protection therapy as well as fluid substitution is useful in cases of lighter liver damage. Further supportive therapy is the same as mentioned above.

The prognosis for advanced stage of active aspergillosis is fair.

Active Aspergillosis – End Stage

In cases of active aspergillosis in an end stage the treatment prospects have to be discussed with the owner as the chances for the bird are extremely bad and sometimes the cases are hopeless due to the massive liver damage and aspergillomas blocking the lungs and airsacs. A removal of aspergillomas does not does not have very successful prospects as the amount of aspergillomas is too much. The treatment is the same as in the case of advanced active aspergillosis. However, the duration of the treatment can take up to 8 weeks.

The prognosis for the end stage of active aspergillosis is poor to very poor in cases of advanced liver damage. In most cases, falcons die due to liver failure caused by the

Aspergillus toxins. In those cases where absolutely no hope for a successful treatment is given and the liver is fully damaged and the airsacs and lungs are entirely blocked already, euthanasia of the falcons should be considered as being more favorable and humane than to prolong the suffering of the bird.

11.2.5.3. Treatment of Syringeal Aspergillosis

Syringeal aspergillomas can be diagnosed during tracheal endoscopy. Often sound changes or heavy breathing through open beak can be observed. In cases of bilateral stenosis, a removal of the aspergilloma has to be performed immediately as otherwise the falcon might suffocate. An incision of the lower trachea close to the syrinx has been described [7], but seems too invasive in the author's opinion. A less invasive non-surgical method is the removal of the aspergilloma through biopsy forceps (Figure 11.23). Hereby the bird and its head need to be held in very straight position by an assisting person while the surgeon enters into the trachea with the biopsy forceps attached to the endoscope under camera view. Great care has to be taken that the falcon has been deeply anestathized before the procedure starts to avoid any movement of the bird. The tip of the biopsy grabs the lesion and return back as fast as possible as this irritation might lead to coughing of the falcon. If it was not possible to grab the aspergilloma during the first trial, the procedure has to be repeated. However, in most cases the procedure can be performed maximum 3 times as the tracheal mucosa might start to bleed or the irritation causes severe coughing of the bird. If mucous is present, the falcon has to be turned head over and moved carefully to throw up the mucous or blood. A small metal ENT swab can be used to clean the glottis area. On the following day the trachea should be endoscoped again to review the syringeal area. If still a larger part of the syringeal aspergilloma is present, it has to be removed in the same way. If only a small part is attached to the tracheal mucosa, no further endoscopic removal procedure shall be performed.

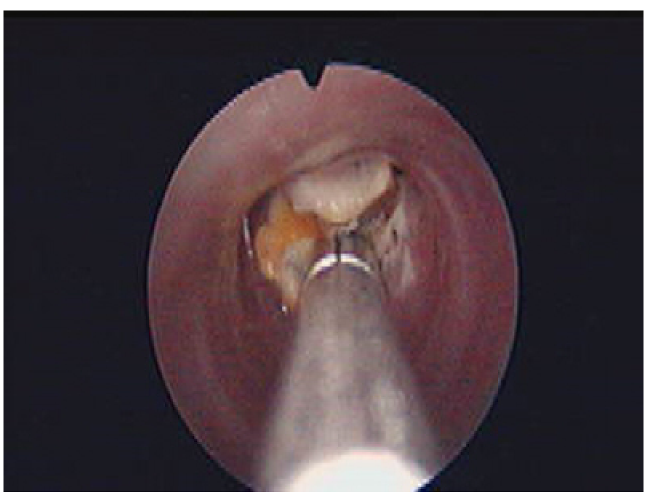

Figure 11.23. Endoscopic removal of syringeal aspergilloma.

After removal of the syringeal aspergilloma, intratracheal administration of amphotericin B is the gold standard as treatment. While applying amphotericin B intratracheally, no further tracheal endoscopy should be performed as the visibility is not good due to the medicine application. The tracheal endoscopy can be repeated after 5 days to review the progress of the treatment until the syringeal aspergilloma disappears completely or if breathing problems occur.

Additional treatment can be given by administration of itraconazole for 1-2 weeks. Antibiotics like marbofloxacin for 8 days intramuscular are helpful to cover up any injuries of the tracheal mucosa while removing the aspergilloma with the biopsy forceps. Inhalation therapy with enilconazole provides very useful support and can be applied 3 times per day for 20 minutes.

11.2.5.4. Cutaneous Aspergillosis

Therapy of cutaneous aspergillosis is explained in detail in chapter 9.

11.2.5.5. Preventive Aspergillosis treatment

Preventive aspergillosis treatment is advisable in several cases such as transportation of young falcons to new owners or countries. Moreover, in phases of heavy training in hot climate aspergillosis prevention might be indicated. For preventive purposes, 10-20 bids of one itraconazole capsule can be administered once per day starting one week before the expected stress situation and then continued for another 7-14 days. Voriconazole should not be used as preventive treatment for aspergillosis in birds. In several first year birds from breeders that have received voriconazole as preventive treatment in an early age and sometimes over a prolonged period of time, damage of the liver has been observed in the Abu Dhabi Falcon Hospital as part of pre-purchase examinations.

11.3. Candidiasis

Etiology, Distribution and Transmission

Candida albicans (Figure 11.24) is one of the most common fungi in various birds. Predisposing factors like viral or bacterial diseases, metabolic disorders, antibiotic administration [3] pave the way for candidiasis.

Figure 11.24. Candida albicans.

Identification

Crop samples reveal in the parasitological examination *Candida* as well as budding cells and/or pseudohyphae.

Symptoms

Symptoms of Candidiasis include reduced appetite, flicking of food and vomiting. In the endoscopy of the crop reddening of the crop mucosa and sometimes whitish lesions can be seen.

Therapy

Candidiasis can be treated with itraconazole or nystatin for a period of 6-8 days.

11.4. Conclusion

Fungal infections like aspergillosis are serious diseases in falcons that can be life-threatening if detected too late. However, routine endoscopies can detect aspergillosis in early stage. Treatment has to be decided according to the stage of aspergillosis. Regular re-examinations including blood sampling and endoscopies are required during the treatment course to determine the treatment success. Treatment includes inhalation and systemic therapy and in some cases of syringeal aspergillosis intratracheal treatment. Supportive therapy includes liver and kidney protections as well as immunostimulant medicines. Successful aspergillosis treatment leads to vascularized and encapsulated aspergillomas. They can stay in the same condition for a long period of time without having negative impact on the falcon's hunting ability.

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Chapter XII

Bacterial Infections

Abstract

The problem of bacterial infections in falcons can be traced back to the 8th century. Studies in the literature on infectious diseases showed that the most common bacterial pathogen is *Escherichia coli*, followed by the second frequent bacterium, *Clostridium perfringens* and by *Pseudomonas aeruginosa*. However, other infections like *Salmonella sp,. Klebsiella pneumonia, Mycobacterium sp.* etc can be found as well. Study results reveal that falcons show a species specific susceptibility with respect to bacterial infections. *E.coli* infections can be found relatively equally distributed among the main falcon species. However, heavy *E.coli* infections affect mainly Peregrine falcons. Gyr-peregrine hybrid falcons are more frequently affected by *Clostridium perfringens* infections. Saker, gyr, and gyr-peregrine hybrid falcons are most susceptible for *Pseudomonas aeruginosa* infections whereby gyr and peregrine falcons are more prone to heavy *Pseudomonas aeruginosa* infections.

12.1. Introduction

As early as in the 8th century, Arab falconers were aware that falcons can suffer from general infections as well as infections in the throat [6]. Until today, infections remain one of the most common health issues not only in living falcons, but also in post mortem findings of raptors [2, 12]. Studies on infectious diseases in falcons have revealed that the main bacterial pathogen is *E. coli* (11.13%), followed by Chlamydophilosis (4.75%), *Pseudomonas* infection (4.31%) and Clostridiosis (3.20%) [2]. The most frequently isolated bacterial pathogens in crop and fecal samples in large sample collections are *E. coli, Clostridium perfringens* and *Pseudomonas aeruginosa* [7, 8]. *E. coli* can be found in 90% of the fecal samples of clinically healthy raptors [1, 9]. In addition to this bacterial basis, unhygienic conditions, stress and other infectious agents seem to contribute to a great extent to the disease outbreak [16] as well as large numbers of isolated *E.coli* bacteria [3]. Regarding infections caused by Clostridium perfringens, the conditions for the disease outbreak are still not fully identified [2]. A *Clostridium* enterotoxaemia does not seem to be caused by poor quality food alone. However, predisposing factors like emaciation, dehydration and training, transport, overeating, sudden ration changes, the addition of new groups to the collection [15] seem to pave the way to an infection. The research on *Pseudomonas sp*. infections does not show a much unified picture, too. Being one of the most frequent bacterial infections in Saudi-Arabia among falcons [2], a relationship between trichomonas infections and stress through training exists [11]. Nevertheless, it is also stated that falcons are not affected by *Pseudomonas* infections [16]. Samples for bacteriology can be taken from various parts of the body like wounds, crop, airsacs and feces. Cytology can be performed before plating samples for culture. This might reveal bacteria in airsacs (Figure 12.1) and inflammatory cells in the crop sample (Figure 12.2, 12.3). The microbiological culture result will then determine the exact bacterial agent.

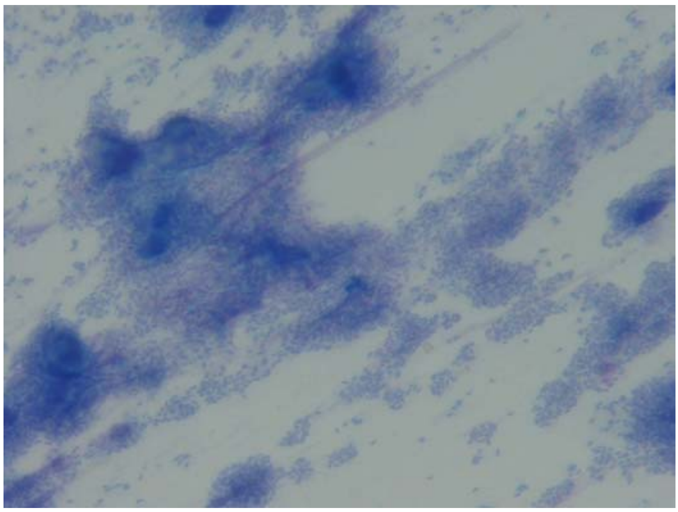

Figure 12.1. Cytology showing bacteria in airsacs.

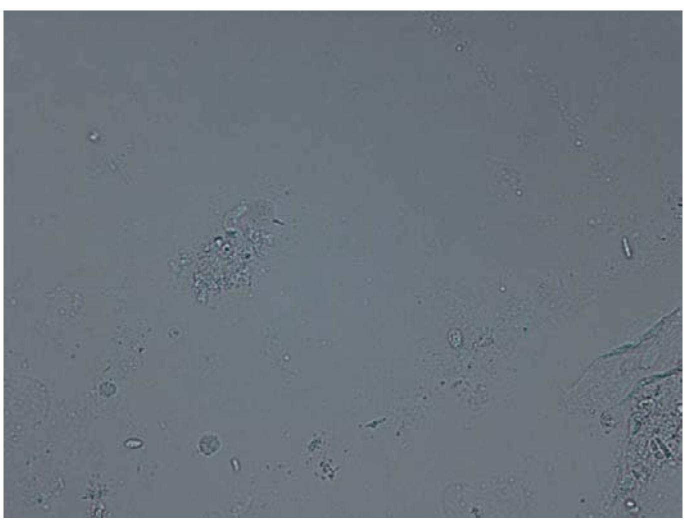

Figure 12.2. Cytology showing few inflammatory cells in crop.

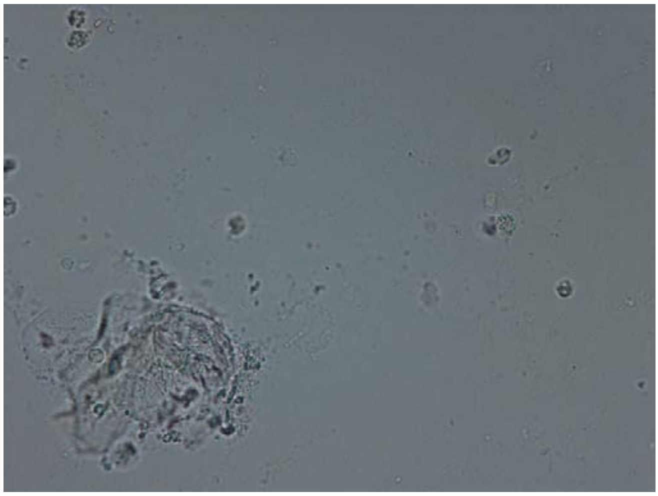

Figure 12.3. Cytology showing inflammatory cells in crop.

12.2. Escherichia Coli

Etiology, Distribution and Transmission

Escherichia coli is a gram-negative anaerobe rod-shaped bacteria that belongs to the group of Enterobacteriaceae. The E. coli bacterium can be found in soil, water, animals, humans and plants. In bird and poultry species, the pathogenic *E. coli* strains are called APEC (avian pathogenic *E. coli*) and are composed of several antigens like O and K. O-antigensare heat stabile somatic antigens that can be found in the LPS complex of the cellular walls. The K-antigens are capsule antigens and polysaccharids. They can block the agglutination of O-antigens. In avians, *E.coli* strains of serovars O1:K1, O2:K1 and O78:K80 are the pathogens for coli septicemias. They form special fimbriae. Fimbriae type 1 are used for the infiltration of the respiratory tract whereas fimbriae of type P are developed by *E.coli* strains that invade the inner organs. Moreover, apart from heat labile enterotoxins, other cytotoxic activities are developed like toxic polypeptids which binds at flagellas. It is therefore called flagella toxin. Another high pathogenicity island (HPI) called pathogenicity area is a sign of virulent strains [13].

The disease transmission is caused by aerogen route mainly through contaminated feces. Primary infection is the result of high virulent strains and can be found in young birds. In older birds, the infection is also favored by predisposing factors like mycoplasma infections, viral infections [13], as well as stress, poor environmental conditions and husbandry.

Identification

Specimen swabs are plated on blood agar and Mac Conkey agar (Figure 12.4, 12.5). Inoculated plates are incubated for 18-24 hrs at 37°C. Further identification can be done by

Mini-API systems through Rapid ID 32E (Automatic) and API 20E Manual strips (Biomerieux). Swabs are also plated on Sorbitol Agar for the identification of enteropathogenic *E coli* [8]. Typical for the identification of *E.coli* bacteria are hemolysis and the slimy growth of the bacteria [13]. Special agglutination test can reveal the enteropathogenic virulence.

Figure 12.4. E. coli colonies in MacConkey agar.

Figure 12.5. E.coli colonies in EMB2 agar.

Age and Species Distribution

E.coli infections were more frequently diagnosed in 69.1% first year old falcons followed by 22.3% second year old falcons tested, but also falcons of 3 years of age and above can be affected [8]. Peregrine and gyr-saker hybrid falcons showed a higher susceptibility to *E.coli* infections compared to other species [7]. However, over the past years a small change in the species distribution can be observed as the falcon species are distributed in a similar way except peregrine falcons with a high number of heavy *E.coli* infections [8].

Symptoms

E.coli infections are not only the most common bacterial infections, but seem to be also the most dangerous one with the highest number of heavy infections. In some cases *E.coli* bacteria can be observed in the blood smear (Figure 12.6). This directly points to the problem of *E.coli* septicemias which can end fatal if detected too late due to its rapid progression [3]. In the Abu Dhabi Falcon Hospital, cases of *E.coli* septicemia have been observed in direct connection with feeding and not digesting large amount of meat. Especially tired and over-trained falcons often have problems to pass their full crop properly and the food remains for several hours, sometimes even up to 24 hours in the crop. This results often in massive *E.coli* septicemias and fatal intoxication of the falcons [7]. In *E.coli* septicemia cases, often only unspecific disease symptoms can be found like weight loss and tiredness [3].

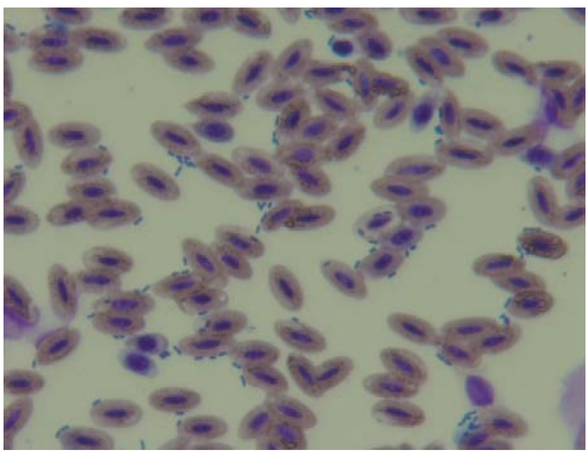

Figure 12.6. E.coli bacteria in blood smear

Therapy

The two most effective antibiotics are amoxicillin-clavulanic acid and enrofloxacin according to research results [7]. Further research shows a changed increased sensitivity of *E.coli* infections to ceftazidime followed by enrofloxacin and ciprofloxacin. The most effective antibiotics in cases of scanty and moderate *E.coli* infection are ceftazidime followed by enrofloxacin and ciprofloxacin. Nevertheless the most effective antibiotic in case of heavy *E.coli* infections is still amoxicillin-clavulanic acid [8] and ceftazidime.

12.3. Clostridium spp

Etiology, Distribution and Transmission

Clostridium spp. are gram-positive, obligate, anaerobe spore-forming bacteria. They are rod-shaped and most *Clostridium* species are motile, but not *C. perfringens*. The virulent potential is caused by the toxins which are different for the individual strains. *C. perfringens* is a non-motile bacteria that produces different toxins like A, B, C, D and E. *C. perfringens* A can be commonly found in birds whereas type C is the less common toxovar. The A toxin results in necrotizing enteritis. *Clostridium* bacteria are widely distributed in the environment and may be found in small quantities in the intestines of humans and animals alike [13].

12.3.1. Clostridium perfringens

Identification

Fecal swabs are inoculated in cooked meat medium. Tubes are heated at 80°C and then cooled before plating. The swab is then plated on to blood agar and special *C. perfringens* agar base (Figure 12.7) [8]). Other agars are Schaedler Bouillon, RCM (reinforced clostridial medium) and Clostridium-Differentiation-agar [13]. Inoculated plates are then incubated at 37°C anaerobically for 18-24 hrs (Genbox, Biomerieux). Further identification is performed with ID API 20A Manual (Biomerieux) [8].

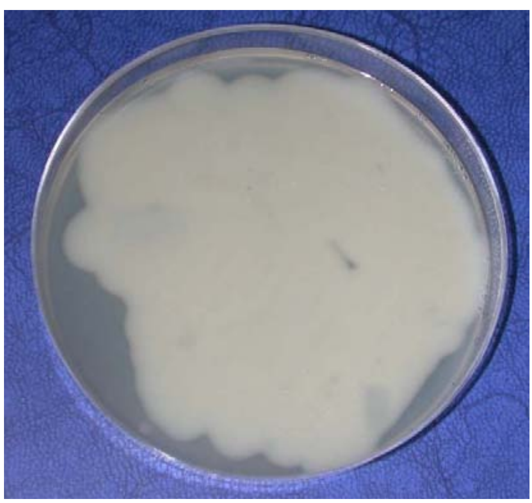

Figure 12.7. Clostridium perfringens in anaerobic MacCLungToabe agar.

Age and Species Distribution

The age distribution shows that *Clostridium perfringens* infections mainly affect young first year falcons in 67.9% of the cases and in 23.4% second year falcons [8]. This supports the assumption that problems to adept to a new feeding scheme, lack of exercise and climatic change may favor the development of this kind of infections [2].

The most susceptible species are gyrfalcons where *Clostridium perfringens* infections are the most frequent infections compared to other bacterial infections [8]. In a research study in 2004 the *Cl. perfringens* infections in gyrfalcons were followed by saker falcons, gyr-peregrine hybrid and peregrine falcons [7]. However, a change can be observed regarding the species susceptibility. *Clostridium perfringens* infections affected by far more gyr-peregrine hybrid falcons than gyr-saker hybrid and saker falcons [8]. Assumptions that saker falcons are more resistant to *Clostridium* infections [2] due to their robust nature [6] was not proven in research studies with 41.8% infected saker falcons out of all saker falcons [8].

Symptoms

C. perfringens can cause necrotizing enteritis, enterotoxaemia and in rare cases wound edemas and gas gangrene (Figure 12.8). The latter can be associated with *C. novyi, C. septicum and C. histolyticum* [13]. *Clostridium perfringens* infections are frequently observed in the United Arab Emirates [7] and the numbers seem to rise over the past few years due to intensified training methods and increase of susceptible species [2]. Moreover, this bacterial infection affects much more young falcons and was found only in few falcons above three years of age in this study. This might support the theory that falcons might be more able to eliminate enteric *Clostridium* bacteria [2]. Moreover, the exposure time to this bacterium in the environment might not be the main factor for the disease outbreak [2].

Moreover, stress due to inadequate and long transportation as well as lack of hygiene should not be underestimated as predisposing factor for *Clostridium perfringens* infections.

In cases of gas gangrene, the bird's skin shows a black discoloration and the typical crepitation of the skin and underlying tissue can be palpated. The legs seem the region more often affected by the gas gangrene. However, in falcons it is a very rare, but mostly lethal infection. Death can occur 24 hours after infections. Therapeutic approaches with amoxicillin-clavulanic acid can be tried, but are often unsuccessful due to the rapid progression of the disease.

Figure 12.8. Gas gangrene on leg caused by Clostridium perfringens infection.

Therapy

Clostridium perfringens infections are responding well in most of the cases to amoxicillin-clavulanic acid [8]. In scanty and moderate *Clostridium perfringens* infections with amoxicillin-clavulanic acid being the most efficient drug followed by pipracillin and enrofloxacin. Moreover, pipracillin has taken the lead in combating heavy *Clostridium perfringens* infections followed by amoxicillin-clavulanic acid and enrofloxacin [7, 8].

12.3.2. Clostridium Botulinum Infections

C. botulinum infections can be caused through contaminated soil and water. It is not an infectious disease as such, but a pure intoxication. The neurotoxins that are ingested by the affected bird are produced in the outside anaerobe environment, often in ponds, and temperatures above 20° Celsius and not inside the body. These toxins lead to paralysis of the affected birds [13]. In waterfowl like ducks, *C. botulinum* infections are therefore more frequent. In contrast, *C. botulinum* infections are very rare in birds of prey. They might get affected though ingestion of infected prey, especially ducks and other waterfowl. The symptoms are the same as in waterfowl. A therapeutic approach can only be tried in an early disease stage with an antitoxin serum [13], but there exist no such serums in falcons. Therefore this disease ends usually deadly.

12.4. Pseudomonas Aeruginosa

Etiology, Distribution and Transmission

Pseudomonas sp. are gram-negative, motile and aerobe rod-shaped bacteria. The most important pathological species is *Pseudomonas aeruginosa.* They can be excreted with the feces in the environment where they can survive for a very long time. Especially in humid conditions and water environment, *P. aeruginosa* can get multiplied despite being outside the host organism. Moreover, *P. aeruginosa* is often resistant to disinfectants and is one of the most important hospital infections (nocosomial infections). Suppressed immune system of the host animal poses a predisposing factor for this infection. *P. aeruginosa* can be found in various general infections and lead even up to septicemias. Known for the occurrence of putrid infections, the blue-greenish color of the pus is typical for *P. aeruginosa* infections [13]. Moreover, this bacterium can frequently be found in refrigerators thus leading to the typical "fridge" smell. This is highly important for disease transmission as well as often the food for falcons gets defrosted in the refrigerators and might get contaminated with *P. aeruginosa*.

Identification

Swabs are plated on blood agar (Figure 12.9), Mac Conkey agar and Cetrimide agar (Figure 12.10). The plates are incubated at 37 °C for 18-24 hrs. An oxidase test is performed for primary identification. Further identification to the species level is done e.g. by Mini-API systems with API 20NE (Biomerieux) [8]. The colonies have a characteristic odor and appear as typically flat, rough and metallic shining colonies. Moreover, *P. aeruginosa* can be identified through its typical color pigments, mainly the non fluorescent blue-green Pyoscyanin [13].

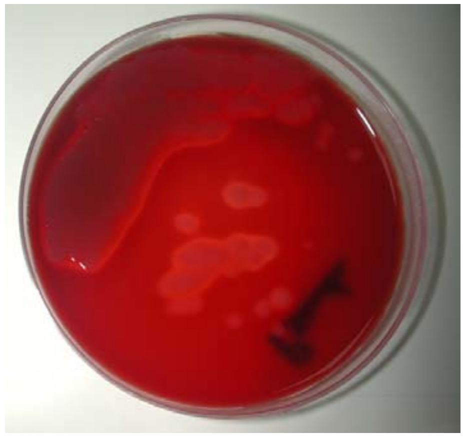

Figure 12.9. Pseudomonas aeruginosa on blood agar.

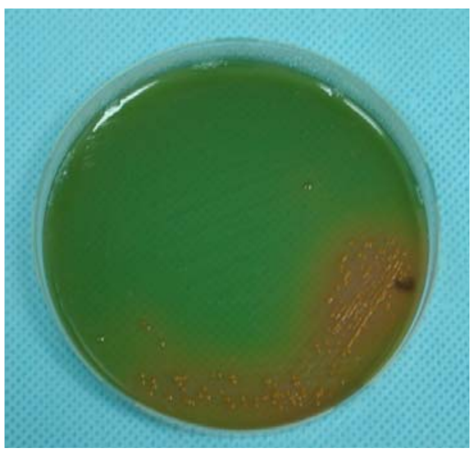

Figure 12.10. Pseudomonas aeruginosa on cetrimide agar.

Age and Species Distribution

An interesting feature of this infection is the fact that a large number of first year old falcons are affected (79.3%). In contrast, only 12.1% second year old falcons were affected. However, there are differences in the degree of the infection which can be observed in the various age groups. Heavy *Pseudomonas aeruginosa* infections can be more frequently found in falcons of 2 years of age and above with 41.7% infected falcons in these age groups, whereas a higher number of first and second year old falcons suffer from scanty and moderate *Pseudomonas* infections [8].

Despite a relative equal species distribution among the different stages of this infection, it has to be noted saker, gyr, and gyr-peregrine hybrid falcons are most susceptible for *Pseudomonas aeruginosa* infections. Moreover, peregrine and gyr-peregrine hybrid falcons are much more susceptible to moderate and heavy *Pseudomonas aeruginosa* infections than any other species. Compared to the other species, the number of heavy *Pseudomonas aeruginosa* infections especially in gyrfalcons is much higher in proportion to moderate and scanty bacterial growth than in the other bacterial infections [8].

Symptoms

Another very common bacterial infection in the Middle East is the *Pseudomonas aeruginosa* infection [2, 8, 11] although not all authors do recognize the importance of this disease in falcons [16]. Clinical symptoms are white spots or lesion in the tongue (Figure 12.11, 12.12) and oropharynx. Swollen tongues and choanal lesions are often observed. In advanced disease stages, a blockage of the jaw joint can be seen which leads to difficulties up to inability of the bird to open the beak. The owners present such falcons often with the complaint that the falcon is not eating well. Bluish, cyanotic mouth mucosa can be frequently seen. In advanced stages of the pseudomoniasis, a generalized septicemia can be observed with emaciation, weakness, weight loss and severe dehydration. *P. aeruginosa* can also cause large lesions in the trachea leading to tracheal stenosis (Figure 12.13) which can be removed by biopsy forceps during endoscopy. The hematological blood results often reveal highly increased WBC of 20 to 45 x 10^9. The differential diagnosis aspergillosis should always be ruled out.

Findings that *Pseudomonas aeruginosa* infections are frequently combined with *Trichomonas* infections [11] can be fully supported by the observations in the Abu Dhabi Falcon Hospital. However, at the current stage of research it cannot be determined whether this combined disease problem is a special feature of Middle Eastern countries or whether it has simply not yet often been diagnosed in other countries.

Figure 12.11. Pseudomonas aeruginosa lesions in tongue.

Figure 12.12. Removal of Pseudomonas aeruginosa lesions in tongue.

Figure 12.13. Pseudomonas aeruginosa lesion in trachea.

Unrecognized *Pseudomonas aeruginosa* infections might lead to either chronic cases often manifest as chronic sinusitis cases or especially in moderate and heavy stages to systemic diseases which ends often in a fatal way [8].

Therapy

Pipracillin is described as the antibiotic of choice for *P. aeruginosa* infections [11] with a sensitivity of 85.4% in the cases tested [7]. In severe cases, piperacillin should be given as initial bolus intravenously. In contrast to these findings, a change in the effectiveness of pipracillin as drug of choice can be observed by adding ciprofloxacin and ceftazidime to the most effective drugs against *P. aeruginosa* infections, especially in infections with scanty growth. The two most sensitive antibiotics in the case of moderate and heavy *Pseudomonas aeruginosa* infections are pipracillin and ciprofloxacin [8]. Ceftriaxone can also been used effectively against *P. aeruginosa* infections.

The surgical removal of those *Pseudomonas aeruginosa* lesions is described in detail in chapter 15.

12.5. Chlamydophilosis

Etiology, Distribution and Transmission

Chlamydophila psittaci (formerly known as Chlamydia psittaci) is a world-wide distributed gram-negative, obligate intracellular bacilli and divided in serotypes [17]. The genotype A is found in psittacines and poses the major pathogen for the human psittacosis. Genotype B is commonly found in pigeons whereas genotype C affects ducks. Poultry species and turkeys might get infected with genotype D. The genotypes E and F are very rare and can be isolated in various other avian species [17].

Disease transmission occurs through nasal secretion and discharges. However, infectious material can be found in fecal, tears, ocular discharges, crop food and crop milk as well. In pigeons, the most frequent transmission route is through feeding of crop milk to the young birds. The infection can spread through droplets of infectious material. The indirect infection can get manifest through an infection of the respiratory or digestive tract epithelia of the new host. Carriers are also found especially under predisposing conditions like stress [17].

Identification

Identification of *Chlamydophila psittaci* can be performed of eye, choanal and cloacal swabs with ELISA testing or rapid tests. Furthermore, PCR testing is an excellent method for the diagnosis of *Chlamydophila* infections.

Symptoms

Ornithosis can be differentiated in various forms like an acute, subacute and chronic form. The acute form is usually found in young birds. The symptoms are anorexia, apathy, breathing problems and diarrhea and can lead to death. The subacute form shows the same symptoms, but mainly affects adult birds. Adult birds are also suffering from chronic forms which can display the same symptoms as in the subacute form [13].

Therapy

Treatment for *Chlamydophila psittaci* can be performed with acithromycin. Doxycycline can be used as well.

12.6. Avian Tuberculosis (Mycobacteriosis)

Etiology, Distribution and Transmission

Mycobacteria are gram-positive non-motile rods. They are highly resistant bacteria and can remain infectious in the environment for several months. These bacteria show a strong resistance against disinfectants and acids. Therefore only specially approved disinfectants can be used for cleaning and disinfection [13]. Water, soil, plants and other environmental sources serve as reservoir for the isolation of Mycobacterium avium complex [10].

Identification

Mycobacteria are growing very slowly. Therefore the staining with Ziehl-Neelsen stain can reveal acid-fast rods and are helpful to detect possible tuberculosis earlier. Special media like Loewenstein-Jensen, Middlebrock, Kirchner, Stonebrink, Ogawa, Petragnani, Gottsacker, Hohn and MB-Redox-medium can be used to grow mycobacteria [13]. Recently, testing with Polymerase-Chain-Reaction has become more and more popular due to its faster results.

Mycobacterium Avium

In birds, infections with mycobacteria are well-described. Mainly *Mycobacterium avium ssp.* avium and Mycobacterium avium spp. paratuberculosis can be isolated [13]. Mycobacterium genavense can be found in birds as well. The mycobacteria pathogens are excreted with the feces [5] and affect mainly hepatic and gastrointestinal organ systems [14].

M. avium is known to have zoonotic potential and can be transmitted from birds to immune suppressed humans e.g. HIV infected people [10].

Symptoms

Typical granulomas can be found in liver, intestines and spleen [13]. General symptoms of mycobacteriosis include weight loss, polyuria, coelomic distention and diarrhea. Rarely cutaneous masses and lameness can be found [5]. Cutaneous tuberculosis is explained in detail in chapter 9.3.4.

Therapy

The chances for treatment are not very good. Treatment approaches can be tried with rifampicin for several months. However, it is highly questionable if a treatment can be recommended due to its zoonotic potential and the danger of disease transmission to other birds and the long survival of the infectious agent in the environment. Hygienic procedures like cleaning and disinfection and disease control is highly important [13].

12.7. Salmonellosis

Etiology, Distribution and Transmission

Salmonella infections can be regarded as one of the most important bacterial infections in humans and animals world-wide with zoonotic potential. This large bacteria group includes more than 2541 serovars. Through a new nomenclature, *Salmonella ssp. I* has been renamed in *S. enterica* and forms the largest *Salmonella* group. *Salmonella* strains have O- and H-antigens [13].

In birds, *S. gallinarum* can be isolated from chicken. *S. typhimurium* is not host specific and can be isolated from different animals, but shows heavy diseases symptoms as well as latent infections. This strain is known as one of the most common strains for zoonotic infections [4]. The disease transmission can be orally through food which got infected though direct contact with contaminated material of feces, sewerage and manure. Other transmission routes are aerogen, conjunctival, over the oropharynx and infected eggs [13]. Disease transmission to falcons may arise through infected quails and pigeons [4]. Direct contact infection of animal to animal or animal to humans may exist, but occur rarely. Often latent infected animals bring the infection in new flocks or animal groups. Carriers are mainly older animals and can be found without previous manifest *Salmonella* infection. Severe manifest *Salmonella* infections are often affecting younger animals and can be observed as enteritis and septicemias [13].

Identification

Salmonella strains require special differential agars (Figure 12.14). Due to their inability to split lactose, the growth on Gassner agar helps to differentiate lactose negative *Salmonella* colonies from lactose positive *E.coli* and *Klebsiella* colonies. Moreover, a characteristic red coloration of *Salmonella* strain can be found on Rambach agar whereas the colonies show a pink color on SMID-agars.

Another selective agar is Salmonella-Shigella Agar where *Salmonella* colonies appear in pale pink color. The biochemical properties can be identified by Mini-API system through API 20E (bioMerieux). The different antigens can be identified with special Salmonella serotyping tests [13].

Figure 12.14. Salmonella colonies on Mac Conkey agar.

Symptoms

In falcons, salmonellosis has been occasionally reported but is still a rare disease. *S. typhimurium* infections develop when other underlying diseases like *Clostridium perfringens* infections are present. Moreover, *S. subspecies I* or according to the new nomenclature *S. enterica* has been isolated in gyrfalcons. Gyrfalcons seem to be the species most affected by salmonellosis whereas gyr-hybrid falcons seem to be more resistant to this bacterial infection. A seasonal correlation of *Salmonella* outbreaks during spring time has been observed [2]. Sudden deaths have been observed in falcons suffering from salmonellosis. The pathology revealed mild fibrinous peritonitis, hemorrhagic enteritis and swollen liver and spleen. *S. enterica* infections show histopathological features like miliary white-yellowish in the subpleural area and liver. Acute hepatic necrosis and microabscesses with giant cells may be present [4].

Therapy

Treatment includes chloramphenicol and enrofloxacin. Moreover, underlying diseases have to be treated accordingly.

12.8. Klebsiella Pneumoniae Infections

Etiology, Distribution and Transmission

Klebsiella sp. bacteria are non-motile *Enterobacteriaceae* with characteristic capsule development and slimy colonies. They can be found in the normal bacterial flora of animals and environment. The pathogen *Klebsiella* species is *Klebsiella pneumonia* which can be found in animals and humans. Due to its relatively low pathogenicity, predisposing factors are often found in *K. pneumonia* infections [13].

Identification

K. pneumonia can be isolated from MacConkey agar (Figure 12.15). Its slimy mucoid colonies are pink colored and lactose positive. They can be identified with Mini-API system.

Figure 12.15. Klebsiella pneumoniae on blood agar.

Symptoms

In falcons, *K. pneumonia* infections are often seen as secondary infections often of the respiratory tract e.g. in the case of other bacterial infections. They might be supported by reduced immune system through stress and poor ventilation. Main species affected from *K. pneumonia* infections are gyr-saker and gyr-peregrine hybrid falcons.

Therapy

K. pneumonia infections can be treated with enrofloxacin, pipracillin, ciprofloxacin and ceftazidime.

12.9. Mycoplasma

Mycoplasma infections can be found in peregrine and saker falcons. In peregrine falcons, mycoplasma infections can lead to airsacculitis, tachypnoe and regurgitation. Affected saker falcons suffer more from synovitis [3]. Diagnostic procedures can be performed with ELISA and PCR tests.

12.10. Staphylococcus

Staphylococcus infections are discussed in detail in chapter 9 (Figure 12.16).

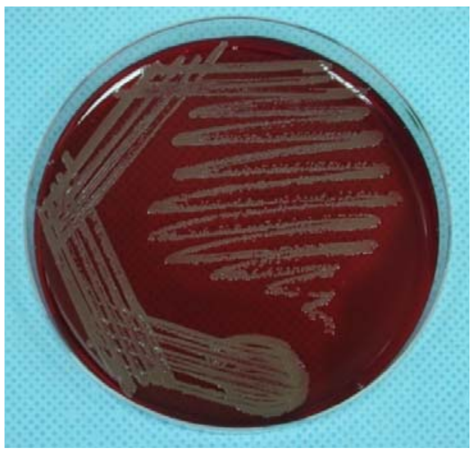

Figure 12.16. Staphylococcus aureus on blood agar.

12.11. Conclusion

Bacterial infections are a common, yet often highly underestimated feature in the United Arab Emirates and may pose a severe threat to the falcon populations [7].

As the normal bacterial flora of falcons has not been fully studied yet, it is difficult to judge to which extent scanty bacterial agents like *E.coli* or *Clostridium perfringens* can be still regarded as part of the normal bacterial flora and from which level of occurrence they are pathogenic already. Nevertheless, observations in the Abu Dhabi Falcon Hospital have shown that even falcons with scanty (+) bacterial infections have a reduced flight performance, reduced appetite or are not well. Those falcons are improving well when given the appropriate antibiotics. Moderate (++) or heavy (+++ and above) bacterial infection definitely require appropriate treatment with suitable antibiotics following an antibiogramm.

Research results [8] lead to the question whether resistances towards certain common antibiotics are on the rise in birds like it has been already observed in humans. Therefore the effectiveness of common antibiotics needs to be monitored on a long-term basis. Such increased antibiotic resistances would even more emphasize the necessity to test latest human antibiotics for their possible use in birds.

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Chapter XIII

Viral Diseases

Abstract

Different viral infections can be found in falcons. Some of them are life-threatening. Notifiable viral diseases like Newcastle Disease virus and Avian Influenza virus infections have to be reported to international organizations like OIE and WHO. Avian Influenza infections have been reported especially in peregrine and saker falcons and can lead to their death. Common virus infections in falcons are infections with Avian Influenza virus, Newcastle Disease Virus, Avian Poxvirus, Herpesvirus, Reovirus and Adenovirus. No specific treatment exists for viral infections. However, either vaccinations or supportive therapy is possible in some cases.

13.1. Introduction

Some of the most serious infections in falcons derive from viral agents. Well-known for decades, the Newcastle Disease Virus has affected falcons in different countries with very typical symptoms. Vaccinations are in place in some countries, whereas in other countries vaccinations against this disease are not allowed. Other viral infections with less distinct symptoms are Reovirus infections and Adenovirus infections. Herpesvirus infections have been encountered in various falcons, too. However, one of the emerging new viral infections is the Avian Influenza virus infection that has killed several peregrine and saker falcons already. Due to the close contact with the falconers, this disease has to be seen in a different light than as just a normal viral infection. Therefore it is essential to have appropriate surveillance and preventive measures in place. Poxvirus infections are frequently encountered in falcons. Sometimes these infections lead to severe damage of the affected areas around the face and toes. In advanced poxvirus infections, parts of the toes may fall off completely.

This chapter emphasizes the most common viral diseases that affect falcons as well highlight emerging viral infections.

13.2. Avian Influenza Virus

13.2.1. Etiology, Distribution and Transmission

Avian Influenza (AI) is a viral infection caused by Influenzaviridae which occurs in two forms, namely the highly pathogenic form with a mortality rate of almost 100% and the low pathogenic form. Due to the fact that the LPAI (=Low Pathogenic Avian Influenza) are well-known to be able to mutate to HPAI (=Highly Pathogenic Avian Influenza), they should be also considered in the compulsory surveillance and control measures for Avian Influenza Virus (AIV). This virus is affecting mainly birds, but can be transmitted to humans, pigs and cats as well. This implicates that an action plan should not only take birds into consideration, but also humans and other animals. However, Avian Influenza virus is mainly a poultry disease. Wild birds pose a reservoir for the AI virus, but are not a major transmission factor. However, raptors (e.g. falcons, hawks) can be infected by eating infected prey such as ducks thus leading to a secondary AI infection [8].

13.2.1.1. Ways of Spreading the Avian Influenza Virus

The Avian Influenza virus is mainly a poultry disease. The main spreading of the virus occurs through legal and illegal poultry trade [25]. Moreover the AI virus can be spread by fomites like contaminated shoes, equipment, vehicles [8]. The virus can survive and spread in water and is often found in reservoir strictly tied to water (e.g. ducks) [21].

Wild Birds

It has been known for long time that wild birds pose a reservoir for the AI virus. Moreover, they are able to introduce novel influenza gene segments into population. Those novel genes can produce a dissimilar virus with different antigenic and other biological characteristics when they are reassorted with existing virus. Ducks are carriers without displaying disease symptoms whereby juvenile ducks have the highest rate of virus infection and shedding. The virus titers are high in late-summer when the birds are leaving for northern breeding areas and decrease when flying southwards [8, 21].

Susceptible wild bird species are colonially-nesting of flocking waterfowl which feed in water bodies or in nearby farmland (e.g. swans) as well as wild bird species feeding in polluted waterways (e.g. herons, gulls, egrets) near towns, farms, fish-farms. Raptors (e.g. falcons, hawks) can be infected by feeding on other birds like ducks thus being a secondary AI infection. Other susceptible species are scavenging species like crows, magpies. Pigeons are less susceptible for AIV infection and excrete less amount of the virus. Therefore they play a minor role in the disease transmission [21]. So far, no infections have been reported in swallows and carols [8], however, three sparrows were confirmed with AIV in China [21].

Aquatic Migratory Birds

A special role of aquatic migratory birds in the AI transmission can be assumed as all known subtypes from H1-16 and N1-9 occur primarily in aquatic migratory birds. However, this does not cause the disease in infected birds, but the virus is excreted in large amounts in the fecal. Therefore the aquatic migratory birds may play a possible initial role in AI transmission. The AI virus might be transmitted by infected domestic poultry through contact with resident waterfowl. This can lead to a possible transmission between migratory birds [21]. However, wild waterfowl which got infected with H5N1 will result either in dead or sick birds being unable to fly over long distances. In case of subclinical infection, the carrying of virus over long distances might be possible. In contrast, a short distance transmission between farms, villages, and contaminated local water reserves is very likely [35].

Moreover, the spreading of AI in aquatic migratory waterfowl was observed mainly along the sea coasts where infected wild waterfowl can mingle with domestic poultry at lakes and ponds as often domestic poultry is kept in yards outside. This can lead to the contact with infected wild waterfowl or their feces. Furthermore, the infected fecal might go in smaller rivers. Canine and feline species are eating infected waterfowl or get in contact with it thus resulting in a transmission of AI from avian species to mammal species [21]. The AI virus was confirmed in a domestic cat in February 2006 in Germany [24].

Migration Routes of Wild Birds

One major migration routes of wild birds is the route via Azerbaijan, Georgia, Ukraine, Iran, Iraq, some Mediterranean countries and Southwest Asia. This is especially used by northern-breeding Anatidae (ducks, geese, swans) which are migrating southward migration at beginning of July. They reach their winter areas in November to December and then move to northern areas beginning of spring for reproduction. The Cygini (swans) populations from West Europe (Scandinavia, Germany) fly to wintering habitats along the Baltic coasts whereas other populations are resident in France and UK [8].

13.2.1.2. Relation of Wild Bird Migration and AI Outbreaks in Domestic Poultry

The winter 2003-2004 outbreaks in Asia occurred during the high peak of migration, but not all countries on migratory pathways got infected. The outbreaks in December 2003 in Korea and in January 2004 in Japan did not coincide with the water bird migration taking place in July to November. The same applied to the outbreaks in January/February 2004 in China and in January 2004 in Hong Kong which happened before the water bird migration in August to November. The outbreaks in Indonesia, Malaysia were observed outside the migration time as well [21].

The interesting fact is that no infections were reported in e.g. Australia, New Zealand, South Korea, Africa, Philippines although those countries are located on flyways of esp. shorebirds (Charadiformes). Moreover, no flight routes go over mainland China where many outbreaks have occurred [21]. In Africa no outbreaks of wild birds have been reported despite being a favorite wintering area of many migratory bird species [8]. The recent outbreaks in eight African countries were related to poultry trade including illegal poultry trade for human consumption [25].

According to FAO [7], AIV outbreaks occurred in wild birds already in the years 2004 and 2005. The outbreaks were located mainly in Asia, China and the Caucasus and Russian region. In 2004, one heron and one peregrine falcon died in Hong Kong and in Cambodia wild birds in zoo collection were affected. In Japan crows got sick as well as magpies in Korea. Dead and dying birds including wild bird (pigeons, cormorants, storks, doves) were reported from Thailand. In 2005, more than 6000 migratory birds died in the Qinghai Lake Nature Reserve in China followed by AIV cases in poultry and wild birds during July/August 2005 in Russia and Kazakhstan. Moreover, in August 2005, deaths of 90 migratory birds at 2 lakes (water birds, H5 confirmed) were reported in Northern Mongolia. In Oct 2005, the Avian Influenza virus spread to Croatia, Romania with dead mute swans at fish farms. In 2005, the H5N1 virus was confirmed in Ukraine in zoo birds like geese, swans, cormorant, chicken, falcon, kestrel through contact with wild birds [21].

13.2.1.3. Special Factors for Avian Influenza Spreading in Europe, Caucasus and Middle East

Special factors for Avian Influenza Spreading in Europe

The outbreak trigger for Avian Influenza spreading in Europe started in China in the Qinghai Lake Nature Reserve when more than 6000 migratory birds died during April-June 2005. Poultry farms are not located close to this region. Among the dead birds were bar-headed geese (Anser indicus), great black-headed gulls (Larus ichthyaetus), brown-headed gulls (Larus brunnicephalus), ruddy shelducks (Tadorna ferruginea) and great cormorants (Phalacrocrax carbo). The isolates from Qinghai Lake, China showed almost identical to isolates in the most recently affected countries including the first two human cases in Turkey and the cases in France. Interestingly all affected countries were located on migratory flyways [21]. Therefore the Qinghai Lake outbreak is likely to be one of the major factors of the AI outbreaks in Europe end 2005/beginning 2006 [8]. During the spring migration 2006 from southern zones, birds have intermingled with European Russian and Siberian-origin birds during 2005/2006 winter nesting areas. The breeding grounds of swan populations from Europe and Asia in Northern Russia nested in overlapping breeding grounds. Moreover, winter-resident birds or birds from Siberia flew to warmer areas in Europe due to long cold winter which contribute to the European outbreaks [21].

Special Factors for Avian Influenza Spreading in the Caucasus Region

The Caucasus region has a lot of open water reservoirs where contact between domestic poultry and wild waterfowl is possible and has been regarded as the possible primary source of infection e.g. in Kazakhstan outbreaks. Moreover, the Caspian Sea and Black Sea offer large breeding grounds for aquatic migratory birds which pose a special danger for adjacent countries. Other factors contributing to a spreading of AIV are the use of poultry manures which are used as fertilizer in agriculture and aquaculture as well as feed for fish-farms in Kazakhstan, southern Russia, west to Ukraine, Moldavia, up to Asia. They can easily contaminate waterways and result in AI spreading [21].

Special Factors for Avian Influenza Spreading in the Middle East Region

By regarding wild migratory birds as a primary source for AI transmission, other more important factors will be neglected in the Middle East region. One important factor for a possible spreading of AIV in the Middle East region is the illegal trade in wild/cage birds

[18] even from places like Mongolia and the Caucasus region. Other factors are uncontrolled import of poultry and poultry products, lack of adequate quarantine measures and routine screening measures as well as lack of consistent measures in case of an AI outbreak and lack of investigations in AI outbreaks. Unclear information politics can also contribute to the disease spreading [21].

13.2.1.4. Preventive Measures and Surveillance of Avian Influenza

Preventive Measures and Surveillance of Avian Influenza Worldwide

The most important factors for the management of the HPAI are surveillance, improved biosecurity and enhanced hygiene at production level in the poultry industry as well as reduced contact between wild and domestic birds. Moreover, rapid response to disease outbreaks is highly critical. In this content, WHO, FAO and OIE have provided a strategic framework for countries to prevent and control the Avian Influenza threat [6]. Apart from this, the WHO had established an AI diagnosis and surveillance manual [42] and the OIE has set up guidelines for the surveillance of Avian Influenza in their Terrestrial Animal Health Code [23]. This includes an early warning system as well as testing of animals. Their proposed surveillance strategies include guidelines for clinical, virological and serological surveillance in non-vaccinated as well as vaccinated populations. Moreover, these guidelines provide information about the documentation of an Avian Influenza free status as well as clearance after an outbreak. They also give information about the use and interpretation of Avian Influenza detection tests. In order to raise awareness among the population in severely affected Asian countries, FAO has published special prevention guides for Avian influenza for veterinary paraprofessionals e.g. in Cambodia and Vietnam [4, 5].

Following a report about the potential threat of falcons and disease transmission to falconers in the Middle East [20], special surveillance measures and action plans have been set up first in Abu Dhabi and then in the overall United Arab Emirates from 2005 thus taking a lead in the Avian Influenza prevention in the Middle East [22].

Surveillance Studies

In Pakistan, a study about the presence of Avian Influenza in wild birds was conducted between December 2003 and May 2004. 50% eagles, 17% crows, 10% ducks, 30% goose and 33% fowls carried the H9 AI virus [14]. AI testing/monitoring of clinically normal migratory birds revealed negative results for H5N1. In China, more than 13,000 wild birds were tested and 6 were confirmed positive for AI whereas 3% had antibodies to H5N1. More than 100,000 tests world-wide had been performed for AIV since the last decade.

Several thousands of migratory water fowl tested in New Zealand, Australia, and Canada with negative results for H5N1. In Europe wild birds monitoring program was conducted e.g. Switzerland. In the United Arab Emirates, routine surveillance programs were introduced from 2005 to screen the wild migratory birds as well as other domestic avian species including falcons [21].

Preventive Measures

In several European countries, domestic poultry had to be kept in indoor pens in order to avoid any contact and possible disease transmission from wild birds. These lockup orders were done e.g. in Germany and Belgium [29]. Both, highly pathogenic and low pathogenic Avian influenza in poultry notifiable by the World Health Organization for Animal Health (OIE) and the OIE Terrestrial Animal Health Code for International Trade (OIE).

13.2.1.5. Avian Influenza Cases in Falcons and Raptors

Falcons are highly susceptible to Avian Influenza virus infections, especially with HPAI (H5N1) [15]. Due to the close relationship between falcon and falconers, the potential threat of this disease should not be underestimated [20]. In several falcons, AIV has been isolated in recent years. A peregrine falcon in the United Arab Emirates was diagnosed with the highly pathogenic Avian influenza virus (H7N3) in 2000 [17]. During an outbreak in poultry with H7N7 Avian influenza strain in Italy in the year 2000, the Avian Influenza H7 subtype was isolated in a saker falcon [16]. In Hongkong, a peregrine falcon had died of H5N1 infection in January 2004 [2, 36]. This was followed by another one peregrine falcon in March 2006 with isolated HPAI H5N1 infection [3]. Again, in March 2008, another wild peregrine falcon had been found sick and H5N1 virus was confirmed [13]. In recent years, other cases of falcons infected with Avian Influenza virus were reported in the Middle East. Saker falcons in Saudi Arabia were infected with HPAI H5N1 Avian Influenza strain [32]. In Kuwait, 20 falcons were confirmed to be infected with HPAI H5N1 in February 2007 [30]. In Europe, peregrine falcons and kestrels found dead were confirmed with H5N1 during the influenza (H5N1) outbreak among wild birds in Germany [10].

Avian Influenza virus has been isolated in other raptors, too. In Belgium, HPAI virus (H5N1) was isolated from 2 crested hawk eagles (Spizaetus nipalensis) that had been smuggled from Thailand [41]. During outbreaks in Germany in 2006, common buzzards (Buteo buteo) and European eagle owls (Bubo bubo) were found dead and H5N1 Avian Influenza strains were isolated [10].

Identification

Identification of Avian Influenza virus is performed in accordance to the protocols of OIE and includes PCR, inoculation on embryonated chicken eggs, hemagglutination and hemagglutination inhibition tests as well as agar gel dimmunodiffusion [28]. Phylogenetic and antigenic analyses of one saker falcon that died of Avian Influenza each in Saudi Arabia and Kuwait revealed that the AI strain originated from Qinghai-like H5N1 viruses [18]. They led to a massive outbreak among wild birds in China in 2005 as mentioned above in this chapter.

Symptoms and Clinical Diagnosis

Symptoms of Avian Influenza like depression and sudden death have been described in falcons [16, 17]. Inappetence and green feces two days before death was observed in a saker falcon [32]. However, falcons can also die of AI infections without showing any clinical signs [15]. In falcons experimentally challenged with AI virus, a reduced food intake a few days before their death was observed as well as pancreatitis [15].

Therapy

No treatment exists for birds with Avian Influenza infections. Vaccinations trial have been performed recently and showed that falcons vaccinated intramuscularly or subcutaneously with inactivated H5N2 virus survived artificial HPAI H5N1 infections. However, shedding of the virus was observed although the titers were reduced [15].

13.3. Newcastle Disease Virus

Etiology, Distribution and Transmission

The Newcastle Disease Virus (NDV) belongs to the group of avian Paramyxoviridae and is a RNA virus characterized by a helical structure. This virus can be isolated in more than 100 avian species. Moreover, Newcastle Disease virus is notifiable by the World Health Organization for Animal Health (OIE) and the OIE Terrestrial Animal Health Code for International Trade (OIE) [27]. So far, 9 avian paramyxovirus strains have been isolated [12, 31]:

- PMV-1 Newcastle Disease Virus
- PMV-1 Pigeon/Munich/14/83
- PMV-2 Chicken/California/Yucaipa/56
- PMV-3 Turkey/Wisconsin/68
- PMV-3 Parakeet/Netherlands/449/75
- PMV-4 Duck/Hong Kong/D3/75
- PMV-5 Budgerigar/Japan/Kunitachi/75
- PMV-6 Duck/Hong Kong/199/77
- PMV-7 Dove/Tennessee/4/75
- PMV-8 Goose/Delaware/1053/76
- PMV-9 Duck/New York/22/78

It is epidemiologically highly important that due it its heat stability the virus can remain alive in the environment for 235 days in room temperature and for 538 days at 4°C. Moreover, in muscles and bone marrow of slaughtered poultry, the virus can stay infectious for at least 6 months in a temperature of -20 °C and for up to 134 days in a temperature of 1°C. In dried condition, the virus remains infective for years [19].

The infection has aerosol transmission though infectious dust and air as well as directly through contact in cages, pens, transports or bird markets. Another way to transmit the virus is though infected eggs thus leading to infected hatching chicks. The Newcastle Disease Virus gets easily distributed due to its high tenacity and wide host range. Important sources of infection are inapparent infected birds as well as bird during the incubation period or already sick ones. The main distribution of the disease in disease-free regions is through infected poultry meat. Living reservoirs play a minor role in the disease transmission. However, a disease transmission through infected wild birds and parasites like lice might be possible [19].

The Newcastle Disease Virus gets secreted through feces, eggs and discharges from nostrils, oropharynx and eyes. The portal of entry is the mucosa of upper respiratory and digestive tract. Incubation period are up to 26 days and in vaccinated birds 40 days [19].

Identification

Direct virus isolation can be performed by inoculating organ suspension of spleen, brain and lungs of infected birds in 10 days old chicken embryos. Serological tests like hemagglutination and hemagglutination inhibition tests are useful in chronic disease forms as antibodies can be detected within 2-5 days after infection. These tests can also be used to differentiate NDV from other viruses [19]. Polymerase chain reaction is another possibility to determine the presence of the RNA of the Newcastle Disease virus.

Classification, Symptoms and Clinical Diagnosis

Newcastle Disease is a highly contagious systemic infection that can result in high mortality in some avian species. The different virus strains show a strong variety regarding their virulence and symptoms. Different classifications exist for NDV. Mainly used in chicken, one classification differentiates into lentogenic (avirulent to weak virulent), mesogenic (moderate virulent) and velogenic (highly virulent) strains [19]. Whereas the lentogenic form does not show diseases symptoms or only mild unspecific signs, the velogenic form results in peracute to acute systemic disease. The signs range from cyanosis, edema in face and around the eyes, ruffled feathers, severe respiratory disorders following pulmonary edema, tracheitis and diarrhea. A high mortality of up to 50-90% can be observed after 4-8 days. CNS signs are rarely observed and only during longer survival periods. Mesogenic forms show acute respiratory symptoms like coughing and discharge from the nostrils and headshaking. 2-3 weeks later, nervous symptoms like paresis of the legs, ataxia, torticollis and fits can be observed with a mortality of 5-50% [12].

Another classification is based also mainly on chicken und differentiates the previous classification in further classes. The viscerotropic velogenic form with high mortality and clinical symptoms is more susceptible to proventriculus and intestines and the tissue around the eyes. In contrast, the neurotropic velogenic form of NDV shows the respiratory tract and CNS affected. This results in high mortality with nervous symptoms like torticollis, paresis of legs, tremor, circling and rounding movement as well as respiratory sign. The mesogenic form includes respiratory signs and sometimes nervous symptoms, but the mortality is low to moderate. Respiratory lentogenic form of NDV leads to mild or subclinical infection of the respiratory tract. The last form, the asymptomatic enteric form, shows just mild enteritis [1]. The virulence of the virus depends mainly on its host spectrum. Therefore highly pathogenic NDV strain in one species might be weak pathogenic in another avian species [12].

Falcons show often CNS symptoms like torticollis, ataxia, paralysis, head shaking and massive fits that can take hours (Figure 13.1). However, in falcons and hawks, an untypical form of Newcastle Disease Virus has been observed with mild sadness and circulatory disorders. Owls have died of NDV following unspecific symptoms like inappentence and head turning [12].

Figure 13.1. Falcon with torticollis caused by NDV infection.

The pathological or microscopic examination does not reveal specific pathognomic changes for Newcastle Disease Virus. Gross pathology shows hemorrhagic lesions of the intestines as well as petechiae in the proventriculus. In the case of respiratory NDV forms, hemorrhages and congestion is visible in the respiratory tract. No pathological gross lesions have been isolated in NDV infected falcons with head tics and paralysis. Falcons with gastrointestinal symptoms have empty proventriculus, ventriculus and intestines, but an increased amount of bile can be identified thus leading to bile staining of duodenal and jejunal mucosa [41].

Therapy

Newcastle Disease virus infections cannot be treated. Infected birds should be euthanized in order to prevent the spreading of this highly contagious disease. However, in those countries where vaccinations against NDV are allowed, this approach is highly useful. Falcons can be vaccinated with the commercially available NDV vaccine 0.25 ml subcutaneously per bird. The vaccination should be boostered after 3-4 weeks and then repeated once annually. Through these vaccinations that are performed routinely in falcons in the Middle East, the incidence of NDV has been tremendously reduced. Following routine NDV vaccinations, the incidence of NDV positive falcons has been reduced to one or maximum two cases per year at the Abu Dhabi Falcon Hospital.

Disinfection of infected cages or pans can be performed with quarternary ammonium compounds, 1-2% Lysol®, 0.1% cresol and 2% formalin [9].

13.4. Avian Pox Virus

Etiology, Distribution and Transmission

Avipoxviruses belong to the poxviridae and can be found worldwide. Avian pox viruses are the largest viruses among all poxvirus species. 10 different avian pox virus species have been identified among them the Falconpox virus (FPV). Apart from falcons, other raptors like buzzards and golden eagles have been infected with avian pox virus. It has been suggested that the chickenpox virus can be transmitted to falcons. Falcons are also susceptible for pigeonpox virus. However, no data exist about the immunological relation between chickenpox and pigeonpox virus and falconpox virus [19].

Pox infections in birds have a cyclical manifestation. They get transmitted through either insect bites like arthropods as well as through small cutaneous or mucosal injuries. The virus develops at the portal of entry and then starts the primary viremia when reaching the lymphatic organs and the liver. After a sufficient multiplication of the virus, the second viremia happens in the unfeathered avian skin [19].

Identification

The clinical picture is typical for poxvirus infection. Further testing methods are electron microscopy of scabs, fluorescent antibody and immunoperoxidase tests. Furthermore, avipox virus can grow pocks on the chorioallantoic membrane of empryonated chicken eggs [40].

Symptoms and Clinical Diagnosis

Avian pox infections can be found in different forms, the cutaneous or dry forms, the diphtheritic form and the septicemic form. The cutaneous form is the most common form of pox infections. It can be found on the unfeathered skin, around the eyes, the nares and cere and the legs and toes. The pox lesions or so-called pocks start to develop with small vesicles that start to grow. The scabs dry out from the central part of the lesions until they are fully dry. As long as they still have an active area, the pox lesion continues to grow. After the pox lesions have dried out completely, sometimes after weeks, they come off. Scars are visible after the scabs fell off.

The diphtheritic form develops on the mucosa of the oropharynx, tongue, pharynx and larynx. Often fibrinous lesions can be observed on those mucosal membranes. Mixed forms of both clinical pictures can occur [19].

The septicemic form of pox infection is a systemic disease with unspecific symptoms like ruffled feathers, inappetence, fatigue and cyanosis. Cutaneous lesions do not get manifest, but in canaries pulmonary lesion and in psittacines necrosis in the myocardium have been observed [19]. In falcons, the pox infection starts with small cutaneous lesions either on the feet, toes or around the cere and eyes. They might look like tiny reddish bites and can easily be mistaken by ant or insect bites. The lesions start to grow. In this stage they lead to puffy edematous skin (Figure 13.2).

Figure 13.2. Advanced pox infection on toes with puffy edematous skin.

Figure 13.3. Drying scab at central part of pox lesions.

When the lesions start to dry out from the center, the surrounding skin area might still grow more and lead to edematous circles around the dry scab (Figure 13.3). Pox lesions are mainly found on the dorsal part of the toes and less on the plantar part (Figure 13.4). However, in cases of large pox lesion, the lesions can grow to the plantar side, too. The pox vesicles can get manifest around the eyes or eyelids. Here they can grow to such size that the eyelids close or that the pox lesion grows on one eyelid and then over the cornea (Figure 13.5).

Figure 13.4. Pox lesions on dorsal side of toes growing to the plantar side.

This might result in corneal abrasions or in advanced stages in corneal ulcers. Pox lesions can grow at the nares and nostrils and close the nostrils completely. This can lead to breathing problems and breathing through the open beak. After the pox scab drops off the nostrils, the nostril can be damaged and the shape can change to a larger nostril opening. The rods inside the nostril can come off, too. The beak can get deformed through large pox lesions (Figure 13.6). Moreover, in cases of severe pox infection around the cere, the mandible can get damaged (Figure 13.7) and in some cases might get loose or drop off. On the feet, pox lesions might grow around the talons of falcons. This can result in deformation of the talons or the complete loss of talons (Figure 13.8).

In mixed cutaneous and diphtheritic forms of falcons, the pox scabs mainly arise around the beak area and then grow into the choana and the upper part of the mouth. This may lead in extreme cases to irreversible damage and subsequent falling off of the mandible.

Figure 13.5. Advanced and active pox lesion in the face region.

Figure 13.6. Deformed beak and closed nares due to large pox lesion.

Figure 13.7. Advanced pox lesions growing into mandible and oral cavity.

Therapy

A prophylactic vaccination is possible with chickenpox or pigeonpox virus. However, in falcons those vaccinations are not leading to a full protection.

The pox vesicles can be carefully cauterized without cauterizing too deep. This prevents damage to the underlying anatomical structures. Iodine solution or mercurochrome can be applied gently to the cauterized lesions. Moreover, it is helpful to support the falcon's immune system with immunostimulants like echinacea. Great care has to be taken that scabs are not removed before drying completely as this will leave wet hemorrhagic skin surfaces that can easily get infected.

Figure 13.8. Pox infection leading to loss of toe.

13.5. Herpes Virus

Etiology, Distribution and Transmission

Herpesvirus infections can be found in almost all animal species and birds. Their typical feature is the lifelong latent presence in the organism. Herpesviruses are 120-180nm large DNA viruses with envelope [19]. They can affect skin, mucosa of respiratory and genital tract, kidneys, lymphatic organs and immune cells thus resulting in general infections, autoimmune diseases and tumors. Plenty of different herpes viruses do exist but not all are classified in subfamilies yet. The so far known subfamilies are alphaherpesviridae, betaherpesviridae and gammaherpesviridae.

Shedding of the herpesvirus happens in irregular intervals and may not be associated with clinical disease symptoms [31]. Increased virus shedding can be observed when the birds are under stress like underlying diseases, transport, new environment, malnutrition or dietary changes or breeding [31].

In raptors, falcons, eagles and owls can be affected by this disease but the causative herpesvirus have not been classified yet [19]. Herpesvirus infections in falcons have been reported back to the early 1900s in Austria. They have been identified in Europe, USA and Asia in wild as well as domestic falcons [31]. Although herpesvirus infections are not among the most common diseases in falcons, but can have severe outcomes if present. The falcon herpesvirus is called Falconid HV1 and causes the inclusion body hepatitis of falcons [12].

Falcon inclusion body hepatitis can be found in various falcon species among them peregrine falcons, kestrels, merlins, prairie falcons and red-headed falcons [12]. Moreover, other susceptible species are gyrfalcons and gyr-hybrid falcons [40]. No difference in the susceptibility of juveniles and adult falcons can be observed in falcon herpesvirus infections [31]. The transmission route of the herpesvirus has not been fully clarified yet. One possibility might be the disease transmission through feeding on contaminated prey like infected pigeons [11]. It has been assumed that the possibility of an oral or nasal transmission route might exist [39].

Furthermore, it is known that close serological relationships exist between several avian herpes viruses. Among them are pigeon herpesviruses, falcon herpesviruses and owl herpesviruses [31]. Both, herpesviruses of falcons and owls have similar infections spectrums. They include a large number of raptor species as well as other avian species, too [19]. The falcon herpesvirus has been isolated in Muscovy ducks, budgerigars, amazon parrots, owls, ring-necked doves, American coots and green herons [31]. Moreover, the owl herpesvirus has been identified in falcons and ring-necked doves. In falcons, the Marek's Disease Virus has been isolated in a kestrel, too [31].

The infectious hepatitis or hepatosplenitis in owls is caused by the owl herpesvirus Strigid HV1 [12]. The infectious hepatitis or hepatosplenitis in owls affects owls in the wild where it is the most frequent infectious disease in owls. Moreover, owls in captivity can also contract the virus and it can be lethal within a few days [12]. It is assumed that mainly owls with yellow or orange iris color are more susceptible to the herpesvirus infection compared to more resistant owls with dark iris color. Several owl species are susceptible to herpesvirus infections. Disease transmission can be through contact and infection through prey seems possible. Moreover, the virus has an affinity to the cells of the epithelium and mesenchym. Virus shedding occurs through urine and the oral cavity [12].

Eagles infected with eagle herpesvirus Accipitrid HV1 may suffer from inclusion body hepatitis [40].

Identification

The identification of avian herpesvirus can be performed through typical necropsy findings [40]. Virus isolation can be done on cultured cells. Other diagnostic tests include identification of viral-specific antibodies. Viral-specific DNA probes through PCR testing can be performed [31].

Symptoms and Clinical Diagnosis

Falcon inclusion body hepatitis can be asymptomatic or show classical symptoms like necrosis in liver and pharyngeal epithelium [31]. Moreover, other symptoms like mild to severe depression, weakness, anorexia can be observed within 24-72 hours before death [12, 31]. Sudden deaths without any previous disease signs are possible (Ritchie). Lime-green urates in the feces are typical signs of herpesvirus infections apart from other liver diseases, aspergillosis or malnutrition. In the post mortem, typical findings are light colored necrotic areas in the liver, necroses in spleen, bone marrow and intestinal lymph follicles [12]. Hepatomegaly, splenomegaly and hyperemia of the small intestines can be observed in the gross pathology [31]. Yellowish focal necrosis of liver (Figure 13.9) and kidneys (Figure 13.10) can be observed. The histology reveals focal or diffuse degeneration and necrosis of liver, pancreas, lung, kidneys and other organs that might be with or without inflammatory reaction [12].

Figure 13.9. Focal necrosis of liver due to herpesvirus infection.

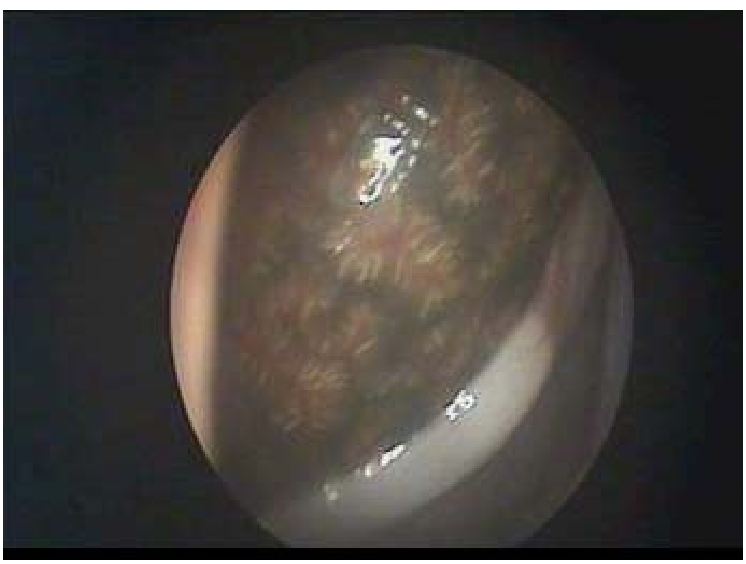

Figure 13.10. Focal necrosis of kidney due to herpesvirus infection.

The infectious hepatitis or hepatosplenitis in owls has an incubation period of 7-10 days. Typical symptoms are apathy, ruffled feathers, inappetence, sitting on the ground and sleepiness. Death occurs after falling over in abdominal position. Rarely yellowish nodules in the choana can be observed. However, antibodies in the wild owls were isolated thus indicating the survival of the herpesvirus infection. Post mortem findings reveal swollen livers and white focal necrosis in spleen and bone marrow.

Focal yellow diphtheric granulomas can be found in choana, esophagus, proventriculus, duodenum and rectum. In the histological examination, coagulation necrosis with basophil centers can be identified in the liver tissue [12].

Therapy

No specific treatment exists for herpesvirus infections in raptors. However, acyclovir can be administered but shows limited results. Prevention should be taken to avoid feeding contaminated prey like infected pigeons to falcons. It is advisable to feed only captive-bred pigeons from controlled farms to falcons and not to house them in close neighborhood.

13.6. Avian Reovirus

Etiology, Distribution and Transmission

The avian reo virus or orthoreovirus can be found in different avian species and is world-wide distributed. 11 serotypes exist that are showing cross reaction between different avian species. They have been isolated in raptors, chicken, turkeys, geese, ducks, pigeons and parrots [12].

The disease transmission can be via oral route, through air and through the eggs [12].

Identification

In the case of viral arthritis, the clinical symptoms are leading to the diagnosis. Typical pathological changes are supportive for clinical diagnosis. Moreover, serology like ELISA and can be used for identification of antibodies [19].

Symptoms and Clinical Diagnosis

Disease symptoms include lameness with a mortality of up to 16%. Tendinitis with strongly thickened tendon sheaths and synovitis can be observed. Fibrotic changes can lead to immobility [19]. Other disease symptoms include enteritis, emaciation and reduced flight performance. Often secondary infections with *Salmonella sp*., *Aspergillus sp*. and *Chlamydophila* can be found.

Therapy

No specific medicine exists against avian reovirus infections. However, sick birds can be supported by immune stimulants, electrolytes, vitamins and warm [12] and stress-free environment.

13.7. Adenovirus

Etiology, Distribution and Transmission

The avian adenovirus is the so-called aviadenovirus. Widely distributed the aviadenovirus causes mainly clinical inapparent infections. However, infected birds are a permanent virus reservoir and shed the virus with the feces [19]. The falcon adenovirus has been recently discovered and is closely related to the fowl adenovirus [33]. However, adenovirus infections in falcons seem to be rare [38]. The infection seems to affect hatchling and young falcons to a greater extent than older ones [33]. Apart from American kestrels [34], peregrine falcons [33], and gyr-peregrine hybrid falcons [38], other raptors might be affected, too. One way of disease transmission might occur through infected food sources. The incubation period might take approximately 10 days in falcons. Predisposing factors might be transport and stress [37. 38].

Identification

Adenovirus infections in birds can be identified through PCR method as preferred method. Virus isolation through egg inoculation did not result in successful results.

Symptoms and Clinical Diagnosis

Symptoms of sick raptors include anorexia, depression with death within 3-5 days. Necropsy reveals the enlarged and brownish discolored liver, mildly enlarged spleen and congested lungs. Enlargement of the kidneys with cystic changes can occur. Those cysts might be filled with fluid. The histopathology shows moderate to marked hepatocellular necrosis with basophilic intracellular bodies. Necrotizing hepatitis [37] and splenitis, necrosis of the pulmonary septum, multifocal necrosis of the myocardium as well as necrotizing colitis and nephritis can exist [38]. Congested mucosa of ileum and jejunum can be observed as well [37]. Hemorrhagic enteritis has been found in kestrels [34].

Therapy

No specific antiviral medication exists for aviadenovirus infections. However, prevention of the adenovirus infections can be performed through separating newly arrived and falcons already accommodated in cages. Especially newly hatched and young falcons have to be strictly separated from other falcon groups. Reduced stress situations as well as hygienic measures are helpful in avoiding the outbreak of the disease [38].

13.8. Other Viral Diseases in Falcons and Raptors

Eastern Equine Encephalitis (EEE) has been isolated in Falconiformes, Strigiformes, red-shouldered hawks and bald eagles. The Eastern Equine Encephalitis is caused by a togavirus of the genus alphavirus and gets transmitted through mosquitoes, ticks and biting flies. This virus is geographically restricted and affects mainly young birds. A large variety of symptoms can be observed in EEE cases. They range from asymptomatic forms to sudden death without previous diseases signs as well as enteritis and neurologic signs. Sings can be depression, anorexia, weakness, and diarrhea. Neurologic symptoms include partial or complete paralysis of one or both legs, circling movements including partial wing paralysis [31].

13.9. Conclusion

Viral infections cannot be treated like other disease as specific medicines against the viruses do not exist. However, prevention of the environment like pest control as well as hygienic measures can have a positive impact on the reduction of virus infections. Moreover, vaccinations wherever possible and allowed by legislature help to prevent or at least reduce disease symptoms. Infected falcons should be separated from other falcons to prevent possible disease spreading. Moreover, reduction of stress and aggravating environmental factors especially in young falcons and falcons under training helps to keep a well-balanced immune system. Immune stimulating medicines and vitamins help also in such situations.

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Chapter XIV

Orthopedic Problems and Surgery

Abstract

Fractures of the tarsometatarsus, tibiotarsus, femur, humerus, ulna and radius are very common fractures in birds. Several methods exist to fix those fractures. They range from special bandaging as in the case of wing fractures to surgical methods like intramedullary pinning of fractures. The exact fracture repair method has been explained including the perioperative preparation and postsurgical care as they form an essential part of the successful fracture management. For all non-invasive as well as invasive surgical methods the aim has to be to fully restore the mobility of the affected limb or wing. One very useful system is the FixEx tubulaire Type F.E.S.S.A. fixation bar system that is used to achieve an improved fracture healing and enable better weight bearing of the fractured legs. Other orthopedic topics like osteomyelitis and amputation of toes are explained.

14.1. Introduction

Fractures, especially of the legs and wings, in falcons are common and frequently experienced during the training and hunting period from September to April. Other common fractures include the fractures of the scapular girdle. Fractures can be repaired either through non-invasive methods like figure-of-eight bandage or invasive surgical approaches. The right choice of fracture repair method helps to achieve the best possible bone healing. Moreover, it is of utmost important to achieve a full mobility and restoration of the limbs or wings to use the raptor for hunting again or to be released to the wild again. The therapeutic approach for fractures depends on the fracture itself, the experience and skill of the veterinary surgeon and the equipment or specialization of the veterinary practice. However, it has to be kept in mind that the very small and fragile avian bone requires a very careful treatment approach in order to avoid further damage to the already broken bone. In literature, in many books on avian medicine different fracture repair methods have been described of whom several are not practicable or are not suitable in reality. Therefore, in this chapter, the most practical fracture treatment approaches have been described. Moreover, the correct and careful perioperative and postsurgical management is highly important to ensure the success of the operation. The main problems in fixing especially wing and leg fractures are the heavy weight of the fixation bars or polymethylmethacrylate bars in ordinary external fixations and rotation of intramedullary pins. The use of acrylics has been recommended [5], but has major disadvantages like strong heat development during the hardening process and no changes can be done after the hardening. The other problem is that a partial removal of the pins with such bar systems is difficult as it affects in most cases the stability of the fractures. Therefore acrylics are not anymore the material of choice as more modern flexible fixation systems have replaced them. The flexible surgical system like the FixEx tubulaire Type F.E.S.S.A. fixation bar system helps to overcome those challenges. The advantage of the FixEx tubulaire Type F.E.S.S.A. system (Figure 14.1) is the easy use, light weight, flexibility of the size and holes of the bars for the realignment of the bones, the possibility of partial pin removal or partial connection. Research suggests that this system is very well suitable for all different kinds of fracture repair in falcons and other birds as well as in other animals species like exotics or small animals. However, due to the fragile condition of the avian bones, great care has to be taken not to put too much pressure on the bones during a surgical fracture repair. This chapter does not elaborate on surgical methods that are not practicable or too expensive to be executed by normal veterinary practices. This chapter has been developed with giving general information about fracture repair and its perioperative and postsurgical management followed by a detailed description of the individual types of surgery for the different fractures. Emphasis has been laid on the practical oriented approach to fracture management and rare surgical methods have not been included. Moreover, orthopedic problems like osteomyelitis and amputation of toes have been included in this chapter, too.

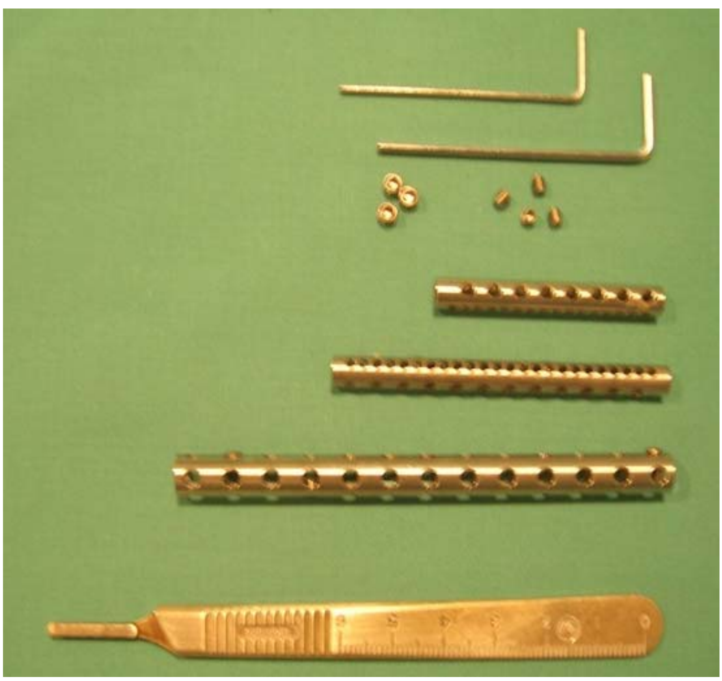

Figure 14.1. FixEx tubulaire Type F.E.S.S.A. system.

14.2. First Examination

In falcons and raptors, fractures may arise through trauma like hitting prey or hard obstacles. This might affect captive-bred raptors trained for falconry as well as wild raptors that had accidents. Complaints of owners in cases of such trauma are frequently that the bird is not putting pressure on its leg or lifts up the leg. Moreover, typical symptoms for wing fractures are wings that are either dropping down or slightly hanging. Other disease symptoms are reduced flight performance or injuries. The first examination should be the observation of the bird while sitting on a perch to see any difference to the correct physiological position. The further examination is best carried out under general anesthesia. This includes a thorough palpation of the affected limb. It is very helpful to use surgical spirit to straighten the feathers, make the skin visible and review the affected area thoroughly. Often hematomas or abrasions and well as swelling and increased skin temperature might be present. In case of open fractures, damage of the skin might be present or bone pieces might have punctured the skin. In any case, the affected limb should also be compared to the healthy one to see any small difference.

It is advisable to get more detailed information thorough diagnostic imaging like radiography or other diagnostic imaging like C-bow imaging. X-Rays can be performed conventionally or digitally. The X-ray should be taken in ventro-dorsal and latero-lateral position. A full body X-Ray on a 30x40 cm cassette is recommended to get a full overview of the complete skeleton of the falcon and to assess the internal organs for the presence of any damage. For wing fractures a special X-ray on a 30x40 cm cassette of different wing positions is helpful to review the wing and shoulder girdle. Hereby, the cassette gets split in three parts, two for the fractured wing and one for the healthy wing. For leg fractures, the injured and non injured limb should be radiographed together. For this purpose a 24x30 cm cassette can be used. Moreover, it is useful to fix the legs or wings in correct physiological position with a masking tape to avoid any movement during radiography.

14.3. Perioperative Fracture Management

In case of a fracture requiring surgical intervention, blood sampling before the surgery is a good step to avoid any bad surprises during or after the surgery. This pre-anesthetic blood profile is a great help to control the anesthesia during surgical interventions as complete fracture repair may require an operation of two to three hours. In the case of leg fractures, a protective bandage or a specially made shoe can be put on the contralateral and non injured leg during the first examination to avoid pressure sores on the feet.

For either non surgical or surgical fracture management, an early decision regarding the fracture repair approach is useful. Surgical intervention can be best carried out during the first days after the fracture has occurred. However, it should be tried to repair even older fractures of up to 2 weeks as they can still heal very well according to the author’s experience.

Antibiotic treatment with injectable antibiotics in the pectoral muscle is recommended before any surgical procedure, especially in open fractures. For open wounds, immediate wound cleaning with iodine solution and antibiotic flushes should be performed as soon as possible. Enzymatic wound cleaning agents are extremely helpful to gently debride the often difficult approachable wound inside. Moreover, antimycotic treatment as supportive therapy in cases of open fractures has been recommended in literature [2]. However, from the author's experience antimycotic treatment is not indicated as supportive therapy in fracture treatment. Moreover, great care should be taken not to administer medication via oral or subcutaneous route as this will lead to grabbing of the falcons and subsequent danger of iatrogen injuries. Injectable medicines are much better in those cases to minimize the pressure on the bird. Another way of applying medicines is by injecting food pieces with medicines.

Feeding is another important factor for the success of the fracture management. One time feeding per day with chopped quail is sufficient for a falcon. During the complete time of the fracture healing process, the feeding with chopped quail should be continued. This applies to all different kind of fractures as this will enable the bird to eat without using the injured legs or wings.

14.4. Surgical Intervention

14.4.1. Anesthesia

The falcon is anaesthetized with isofluorane with initial flow rate of 4.5-5% isofluorane which gets reduced to the maintenance rate of 2.5-3% isofluorane combined with oxygen at 2-3 l/min. per min. It is useful to control the anesthesia with surveillance monitors. Moreover, it is important to monitor the temperature either through a heated table or heating pad under the falcon [3].

14.4.2. Surgery Preparation

The falcon is laying on a sterile drape in dorsal recumbency. All feathers of the fractured leg or wing have to be plucked completely. The distal part of the leg or wing has to be covered with sterile gauze and the exposed fracture area is cleaned with commercial surgical preparation solution containing 10% povidone iodine followed by iodine scrub. Then disinfection with surgical spirit is performed and the povidone iodine disinfection is done. This is repeated three times altogether. The rest of the bird's body has to be covered with a sterile drape [3].

14.4.3. Open Fracture Repair

In case of open fracture repairs, an incision of appropriate length is made using a medial or dorsal approach (depending on the fractures type which is explained in detail later in this chapter) and the muscle layers are carefully divided to reach the fractured bone ends. Under sight, the intramedullary pin (3/16" (4.8mm), trocar point) is put in normograde way into the distal medullary cavity of the fractured bone until the end of the bone marrow cavity of the fractured bone. Then the open wound is flushed with piperacillin and sodium chloride. Sterile gauze is used to dry the wound area. The muscle layer is stitched with absorbable suture 4/0 and the skin is sutured with polyamide monofilament non-absorbable suture 3/0 or 4/0 in single mattress pattern [3].

14.4.4. Closed Fracture Repair

In case of closed fracture repairs, the intramedullary pin of appropriate size e.g. 3/16" (4.8mm) (trocar point) is inserted on the proximal fragmented bone end below the condyle or epicondyle and pushed down in normograde fashion to the fracture site. The fractured bone ends are held in correctly aligned position and the pin was carefully pushed through the fracture site until the end of the bone marrow cavity of the distal bone fragment [3].

14.4.5. External Fixation

The lateral and medial area of the intended pin is disinfected again with 10% povidone iodine. Then one or two external pins (1.8" (3.2mm), trocar point) are carefully drilled proximal of the fracture site from lateral to medial through the bone while rotating the leg to the medial side in exactly the same position as the non-fractured leg. The second external pin is placed distal of the fracture site in the same way. In the open fracture repairs, the external fixation can be performed with 2 distal external pins on either side of the fracture location. After insertion of the extramedullary pins, the IM pin is bent at a ninety degree angle to the long axis of the fractured bone. The external fixation of the pins followed by selecting the suitable fixation bars FixEx tubulaire M3 16 hole 6mmx46mm, FixEx tubulaire M3 24 hole 6mmx67mm and FixEx tubulaire 13 hole M4 8mmx97mm. The selected bars are fixed with hexagonal screws in the medial and lateral side of the extremity (Figure 14.2) [3].

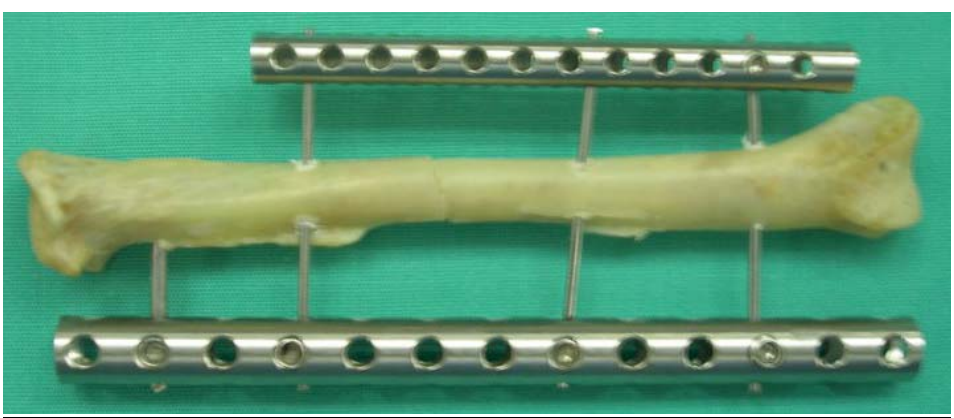

Figure 14.2. Model of medial and lateral FixEx tubulaire Type F.E.S.S.A.

14.4.6. Radiography

Radiography is an essential diagnostic tool in judging the fracture repair progress and proper alignment of the fractures. In literature, the frequency of radiographs is described as one radiograph taken immediately postoperatively and another one after two weeks [2]. From the author's experience, this is not sufficient to control the healing process. During surgery, an X-ray in ventro-dorsal and latero-lateral position should be taken after every important step. This can be after inserting the intramedullary pin, fixing of the external pins on one side of the fracture site and then on the other side, tying of the fixation bars and as final X-ray at the end of the surgery. When the radiography reveals that either the pins are not inserted exactly in the bones or that the alignment of the bone fragments is not fully correct, corrective measures should be taken immediately. It is not sufficient to take radiographs only at the beginning and the end of a fracture surgery as valuable time will be lost and the complete surgery will not be successful. As rule of thumb it can be said that the more radiographs are taken during the surgery to cover each surgical step, the better the chances of a successful surgery outcome will be. While taking X-rays, the wound area has to be covered with sterile gauze to avoid contamination.

The first radiographs 24x30 cm can be taken after 7 to 10 days postoperatively and then routinely after every 7-10 days.

14.4.7. Bandaging

The suture in the case of the open fracture repair and the pin entry area is disinfected with a sterile swab dipped in iodine solution and then veterinary woundpowder is applied. The suture of the open fracture repair cases and pin areas are covered with low adherent absorbent non-adhesive dressing and bandaged with conforming bandage and adhesive bandaging tape [3]. The fixation bar ends and the bar on the medial side of the bird should be covered with cotton to soften the bandage and to avoid any pressure sores. It has been suggested that it is sufficient to keep the bandage only for 2-3 days in uncomplicated cases [2]. However, in the author's experience the bandage should be left in place for the complete time of fracture healing to avoid any contamination of the pin area. The first bandage change should be performed on the first postoperative day. This can be followed by rebandaging with woundpowder and non-adhesive dressing every 7-10 days until the pins are removed. The radiographs can be performed together with the bandage change as this reduces the necessary handling of the bird. In cases with damage to the skin or open fracture repair, the bandage can be changed every 3-5 days. In few cases where the skin might get dry and darker colored the application of homeopathic skin granulation ointment is useful to enhance the granulation of healthier skin. In rare cases of skin infections, antibiotic wound ointment containing either amoxicillin-clavulanic acid or chloramphenicol and iodine ointment can be applied on the infected skin areas and around the insertion place of the pins. In all cases, the bandage should be light-weighted and not too bulky or heavy.

14.5. Postoperative Fracture Management

14.5.1. Immediate Post Surgical Management

The falcon should receive marbofloxacin 10% injection intramuscular as antibiotic coverage. An intravenous injection of 0.9% sodium chloride and 5% glucose or plasma expander can be administered with the amount of 10ml pre-surgically or post-surgical especially in case of strong hemorrhage. After surgery the subcutaneous application of 40 ml compound sodium lactate can be administered. Non steroidal anti-inflammatory analgesic drug is applied directly after surgery for the initial pain management. For an enhanced wound healing, homeopathic drugs are injected via subcutaneous route after the surgery [3].

14.5.2. Post-Surgical Management

After surgery, the falcon normally stands on both legs with equal pressure distribution either immediately or up to approximately 24-48 hours after surgery in cases of very long and complicate surgical repairs. No lifting of the fractured leg is observed in most cases. In a few cases and especially in tarsometatarsal fractures, it might take two or three days until the falcon fully opens the toes. Post-surgical fracture management includes the antibiotic coverage with marbofloxacin injection for a time period of seven days. In cases of open fracture repair with stronger hemorrhages, the bandage should be changed on first postoperative day and wound powder can be applied on the skin and around the pin insertion area. On this occasion, an intravenous injection of 0.9% sodium chloride and 5% glucose or plasma expander can be administered with the amount of 10 ml per falcon post surgically especially in case of strong hemorrhage. Moreover, the subcutaneous application of 40 ml sodium lactate can be given. The non steroidal anti-inflammatory analgesic drug tolfenaminacid can be administered on the day after surgery for the initial pain management in case of a complicate fracture or strong pain. For an enhanced wound healing, homeopathic medicines are injected in the food pieces for 3-7 days starting on the day after surgery. The pin removal can be performed in steps if necessary. The great advantage of the F.E.S.S.A. fixation system is the possibility to remove the pins partly and to leave the other pins in place. This allows the kallus to cover the pin holes and to further stabilize the fractured bone. After the complete pin removal, the falcon should be kept another 5-7 days in the hospital without any medication to observe the healing process and proper motion. Before being discharged the falcon should be radiographed again [3].

14.5.3. Housing and Husbandry

Falcons or raptors should be housed alone in a quiet room. Due to the fact that often injured falcons were not trained yet and therefore very nervous and jumpy, they can be kept on a sponge covered with artificial grass carpet before surgery and for one or two days after surgery in case of leg fractures. Then they should be moved to a square perch of 12.5 cm diameter and 25 cm height. Only the not fractured leg should be tied with jesses [3]. The fractured leg should not be tied at all. If the falcon is very nervous or not quiet enough, the hood can be kept on the birds. Moreover, the falcon should not be carried for daily weight taking after surgery. It is sufficient to take the weight once or twice per week, preferably when a routine X-ray has to be taken, if the falcon is eating well. This helps to avoid jumping or any other unwanted movement of the falcon.

14.5.4. Postoperative Feeding

Suitable food for falcons with fractures is fresh or frozen quail cut in small pieces to which calcium and vitamin D_3 supplement is added daily over a period of 3 weeks to support a faster kallus formation [3].

14.6. Non Surgical and Surgical Fracture Management

14.6.1. Fractures of the Thoracic Girdle

Fractures of the thoracic girdle may arise while hitting either prey or obstacles often with high speed. Those fractures can involve the coracoid, clavicula and scapula. The more common fracture is the fracture of the coracoid whereas fractures of clavicula and scapula are rare.

Hitting objects or prey with high speed may lead to coracoid fractures that can be transverse diaphyseal fracture or an injury of the tendinous articulation with the sternum. Transverse diaphyseal fractures lead to a displaced proximal coracoid part that can be clearly identified in the X-Ray. A potential threat of crop or trachea can be caused by the fragmented coracoid parts. A much more difficult diagnosis can be done in the case of the tear of the coracoid articulation as this is not easy to detect in the radiography. A slight asymmetry might be an indication for this injury. Different therapeutic approaches can be performed. One possibility is complete rest and a figure-of-eight bandage of the wing if light wing drooping is present. However, the bandage should not be left in place for a too long time as the joint might get stiff and the propatagial tendon might get shorter. Another treatment method is the surgical approach with either intramedullary pins or plates. The surgical approach can be performed from the ventral side through the pectoral muscles under careful consideration of nerves and blood vessels. A retrograde intramedullary pinning is possible from the fragment that is located closely to the shoulder. However, there is a danger that the pin might enter the thoracic cavity or sternum if not carefully enough pushed forwards [2].

A surgical treatment approach for clavicula and coracoid fractures is not recommended as a surgical intervention is limited through the complex anatomical location of the shoulder bones and adjacent anatomical structures. To correctly diagnose the fracture, the bird has to be positioned in exact ventro-dorsal position for the X-ray. In this position, the sternum is overlapping the vertebral column. An appropriate way to deal with such fractures is to keep the bird in a dark quiet room without any exercise. It takes usually three to four weeks to heal completely. In case of proper wound healing, the falcon can be used again for hunting.

14.6.2. Fractures of the Humerus

Humerus fractures may arise when hitting objects or incorrect and not careful handling like wrong grabbing of the falcon. Typical clinical symptoms are hanging or drooping wings, slight rotation of the wing or poor flight performance. In case of open humerus fractures, blood and damage to the feathers and skin might be visible. Palpation might reveal separated bone fragments, crepitation and instability of the humerus. In open fracture wounds, the humerus fragments might be visible through a damaged and penetrated skin, often surrounded by blood and bloody feathers. Radiography provides a clear diagnosis and gives valuable information about the possible surgical approach.

The humerus might break as oblique fracture, often as comminuted fracture, or diaphyseal transverse. An overlapping of the broken bones can be frequently observed and mainly the distal part of the bone moves backwards as the muscles holding it in place are not strong enough [2]. Puncture of the skin can be frequently found in oblique fractures where one bone fragment has penetrated the skin. This may lead to infections not only in the humerus itself but also in the adjacent clavicular airsac as the humerus is connected to this airsac.

Due to the massive instability and rotation of the humerus fragments, a surgical fracture management approach is recommended [2]. This approach should include intramedullary pinning with external fixation as tie-in method. This has the advantage that the rotation gets fixed and the original length of the bone fragments can be restored again thus leading to a correct flight performance. However, great care has to be taken that the humerus does not break into further bone fragments during surgery if too much pressure is exercised on the bone. Moreover, the radial nerve can be found in the distal third laying directly over the humerus [2].

The kind of fracture determines the falcon's position and side of the surgical approach. In case of a closed fracture the bird can be positioned in ventral recumbency with surgical approach from the lateral side. The intramedullary pin is inserted in normograde way proximal to the dorsal epicondyle of the humerus and should be at least 50% of the bone cavity [2]. It can also be inserted close to the proximal epicondyle of the humerus if the bone fragment seems to be more suitable for the entry of the intramedullary pin. The pin insertion should never be performed too close to both joints the humerus is taking part in. Pinning through the joints might lead to ancylosis and stiffness of the joints. Moreover, an infection of the joints cannot be ruled out with negative effects on the full mobility of the joints. Another one or two smaller pins have to be gently placed on either humerus fragment. The intramedullary pin is bent to the lateral side. While bending it is very useful to fix the part of the pin that is inserted in the humerus with a plier to avoid further breaking of the bone fragments due to the strong pressure while bending. The part of the pin that will be moved up laterally is bent with another plier at the same time. It is also helpful to move the pin out approximately 0.5 -1 cm when bending to insert it again into the humerus after bending.

Before insertion, the pin should be disinfected with iodine solution once again to prevent any infection. Through this movement, the pin is bent much closer to the wing and the area for the fixation bars gets smaller. This prevents the falcon from unnecessary large bandages and heavier fixation bars. The fixation pins can be manually drilled in the bone fragments up to the corticalis of the medial side without drilling through the bone completely. This has the advantage that the medial side of the humerus remains without fixation bars and thus helps in keeping the wing in a physiological position in the figure-of-eight bandage. If this is not possible, then the pins have to be drilled through and fixed with a small fixation bar on the medial side and tied with the intramedullary pin end through a larger fixation bar on the lateral side of the humerus.

However, in case of an open fracture that has penetrated the skin at the ventral side the surgical management should be performed from the medial side with the bird laying in dorsal recumbency. Nevertheless, the external fixation has to be tied to the lateral side as otherwise the wing cannot be placed in physiological position. In the case of an open comminuted fracture, the only way of repairing the fracture might be the application of cerclage wires or a combined cerclage wire and intramedullary pin fixation approach. The cerclage wires have to be very carefully moved around the bone pieces with the help of a wire driver and then tightened to the medial side of the humerus. The cut wire ends have to be pushed to the bone to avoid damage to the skin after wound closure. Often, the humerus fragments are not intact and stabile enough that external pins can be used for an additional stabilization. In such a case, the intramedullary pin can be inserted in retrograde fashion into the longer bone fragment through the open and disinfected wound close to the proximal or distal epicondyle of the humerus.

Information of the pins and the surgical aftercare has been provided in an earlier part of this chapter and can be applied accordingly.

14.6.3. Fractures of Radius and Ulna

Fractures of radius and ulna (Figure 14.3) happen frequently when the falcon is catching its prey. Either both bones can break or only one of them. The diagnosis can be done by palpation and confirmed by radiography. In case of a closed and aligned fracture of only radius or ulna with still intact other bone, then it is possible to use a non surgical approach (Figure 14.4). The intact bone will hold the fractured one in place.

A figure-of-eight bandage is a suitable solution for the management of this kind of fracture. However, once or twice per week physiotherapy in form of mild gentle extension of the wing, the propatagium and propatagial tendon is useful to avoid shrinking of the propatagium.

In case of a fracture of both bones, radius and ulna, a surgical approach is advisable as a non surgical approach is not leading to full restitution of the wing. An intramedullary pinning or external tie-in with threaded pins is a suitable surgical approach for a fractured ulna.

Figure 14.3. Fracture of ulna.

Figure 14.4. Healed fracture of ulna after conservative treatment.

Figure 14.5. Oblique fracture of femur.

14.6.4. Fractures of the Carpometacarpus

Fractures of the carpometacarpus are not very common in falcons but can happen as comminuted fractures when the bird gets hit or squeezed. The carpometacarpus is supplied by one artery only. A damage of this artery can result in a necrosis of the wingtip [2].

Clinical symptoms are rare and might only be a mild hanging of the wingtip. Radiography will show the extent of the fracture.

A non surgical treatment approach can be chosen in falcons. Splints in U-form can be used to as fixation. The figure-of-eight bandage is a useful approach to this kind of fractures. Healing will take approximately three weeks [2]. In the author's experience, a surgical approach cannot be regarded as recommended treatment for carpometacarpal fractures.

14.6.5. Fractures of the Femur

Femur fractures are common in falcons, but open fractures are rare. Femoral fractures are not easy accessible due to several layers of musculature around this bone. This leads to strong muscle forces on the fracture fragments [2]. The distal femur fragment gets contracted and moves more distally. This can result in an overlapping of both femur fragments of more than 1cm. Clinical symptoms of a femur fracture are lameness and difficulties in perching and catching prey and other objects [2]. Palpation might be difficult due to the muscle layers. Radiography visualizes the extent and location of the fracture.

The surgical approach with intramedullary pinning and external fixation is the treatment of choice. However, due to the strong muscles and the difficult approachability of the femur, the surgical management of femur fracture is not an easy task. If the femur fragments are overlapping to a large extent, the open surgical approach needs to be chosen.

Great care has to be taken to avoid vital structures like the ischiadicus nerve and the femoral artery. The surgical approach is from the lateral side through the carefully diverted muscle layers. The intramedullary pin is inserted in normograde way at the lateral side of the femur head and moved distally. A retrograde insertion of the intramedullary pin is possible if the distal bone fragment cannot be manually retracted to such an extent that the pin can be inserted in normograde way. The tip of the intramedullary pin is pushed ahead until it reaches the end of the bone cavity close to the femur condyles. In the case of an oblique fracture, cerclage wires are required to stabilize and attach the bone fragments (Figure 14.6, 14.7).

The intramedullary pin is then bent as described previously in this chapter. At least one external pin has to be drilled in each femur fragment. It is possible to use threaded pins that are anchored in the femur corticalis. This avoids the use of a medial fixation bar and therefore only the lateral fixation bar is required (Figure 14.8).

Figure 14.6. Cerclage wire around bone fragments.

Figure 14.7. Femur repair with intramedullary pinning and cerclage wires.

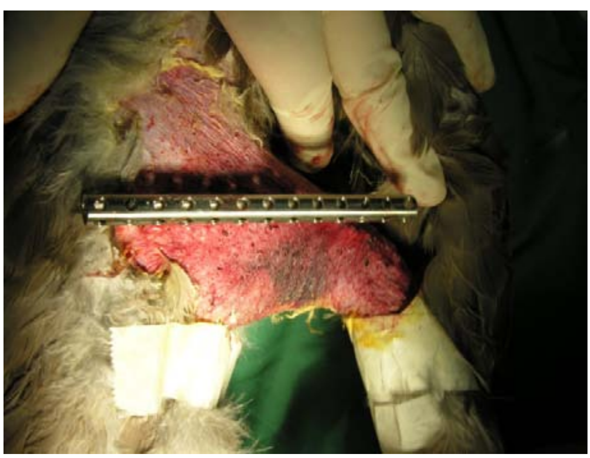

Figure 14.8. Fixation bar of femur fracture.

14.6.6. Fractures of the Tibiotarsus

In falcons, tibiotarsal fractures are the most common fractures (Figure 14.9). This might happen when falcons hit prey while catching or landing. Another reason for broken tibiotarsal bones are jumping falcons that are tied with jesses.

Figure 14.9. Oblique fracture of tibiotarsus.

Clinical symptoms are falcons that can only stand on one leg. The other leg is either hanging down or the bird does not put any pressure on it. Swelling may be visible and crepitation can be felt during palpation. In case of an open tibiotarsal fracture the skin might be punctured and bone fragment pieces might be visible. A clear diagnosis can be given after radiography of ventro-dorsal and latero-lateral position.

In case of an open tibiotarsus fracture an approach with intramedullary pin and external fixation can be chosen for a successful fracture repair. First, an incision of appropriate length is made using a medial approach and the muscle layers are carefully divided to reach the fractured bone ends. Great care must be taken not to damage the two tendons that run on the tibiotarsus. An intramedullary pin is inserted on the lateral condyles of the proximal tibiotarsus end and pushed down to the fracture site. Under sight, the intramedullary pin is put in normograde way into the distal medullary cavity of the fractured bone until the end of the bone marrow cavity of the distal tibiotarsus. External pinning can be performed with one external pin at the side where the intramedullary pin will be bent and one pin (Figure 14.10) or if possible preferably two pins on the other bone fragment. This will provide a strong stabilization for the healing process. The pins are then fixed with fixation bars (Figure 14.11).

Figure 14.10. Intramedullary pinning and external fixation of tibiotarsal fracture.

Figure 14.11. View of fixation bars of tibiotarsal fracture after fracture repair.

In case of closed tibiotarsus fracture, the intramedullary pin (3/16" (4.8mm), trocar point) is inserted on the lateral condyles of the proximal tibiotarsus end and pushed down in normograde fashion to the fracture site. The fractured bone ends are held in correctly aligned position and the pin is carefully pushed through the fracture site until the end of the bone marrow cavity of the distal tibiotarsus [3].

14.6.7. Fracture of the Tarsometatarsus

Tarsometatarsal fractures (Figure 14.12) can happen when the falcon jumps with its tied legs or when the jesses are tangled around the leg and the falcon tries to move or jump. Those fractures are often in the middle of the bone or in the distal part. They can be comminuted but are more frequently simple fractures. The main problem for the fixation of tarsometatarsal fractures are the flexor tendons that are anatomically located on the groove on the plantar side of the tarsometatarsus. The extensor tendons run on the dorsal groove of this bone. Both tendons have to be avoided while inserting the pins in the tarsometatarsus as especially in hunting falcons the correct use of the toes is highly essential for the hunting success. No intramedullary pin is inserted in most cases as an external fixation is the method of choice for tarsometatarsal fractures. In closed fractures, the surgical approach should be only from outside without opening the fracture site. If the fracture is in the middle of the bone, two pins above and two pins below the fracture site are sufficient for a kallus formation. It is useful to use a pin in the most proximal location that is one size bigger than the other pins. They can be of smaller diameter as the bone itself is also a relatively small one. The non-threaded pins have to be inserted from the lateral side in the center of the bone and carefully drilled to the medial side. The pins on the medial side are drilled approximately 1 cm out of the bone to keep space for the fixation bars.

Figure 14.12. Fracture of tarsometatarsus.

All pins have to be aligned in exactly the same horizontal line in order to fix the fixation bar correctly without putting pressure on the pins during aligning of the fracture ends. If this is not the case, the danger might arise that while putting pressure on the pin to get it into the fixation bar, this pressure may relay to the bone and thus the alignment will get dispositioned. The correct alignment can be done in the way that one assistant is holding the bone at its fracture site correctly in place and the veterinary surgeon is tying the bars in the correct position. The bars can be fixed in a distance of 3-5 mm from the leg (Figure 14.13).

Figure 14.13. External pinning and fixation bars of tarsometatarsal fracture.

It is recommended to hold the leg rotated to the inside to achieve a physiological position of the leg. Full restoration of the tarsometatarsus (Figure 14.14) and leg function can be achieved through this. Otherwise it might be that the leg is rotated to the lateral side and thus might create problems while perching or hunting.

Figure 14.14. Healed tarsometatarsal fracture after pin removal.

14.6.8. Fractures of the Phalanges

Fractures of the phalanges (Figure 14.15) are also relatively common in falcons. They can happen if the falcon gets stuck with the respective talon and tries to pull it out. Other reasons for fractured phalanges are rough landings or landing on hard surfaces or stones.

Figure 14.15. Fracture of phalanx.

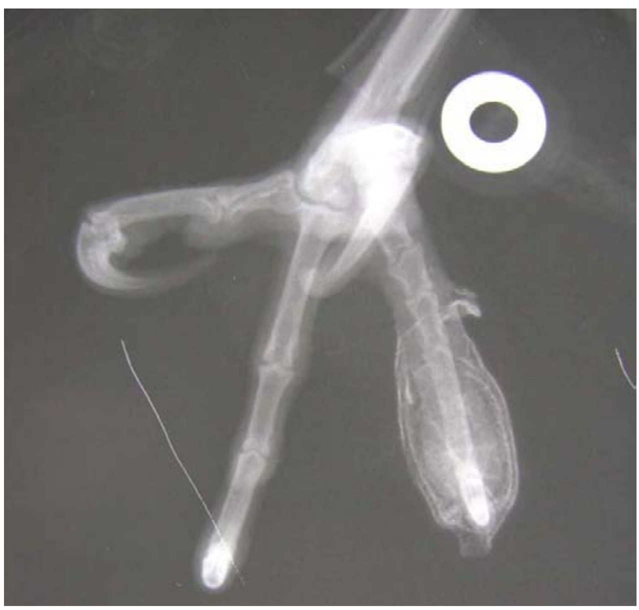

Figure 14.16. Fractured phalanx in fixation bandage and splint during healing process.

Clinical signs are swollen parts of the toes. The bird does often not put full pressure on the affected toe and starts to pick the injured area with resulting automutilation. Surgical intervention is not indicated. A conservative fracture approach is recommended and can be performed with the help of a splint. Several splints are possible that include either a padded metal splint or padded tongue depressors. Other possibilities for splints are splints with cotton buds that are cut in two halves. They can be arranged around the fractured phalanx exactly as required. Before the splint can be fixed, the phalanx should be covered with a soft bandage and padded with cotton. The splint is fixed from the plantar side and tied with an adhesive bandage like Vetrap. This bandage can be additionally stabilized with epoxy glue to harden the bandage and thus prevent a movement of the phalanx. It also stops the falcon from picking and damaging the bandage. A regular X-Ray without removing the bandage (Figure 14.16) gives clear information about bone healing progress. The full kallus formation takes as average 2-3 weeks.

14.7. Other Orthopedic Problems

14.7.1. Osteomyelitis

Osteomyelitis can be frequently found in falcons and birds of prey. In most cases, the osteomyelitis starts at the medullary cavity of the bones and might be resulting from open fractures [4]. Osteomyelitis can be observed in joints as well (Figure 14.17). Reasons for those cases can be puncture wounds that happen while fighting with the prey or traumatic injuries. Another reason for osteomyelitis might be injuries and constriction of the toes through the falcon's own jesses. These types of injuries are explained in detail in chapter 15.

Figure 14.17. Osteomyelitis and osteolysis in femur and knee joint.

Clinical symptoms are hanging or drooping wings or reduced flight performance in cases of osteomyelitis in the wing or shoulder area. Swelling of toes or toe joints as well as reduced pressure on the affected leg or toes are other signs for this disease. In case of toes that got constricted with jesses a massive tissue damage and constriction area is visible. The ideal way to clearly identify the problem is to radiograph the falcon. The X-ray reveals increased radiodensity in the medullary part of the bone [4] and the corticalis. Moreover, osteolysis can be observed if the ends of the bones have become rougher than normal [4] and look like "eaten up". In those cases where the joint is affected, an increased soft tissue density is visible.

Therapeutic management of osteomyelitis contains the application of clindamycin for at least 10-14 days. The treatment can take up to 3 weeks in some advanced cases. Supportive therapy can be done with homeopathic medicines. After 7 days another radiograph should be taken to assess the changes of the bony structure and the treatment progress. It is advisable to take a blood sample to review especially the hematological parameters as an elevated white blood cell count might be present in such cases. Falcons with osteomyelitis in the shoulder or wing area can be bandaged initially with a figure-of-eight bandage for 3-7 days to support the correct holding of the wing and to reduce the pressure on the joint and wing. A full rest for the duration of the treatment is recommended. Osteomyelitis cases in the joints especially of the toes needs to be supported by application of local antibiotics through chloramphenicol or gentamicin ointments and iodine ointment. The management of injuries caused by jesses are explained in detail in chapter 15.

The prognosis is good as in most cases the osteomyelitis gets under control within 1-3 weeks and the falcons can be used for hunting again. However, the prognosis is guarded in cases of advanced osteomyelitis in joints.

14.7.2. Luxation/Subluxation

Luxations of the joint are often caused by traumatic impact in raptors and can affect the different joints as well as the tendons and ligaments. Delays in treatment can lead to permanent disabilities as the functionality of the joint gets affected within 3 days of the traumatic damage and luxation with resulting fibrosis [2]. This can prove fatal in wild raptors or falcons used for hunting.

Clinical symptoms include mild soft tissue swelling of the joint, drooping wings and increased rotation of the joint. Paresis of the feet might be a sign for a femorotibial joint luxation [2]. Radiography is suited best to reveal the luxation. Two positions are recommended for the radiograph and the wing or leg should be extended as much as possible to clearly assess the damage. In case of ruptured ligaments, an enlarged joint space is visible [2].

Therapeutic approaches include repositioning of the luxated joint, complete rest for up to 3 weeks and bandages like figure-of-eight bandages of the wings. The repositioning can be performed under general anesthesia by holding the proximal part of the joint and flexing the joint. The lateral part of the luxated limb is grasped with the other hand and pressure is applied on this bone. Through the applied pressure and rotation, the luxated bone gets repositioned into the joint again which might resemble a snap mechanism. The joint then gets gently extended [2]. In case of luxated femorotibial joints, a protective bandage of the contralateral leg is advisable to prevent pressure sores and bumblefoot. Surgical treatment approaches have been tried but the success rate varies only between 25-50% [2].

14.7.3. Amputation of Digits

Amputation of digits can be required in cases of severe comminuted fractures [2], injuries through jesses, severe pox infections that have led to completely constricted toes and osteolysis of the phalangeal bones (Figure 14.18). However, before any decision to amputate the digit is taken, other therapeutic measures should be tried like bandaging or splinting. Amputation should always be the last method and needs to be very carefully considered due to its severe impact on the hunting ability of falconry birds. Especially the first and second toes are essential for hunting prey and an amputation of those toes might affect the hunting ability. However, in the author's experience, falcons with amputated first and second toes have been able to compensate the disability with the other foot.

The surgical procedure is performed under general anesthesia. The foot area has to be cleaned and disinfected thoroughly and a tourniquet is placed in the tarsometatarsal region. The amputation can be performed in two places: in the joint through exarticulation or in the middle of the bone [2].

Figure 14.18. Constricted toe due to pox virus infection for amputation.

Figure 14.19. Toe after amputation.

The incision with a scalpel blade is done at least 2-3 mm distal of the amputation area in order to preserve as much skin as possible for suturing. In some cases, this is not possible as not enough healthy and intact skin is left. In those cases, all available skin should be preserved, even if it is only little. It is very useful to preserve the digital pads of the skin as they can act as polster after the amputation. The extensor and flexor tendon is grasped with a forceps. The muscles and soft tissue are carefully prepared below the amputation area to get free access to the bone. The bone can get exarticulated by cutting the ligaments with the scalpel blade or by cutting the bone with a saw or heavy orthopedic scissor. In the case of cutting the bone in the mid-diaphyseal region, the sharp cut bone edges should be filed gently to smoothen and round up the edges. The wound gets flushed with marbofloxacin or piperacillin. The tendons get attached through stitching them together with 4-0/5-0 absorbable sutures. The remaining muscles can be used to cover the bone edges and stitched with 4-0/5-0 absorbable suture material. The skin gets attached in a way that the suture will not be too tight. If the digit pad is intact it can be very well used to cover the bone end from the plantar side as this will help to protect the bone edge (Figure 14.19). The suture of the skin can be performed with 4-0 non-absorbable monofilament suture [2]. After touching the suture line with iodine, woundpowder is applied. The amputation area gets covered with non adhesive wound dressing followed by bandage.

An intramuscular injection of antibiotics is given after surgery. The non steroidal anti-inflammatory analgesic drug is applied directly after surgery for the initial pain management. For an enhanced wound healing, homeopathic drugs are injected via subcutaneous route immediately after the surgery.

Post-surgical fracture management includes the antibiotic coverage with marbofloxacin injection for a time period of seven days. Homeopathic drugs are injected via subcutaneous or oral route for 3-5 days after surgery [3].

The bandage should be changed the first postoperative days to remove clotted blood. Bandage chances are then performed every 2-4 days. The bandage is left in place for up to 7-10 days until the wound healing is complete.

14.8. Conclusion

Fractures and orthopedic problems are frequently encountered in raptors. Although often believed by raptor owners, fractures do not have to be the end of falconry use of the raptor. Surgical fracture management is the most promising approach for successful rehabilitation of the injured bird of prey. One of the most favored surgical approaches is a tie-in method with intramedullary pin and external fixation with pins and bars. The FixEx tubulaire F.E.S.S.A. system has been used in wing fractures [1] and is very helpful in the repair of different avian fractures either for large or small birds due to different size of the bars. Moreover, its major advantages are light weight, easy application, early return to normal limb function, re-usability and cost-effectiveness. This system can even be used for other animal species like exotics or even small mammals. The light weight of the connector bars enables the birds to early weight bearing of the operated extremity. The flexibility of the FixEx tubulaire F.E.S.S.A. system allows partial removal of pins depending on the healing process without disturbing the other remaining pins. Moreover, the different placement of the holes allows vertical and transversal placement of pins which might be useful in fractures with many comminuted bone pieces. It allows also the use of different sizes of pins due to the varying diameters of the bar holes. The FixEx tubulaire F.E.S.S.A. system is a practical osteosynthesis system which allows faster and more accurate fracture repairs and is highly recommended for fracture repair in falcons.

Moreover, the perioperative and post surgical fracture management is essential for the success of the surgery. It is very important to reduce the handling of the operated falcon to avoid iatrogen injuries and delayed healing. This includes the application of antibiotics and other medicines. Careful and correct surgical treatment is the only way in most fractures to regain the full flight and grasping ability of the falcon.

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Chapter XV

Soft Tissue Problems and Surgeries

Abstract

Soft tissue injuries are commonly encountered in veterinary practice. Most injuries occur during training or hunting or if falcons are attacked by other falcons. Smaller injuries can be bandaged but surgical care is required in most cases as the injuries are normally too large to heal by themselves. The perioperative management as well as the surgical procedure form key elements of successful soft tissue management. The postoperative care including medication and feeding is another key for fast wound healing. This chapter discusses in detail various surgical methods for soft tissue surgeries like keel surgeries, injuries of attacked falcons and abscess management. Moreover, in-depth information is provided about the perioperative preparation of the patient including anesthesia, cleaning and disinfection of the wound as well as medication, bandaging and feeding as postsurgical aftercare.

15.1. Introduction

Soft tissue surgeries can be frequently found in raptors, especially during the training and hunting period. They may range from keel injuries to more complex damage of the propatagium. Most of those injuries are caused by accidents or when falcons are attacked by other raptors. Due to the very thin skin, even mild injuries can cause considerable damage. Moreover, the skin can dry out very fast and become devitalized. Therefore surgery should be performed as soon as possible to avoid that the soft tissue damage cannot be closed anymore due to dry, devitalized and necrotic skin. Mild injuries or abrasion can heal by first intention whereas in most cases surgical intervention is more advisable. The secret to successful soft tissue surgeries are the careful preparation of the remaining skin and the gentle suturing methods. Often soft tissue surgeries fail due to the lack of carefulness and gentleness of the veterinary surgeon. In cases of not properly dissected skin preparation as well as too tight and too distant sutures the skin healing is disturbed and can lead to wound opening and iatrogenic cutaneous necrosis. The possibility of using skin grafts has been discussed in literature [1]. However, in the author’s practical experience, skin grafts have not been proved to be a beneficial method in avian skin repair.

The perioperative preparation of the falcon is one of the key elements in a successful surgical management. Cleaning and disinfection of the wound is essential to achieve good surgical results afterwards. Moreover, a major part in soft tissue healing and postoperative aftercare is the correct way of bandaging, medication and feeding. Even the best surgery might fail if those essential postoperative conditions are neglected or not correctly performed.

This chapter covers the management of the avian patient before soft tissue surgeries including aesthesia, cleaning and disinfection of the wound. It includes information about the most common soft tissue problems and surgeries to provide the practicing veterinarian with a clear clinical help to deal with those frequently encountered issues. Topics covered are crop surgeries, surgeries of the infraorbital bone area, keel surgeries, propatagial injuries, abscesses, large soft tissue damage and injuries caused by toes constriction through jesses. Emphasis is laid on the postsurgical management as only appropriate aftercare will help to enhance the surgical success but its importance is often underestimated.

Feather cysts and neoplasias like lipomas are not frequently found in raptors [1] and therefore not covered in this chapter. Moreover, surgeries of the reproductive tract like castration, neutering and salpingohysterectomy are not included in this chapter as they do not form an important part of the normal veterinary practice.

15.2. Preparation for Surgery

15.2.1. Anesthesia and Perioperative Preparation of the Patient

The various anesthesia methods have been described in detail in chapter 6. They apply also to soft tissue surgeries. However, great care has to be taken in case of highly traumatized falcons. Severe trauma can be commonly observed in falcons that had been attacked by another falcon or raptor. Those attacked falcons suffer from massive hemorrhages and large soft tissue injuries that can be life-threatening. In those cases, fluid substitution through intravenous injection of warm plasma expander or 0.9% sodium chloride and 5% glucose should be administered at the beginning of the surgery. Anesthesia surveillance is helpful especially in surgeries of expected longer time duration. The falcon needs to be positioned in a way that the veterinary surgeon has free access to the surgery area. This can be achieved by foam pieces that are put under the surgery region like crop, wing or head. Sometimes specially folded surgical drapes can provide a useful fixation and positioning of the falcon, too. It is often helpful for the surgeon to have a support for the hand or arm as this will reduce shaking and tiredness of the hands during a long surgery. Good surgical lights are inevitable.

15.2.2. Skin Preparation and Disinfection

The falcon is laying on a sterile drape. All feathers of the injured area have to be plucked completely up to a distance of 0.5-1cm to the injured skin. This will greatly ease the surgical repair of the skin without being disturbed by feathers. As sometimes feathers cannot be easily plucked and the danger of further rupture of the already damaged skin is high, it is advisable to fix the feather with a forceps or hemostat and to pluck it out with this instrument while holding the skin tightly. This helps to keep the skin intact. The surrounding region of the soft tissue injury has to be covered with sterile gauze and the damaged skin area is cleaned with commercial surgical preparation solution containing 10% povidone iodine followed by iodine scrub. Then disinfection with diluted surgical spirit is performed and the povidone iodine disinfection is done. This is repeated three times altogether. The disinfected cutaneous area is dried with sterile gauze and then covered with sterile surgical cotton drape or sterile transparent plastic drape. The other parts of the bird's body can be covered with a sterile drape [4].

15.3. Postoperative Wound Management

15.3.1. Bandaging

After surgery, the suture line should be gently touched with the tip of a sterile cotton bud mildly soaked in iodine solution. Then the skin is covered with veterinary woundpowder to keep the area dry. Low adherent absorbent non-adhesive dressing is applied on the wound. In cases of keel surgeries or soft tissue surgeries on the thoracical or abdominal region, the use of adhesive dressings is advised.

For other surgeries e.g. of wing, leg or foot injuries, bandaging can be performed with soft conforming bandages followed by an adhesive bandaging tape [4].

The first bandage change should be performed on the first postsurgical day as sometimes clotted blood, antibiotic flushing solution, saline or wound liquid might drip out of the suture line and get clotted. If these clotted particles are not gently removed, a disturbance in the wound healing may occur. The sutured area is covered with woundpowder and bandaged as explained above in this chapter.

15.3.2. Medication

An intramuscular injection of marbofloxacin is given after surgery. In cases of infected wounds, antibiotic culture and sensitivity has to be performed and the antibiosis adjusted accordingly. The non steroidal anti-inflammatory analgesic drug is applied directly after surgery for the initial pain management. For an enhanced wound healing, homeopathic remedies are injected immediately after the surgery.

Post-surgical fracture management includes the antibiotic coverage with e.g. marbofloxacin for a time period of 7-10 days. Homeopathic remedies are injected for 3-5 days after surgery [4]. Especially in larger surgeries, it is highly recommended to minimize the catching and grabbing of the patient as much as possible and to choose intramuscular injectable antibiotics or oral medications that can be administered in the meat.

15.3.3. Feeding

The appropriate feeding depends on the kind of surgery. In cases of crop surgeries with stitching of the crop mucosa, no food should be given to the falcon on the day of the surgery and eventually on the first postoperative day. If the surgical area was large, it is more advisable to administer tube feeding for another 3-4 days by placing a stomach tube directly in the stomach as described in detail in chapter 6. Further information about various feeding preparations can be found in detail in chapter 16. The stomach tubing has the advantage that the crop does not get extended and therefore less pressure is applied on the suture of the crop mucosa. If required, the duration of the stomach feeding can be prolonged without any problems. After an initial healing process, the falcon can be changed to tiny cut pieces of clean meat and liver 3-4 times daily for another few days, followed by tiny chopped quail without long bones. For any crop injury and surgery it is of critical importance not to overextend the crop during the healing process through feeding the bird a full crop. It is much better to feed small quantities 3-4 times per day.

Falcons with larger surgeries either on the sternum, wing, body or legs can be fed with chopped food like chopped quail. This reduces the pressure on the suture line as the falcon does not have to tear the food. This kind of feeding can be also given to falcons with bumblefoot especially when their feet are covered with larger ball bandages or shoes.

15.4. Specific Surgery Methods

15.4.1. Lesions in the Choana

A swollen choana or nodular lesions in the choana can be frequently encountered in the case of *Pseudomonas aeruginosa* and/or *Trichomonas sp*. infections (Figure 15.1) as detailed in chapter 10 and 12. A surgical removal is indicated in case of larger lesions or very swollen choanal region. An incision of 0.5-1cm can be made with a scalpel blade in the choanal skin parallel to the choana slit in the area where caseous masses can be seen or palpated. A possible hemorrhage due to the highly vascularized choanal skin can be reduced by incising closer to the outer side of the choana. A curette can be used to remove those masses through the incision. The fragile bony structure of the sinus should not be damaged if possible. It is possible to flush the cavity with antibiotics. The incision is not sutured as often mucous will get out of this opening. Moreover, it is possible to curette the area on the following day again if required. The insertion of enzymatic wound cleaning bits is very useful as they continue in-depth wound cleaning after the curettage.

15.4.2. Infraorbital Surgery of Trichomonas/Pseudomonas Aeruginosa Lesions

The above in this chapter and in chapter 10 and 12 mentioned lesions of *Pseudomonas aeruginosa* and/or *Trichomonas sp*. infections can be found in the infraorbital region, too

(Figure 15.2). They can get extended to parts of the head as well as below the infraorbital bone and to the rostral part of the eye lids. Repeated flushing of the nostril and puffing up of the rostral parts of the eye lids and skin above the infraorbital bone reveals the complete blockage of this region through caseous material. In those cases where flushing does not lead to the opening of the infraorbital region, surgical opening is indicated. Disinfection is performed as described above in this chapter, but should be done with sterile cotton buds under great care that no disinfectant is poured into the eyes.

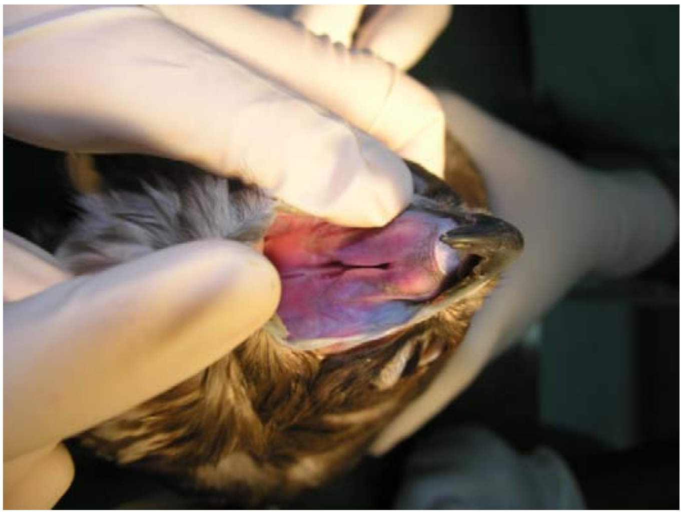

Figure 15.1. Trichomonas lesion in choana.

Figure 15.2. Infraorbital Trichomonas/Pseudomonas lesion.

An incision of 1-3 cm can be made with a scalpel blade in the skin above the infraorbital bone where caseous masses can be palpated. The hemorrhage is usually not too much and can be stopped by use of sterile gauze. A larger curette can be used to remove the caseous material that might reach up to the middle of the head. Sometimes it is required to make one larger incision or two incisions if other pockets with necrotic material are detected on the lateral side of the infraorbital bone. In some cases caseous material is coming out of the incised infraorbital area by itself (Figure 15.3).

Figure 15.3. Caseous material coming out of infraorbital Trichomonas/Pseudomonas lesion.

The curetted cavity is flushed with sterile saline and with antibiotics through a small sterile tube that is inserted in the skin opening. In those cases where another curettage might have to be performed on the following day, the skin should not be closed yet. Antibiotic ointments like chloramphenicol eye ointment can be applied on the wound to prevent infection and the bird should be left unhooded. The insertion of enzymatic wound cleaning bits is very useful as they continue in-depth wound cleaning after the curettage. Suturing of the skin incision is performed with single sutures of non absorbable suture material 4-0. The ends of the suture have to be shortened enough that they do not irritate the cornea and lead to corneal abrasions.

In rare cases, this surgical procedure has to be repeated if some pockets with caseous material were not detected or if more material gets consolidated in this region.

15.4.3. Crop Surgeries

Crop injuries are frequently encountered during the training and hunting with falcons especially when they get attacked by other falcons or birds of prey or when they have accidents (Figure 15.4). Those injuries can have extensive damage of the crop skin and the esophageal mucosa and musculature. This leads to the problem that the falcon cannot digest the food properly and it might even fall out of the esophagus if the hole is large enough. Therefore surgical closure is the only way of repairing this injury and should be performed as soon as possible.

Figure 15.4. Crop injury.

The affected area should be disinfected as described above in this chapter, but surgical spirit should not be used to disinfect the mucosa of the esophagus.

All necrotic material around the surgical region should be neatly removed. It is highly important to clearly identify all anatomical structures to prevent that wrong parts are stitched together. The skin layer should be gently dissected from the esophagus musculature to ease tension after suturing. First, the esophagus mucosa edges can be touched with sterile swabs or cotton buds soaked with antibiotics. Then it can be stitched with absorbable suture material 4-0 or 5-0 in continuous suture. The distance between each stitch has to be less than 1mm. The skin is sutured separately with non absorbable suture material preferably in continuous pattern (Figure 15.5) or single sutures.

Fig. 15.5 Surgical closure of crop injury

15.4.4. Keel Surgery

The sternum or keel bone is commonly affected with injuries (Figure 15.6) as falcons may hit the ground hard while landing. Another reason can be the laying on the chest in case of pain in legs and feet. Often keel injuries are covered with feathers and are often not detected in the first place. They can get infected up to the sternum itself (Figure 15.7) and large injuries are possible. In cases of severe injuries the pectoral muscles are injured and need surgical closure, too.

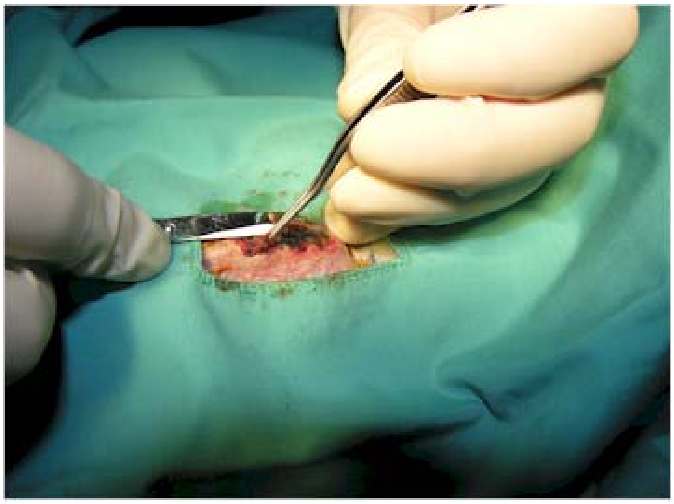

Figure 15.6. Keel injury.

Figure 15.7. Keel injury with infected sternum.

Figure 15.8. Surgical closure of keel injury.

The sternum has to be curetted up to the healthy tissue with a bone curette and all necrotic tissue is debrided. The skin around the keel injury gets detached from the fascia of the pectoral muscle by blunt dissection with a small Metzenbaum scissor for at least 1-2cm. It is very important to detach the skin as much as possible to reduce the tension for the suture. The wound area gets flushed with sterile saline and antibiotics. In case of damaged pectoral muscle, the muscle has to be stitched with absorbable suture material 4-0 or 5-0 in single sutures. In case of massive damage of the sternum and required deep curettage, the pectoral muscle can be flapped over the sternum and stitched. The skin layer is sutured with single sutures of non absorbable material 3-0 or 4-0. The single stitches should have a distance of no more than 1mm between two sutures (Figure 15.8). Larger distances between the sutures lead to a higher likelihood that the skin does not heal perfectly or might open again. Continuous sutures are not recommended.

It is advisable that the falcon rests for 7-10 days to prevent an opening of the suture line.

15.4.5. Injuries of the Propatagium

Injuries of the propatagium occur due to blunt trauma [1] like pipes or fence wires or electrical trauma. Damage caused by too tight bandaging of the wing can lead to necrosis of the propatagium [1]. The damage can be at the muscular or cutaneous part of the propatagium (Figure 15.9).

The propatagium is a very delicate skin area of the wing. It is composed on the ventral side of the Pars propatagialis of the M.biceps brachii and its tendon as well as the propatagium. Its border is formed by the M.biceps brachii and M.extensor carpi radialis. On the dorsal side of the wing, the propatagium is attached to the Pars propatagialis of the M.deltoideus. The humerus, M.extensor longus alulae, M.extensor carpi radialis, M.supinator and M.triceps brachii are the borderline for the propatagium on the dorsal side [3]. The propatagium has a reduced bloody supply through the A.radialis and A.bicipitalis [3, 5].

Figure 15.9. Injury of the propatagium.

Figure 15.10. Surgical closure in progress of propatagial injury.

The propatagial injury has to be stitched as soon as possible as otherwise the skin will shrink and the wing cannot be extended fully anymore. Any necrotic material has to be carefully debrided. In case of infected wounds it is advisable to cover the injury with antibiotic ointment and iodine ointment for 1-2 days and to bandage it. This will reduce swelling and infection of the skin. In cases of fresh or not infected wounds, surgery can be performed immediately. Hereby, the skin edges should only be curetted and not cut in order to create a fresh skin surface. The cutting of the skin would lead to a shortening of the propatagium and thus cause reduced flight performance of the falcon. The ventral and dorsal part of the propatagium has to be very carefully blunt dissected at the remaining skin part. The skin should be kept moist throughout the full duration of the surgery which can be achieved through gauze soaked in sterile saline or sterile saline flushing. Antibiotic flushing can be done several times during the operation. The skin has to be carefully attached and restored in its original form as good as possible (Figure 15.10). Suturing is performed with non absorbable suture material 4-0 or 5-0 in continuous sutures. The closure has to be performed from the medial (Figure 15.11) and lateral (Figure 15.12) side of the propatagium. In those places where a continuous suture cannot be done, single sutures are applicable. The individual stitches have to be placed as close to each other as possible to enhance skin granulation and healing. Moreover, extreme care needs to be taken that not too much pressure is put on the suture while suturing as otherwise the highly delicate propatagial skin may rupture or get necrotic later on.

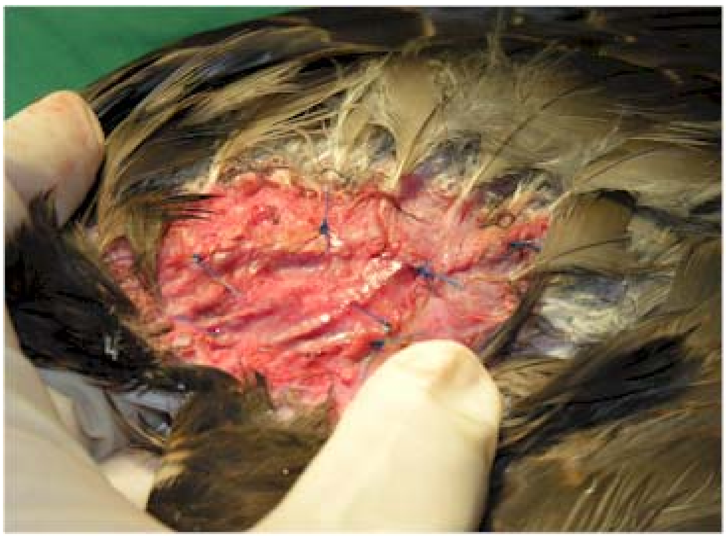

Figure 15.11. Surgical closure of propatagial injury on lateral side.

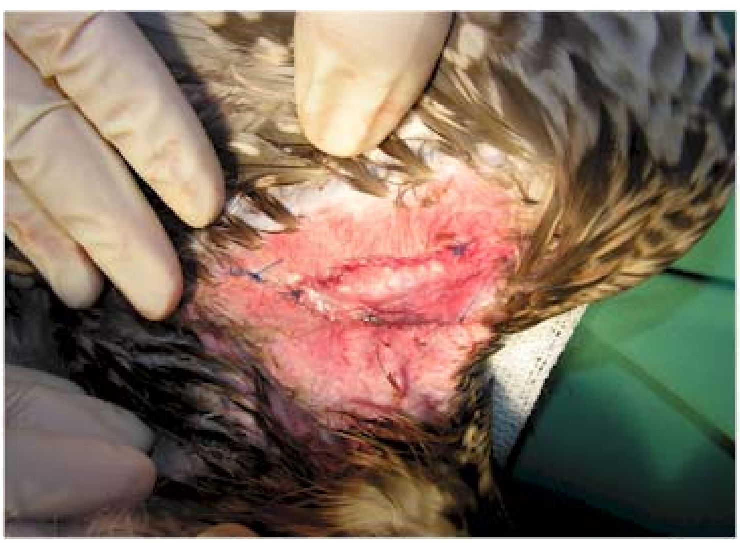

Figure 15.12. Surgical closure of propatagial injury on medial side.

In case of small propatagial injuries, the wing can be bandaged in a figure-of-eight bandage after applying the wound dressing as described above in this chapter. For larger propatagial wounds, a special kind of cast can be made. Paper carton or cartonbox can be cut in the exact shape of the half extended wing while the area of the surgical closure is cut out to ensure that no pressure is applied on the suture line (Figure 15.13). This paper carton cast can be covered with adhesive bandage material and placed on the ventral side of the wing. The surgical area is covered with cotton.

Figure 15.13. Special cartonbox cast for medial wing side after propatagial surgery.

Figure 15.14. Wing and body bandage after propatagial surgery.

The paper carton cast is then bandaged at the ventral side of the wing and if required around the body as well (Figure 15.14). It has been described in literature that a cast should be placed dorsal and ventral and sewn. It is left in place for 2 ½ weeks [1]. In the author's experience, the dorsal side of the wing should always be left without any kind of cast and even the ventral one should not cover the suture line directly. Bandaging and gently physiotherapy should be done every 4-5 days. After bandage removal the full mobility and extension ability of the wing will be restored in as short time even in case of a shortened propatagium.

15.4.6. Soft Tissue Injuries of Falcons Being Attacked by Other Falcons

During the training and hunting period, falcons might attack other falcons when they are not properly hooded or when more than one falcon flies freely at the same time. It can also happen in those cases where unhooded falcons are tied too close together. These attacks often result in massive hemorrhages that can lead to considerable blood loss. Extensive soft tissue damage mainly in the neck (Figure 15.15), shoulder and chest region occurs frequently. Other body parts can be affected as well, but injuries of legs and the abdominal body parts are less common. The soft tissue injuries of attacked falcons involve skin layer and muscles. In many cases, the esophagus and blood vessels like the jugular vein can get ruptured.

Attacked falcons are often admitted in severe shock. Before conducting the surgery, the falcon has to be stabilized as detailed in chapter 16 and rested for 2-3 hours. However, it is often better to perform the operation immediately after the falcon is admitted because the injuries are still fresh. This is advisable especially in cases of hemorrhages as they pose severe emergencies.

Figure 15.15. Extensive neck injury after attack by other falcon.

Figure 15.16. Neck injury after surgical closure.

All necrotic material around the surgical region should be neatly removed. The wound should be thoroughly cleaned as often dirt and soil is inside the wound. It is highly important to clearly identify all anatomical structures before suturing. Ruptured jugular veins might have large blood clots that have to be fully removed.

In case of esophagus damage, the skin layer should be gently dissected from the esophagus musculature as described above in this chapter. First, the muscle parts have to be attached which sometimes poses a challenge if larger parts of the musculature are missing. Before suturing, the muscles can be touched with sterile swabs or cotton buds soaked with antibiotics. Stitching can be performed with single sutures of absorbable suture material 5-0. The skin layer can be stitched with non absorbable suture material 4-0 or 5-0 in continuous suture (Figure 15.16).

Figure 15.17. Extensive head soft tissue injury due to being rolled over by car wheel.

15.4.7. Injuries of the Head

Accidents of falcons can cause extensive damage of the cutaneous structures of the head especially when a car wheel is rolling over the falcon's head. This can lead to huge damage of the complete head area (Figure 15.17) including damage to the ears and shoulder region. The surgical method is the same as described above. After surgery, the head has to be protected with complete bandages to avoid scratching of the falcons (Figure 15.18). Sometimes it is required to conduct a series of surgeries to achieve a step-by-step closure (Figure 15.19) as it is not possible to close the injury in one surgery. Such extensive damage requires careful reconstruction of the muscles, ears (Figure 15.20, 15.21), head and shoulder structures. Following careful surgeries and reconstruction of the destroyed anatomical part, full restoration can be achieved (Figure 15.22).

Figure 15.18. Special head bandage after surgery.

Figure 15.19. Area for follow up surgery after partial closure.

Figure 15.20. Follow up surgery to reconstruct the ear.

Figure 15.21. Successful reconstruction of ear.

Figure 15.22. Successful healing of head injury.

15.4.8. Injuries of the Leg

Soft tissue injuries of the leg can cause considerable damage of the leg's skin (Figure 15.23). They can originate from fights with prey, infections or accidents. Surgical closure can be performed as mentioned above in this chapter. However, great care has to be taken that the skin is not sutured too tight as this will lead to wound dehiscence. One possibility to avoid wound dehiscence is the use of lateral relief sutures (Figure 15.24).

Figure 15.23. Leg injury with extensive soft tissue damage.

Figure 15.24. Surgical closure of leg injury.

15.4.9. Abscesses

Abscesses are common problems in raptors. They can be caused by puncture wounds (Figure 15.25), injuries caused by prey (Figure 15.26), or pressure sores through too tight hoods (Figure 15.27). Sterile abscesses as well as bacterial agents like *Staphylococcus sp*. and

Streptococcus sp. can be identified. Only mature abscesses with caseous or liquid content that are encapsulated and clearly palpable should be removed. The abscess is incised with scalpel blade. The abscess can be either of liquid or hard caseous material (Figure 15.28). The content either comes out by itself upon gentle pressure or is curetted with a suitably sized curette (Figure 15.29). The abscess content is set up for microbiological culture and antibiotic sensitivity. The abscess capsule can be removed in some but not all cases. The abscess opening is flushed with sterile saline and antibiotic solution. In cases of large abscesses, the curettage has to be repeated on the following day. The abscess is sutured with non absorbable suture material 3-0 or 4-0 if it is possible. The antibiotics are administered according to the antibiotic sensitivity.

Figure 15.25. Foot abscess caused by puncture wound.

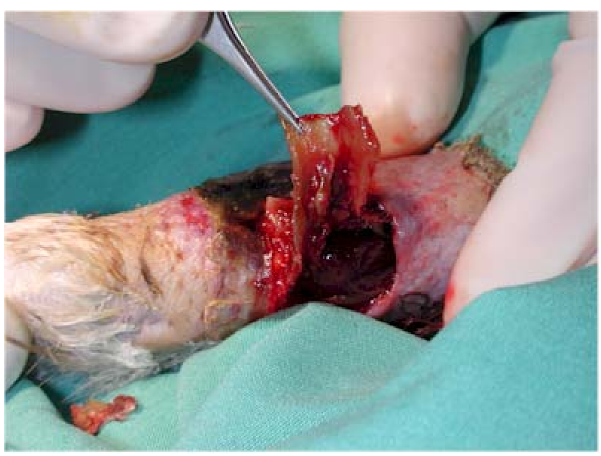

Figure 15.26. Large abscess following a puncture wound on leg.

Figure 15.27. Abscess caused by pressures sores due to tight hood.

Figure 15.28. Hard material of foot abscess in Figure 15.25.

Figure 15.29. Curettage of abscess next to beak in Figure 15.27.

15.4.10. Injuries through Ingrown Rings

Closed rings around the leg serve as unique identification in captive-bred falcons. Open rings can also be used to identify wild raptors. Ingrown rings can be found in captive bred falcons where too tight rings have been put (Figure 15.30).

Figure 15.30. Too tight ring grown deeply in the leg.

Figure 15.31. Massive soft tissue damage up to tendons due to ingrown ring.

It can happen also in cases where rings for male birds were put on female birds without being removed. Wild raptors with open rings often do not tolerate the rings. They can create self-inflicted injuries when trying to remove the ring [2]. Swelling of the leg around the ring can be observed. Sometimes granulating skin covers the ingrown ring. Removal of the ring can be difficult if the ring is not well accessible. Nevertheless, the ring has to be removed immediately. This procedure should not be performed without anesthesia as the falcon might move [2] which can result in fatal damage to the leg. For open rings, both ring ends have to be grabbed with stabile but delicate pliers and bent off slowly. Closed rings are carefully cut off with pliers.

Figure 15.32. Starting skin granulation of damage caused by ingrown ring.

Figure 15.33. Progressing skin granulation of damage caused by ingrown ring.

In some cases, the tendons can be exposed (Figure 15.31). Antibiotic ointment and iodine ointment is applied and covered with non adhesive dressing. Skin granulation takes places in short time (Figure 15.32, 15.33). If it was the only ring, it has to be reported to the local CITES management authority and a new ring has to be fixed. It has been recommended in literature to use saws for ring removal [2]. In the author's experience the use of a saw is dangerous as apart from the ring anatomical structures like tendons can be easily cut.

15.4.11. Injuries through Jesses

Falcons are tied through jesses around the legs. In the Middle East, jesses are not made of leather as in Western countries, but of thin cotton threads. They can get tangled around the toes and hereby especially the hind toe. This kind of soft tissue injuries can be very severe as they may result in constriction, strong swelling (Figure 15.34), exposed or damaged tendon sheaths and tendons (Figure 15.35) as well as osteomyelitis in advanced cases. Radiography is recommended in any case of severe injuries with larger swellings to assess the bony impact.

Figure 15.34. Constriction and swelling of hind toe due to injuries through entangled jesses.

Figure 15.35. Exposed tendons of hind toe due to injuries through entangled jesses.

Figure 15.36. Starting skin granulation over exposed tendon of Figure 15.35.

The scab that constricts the toe has to be removed carefully even if mild hemorrhages may occur. In infected wounds pus might be present. Therefore, the area is gently touched with antibiotic solution. Antibiotic ointment, iodine ointment and homeopathic skin granulation ointment are applied on the wound. The toe has to be bandaged as described above in this chapter. The skin has a good granulation tendency (Figure 15.36). Systemic antibiotics like amoxicillin-clavulanic acid are indicated to reduce the infection and swelling. In case of osteomyelitis, clindamycin can be administered for at least 10-14 days. In the worst case of osteolysis, an amputation of the toe might have to be taken into consideration. It is in any way better to give the injury time to improve before amputating directly. In the author's experience many cases of those injuries even with severe osteomyelitis or osteolysis have recovered to such extent that the falcon could use the toe again for hunting.

15.5. Conclusion

Soft tissue injuries are common problems in falcons and other raptors. Various kinds of soft tissue surgeries may occur. Damage can be extensive and life-threatening in some cases. Especially larger surgeries need good postsurgical management. However, good surgical abilities and aftercare can lead to the full restoration of the injuries and full usability of the affected falcons or raptors for hunting. Due to the high frequency of such cases in the veterinary practice, veterinary surgeon should train very well to deal with them in proficient and confident manner.

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Chapter XVI

Intensive Care

Abstract

The intensive care of critically ill falcons and its successful management depends on an all-round treatment of the falcon. Special medication and intravenous and subcutaneous fluids have to be given to critically ill falcons based on each case and readjusted on daily basis. Moreover, this includes special feeding schemes and medication regimes. Falcons in critical condition require special nutritional measures apart from medical intensive care treatment. This special intensive care patient feeding regime has to be adjusted to each single falcon in an individual way according to its actual clinical condition, although the basic feeding features remain the same. The tree-like intensive care feeding schemes are intended to provide a fast and easy orientation help for veterinarians and falconers alike to successfully support falcons in intensive care.

16.1. Introduction

Falcons have a unique anatomy and physiology, and so the basic concepts of emergency and supportive care of other animals must be modified for successful medical management. In emergency cases, the ABC for falcons has to be applied. The patient under intensive care requires adequate ventilation, warmth, fluid therapy and enhanced nutrition. Fluid therapy is one of the key elements for critically sick falcons as they often suffer from dehydration, emaciation and underlying diseases. Fluids for ill falcons can be administered preferably via intravenous or subcutaneous route. Oral fluids are not indicated as falcons are often too sick to pass the fluids from the crop. Vomiting might also occur. Medication for falcons in intensive care includes broad-spectrum antibiotics as well as supporting medicines for kidneys, liver and sometimes digestive tract. Vitamins and electrolytes are highly important further components of a well-defined medication. The nutritional requirements of the sick falcon must be accurately satisfied because many of the patients would have key nutrient deficiencies along with their presenting complaint [1]. Identifying and correcting these problems early in the hospitalization period will put the bird in a much more advantaged position to be able to respond to medical and physical therapy. The feeding protocol for intensive care patients can be used in modified form for any other critical care condition in falcons.

16.2. ABC for Critically Sick Falcons

The ABC for falcons in critical and life-threatening condition is airways, breathing and circulation. In such emergency cases, immediate action is required even if no full case history can be gathered or no physical examination or other examinations can be performed. It has to be kept in mind that in such emergency cases time is the most essential factor and every second counts to the survival of the falcons.

For every emergency patient, it has to be ensured that the airways are free and not obstructed. Pathological conditions like dyspnea and opening of the beak due to tracheal blockage needs to be addressed immediately. Tracheal blockage can be caused by syringeal aspergilloma, pseudomonas lesions in the trachea and foreign body aspiration. This requires immediate action to remove the blockage. The falcon is hereby placed in isoflurane anesthesia and the blockage is removed with an endoscope as described in chapter 6.

B for breathing is the next step in the ABC for critically sick falcons. Breathing problems are caused by blockage of the airways or a general poor condition of the falcon. The respiratory rate has to be assessed. It is very useful to check the tracheal movements through the glottis. Oxygen has to be administered either through oxygen chambers or oxygen hoods. In case of a respiratory arrest, doxapram is immediately administered via drops sublingual or via intravenous injection. After doxapram application, it is very helpful to touch the glottis entrance with a thin ENT swab to irritate the glottis. This will lead to opening of the closed glottis.

C for circulation is the last part of the ABC for critically sick falcons. Circulation includes the cardiac function and any abnormalities like brachycardia, tachycardia or cardiac arrest. In case of cardiac arrest, manual massage of the thorax is indicated as well as adrenaline injection intravenously. The progress of the emergency measures has to be controlled through auscultation with the stethoscope. Additionally, oxygen supply has to be administered. Massive hemorrhages may also lead to reduced circulation and cardiac problems and have to be tackled immediately as explained below in this chapter.

16.3. Examination of Critically Sick Falcons

In critically sick falcons, a full examination cycle is often not possible as the condition of the falcons might be too deteriorated. However, the case history is essential for a possible tentative diagnosis and start of emergency treatment. In most cases, only physical examination, crop samples (if no crop stasis is present) and feces samples (if available) are possible and should be examined for parasitology and bacterial culture. It is important to assess the dehydration status. Blood samples are very helpful, but are sometimes difficult to take if the blood pressure is very low and the veins are collapsed. In some cases radiographs can be taken although often only the ventro-dorsal position is possible. The initial radiograph does not have to be perfect. It serves only as quick overview to visualize advanced diseases like aspergillosis, renomegaly or hepatomegaly. Endoscopy is not advised for critically sick falcons as the anesthesia duration is too long and the procedure is too invasive. It can be performed after the falcon is stabile and discharged from the intensive care unit.

Treatment has to be started immediately upon tentative diagnosis. Adjustment of the treatment can be done after further laboratory results like microbiological culture results are available on the following day.

16.4. Fluid Administration Scheme

Fluid administration is vital for a critically sick falcon and enhances the chances for survival. The amount of required fluids depends on the general condition and amount of dehydration of the falcon. In most cases of critically ill falcons, dehydration will be at least 5-10% and in some advanced cases will exceed 10%. The level of dehydration can be measured by skin fold test as described in chapter 6.

Initial treatment has to be started immediately with intravenous application of fluids (Figure 16.1). In cases of heavy blood loss, colloids are very suitable. They can be administered very slowly intravenously at a rate of 10ml/kg as bolus. In other cases, intravenous injection of 0.9%Sodium chloride with 5% glucose (Figure 16.2) at a rate of 10ml/kg is well tolerated and usually shows fast results. These intravenous applications can be repeated daily until the rehydration status does not require intravenous fluids anymore. This is usually achieved after maximum 3-5 days.

Subcutaneous administration of fluids (Figure 16.3) is inevitable for therapeutic progress and sodium lactate solution have highly positive effects in such cases. Vitamin supplements can be administered additionally (Figure 16.4)

Figure 16.1. Intravenous injection of fluids.

Figure 16.2. Intravenous injection of sodium and glucose.

Figure 16.3. Subcutaneous injection of fluids.

Figure 16.4. Subcutaneous injection of Hartmann's Solution.

In severely dehydrated falcons, 60 ml (3x20ml) of sodium lactate solution are applied in 3 different places like precrural fold of the thighs and backside between the shoulders immediately after the intravenous fluid injection. The subcutaneous injections can be repeated after 8 hours in severely dehydrated falcons with another 20-40 ml/kg. In few exceptional cases, it might be required to give additional fluids after 4-5 hours and then again after another 4-5 hours on the first day of admission. On the next days, intravenous injections are given as well subcutaneous fluids in the amount of 60-80 ml/kg/day. This is usually sufficient to achieve a good rehydration status of the falcons within a few days.

16.5. Medication

Initial medication depends on the actual condition of the bird and the suspected disease. In cases of respiratory arrest, doxapram can be administered as injection intravenously or as drops under the tongue. Cardiac arrest can be treated with intravenous injection of adrenalin.

Massive hemorrhages need to be tackled immediately with conservative methods to stop the bleeding. Therefore, intramuscular injections of Vitamin K can be administered.

Antibiosis with a broad-spectrum antibiotic is indicated in cases of suspected bacterial infection or septicemia. Suitable antibiotics are piperacillin, marbofloxacin and amoxicillin clavulanic acid. In falcons with suspected bacterial septicemia with *E.coli* or *Pseudomonas aeruginosa* intravenous injection of piperacillin as initial bolus followed by intramuscular injections are recommended. Marbofloxacin is helpful in less advanced cases. Amoxicillin clavulanic acid is indicated as antibiotic of choice in falcons suffering from diarrhea and bloody feces and suspected *Clostridium perfringens* or *E.coli* infection.

Due to the massive impact on the kidneys of severely dehydrated falcons, it is advisable to protect the kidneys with supportive therapy as critically ill falcon patients might end up in a kidney failure if left untreated. Homeopathic medicines like Berberis® and Cantharis® are extremely helpful to restore the impaired kidney function. In cases of additional liver problems, homeopathic and herbal medicines are applicable.

In cases of intoxications of unknown origin, application of the homeopathic medicines is useful.

Crop stasis or “full crop” can also to be regarded as emergency. Injections of levamisole, metoclopramide or homeopathic drugs are indicated for this condition. This condition is explained in detail in chapter 17.

16.6. Shock

Shock is one of the most severe conditions for falcons and requires immediate attention (Figure 16.5). In cases of severe shock, dexamethasone can be administered intramuscularly. This is the only indication for cortisone administration as normally cortisone is contraindicated in birds and falcons. Other shock measures are mentioned in detail in chapter 5.

Figure 16.5. Falcon in shock condition.

16.7. Housing of Critically Sick Falcons

Critically sick falcons have to be housed in a quiet, dark and warm environment. This can be a small room or cage. Oxygen supply can be provided by either oxygen chambers or special baby warmers for neonates that have special oxygen hoods. Towels should be placed under the falcon to keep it padded if the falcon is not able to stand upright anymore. The head is positioned higher than the body to prevent vomiting and asphyxiation. The falcon has to be under constant supervision by the medical staff to observe any slight changes in its condition and to act immediately.

16.8. Feeding of Critically Sick Falcons

Feeding the sick and injured falcon must be done through procedures that minimize further stress, and which maximize the opportunities for the patient to regain normal physiological functions. Important factors to consider are the types of formulations to be fed, compatibility with prescribed medications, frequency of feeding, amounts fed at each feeding, the physical consistency of the food, and the effect of this change in the diet on the bird. Feeding must be approached as one component of an integrated intensive care management scheme of the patient so that monitoring of blood parameters, fecal analysis, and other investigations can gauge progress and suggest modifications to the nutrition of the critically ill bird. The successful intensive care feeding scheme can be evaluated by taking and monitoring the falcon’s weight on a daily basis. According to the weight development, the feeding protocols can be adjusted [1].

If the so-called “formula” cannot be prepared, commercially available readymade preparation like e.g. Hills a/d diet™ can be used instead. Nevertheless, the Abu Dhabi Falcon Hospital has had better experiences with individually composed feeding preparations for critically sick falcons [1].

This feeding scheme for falcons is explained in an easy to follow step-by-step chart which needs to be adjusted for each falcons according to its individual disease symptoms and condition. The most frequently performed feeding scheme for an average recovery process has been used in this chapter as example. It ranges from meat without bones to meat juices with special nutrient supplements and vitamins. These special feeding preparations are shown below in relation to the treatment days, condition and recovery of the falcon [1].

16.8.1. Conditions Requiring Tube Feeding

Sick and weak falcons may require tube feeding (Figure 16.6) if they are not able anymore to digest solid food. Such sick falcons can be infected with trichomonas with large mouth lesions, crop surgery, intoxication, injuries and bacterial infections. Application of ammonium chloride is still practiced in the Middle East although the cases are getting much less due to education and raised awareness among the falconers’ community. However, the administration of ammonium chloride results in severe damage of the gastrointestinal tract and needs to be supported by tube feeding in advanced stages. Prolonged tube feeding might be necessary in many cases and needs to be dealt with in a flexible approach. Through tube feeding, the fluid intake gets increased, too [1].

Figure 16.6. Sick falcon requiring tube feeding.

16.8.2. Tube Feeding

For each falcon, a separate and sterile feeding tube and 50 ml catheter-tipped syringe is required. Lamb feeding tubes are often very useful for this purpose. Moreover, it is mandatory to have a round end of the feeding tube catheter (Figure 16.7) as severe damage of the crop mucosa can arise if the tube end has been cut with sharp edges (Figure 16.8). Moreover, the application of lubricant like KY Jelly™ is advisable (Figure 16.9). The special feeding formula can be prepared for one day and kept in the fridge. The formula given should be lukewarm and not cold [1]!

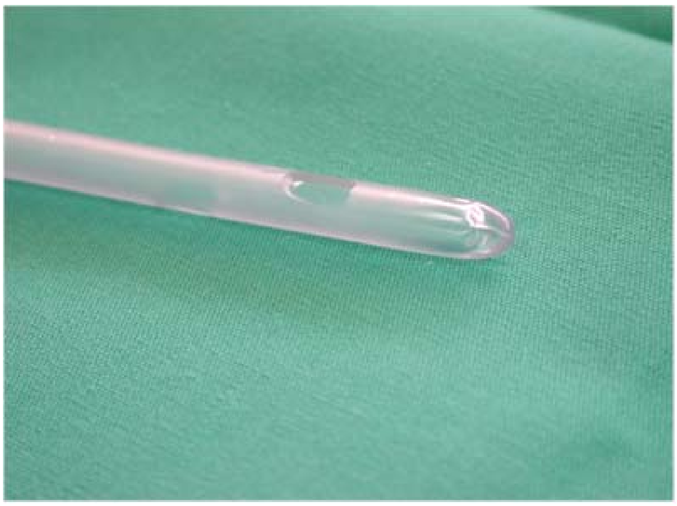

Figure 16.7. Feeding tube with round edge.

Figure 16.8. Incorrect feeding tube with sharp edge.

Figure 16.9. Feeding tube and lubricant.

It is very important to fix the falcon in correct position for the tube feeding. For this purpose, one person needs to hold the falcon in upright position with stretched head. The second person inserts the feeding tube (Figure 16.10) which requires good experience to prevent damage to the falcons and to avoid that the tube content gets into the trachea. The feeding tube has to be carefully inserted in the crop or the middle of the esophagus. In cases of very sick falcons that are not able anymore to pass the crop, it is more advisable to insert the feeding tube into the proventriculus (Figure 16.11). After inserting the feeding tube in crop or proventriculus, the syringe content has to be slowly administered. After emptying of the tube, it is retracted carefully [1]. More detailed information can be found in chapter 6.

Figure 16.10. Correct positioning in falcon for tube feeding.

Figure 16.11. Insertion of feeding tube into proventriculus.

16.8.3. Feeding Scheme

The following charts are explained exclusively for the feeding part of intensive care patients. The special examination features, treatment plan and medication like antibiotics are explained later in this chapter. For all feeding formula, it is very important to observe the falcon if it is passing fecal and thus digests the food [1].

16.8.3.1. Liquid Food

Formula No 1

For very sick and weak falcons that are not able to pass the crop anymore and that did not eat for several days, the feeding can start with formula No 1. This is one single chicken egg-yolk free of egg-white. It can be mixed with Pedialyte™ to make it more liquid and thus easier to digest (Figure 16.12). This formula can be fed three to four times per day [1].

Figure 16.12. Formula No 1.

Formula No 2

The second formula contains 25 g of quail or chicken liver, preferably fresh and not frozen, and 20 ml Pedialyte™ solution (Figure 16.13). Both ingredients are put in the blender and minced thoroughly. This minced solution is applied in 15-20 ml amounts two to three times daily [1].

Formula No 3

For those falcons that are still critically ill, but are able to get are more solid solution, the so-called “quail juice” can be given. This “quail juice” contains 65 g of boneless fresh quail meat, 5 g of Polyaid™ powder and 20 ml of Pedialyte™ solution (Figure 16.14). If no fresh boneless quail meat is available, then frozen quail meat can be used after being defrosted. All ingredients are minced in the blender. This formula can be administered two to three times per day with an amount of 20-30 ml depending on the size of the falcon [1].

Figure 16.13. Formula No 2.

Figure 16.14. Formula No 3.

Formula No 4

Falcons that are still in intensive care, but have already been fed with the formula No 3 “quail juice”, can be fed with a stronger “quail juice”. This is made of 100 g of fresh quail meat with bones, 5 g of Polyaid™ or Spark™ powder and 10 ml of Water (Figure 16.15). All ingredients are minced in the blender (Figure 16.16). This mixture gives a very thick “quail juice” which is usually administered 3 times per day [1].

Figure 16.15. Formula No 4.

Figure 16.16. Ingredients for “quail juice”.

16.8.3.2. Solid Food

Liver

Those falcons that have well digested the formulas No 1 to 4 can be started on solid food. The first solid food given is fresh quail liver or chicken liver that is cut in very small pieces of less the 0.5 cm. The amount in the beginning should not exceed one or two livers per feeding time. If the falcon passes the food well, it can be fed three to four times per day. In most cases, one to three days of liver feeding are sufficient to continue with the next step of feeding [1].

Clean Meat

The next step in the feeding schedule is clean meat. This is meat where all bones were removed. Those large meat pieces are cut in small pieces and fed to the falcon. The amount in the beginning should not exceed the amount of one quail chest. Falcons that are passing the food well can be fed three to four times per day [1].

Chopped Meat

Falcons that are in the process of recovering can be given chopped meat (Figure 16.17). This is meat with bones except the long bones of legs and wings that is cut in small pieces. This can be fed two to three times daily for two to three day [1].

After these feeding regimes, the falcon’s feeding can be returned to normal feeding. In some cases, the duration of the individual formulas have to be extended. For each falcon, an individual feeding plan has to establish and revised on a daily basis [1].

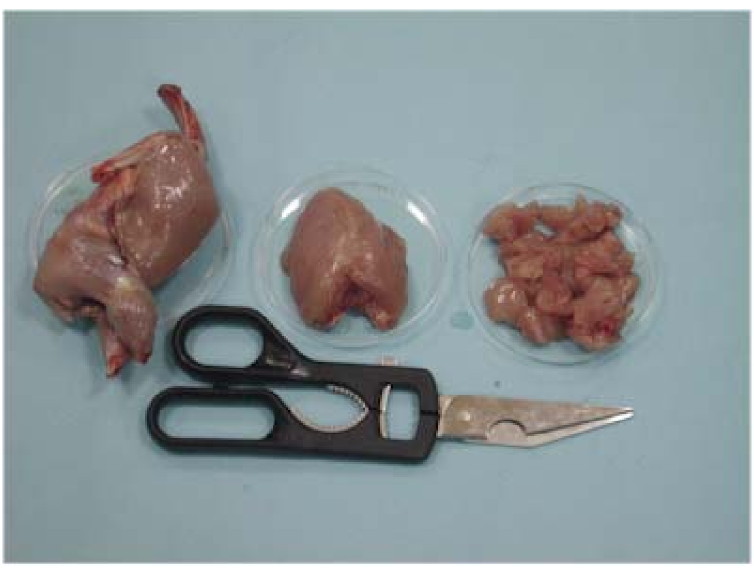

Figure 16.17. Chopped quail.

16.9. Conclusion

Falcons in critically sick condition require intensive care treatment that includes emergency measures, fluid application and medication. Often underestimated, housing and feeding of these ICU patients play a vital role in the recovery process and can make the difference to secure the survival of those birds. It has to be kept in mind that in the critically ill falcon, time is crucial for the bird and immediate measures must be taken even if no full case history or examination can be done. Apart from the ABC scheme, fluid administration is essential. Appropriate housing in quiet dark and warm rooms is important for the well-being of the patient. Moreover, feeding has to be adjusted daily according to the condition of the falcon. It is better to stay with lighter feeding formulas for a longer period than to feed complete meat with bones to a falcon that is not able to digest this food. Only the combination of all those factors can ensure the successful treatment of critically ill falcons.

References

[1] Muller, M. G., Azur, A., Saly, M. and Nafeez, M.J. (2004). *Feeding scheme of falcons requiring intensive care.* Poster at the Wildlife Diseases Association Conference, 11th - 13th December 2004, Abu Dhabi.

Chapter XVII

Miscellaneous

Abstract

Miscellaneous diseases cover a wide range of different diseases like intoxications, pathological changes of the internal organs including eye problems as well as epileptiform fits and bilateral paresis. Moreover, the pathological condition of crop stasis as one important falcon disease is mentioned. It is important to correctly diagnose and treat diseases like crop stasis or intoxications with lead or ammonium chloride as otherwise the condition might become life-threatening. Liver diseases are seen more frequently and require special consideration.

17.1. Introduction

The chapter about miscellaneous diseases includes intoxications that are relevant to falcons and which are often caused by lead or ammonium chloride. Those conditions might lead to rapid deterioration of the falcon's condition and can become life-threatening if detected and treated too late. Moreover, this chapter covers problems of internal organs like kidneys or liver as well as eye problems. In recent years, liver diseases and pathological conditions seem to be on the rise in various forms. However, still more research needs to be performed with regard to liver diseases. Kidney diseases can range from dehydration to visceral gout that can be fatal for the falcon. Moreover, other not fully classified diseases like epileptiform fits or bilateral paresis have been accommodated in this chapter.

17.2. Sour Crop

Etiology

"Sour crop" is a well-known problem in falcons since centuries. It describes the condition that food remains in the crop after feeding, but is not passed to the proventriculus. This can be caused by reduced esophageal or proventricular motility. Moreover, in many cases, a subsequent septicemia due to development of massive bacterial infestation of the food especially with *E.coli* may occur. This leads to toxemia followed by death of the falcon. This pathological condition can be frequently observed in emaciated, dehydrated and starved falcons that are too weak to digest food properly. Often owner feed them large quantities of food either by hand or force-feeding. It may also arise if the falcon has been left without food to keep it hungrier during the hunting trip and then starts to eat large amounts of fresh prey.

Clinical Symptoms and Diagnosis

The most prominent clinical sign is the crop full with food. A typical very distinctive smell of foul meat is exhaled. Other symptoms are far more unspecific. The falcon often looks tired and is thin and weak. Some falcons are too weak to stand on the perch. Dehydration can reach maximal levels of not dissolving skin folds in the skin fold test. The color of the feet, cere and mouth mucosa often becomes cyanotic.

Therapy

The main priority is to remove the food to empty the crop completely as failing to do so will inevitably lead to the death of the falcon. The therapeutic approach includes three main possibilities. One is the injection of emetic agents. The most effective one is levamisole that induces vomiting in falcons within 1-5 minutes and the complete crop content is vomited immediately. This can be performed in falcons that are still able to stand and that are not too weak.

Flushing of the crop is another possibility. This is done with 40-60ml warm water in a feeding syringe to which a plastic tube is attached. This tube is gently inserted in the stomach. Then the falcon is lifted up head downwards and the water is pushed through the tube. In the last third of the flushing, the tube gets gently removed. When removing the tube, the water is flushed out together with the food pieces (Figure 17.1). This might have to be repeated 2-3 times. Moreover, when flushing, care has to be taken that the food pieces that are flushed out do not block the trachea. This can be prevented by removing food pieces that are stuck around the tracheal entrance with a forceps.

Manual removal of the retained food is the third possibility of treatment. Hereby the falcon gets mildly anesthetized with the head in the anesthesia mask placed on a higher level to prevent vomiting while inducing the anesthesia. The falcon is held by one person and another one gently starts to massage the food from the crop to the oropharynx. This works only if no bone is stuck as otherwise massage can lead to puncturing of the crop mucosa. The pieces that are massaged up are then removed with a forceps. Sometimes liquid and partly digested material comes up which can be removed by swabs or small gauze pieces. In all cases of massaging the sour crop, great care has to be taken that no food pieces or liquid content block or enter the trachea as this may lead to suffocation of the falcon. This can be prevented by removing those food pieces with a forceps from the trachea.

Figure 17.1. Pieces of quail meat after flushing out.

For all three approaches, one thing remains the same: the complete food has to be removed and the crop must be fully emptied.

Rehydration therapy has to be started as described in chapter 16. Antibiotic coverage with e.g. piperacillin intravenously as a bolus followed by intramuscular injections has highly positive impact on the overall condition of the falcon according to the author's experience. Kidneys should be supported by administering Berberis® and Cantharis® subcutaneously. Moreover, it is highly advisable to rest the falcon after food removal as this poses a high stress situation for the bird. After recovering a little bit, blood samples should be taken. A crop sample for microbiological culture is essential but can often be taken on the next day only as the immediate sample taking may lead to wrong results due to the massive manipulation of the crop. In any case, it is mandatory to find out the underlying cause for the crop stasis and to treat accordingly. It is also advisable to reduce pressure on the crop by tube feeding the bird in the proventriculus (not in the crop!) for 1-3 days depending on its condition. More details can be found in chapter 16.

17.3. Intoxications

Toxicosis in falcons can be derived from internal sources like fungal infection or external factors. Some of the most important external factors causing intoxications in falcons are lead and ammonium chloride intake.

17.3.1. Lead Intoxication

Etiology

Lead poisoning is one of the most frequent intoxication in birds of prey. They ingest the lead either through feeding on prey that has been shot with lead bullets. This shot prey can either be hunted by the raptor itself or fed by the falconer like it is the case in shot rabbits. In rare cases, lead toxicosis may derive from gunshot wounds that the raptor has experienced itself. Usually those gunshot bullets can be found in the soft tissue or bones of the bird of prey either superficially or embedded in muscle tissue.

Raptors are highly sensitive to lead toxicosis but the clinical effects depend on the amount of ingested lead and the time of ingestion. Ingested shot prey leads to the release of the lead bullets in the stomach where the acidifying gastric juices have a corrosive effect on them. Lead seems to reduce the motility of the stomach thus aggravating the situation. Lead is absorbed in the blood circulation and distributed in the bird's body [4].

Hypochrome anaemia is also caused by lead poisoning. As prey, i.e. small wild birds, is shot with lead bullets and fed to raptors [5] their lead micro dust is released when hitting the prey's bones and then presumably dissolved by raptor's gastric juices [7] causing enteric lead intoxication. The result is an erythropoiesis disorder because ionized lead shows a special affinity for the sulph-hydryl groups of amino acids in the protein molecule [5] and leads to enzyme inhibitions. This increases the δ-aminolaevulic acid level and inhibits the δ-aminolaevulic acid dehydratase in the blood. Additionally the iron incorporation into the hem molecule is inhibited resulting in hypochrome anaemia and reduced hemoglobin content [5]. Thus an oxygen reduction in the blood as well as microcirculatory disorders occur [6]. The diagnostic identification of a lead intoxication in the blood is established by determination of δ-aminolaevulic acid dehydratase [5].

Clinical Symptoms and Diagnosis

Falcons with lead intoxication may show a highly distinctive symptom: voice change. During stress test, falcons intoxicated with lead make a typical ka-ka-ka sound that is derived from a change in the vocal ligaments of the syrinx. This sound change is the main symptom of lead intoxication and should not be overlooked. Therefore a stress test should always be performed because this sound change cannot be heard in a falcon just sitting on the perch in the experience of the author. Moreover, it should not be forgotten that lead intoxication often might not be the first differential diagnosis that comes to the mind of the veterinarian. It is also important to get more information about the case history and to check with the owner if the bird has been fed on shot prey. However, often owners are shy to admit or the bird was given to a friend for hunting. Therefore the case history is not always fully reliable. Other clinical symptoms are lethargy, weight loss and anorexia. In advanced cases, neurological signs may be present that can include limb paresis, impaired visual ability and convulsions [4]. A green diarrhea with biliverdinuria may be present [4] but has not been observed in all cases by the author.

Diagnosis is made by radiography (Figure 17.2) and blood test to examine the lead level in the blood. It should be kept in mind that radiography is not a fully reliable diagnostic tool as the lead bullet may not be present anymore but the lead intoxication might be severe. Lead bullets can be easily recognized as bullet shaped radiodense foreign bodies that are most often found in the proventriculus or gizzard. Latero-lateral and ventro-dorsal view is mandatory to identify and locate the bullet correctly [4].

Elevated lead levels in the blood are the ultimate diagnosis for a lead intoxication. The most sensitive test is the LeadCare® system that is easy to use, fast and very reliable. It measures the lead level in the blood through a sensor as large amounts of lead are attached to erythrocytes.

Figure 17.2. Lead bullet in proventriculus.

A treatment reagent is mixed with whole blood and then the lead is extracted from the erythrocytes. During the analysis, the lead gets collected in the sensor where it gets measured. Results are given in µg/dl. A maximum of 65 µg/dl lead level can be measured; values above 65 µg/dl are just expressed as "high" [10]. Although it is recommended to start treatment only by lead levels of 50 µg/dl as diagnostic level [4, 10], in the author's experience treatment should be started already at lead levels above 10-15 µg/dl as in those cases often clinical symptoms are already present. The positive effect of the treatment can be observed shortly after starting the treatment.

Further blood tests for hematology and biochemistry can be performed although pathological changes are not indicative for a lead intoxication.

Therapy

The therapeutic approach depends on the presence of the lead bullet. If a bullet is present it has to be removed as soon as possible to ease the lead burden on the bird. This can be done preferably by flushing the bullet out of the digestive tract. The falcon is held in upright position while a plastic stomach tube is inserted in the proventriculus. A 60 ml syringe with warm water is attached to this stomach tube. The falcon is then turned by one person head downward. A metal bucket is placed under the falcon. The second person holding the stomach tube flushes the syringe content in the bird's proventriculus and slowly removes the stomach tube. It is important to hold the bird 180° head downwards as otherwise water may enter the trachea. In most cases, one to three times flushing releases the bullet and it gets flushed out in the bucket thus giving a metallic sound. If the lead bullet is already advanced in the intestinal tract, water can be given orally to flush the bullet faster through the intestines. A second radiograph should always be taken after removal of the bullet to ensure that all bullets are removed and not a single one is left.

This applies especially in the cases of multiple bullets. Chelating agents are used to remove the lead from the blood and tissue. The most suitable chelating agent in falcons is Calcium disodium ethylene diamine tetraacetate (CaEDTA). It is administered undiluted for a minimum of 7 days up to 21 days depending on the lead level. Lead level results above 65 µg/dl require usually at least 3 weeks treatment. The lead level should be controlled on weekly basis by the LeadCare® test. Moreover, it is important to control the liver and kidney parameters from the beginning of the treatment throughout the whole therapy course. After 3 weeks, a rest period of 1 week is advisable to allow the not yet bound lead to get released. After this week, another lead test has to be performed to determine the lead level and further medication duration if required. This applies also for treatment of less than 3 weeks as in some cases the lead still gets released und increases again in the blood although the lead levels have come down to normal levels after treatment. Additionally, antibiotic coverage in the first up to second week of treatment with broad spectrum antibiotics like marbofloxacin is useful. Moreover, fluid therapy should be applied daily throughout the treatment period to support the kidney function. Moreover, if kidney or liver biochemical parameters are elevated, appropriate treatment should be performed accordingly.

17.3.2. Ammonium Chloride Intoxication (Shenadra)

Etiology

Ammonium chloride (NH_4Cl) or ammonium murate is commonly used in Arab countries under the name "Shenadra". It is an inorganic salt that is commercially available as colorless crystals or white powder [10]. Its use in veterinary medicine is mainly to acidify the urine and to enhance the secretion of the cilia. It is metabolized in the liver and leads to severe acidosis due to its conversion into urea and hydrochloric acid [10]. This may result in acute hyperammonemia which high NH_3 levels cannot be detoxified by the liver anymore. It starts to show cytotoxic action that may also reach the brain [10].

Ammonium chloride is used in Arab Gulf countries since a long time. Falconers gave it to their birds especially in the beginning of the hunting season in the hope to improve flight performance and hunting ability. It was often applied to falcons that were not interested in killing prey or were not able to kill the prey. Despite the fact that most falconers are aware that "shenadra" kill their bird, they still continue using it. Their belief is that the ammonium chloride would remove fat from the stomach and therefore clean the falcons thus making it more aggressive and hungrier to hunt and kill prey [10]. However, due to increased awareness by falcon veterinarians in the Gulf region and the Abu Dhabi Falcon Hospital, the number of falconers using ammonium chloride is strongly decreasing. In former times, crystals of ammonium chloride have been force-fed to the falcon. If those crystals were not vomited by the bird within a few minutes, death would result [10]. However, today ammonium chloride is sold in a more sophisticated way. Nowadays, small capsules are made containing powdered ammonium chloride and sold as "safe" medicine. The purpose of administering ammonium chloride, however, has remained the same. After events where a larger number of falconers gather and medicines are sold like hunting exhibitions, a large number of ammonium chloride cases can be frequently observed.

Clinical Symptoms and Diagnosis

Clinical signs can be acute or more chronic. Acute symptoms are massive vomiting directly after ammonium chloride application and large amount of thick green-yellowish mucous is thrown up, sometimes mixed with partly dissolved crystals [10]. Lethargy and anorexia follows with inability of the falcon to stand upright on its perch. Dark green-metallic feces can be observed. In severe cases, neurological signs like opisthotonus and fits can evolve within 6-8 hours followed by death [10]. Chronic symptoms include inappetence, rapid weight loss and massive lethargy. Often dark colored and sometimes blackish fecal can be seen. In those cases, crop, feces and blood samples should be taken. Moreover, an endoscopic and radiographic examination is highly indicated. The blood examination reveals normally massive anemia with highly decrease RBCs, PCV, Hct, Hb and sometimes elevated WBC and heterophilia. Kidney and sometimes liver parameters are elevated. The endoscopy of the crop shows dark blackish discoloration of crop (Figure 17.3) and proventricular mucosa due to the acidifying effects of ammonium chloride. The laparoscopy reveals enlarged and swollen kidneys and sometimes enteritis. Radiographic examination shows thickened intestinal walls and enlarged kidneys. Crop samples might show inflammatory cells due to the massive acid effects on the crop mucosa and sometimes red blood cells or mucous can be found in the fecal samples due to the advanced and often hemorrhagic enteritis. Those disease signs can be observed even 2-3 weeks after ammonium chloride administration as due to the powdered form the effects might result in chronic disease.

Pathological examinations reveal generalized mucosal congestion and dark metallic mucous that covered the entire digestive tract. This feature can be observed in endoscopy already. Massive hepatic changes like uniform dark and sometimes metallic green color. Kidneys are edematous and congested. Histopathological findings are unspecific and include hepatic necrosis and nephritis [10].

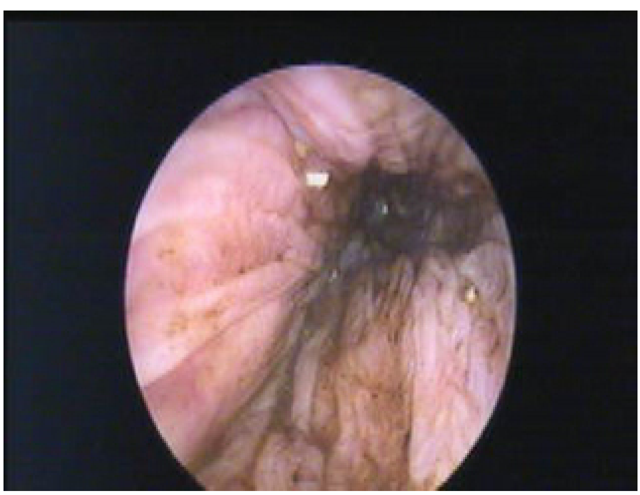

Figure 17.3. Acidized crop mucosa.

Therapy

Only supportive therapy can be administered. The main feature is fluid substitution with intravenous and subcutaneous fluids to support the kidney function. Moreover, subcutaneous injections of homeopathic drugs can be given depending on the severity of the impaired kidney function. Liver support is essential and can be performed with homeopathic medicines. Moreover, the anemia has to be treated with iron injection. A lot of fresh quail or chicken liver also helps to get the anemia faster under control. In case of elevated WBCs and enteritis, antibiotic application with marbofloxacin or amoxicillin-clavulanic acid can be done. Homeopathic medicines help to restore the intestinal balance. Vitamin and dietary supplements like multivitamin tablets or electrolytes is advisable. Food should not contain bones in the beginning of the treatment to allow the mucosa of the digestive tract to heal faster.

17.4. Kidney Diseases

Kidney diseases exist in falcons, but are not fully researched yet. They can be caused by exogenous influences like toxins or endogenous factors like massive dehydration.

Clinical Symptoms and Diagnosis

The main symptom for renal problems is massive dehydration to such an extent that the skin fold does not dissolve anymore. Moreover, hard and relatively solid urates can be indicative for renal disorders. Color changes do not always have to be present in cases of kidney disorders. Another important sign is polydipsia and polyuria in more advanced cases. Hereby, falcons start to drink from their water bath and do not stop drinking anymore. Moreover, other unspecific signs like lethargy, inappetence, weight loss and emaciation might be present.

Clinical diagnosis can be performed through assessing the grade of dehydration by performing the skin fold test as mentioned in chapter 6. Urates have to be evaluated on their color, consistency, amount and frequency. Moreover, urate tests performed with commercially available urine strips are very useful in order to identify possible blood in the urates or other pathological changes. Those tests can be easily made and are very fast. Comprehensive blood tests including hematology and biochemistry are very useful to see especially the values of uric acid and urea. They also give indication about other underlying diseases like infections or liver problems. Moreover, radiography clarifies the extent of possible kidney swelling and radiodensity thus indicating severe dehydration and possible impaired renal function. The endoscopic evaluation of the kidneys can be helpful in determining if kidney abscesses or visceral gout might be present.

Visceral Gout

Visceral gout can be observed in falcons whereas articular gout is extremely rare. It is a hyperuricemia caused by high plasma uric acid concentration and is characterized by whitish urate crystals that can cover the heart, (Figure 17.4), liver (Figure 17.5) and other internal organs (Figure 17.6), too. The porous kidneys tissue shows urate crystals and therefore whitish discoloration (Figure 17.7). In most cases, no previous disease symptoms for visceral gout do exist and the falcon falls dead from its perch and is brought for necropsy. In some cases, whitish urate crystals covering the viscera of kidneys, liver and other internal organs might be diagnosed during endoscopy.

Figure 17.4. Heart covered by urate layers due to visceral gout.

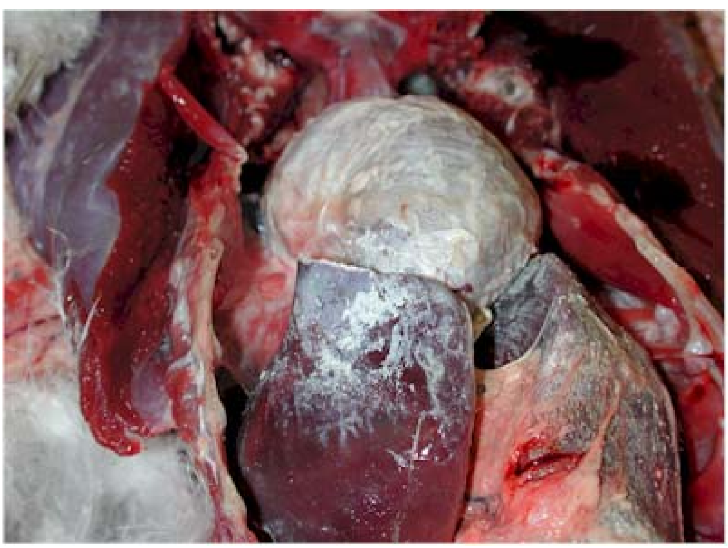

Figure 17.5. Liver covered by urate layers due to visceral gout.

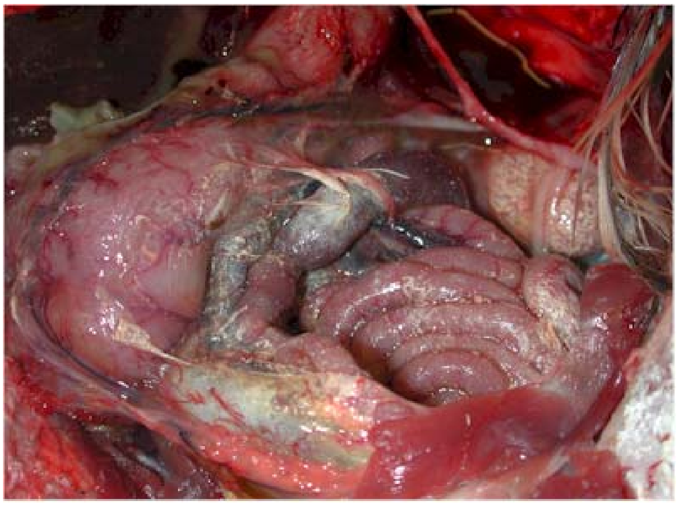

Figure 17.6. Intestines covered by urate layers due to visceral gout.

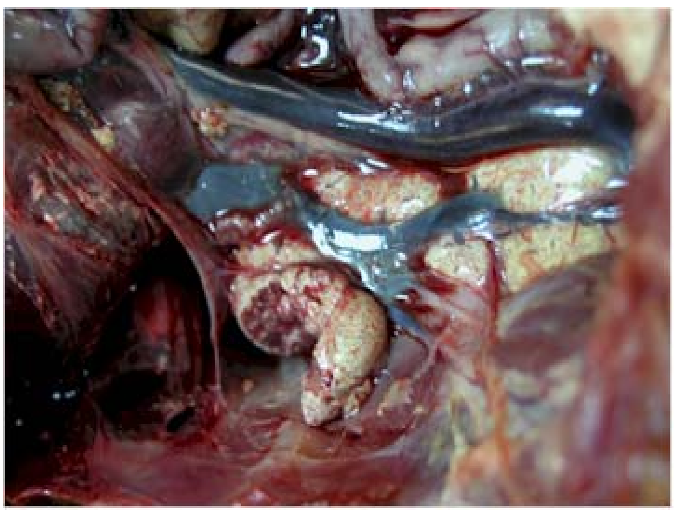

Figure 17.7. Kidneys changes due to visceral gout.

Lameness

In cases of severe renal dysfunction, like in *E.coli* septicemias in association with severe dehydration, the kidney parameters of the blood chemistry like urea and uric acid can be highly elevated. Uric acid can rise of up to 30-60 mg/dl and urea can be increased to 50-80mg/dl in very advanced cases. This leads inevitably to a swelling of the kidneys that might be unilateral or bilateral. The swollen kidney puts massive pressure on the ischiadic nerve thus resulting in unilateral or bilateral lameness of the legs. Falcons might be presented with lameness already and then the renal condition has always to be tested. Gradually deteriorating lameness might occur also within the first days after the falcon gets admitted. This kind of lameness can be regarded as alarm sign and the prognosis is guarded. In the author's experience, it is possible to reverse the lameness through renal therapy and vitamin B complex application if it is in an earlier stage, but in some cases the renal condition is too advanced to get restored and the falcon will die of renal failure.

Kidney Abscesses

Kidney abscesses can be found in various forms and sizes. They can be a result of a microsporidiosis caused by *Enterocytozoon bieneusi* infection as detailed in chapter 10.

Therapy

Falcons with advanced impaired renal function are intensive care patients. The main goal of kidney therapy is to provide as much fluids as possible. In severe cases, intravenous injections of 10ml 0.9% saline and 5% glucose as initial bolus for at least 3-4 consecutive days can be given. Moreover, subcutaneous administration of sodium lactate solution can be provided with an average of 60-80 ml/kg and a maximum of 100-140 ml/kg per day in very severe cases distributed in 3-4 times per day. More information on fluid therapy can be found in chapter 16. The general condition of the bird and dehydration status has to be taken into consideration when deciding on the amount of the fluid therapy. Allopurinol is contraindicated in birds and should not be used in falcons. A highly suitable way to support impaired kidney function is the use of homeopathic medicines. They can be applied subcutaneously until the urea and uric acid levels normalize. In severe cases with very high uric acid levels, the blood levels of uric acid and urea have to be closely monitored every 3-4 days to readjust the medication accordingly. In moderate cases, blood tests can be repeated every 5-7 days. The feeding schedule has to be readjusted as in advanced cases of kidney disorders falcons are too weak to eat and require liquid food via stomach tube. Otherwise they may not be able to digest the food thus leading to “sour crop” being described in detailed in this chapter. In the author’s experience, excellent results have been achieved by this kind of comprehensive treatment and daily readjustment according to the falcon’s condition. In more moderate cases homeopathic remedies can be administered orally for a period of 5-10 days. Electrolytes are useful to be given over food to enhance the rehydration of the bird.

17.5. Liver Diseases

Liver diseases are relatively common in falcons and their incidence seems to be on the rise. However, it remain unclear whether genetic factors have any influence as more cases of liver diseases are observed in captive-bred falcons. Liver diseases and hereby especially hepatomegaly are often side effects of other infectious diseases as the liver is the main metabolic organ. The origin and disease progress of liver disease in falcon is still poorly understood and requires further research work. In this chapter, the main pathological liver conditions are mentioned as well as a treatment plan for liver diseases has been established.

Clinical Symptoms and Diagnosis

The main symptom of liver problems is green fecal (Figure 17.8). The differential diagnosis for green fecal is a color change caused by aspergillosis and malnutrition over a longer period of time. Other symptoms for liver diseases are frequently unspecific and often observed only during radiography and endoscopy. They may include apathy, lethargy and reduced appetite. Moreover, in cases of advanced hepatomegaly and ascites, breathing difficulties with heavy breathing in the abdominal region or the so-called double-pump might be observed.

Figure 17.8. Green feces due to hepatomegaly.

Radiography in two positions, latero-lateral and ventro-dorsal reveals any enlargement of the liver, ascites or radiodensity inside the liver itself. The endoscopic examination is the most useful one as it visualizes the surface and color of the liver. Hereby, often color changes of the complete liver, necrotic hepatic or interstitial tissue, abscesses, visceral gout and enlargements can be seen and assessed. Biopsies of the liver can be taken but often hemorrhages can be considerable.

Blood hematology gives only unspecific information with possibly, but not necessarily elevated PCV, hemoglobin and leucocytes [4]. Blood chemistry might not be in all cases reliable as sometimes AST, ALT, CK or bile acids may not be elevated in chronic hepatic diseases as detailed in chapter 7. However, a strong increase in those parameters is indicative for liver damage although the blood result alone cannot reveal the cause of the liver problem. Gentle palpation of the abdominal region reveals enlarged livers and ascites. However, great care has to be taken not to press on the abdomen as this might be painful for the falcon.

Hepatopathy of Unknown Origin

Hepatopathy of unknown origin is usually found as accidental finding during routine examinations. In most cases, no color change of the feces is present. Those pathological changes can include whitish spots (Figure 17.9), dark or blackish discolored necrotic areas either of liver parenchyma or interstitial tissue (Figure 17.10). They can be localized in small or larger areas or distributed all over the liver. Other hepatopathic changes include pale or dark discoloration of the liver. A complete dark up to almost blackish discoloration of the liver that can have a porous appearance (Figure 17.11) is often associated with hepatomegaly and elevated blood chemistry parameters for the liver. This can be regarded as a final stage of hepatopathy and prognosis is very poor.

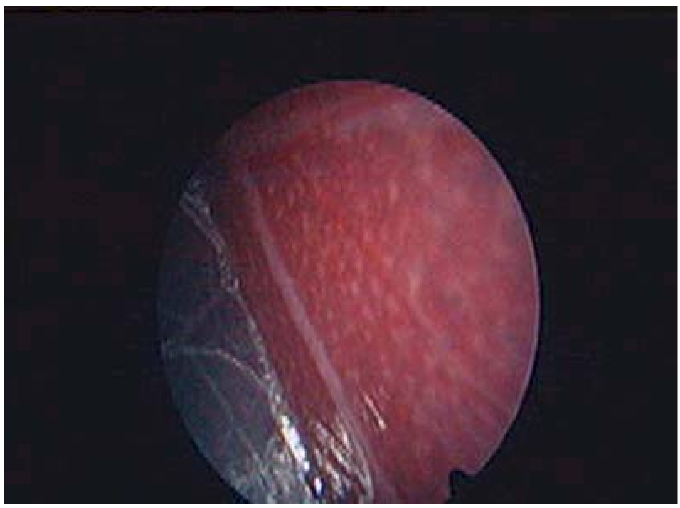

Figure. 17.9 Multifocal whitish spots on liver.jpg

Figure 17.10. Blackish discolored interstitial liver tissue.

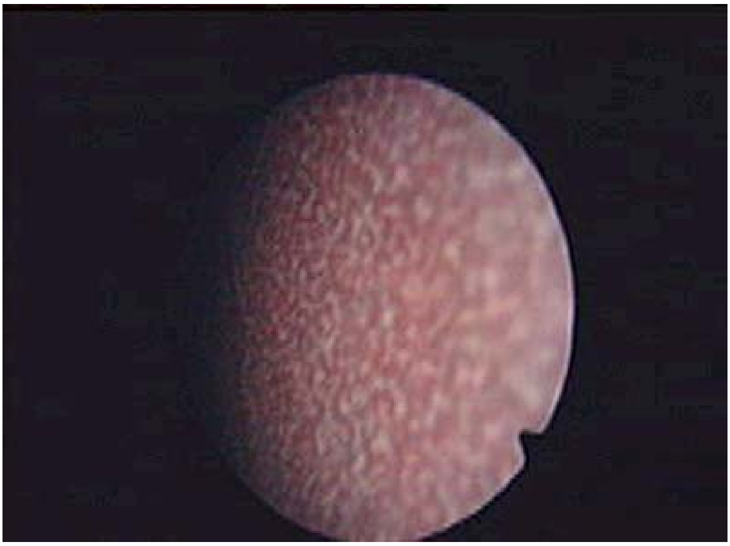

Figure 17.11. Advanced hepatopathy.

One reason for hepatic necrosis may be medication that has been administered to young chicks during the growth period. Some breeders like to use preventive medication in young chicks to avoid diseases and hereby especially aspergillosis. In a series of cases, massive liver necroses were observed in first year falcons from breeders that had been using aspergillosis medication and especially voriconazole as preventive medicine over a prolonged period of time. As voriconazole is well-known to be hepatotoxic in humans, it might be likely that it has negative impact on the liver of those young falcons as they are especially sensitive during the growth period. Liver problems can be caused by toxic substances like poison, bacterial toxins, steroids, lead etc. although the liver is capable to metabolize a vast number of substances from the body as it is the main organ for the metabolism [4]. However, if the amount of toxic substances is too much or some substances get metabolized into toxic substances, then changes in the liver cells lead to hepatocytic necrosis [4].

Hepatomegaly

Enlargement of the liver or hepatomegaly is frequently found following bacterial or fungal infections. Bacterial infection may be caused by *E.coli*, *Clostridium perfringens* or *Salmonella sp.* and especially in cases of heavy bacteria burden, liver damage may result. The best way to diagnose hepatomegaly is through radiography as this allows the veterinarian also a judgment about the extent of liver enlargement (Figure 17.12). Moreover, hepatomegaly can be seen during endoscopy as the liver gets more ball-shaped. In the end stage of hepatomegaly, ascites can be observed.

Figure 17.12. Moderate hepatomegaly in radiograph.

Ascites

Ascites can be found in the final stage of hepatomegaly and can be considerable. In some cases where no previous radiograph has been taken und the falcon is presented for endoscopy, a yellowish colored fluid stream spills out of the endoscopy hole at the beginning of the endoscopy as soon as the muscle wall has been punched. In those cases, no endoscopic examination is possible – and necessary. A radiograph should be taken immediately to assess the extent of the ascites (Figure 17.13, 17.14) and hepatomegaly.

Figure 17.13. Ascites.

Figure 17.14. Extended abdomen due to massive ascites fluid.

Although treatment for ascites can be performed, the veterinarian has to make it clear to the falconer that this is a final stage of a liver disease with such massive hepatic damage that the falcon suffers tremendously and will inevitably die sooner or later. Euthanasia is recommended in those cases as even diuretic treatment and liver supportive therapy can only prolong the condition, but not cure it anymore.

Liver Abscesses

Liver abscesses can be found in various forms and sizes. They can be a result of a microsporidiosis caused by *Enterocytozoon bieneusi* infection as detailed in chapter 10.

Amyloidosis

Amyloidosis has been identified in falcons especially associated with chronic diseases like bumblefoot and aspergillosis. It is often caused by inflammations of longer duration [4]. However, in the author's experience, several cases of suspected amyloidosis did not give positive results in the histopathological examination. Studies have shown that only 0.3% of falcons were diagnosed with amyloidosis [9, 10].

Hepatic Lipidosis

Hepatic lipidosis or "fatty liver syndrome" can be caused by excessive intake of fat through food or as disturbance of the normal lipid or endocrine metabolism. Moreover, in adipose birds, fat may get mobilized in form of triglycerides from tissue. Hepatic lipidosis has been mainly observed in captive merlins [4].

Neoplasia

Neoplasias of the liver are rare in falcons and may include primary tumors or can be caused by metastases. They include carcinomas, adenocarcinomas, cholangiocarcinomas and lymphosarcomas [4, 10].

Visceral gout

Visceral gout can lead to a liver fully-covered with whitish urate deposits. This disease is explained in details in the part kidney diseases in this chapter.

Liver Supportive Therapy

Liver supportive therapy has to be seen in the context of a complete treatment plan for each individual falcon. Such a well-defined treatment plan includes fluid therapy, appropriate feeding and treatment of underlying disease with antibiotics, antifungals or other medication as described in chapters 11, 12 and 16. The liver supportive therapy depends on the condition and stage of the diseases. In an early stage with minor changes of the liver like focal necrosis or color change of the liver, sylamarine (Silybum marianum) which is the active ingredient of milk thistle can be administered to the falcon for 5-7 days. Another excellent homeopathic remedy is Hepar suis that can be given subcutaneously or in tablets form for up to 4 weeks. It is also useful as supportive therapy in aspergillosis treatment. Another very useful liver supportive remedy is amino acids which have shown excellent results in liver disease cases. Moreover, it is very helpful for reconvalescent birds or falcons that show reduced appetite. It should not be given in cases of dehydration and renal problems as this might aggravate the situation of the kidneys. A possible diuretic treatment e.g. in ascites cases can be tried with furosemide but its use remains questionable due to the irreparable damage of the liver.

17.6. Pancreas

Pancreas disorders exist in falcons, and include pancreatitis and pancreatic necrosis. However, pancreas disorders are difficult to diagnose. In the author’s experience the main clinical symptom is pasteous and often foamy feces that is often excreted in larger amounts than normal feces and can be with greenish color. In some cases, weight loss might be associated. In those cases, the pancreas can be supported by pancreatic enzymes in powder form containing amylase and lipase. They can be given daily over the food until the feces consistency normalizes and lead often to excellent results.

17.7. Eye Problems

Eye problems are common, but often neglected features in falcons. It is estimated that approximately 30% of falcons suffer from some form of eye problems throughout their life. Eye problems can arise when falcons get injured when fighting with their prey. They may be caused by branches of trees of bushes when falcons are flying through forests or bushes. The majority of eye problems are conjunctivitis, corneal ulcers, foreign bodies in the eyes and injuries or ruptures of the third eyelid. Other eye problems might be associated with *Chlamydophila* infections or *Pseudomonas* infections and are explained in details in chapter 12 and 15.

Conjunctivitis

Inflammation of the eye lids can arise through too tight hoods, sand or dirt, strong winds or bacteria. A reddening of the eyelids, sometimes up to swelling and discharge can be seen as symptoms for conjunctivitis. Moreover, too tight hoods and sand or dirt leads to layers of dirt on the outer side of the eye lids. Therefore, the eyelids have to be cleaned gently with eye cleaning lotions. In cases of discharge, samples for microbiological cultures should be taken.

Corneal Ulcers

Corneal ulcers occur when sharp objects scratch the corneal layer. This damage can be superficial or deep (Figure 17.15). Fluorescine drops are inserted in both eyes and then washed out with saline. In case of corneal ulcers, the ulcer will stain green. It is very useful to write down the extent of the damage in form of a picture to easier judge the treatment progress. Treatment includes cornea restoring eye gels in combination with antibiotic eye drops or ointment. The falcon should be left without hood during treatment if possible. Fluorescine tests have to be performed in regular weekly intervals.

Figure 17.15. Advanced corneal ulcer.

Foreign Bodies in the Eyes

Foreign bodies like thorns or grains may penetrate the eye during training or hunting when the falcon is flying through fields, bushes or forests. First aid can be performed by the falconer before reaching the veterinarian as described in chapter 5. Before removing the foreign body, the falcon has to be anesthetized. The eye requires special local anesthesia with lidocaine as this procedure can be painful for the bird. The foreign body gets carefully removed with special ophthalmological forceps. Coverage with antibiotic eye drops is advised.

Injuries/Ruptures of the Third Eyelid

Injuries or ruptures of the third eyelid happen especially during the training and hunting season. They can be visible when the third eyelid glides over the eye. The preferred treatment is the surgical intervention. However, special ophthalmological instruments are required for surgeries of the eye. Following the general anesthesia, the eye is anesthetized locally with lidocaine. The third eyelid is fixed with an atraumatic forceps and sutured with single sutures of absorbable suture material 6-0. Mild corneal abrasion through the sutures might be possible. Therefore treatment includes cornea restoring eye gels in combination with antibiotic eye drops.

17.8. Miscellaneous Diseases

17.8.1. Central Nervous System

Newcastle Disease Like Symptoms/Epileptiform Fits

Etiology

Falcons are sometimes presented with Newcastle Disease virus like symptoms that can resemble in advanced form epileptiform fits. Although it has been reported that mainly male birds are affected by this problem [3], also female falcons suffer from fits according to the author's experience. The disease origin is not fully known yet. It has been assumed that genetic disposition especially for peregrine falcons may play a role [3]. However, the author has observed gyr-peregrine hybrid falcons, peregrine falcons, gyrfalcons and gyr-saker hybrid falcons with this pathological picture. Moreover, other possible reasons for fits may be hypoglycemia, calcium/phosphorus/vitamin D3 imbalances, heat stress, idiopathic epilepsy and hepatic encephalopathy [4] as well as excitement [3] and stress.

Clinical Symptoms and Diagnosis

The clinical symptoms can be better described as symptom complex. This includes inability to fly and stand, shaking and turning of the body and head (Figure 17.16, 17.17). Torticollis and opisthotonus may be present. Rolling with the complete body on the floor without stopping, fits of the legs and toes and convulsions are frequently observed in such cases. A real clinical diagnosis is difficult to make and sometimes not possible. A full case history should be gathered to rule out intoxications and to understand the situation of the bird regarding feeding, vitamin supplies, training and stress level.

Moreover, the case history gives information about a possible trauma like hitting an object. However, it is advisable to conduct a full blood examination including lead test to identify other underlying diseases like infections, liver or kidney problems. Moreover, blood chemistry reveals the glucose levels in case of a hypoglycemia. Virus tests for Newcastle Disease Virus should be carried out immediately by PCR methods to definitely rule out this disease. Moreover, it is essential to conduct a full physical exam including checking of the ears as a bilateral otitis media or interna may also cause similar symptoms. Skull fractures may also lead to hemorrhages in the ears. Radiography of the body can provide useful information about the size of liver and kidneys as well possible trauma. Moreover, radiography of the head helps to identify possible hemorrhages in the head region as well as otitis cases and skull fractures although being very rare. Microbiological cultures of crop, fecal and eventually blood are indicated to rule out the possibility of bacterial encephalitis. An endoscopy can be conducted but is not the major diagnostic tool in such cases.

Figure 17.16. Falcon suffering from NDV like symptoms.

Figure 17.17. Falcon with advanced central nervous symptoms.

Therapy

The falcon has to be brought in a dark quiet isolated room. The floor should be covered with a sponge and if this is not available, a towel should be placed under the bird to avoid hitting the ground. The room edges can be padded to reduce injuries during fits. In case of uncontrolled continuous rolling on the ground, diazepam injections are indicated. Antibiotic injections with enrofloxacin can be given as this antibiotic is passing the brain liquor barrier. Moreover, multivitamin injections containing vitamin A, D, E and B complex are helpful. If the diagnostic tests remain inconclusive and are within normal range, the possibility of vitamin deficiency of epileptiform fits is likely. From the author's experience, it might be helpful to expose the falcon to sunlight and remove it from any enclosed rooms. Daily vitamin A and E drops have shown beneficial effects in several cases up to full recovery. Some of the birds, especially older peregrine falcons, have showed recurrences on a yearly basis and recovered again following sunlight and vitamin A and E therapy. In other cases, diazepam followed by antibiotic and vitamin administration proved to be helpful. However, not all cases can be successfully managed as those fits may be fatal due to complete exhaustion followed by cardiac arrest of the birds.

Great care must be taken not to feed the falcon when having fits and while being in an acute disease stage as otherwise the food might be vomited and swallowed in the trachea. This can result in the suffocation of the bird.

17.8.2. Bilateral Traumatic Paresis of the Feet

Cases of bilateral paresis and hyperflexion of the whole foot as side effect of incorrectly conducted endoscopies might be possible in falcons. Those falcons usually are only able to stand on the phalangeal-tarsometatarsal joint on both feet (Figure 17.18, 17.19). Such a case was presented in the Abu Dhabi Falcon Hospital. The anamnestic investigation showed that in such a case the falcon had been one day before in another clinic for routine endoscopy. Immediately after waking up, the falcon was unable to stand in a normal upright position. The owner was told that she will be fine after some time. However, on the next day the falcon showed no improvement and was unable to eat. Then she was admitted to the Abu Dhabi Falcon Hospital for euthanasia as no chance for improvement could be expected. However, she was given a therapeutic experimental trial period of 3 days.

Figure 17.18. Falcon with bilateral paresis.

Figure 17.19. Feet following bilateral paresis.

Clinical Symptoms and Examination

Palpation of the falcon revealed no abnormal abdominal masses, fractures or dislocations of the bones. The patellar reflex and the proprioception of the feet were not apparent anymore. The endoscopy suture was visible in the left inguinal region. No hematoma or other soft tissue injuries were observed. According to the patient's history, a trauma and possible peripheral nerve system damage of the lower motor neuron was suspected.

Therapy

The treatment plan of the hospitalized peregrine falcon was composed of Amynin® 2.0ml and Catosal® 0.5ml sc., Traumeel® ad us vet. 0.5ml and Coenzyme compositum® 0.5ml sc. The bird was handfed with chopped quail meat as she was unable to eat herself. From day 2 of hospitalization onwards, she received daily marbofloxacin (Marbocyl®) 10 mg/kg BID, Amynin® 2.0ml and Catosal® 0.5ml sc., Traumeel® ad us vet. 0.5ml and Zeel® ad us vet. 0.5ml sc. For 3 days she showed no improvement at all. On day 4, she started extending the toes of the right leg. On day 5 after admission, the peregrine was able to stand on her right foot and slowly started to extend the toes of the left leg. On day 6, the falcon stood on both feet and started eating chopped meat herself. Finally, on day 7, she stood normal on both feet (Figure 17.20).

Discussion

It is well-known in birds that abdominal masses or tumors, fractures, luxations, hypovitaminosis B [8] and E [1], vertebral-synsacral junction damage [2], viral and bacterial infections as well as intoxication [1, 8] may cause bilateral paresis/paralysis.

Due to the case history of the falcon in question, most of the possible above-mentioned causes had to be ruled out. In this special case, it can be assumed that a trauma to the peripheral nerves happened during endoscopy. The treatment covered a possible infection with the antibiotic marbofloxacin.

Figure 17.20. Falcon recovered from bilateral paresis after 7 days treatment.

The assumed trauma was treated with the homeopathic medicines Traumeel® and Zeel®. Traumeel® as complex preparation contains among others also Hypericum working especially for the nerves and Arnica for the soft tissue. Zeel® is highly effective for pain or inflammation of bones, joints and tendons. Amynin®, a mixture of electrolytes, amino acids and Vit B complex, helped a lot in stabilizing the falcon. The metabolism was increased by Catosal® containing Cyanocobalamin and Butofosfan, as Vit B 12 supplement.

Although it is not possible to find out in this case what finally helped the peregrine to regain the normal nerval function, it seems to be effective to cover this problem not only with Vit B complexes and antibiotics, but also to enhance the healing of the nerval and soft tissue trauma by administering homoeopathic medicines.

17.8.3. Hereditary Conditions

Hereditary condition can exist in falcons but are not fully researched yet. The loss of the tongue can be regarded as genetic defect in a saker falcon (Figure 17.21) presented at the Abu Dhabi Falcon Hospital.

Only a rudimentary part of the tongue musculature was present. There was no indication of any visible injury. The falcon was able to adjust to this condition without any major problems when provided with suitable food.

Figure 17.21. Saker falcon without tongue.

17.9. Conclusion

Intoxications lead to sometimes life-threatening condition of falcons. In most cases, incorrect husbandry and feeding measures are the reason for intoxications. It is highly important that awareness about intoxication especially with lead and ammonium chloride is performed among the falconers' community to prevent those unnecessary health problems in falcons. In the Abu Dhabi Falcon Hospital, special awareness brochures and education of the falconers have contributed to a much reduced incidence of such intoxications. Moreover, liver problems seem to be on the rise. This is partly due to the fact the often medicines are administered to very young chicks or juveniles falcons with the purpose of preventing diseases like aspergillosis. However, due to the sensitive nature of young falcons, this well-meant intention can result in massive and sometimes irreparable liver damage. Therefore great care should be taken about the application of medicines to young falcons and only veterinarians should perform such medication if the falcon really requires it.

Eye problems are often encountered in hunting falcons due to accidents and fights with the prey. They have to be thoroughly examined and diagnosed thus requiring special ophthalmologic equipment that is unfortunately not in all cases available in veterinary practice. The Abu Dhabi Falcon Hospital was the first falcon hospital to introduce such a specialized and dedicated unit only for ophthalmologic cases.

Further research is required in the cases of Newcastle disease Virus like symptoms that can be classified as fits. Despite the fact that in most cases the real cause for those fits cannot be established treatment has to be performed according to the symptoms. Vitamin injections and direct exposure to sunlight has helped in several cases.

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Appendix: Formulary

The medical formulary includes various pharmaceuticals that give a comprehensive overview of the possible treatments for falcons. It was refrained to use drug names as drug names may vary from country to country. Moreover, it is important to adhere to the respective laws and regulation for countries when using any kind of medicines. Medicines should only be used by qualified professionals.

Anesthetics / Sedatives / Emergency Drugs

Pharmaceutical Content	Route	Dosage	Indication/Remarks
Isoflurane	Inhalation anesthetic	Induction concentration: 4-5% then 2.5%	Narcotic Anesthetic of choice for falcons and raptors
Sevoflurane	Inhalation anesthetic		Narcotic Latest inhalation anesthetic. Expensive, requires specific vaporizer. Induction and recovery faster than isoflurane.
Medetomidine	IM	150-350 µg/kg	Sedative Reversible anesthetic (by equal volume of Antisedan) in combination with ketamine.
Atipamezole	IM	250-380 µg/kg	Used to reverse xylazine/ medetomidine
Ketamine	PO, IM	5-30 mg/kg	Sedative Used on field trips or in case of allergic reaction to isoflurane Reversible anesthetic in combination with medetomidine
Xylazine	IM	1-2.2 mg/kg	Can be used in combination with ketamine (1:3 or 1:5).
Diazepam	IV, IM	0.5-1.5 mg/kg SID, BID, TID as required	Control of fits
Adrenaline	IV, sublingual	0.5-1 mg/kg	Emergency
Atropine	IV, IM	0.04-0.1 mg/kg every 3-4 hours	Acetylcholinesterase and organophosphate poisoning
Doxapram	IV, sublingual	5-10 mg/kg	Emergency, respiratory arrest
Dexamethason sodium phosphate	SC/IV/IM	0.3-3.0 mg/kg	Corticosteroids are normally contraindicated in birds, use only in case of shock

Antibiotics

Pharmaceutical Content	Route	Dosage	Indication/Remarks
Amoxicillin/clavulanic acid	PO	125-150 mg/per kg BID for 5-7 days	Broad-spectrum antibiotic against gram-positive and negative organisms, esp. Staph. aureus, E.coli, Proteus spp., Clostridium perfringens
Carbenicillin	IM	100-200 mg/kg TID for 3-5 days	Gram-negative organisms, esp. Pseudomonas spp., Proteus spp.
Ceftazidime	IM	75-100mg/kg BID for 7 days	Broad spectrum , esp. for therapy resistant bacteria, Pseudomonas sp., E.coli
Ceftriaxone	IM, IV	75-100 mg/kg QID or every 4 h for 5-7 days	Gram-positive and Gram-negative bacteria, including Pseudomonas spp.,
Cephalexin	IM,PO	40-100 mg/kg BID for 3-5 days	Active against many Gram-positive and Gram-negative bacteria. Active against E.coli and Proteus spp., Staph. spp. dermatitis
Chloramphenicol	IM, topical	50-100mg/kg BID/TID for 5 days	Salmonellosis, meningitis, be careful in patients with renal disease.
Clindamycin	PO	50 mg/kg BID for 7-10 days or 100 mg/kg SID	Indicated for osteomyelitis, joint and tendon sheath infections. Can be used for several weeks.
Doxycycline	PO, IM	50 mg/kg BID 75-100 mg/kg for 3-7 days (up to 45 d for chlamydophilosis)	Drug of choice for chlamydophilosis. Be careful as after repeated injections possible muscle necrosis
Enrofloxacin	IM, PO, Nasal flushing	10-15 mg/kg BID for 5-7 days to dilute with sterile saline	Broad-spectrum antimicrobial, gram-positive and gram-negative bacteria including esp. for respiratory disorders, bone and joint problems, Pseudomonas spp., Klebsiella spp., Mycoplasma spp. Might cause vomiting in falcons. Should not be given during molting time.
Lincomycin	IM, PO Intra-articular injection	50-75 mg/kg BID for 7-10 days 0.25-0.5 ml daily for 7-10 days	Can be effective for some gram-positive bacteria. Useful for joint infections and respiratory infections caused by mycoplasma.
Marbofloxacin	IM PO	10-15 mg/kg BID for 5-7 days 10 mg/kg BID for 5-7 days	Broad-spectrum antibiotic as for enrofloxacin, but without causing emesis
Piperacillin	IV, IM	100 mg/kg BID for 5-7 days	Broad-spectrum bactericidal penicillin., gram-negative and gram-positive aerobic and anaerobic organisms, esp. Pseudomonas spp., Proteus spp., Klebsiella spp., E.coli, for severe infections
Rifampin (Rifampicin)	PO	15 mg/kg BID	Avian tuberculosis. Possible side-effects are hepatitis, depression and vomiting.
Trimethoprim/sulfonamide	PO, IM	30 mg/kg BID for 5-7 days	Nephritis

Antiparasitics

Endoparasitic drugs / ectoparasitic drugs

Pharmaceutical Content	Route	Dosage	Indication/Remarks
Fenbendazole	PO	100 mg/kg once 20 mg/kg daily for 5 days	Nematodes, some cestodes, ascarids, capillariasis, Possible feather abnormalities during molting
Levamisole	SC	10-20 mg/kg once	Nematodes, induces vomiting by crop stasis
Moxidectin	PO	500-1000µg/kg once and to be repeated after 1 week	Serratospiculum seurati
Praziquantel	PO	5-10 mg/kg once, to be repeated after 10-14 days	Cestodes, trematodes
Panomomycin	PO	100 mg/kg BID	Cryptosporidium parvum
Permethrin/piperonyl butoxide/methoprene	Spray	Plumage of body and wings, spray cages, aviaries, bird rooms	Ectoparasites including fleas, lice, mites, flies, mosquitoes, use only in small quantities as otherwise intoxications

Antiprotozoal drugs

Pharmaceutical Content	Route	Dosage	Indication/Remarks
Carnidazole	PO	20-25 mg/kg once	Trichomoniasis, giardia, flagellates
Clazuril	PO	5-10 mg/kg for 3 days	Coccidiosis
Dimetridazole	PO	50 mg/kg	Enterocytozoon bieneusi
Metronidazole	PO	50 mg/kg SID for 3-5 days	Trichomoniasis, giardia, in severe cases longer treatment or repetition after 1 week
Pyrimethamine	PO	0.25-0.5 mg/kg BID for 25-30 days	Leucozytozoon, Sarcocystis spp., toxoplasmosis
Toltrazuril	PO	10-25 mg/kg daily for 2 consecutive days	Coccidiosis

Antifungal drugs

Pharmaceutical Content	Route	Dosage	Indication/Remarks
Amphotericin B	IV Intratracheal Inhalation	1.5 mg/kg BID for 3-5 days 1 mg/kg max. 2-3 days Dilute with 10-15 ml/kg saline	Initial treatment in severe fungal infections e.g. Aspergillus spp, syringeal Aspergillosis, Be careful: very hepatotoxic, nephrotoxic
Enilconazole	IT Inhalation Topical	Dilute 1:10, maximum 0.3 ml/kg daily for 3 days 1 ml in 10 ml saline solution Dilute 1:10, apply topically on feathers	Excellent for Aspergillosis and dermatomycoses
Fluconazole	PO	5-20 mg/kg every 2. days	Systemic yeast infections, Cryptococcus sp.
Itraconazole	PO	Prevention: 10 mg/kg SID for 7-10 days Therapy: 10-15 mg/kg SID or BID for 4-6 weeks	Aspergillosis
Ketoconazole	PO	25 mg/kg BID for 7-14 days	Candidia sp., Mucor spp., Penicillium spp.
Miconazole	Topical	20 mg/kg SID or BID for 3-5 days	Candidiasis in oropharynx /crop
Nystatin	PO	300 000 IU/kg BID for 7 days	Yeast infections esp. in gastrointestinal tract, Candida albicans
Terbinafine	PO	10-15 mg/kg BID	Fungicidal. Aspergillus spp

Topical drugs

Pharmaceutical Content	Route	Dosage	Indication/Remarks
Chloramphenicol	Topical	SID	Antibacterial
Gentamycin	Topical	SID	Antibacterial
Povidone-Iodine 10%	Topical	SID	Antiseptic
Propylene glycol, malic acid, benzoic acid, salicylic acid	Topical	SID	For debriding, removes scabs and crusts.
Sodium fusidate	Topical	SID	Antibacterial, particularly against Staphylococcus spp. infections. Might penetrate intact skin
Traumeel cream	Topical	SID	Enhances skin ganulation
Yeast Cell Derivatives	Topical	As needed	Stimulate epithelial healing, especially abrasions and lacerations

Miscellaneous drugs

Pharmaceutical Content	Route	Dosage	Indication/Remarks
Aciclovir	SC, PO	SC: 20-40 mg/kg PO: 80 mg/kg TID	Herpesvirus infection But efficiency questionable
Activated charcoal	PO	2-8 g/kg as required	Used to absorb ingested toxins, including insecticides, heavy metals from the alimentary tract
Amino acids	PO	5-10 ml/kg as required	Electrolyte imbalance, roborans, liver protection
Barium sulfate	PO	Max. 20 ml/bird	Radiocontrast agent, absorbs heavy metal particles in gastrointestinal tract
Biotin	PO	50 µg/kg daily for 30-60 days	Feathers problems, beak or claw regrowth
Bromhexin	PO	15-20 mg/kg SID or BID for 5-7 days	Bronchosecretolytic
Calcium	PO	1 ml/kg over food	Calcium deficiency, fractures
Carprofen	IM, PO	1-2 mg/kg SID for 3-5 days	Analgesic
Electrolytes, vitamins, amino acids,	SC	10 ml/kg	Electrolyte imbalance, hypoproteinemia,
Electrolyte solution, e.g. Tyrode's Solution® Or self-made: 8g NaCl, 0.13g CaCl2, 0.2g KCl, 0.1g MgCl2,0.05g NaH2PO4, 1.0g NaHCO3, 1.0g Glucose, ad 1000ml Aqua dest.	PO	Instead of drinking water	Kidney disease or insufficiency, polyuria, polydipsia,
Electrolyte	PO	5 ml in 250 ml water or over food	Strong dehydration, stress, transport, energy, extra salts
Furosemide	IM	0.15 mg/kg SID to QID as required	Diuretic for ascites, hydropericard, heart insufficiency, do not use in falcons with dehydration and hyperuricemia
Iron dextran	IM	10 mg/kg. Repeat after 1 week if required	Anemia, hemopoiesis
Ketoprofen	IM	1-5 mg/kg SID for 1-5 days	Analgesic, anti-inflammatory, arthritis
Lactulose	PO	0.2-0.5 mg/kg BID or TID	Absorbs toxins from gastrointestinal tract, increases appetite, improved digestion
Meloxicam	PO	0.2 mg/kg SID	Analgesic, antipyretic, NSAID, longer use might lead to gastric ulcers
Metoclopramide	IM	0.3-2 mg/kg SID to TID as required	Anti-emetic, crop stasis
Nandroline laurate	IM, SC	0.4 mg/kg once, repeat after 3 weeks if required	Give only in really required. For chronic and debilitating diseases. Might cause liver disease
N-butyl-cyanoacrylate	Topical	Put small quantity	Surgical glue for the closure of tiny skin wounds

Miscellaneous Drugs (Continued)

Pharmaceutical Content	Route	Dosage	Indication/Remarks
Newcastle Disease vaccine	SC	0.25 ml/kg, repeat after 3-4 weeks, than once yearly	Vaccine for prevention of Newcastle Disease Virus
Oxytocin	IM	2-4 IU/kg	For egg binding, administered together with calcium and vitamin A. Not for mechanical uterine obstruction
Pancreas enzymes (with amylase and lipase)	PO	5 ml over 100g food	Pancreas disorders, pancreatitis
Pedialyte	PO	10-30 ml/kg as required	Mild dehydration, diarrhea
Plasma substitute	PO	8-10 ml/kg	Hypovolemic shock, hemorrhages,
Poly-Aid	PO	5 g/100 g food	For intensive care patients
Sodium Chloride 0.9%	SC	40-50 ml/kg/day for maintenance	Dehydration, massive vomiting. Too high dosage can result in myovardial/renal damage.
Sodium Chloride 0.9% and Glucose 5%	IV	50 mg/kg (max 10 ml/kg)	Isotonic solution. Hypoglycemia and dehydration. Slow IV administration
Sodium lactate solution	SC	40-60 ml/kg/day for maintenance	Dehydration, vomiting, diarrhea. Too high dosage can result in myovardial/renal damage.
Sodium calciumedetate	IM	10-40 mg/kg BID for 5-14 days	Lead intoxication, heavy metal poisoning. Maximum 2-3 weeks continuous administration, then 1 week break
Soluble multivitamins	PO	1 g for 100 ml food	Vitamin support for sick falcons. Additional vitamins if frozen food is used. Nutritional deficiency
Tolfenamic acid	IM	2-4 mg/kg	Analgesic, antipyretic, anti-inflammatory
Vitamin A	IM	Maximum 20 000 IU/kg weekly	Hypovitaminosis A. To increase skin healing, e.g. in bumblefoot. Supplemental therapy for pos infections, sinusitis and ophthalmic disorders.
Vitamin A, D, E	IM	0.1-0.2 ml (10 000-20 000 IU)/300 g, weekly as required	Useful in the treatment of Vitamin A + D deficiencies, reproductive disorders and bone healing
Vitamin B complex	IM	10-30 mg/kg. Repeat weekly as required	Anemia, increases appetite, after long antibiotic therapy, neuro-muscular disease, hepatic disorders, CNS symptoms, fits. Might lead to yellowish discoloration of feces
Vitamin B12	IM	200-500 µg/kg weekly	Roborans, anemia, CNS symptoms, convalescence. Administer together with vitamin B1. Might lead to reddish discoloration of feces
Vitamin E/selenium	SC	0.05 mg selenium + 3.4 IU vitamin E. Repeat once after 72 h	Vitamin E/Selenium deficiency, muscular dystrophy, muscular weakness, capture myopathy
Vitamin K	IM	0.2-2.5 mg/kg as required	To stop hemorrhages

Herbal / Homeopathic drugs

Birds, falcons and raptors respond very well to homeopathic remedies as per the author's experience. For the use of herbal/homeopathic drugs, the potency depends on the actual condition of the birds. Moreover, combination remedies have been highly successfully used in the Abu Dhabi Falcon Hospital. They can be often administered better than single preparation in birds. However, for use of those drugs, clear knowledge about the working mechanism and effects should be available before administering the drugs. A deterioration of the actual condition is possible in homeopathic remedies and is a sign that the medicines is working well. After this initial deterioration, improvement of the condition is usually observed.

Pharmaceutical Content	Route	Dosage	Indication/Remarks
Arnica	SC, PO, topical	As required	Inflammations, injuries, wounds, shock
Berberis	SC	As required	Urogenital, kidney and liver infection, gout, diarhea
Cantharis/ Lytta vesicatoria	SC	As required	Nephritis, kidney disorders
Cerebrum suis	SC	As required	CNS symptoms, brain concussion, feather plucking
Chamomilla	SC, PO, topical	As required	Inflammations, wounds
Chelidonium	SC	As required	Liver damage, gastroenteritis
Crataegus	SC, PO	As required	Improves cardiovascular function
Cutis suis	SC	As required	Skin diseases
Echinacea	SC, PO	As required	Immune stimulant, bacterial and fungal infections, respiratory infections
Euphorbium	SC	As required	Respirator disorders, sinusitis
Gelsemium	SC	As required	Shock, paralysis, convulsions
Graphites	SC, PO	As required	Eczema, beak and talon deformities
Hepar suis	SC	As required	Liver diseases, metabolic disorders
Hepar sulfuris	SC	As required	Suppurative wounds
Ignatia	SC, PO	As required	Paralyses, nervousness
Lycopodium	SC	As required	Pancreatitis, liver disorders
Melaleuca alternifolia (Tea tree oil_	SC, topical, inhalation	As required	Skin problems, respiratory and fungal infections

Herbal/Homeopathic drugs (Continued)

Pharmaceutical Content	Route	Dosage	Indication/Remarks
Milk thistle extract (Sylamarine)	PO	1 tbl/kg SID or BID for 5-7 days	Liver prevention and treatment, antioxidant
Mucosa suis	SC	As required	Mucosal and respiratory disease, ingluvitis,
Nux vomica	SC, PO	As required	Gastrointestinal disorders, diarrhea, crop stasis, ingluvitis,
Psorinum	SC	As required	Skin disorders
Rhus toxicodendron	SC/PO	As required	Pain in bones, joints, tendons, muscles
Veratrum	SC	As required	Intoxication, diarrhea, ingluvitis, circulatory disease
Vincetoxicum	SC	As required	Immune stimulant, viral disease, general strengthening

Appendix: Abbreviations

The book and medical formulary includes various general abbreviations that are listed below:

BID	twice a day
BW	bodyweight
cm	centimeter
d	day
dl	deciliter
e.g.	for example
g	gram
kg	kilogram
i.m.	intramuscularly
IU	International Unit
i.v.	intravenously
mg	milligram
ml	milliliter
mm	millimeter
p.o.	per orally
QID	four times a day
s.c.	subcutaneously
SID	single time a day
Tbl	tablet
TID	three times a day
μg	μ gram

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