Biology and Behaviour of Falcons with Emphasis on Captive Breeding and Healthcare of Peregrine Falcon *Falco peregrinus*

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in

ZOOLOGY

by

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CERTIFICATE

This is to certify that, this thesis is a record of the bonafide research work carried out by **Mr. Zubair M**, M.Sc., from November 1999 to February 2004 under my supervision and guidance and that neither this thesis nor any part of the same has previously formed the basis for the award of any degree / diploma / associateship / fellowship or other similar title to any candidate of any University. It is further certified that Mr. Zubair has passed the Ph.D preliminary qualifying examination in June 2001 conducted by the University of Calicut.

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DECLARATION

I, **Zubair M**, hereby declare that the thesis entitled "**Biology and Behaviour of Falcons with Emphasis on Captive Breeding and Healthcare of Peregrine Falcon *Falco peregrinus***" submitted to the University of Calicut, in partial fulfillment of the requirements for the award of the degree of Doctor of Philosophy in Zoology is an authentic record of original and independent research work done by me during November 1999 to February 2004. The research was carried out under the supervision and guidance of Dr. E.A.A. Shukkur, Senior Selection Grade Lecturer, Division of Wildlife Biology, Farook College, Calicut. It is further declared that this has not previously formed the basis for the award of any degree or diploma of any University.

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ABSTRACT

The falcon species has always been regarded as a very uncommon and shy bird, and it is very rarely met with amateur birdwatchers (Ali 1968). Falcon is the national bird of UAE and is a symbol of force and courage recognizing the importance of falconry in their tradition and culture. Arabs constitute 1/3rd part of the world's falconers. They are fast flying hunters suited for taking prey in the air. In this pesticide era they are facing serious ecological risks, as their position is top in the biological pyramids.

The falcons are extremely accomplished and swift fliers generally killing their prey on the wing (Ali 1967). The most important activity of falcons is hunting (Baker 1967). Some species of falcons are extensively used as sport of falconry (Ali 1983). Unlike many birds, falcons live as single pairs within the community (Ratcliffe 1980). The documented speed of a Peregrine's stoop is over 320 km/hr (Cade 1980). Peregrine falcons generally mate for life, but will readily accept a new partner if their mate dies (Newton 1990). Food requirements vary depending on a bird's age, size, activity and season (Thorstrom 2000). Riddle and Remple (1994) estimated that there might be 8600 Saker and Peregrine falcons in captivity in the Middle East. A lot of works and studies have been conducted across the world, from time immemorial to the present, regarding falcons and falconry. Eminent writers and bird watchers have contributed memorable and informative works on this subject.

My study was to examine behaviours like vocalization and timing of movement by field observation in and around the aviaries, cages and flight pens of various centres. Vocalization helps them to communicate each other. The main objectives of study were to document the knowledge that relates with the biology, behaviour and captive management of falcons. The prime focus of the study was in captivity. Field observations were also made especially with reference to hunting behaviour, training and other related aspects. Data relevant to feeding, breeding, health and healthcare, management in captivity were collected. Data on roosting, bathing, foraging and vocalization, and different types of food, feeding methods and food consumption in captivity and in the field were also collected.

The other objectives of the study were to examine the environmental requirements at different stages of breeding, to observe and acquire knowledge of pterylographic and taxonomic patterns of feathers on body tracts of adults and nestlings and to observe and document the sequence of moulting and plumage. An attempt is also made to document various species of falcons used for falconry in UAE, methods of hunting and training practices, the reasons for falcon's extinction and their remedies and falconry through ages and its current state.

The present study on the biology of falcons was carried out in different parts of UAE, mainly because of their large number in captivity. The study was started from November 1999, and more intensively from August 2001 till December 2003. The study was conducted in falcon breeding and research centres, falcon hospitals and falcon clinics, concentrating in H.H. Sheikh Zayed Ibnu Sultan Al Nahyan Falcon Research Hospital, Abu Dhabi; Environmental Research and Wildlife Development Agency (ERWDA), Abu Dhabi; National Avian Research Centre (NARC), Sweihan; Nad Al Shiba Avian Reproduction Research Centre, Dubai; Dubai Falcon Hospital; and Falcon Clinic, Sharjah.

The falcon cages were monitored through spy holes during breeding season. Through lab test results of fecal samples and pharyngeal swabs, attempt was made to find disease-causing organisms. For observations on various behavioral aspects standard methods were adopted. Eggs were measured and weighed by Brunham formula. Falcons were closely followed to maximum possible period through their fledgling, juvenile, one-year-old and adult at different ages. Colour rings were used to make individual recognition possible in cages. Feathers were plucked and patterns of follicle arrangements were observed for pterylographic study as adopted by Naik (1965). Moult of feathers was studied by measuring various feathers of the individual primaries, secondaries and tail feathers of 40 birds of Peregrine, 20 each of Saker and Gyr falcons by using the scoring system adopted by Miller (1928). Formalin preserved specimens were washed thoroughly in water for many hours and dried.

The weather plays a major role regarding the hunting and abundance of preys. The climate in UAE is hot and rainfall is low. Falcons are very sensitive to climatic

conditions and fastest in the animal kingdom. They have special characters some of which are mentioned below. Twice number of cervical vertebrae of falcons enables them to rotate head on its axis almost 360 degrees. Falcons have two regions of retina for acute vision. Nostrils have needle like projection for cutting air and easy flight.

It was observed that all falcons of the area were early raisers, makes morning calls and move out of roosts, preened feathers, moves from one roost to another and glides down to start foraging. In aviaries and pens small boxes are provided for roosting. It was noticed that falcons foraged in morning twilight but not in evening. They drank water many times in summer.

Falcon is very aggressive and a busy bird. Unlike most other birds females are larger than males. It is observed that hungry falcon will attack even other falcons in aviary for food. Their body is well adapted for attacking and capturing prey. They have specific timings for each activity like roosting and sleeping. In captivity they are busy by moving from one roost to another. Falcons are migratory birds from breeding grounds to wintering grounds and back.

Falcons are carnivorous and sensitive to stored food during breeding. There are several species of falcons, but in UAE three major species are used for falconry. They are Peregrine, Saker and Gyr. Peregrine is widely spread all over the world except Antarctica. Saker flies fast and hunts at low level and Gyr is powerful and prefer to catch larger preys. Birds, large insects, rodents and other small ground animals are main food. It is found that larger falcons have a tendency to hunt bigger preys than smaller ones. It is observed that the majority of food items were sand grouse (31.3%), stone curlew (24.8%), houbara bustard (13.5%) and desert hare (10.3%). They also consumed rat, pigeon, lizard, quail etc.

The consumption of only live food may cause diseases; so mixed food (frozen and live) is advisable for proper health. If they fed on boneless meat regularly, calcium deficiency occurs and affects bones, beak, claws etc. and casting does not occur properly. The boned and boneless mixed food is suggested to help retain calcium deficiency and casting. It is noticed that falcon's digestive system can dissolve

bones. Although fresh food is best for them, sometimes frozen food is unavoidable. Falcons are fed with live or frozen food in hunting season, but in moulting period they are given frozen food. Fasting once fortnightly is recommended for proper casting. It is advisable to spray water on facial and thoracic regions of falcons, speed up defecation.

As falcons are royal birds, breeding and management are expensive. The objectives adopted were to examine the environmental requirements and different stages of breeding. In UAE the breeding season starts from February-March to August-September. Most falcons are monogamous and they have unique breeding cycle. They breed once a year and live with same mate until death.

Through artificial insemination, the breeding centres have helped the falcons from the decrease in population. During artificial semen collection urine contamination may occur, and is solved by seminal washing. DNA testing and laproscopy are used to determine sex. Falcon's life span is as high as 10 to 12 years, but captive falcons live longer. In Peregrines and large falcons males apparently reach sexual maturity on an average, about a year later than females.

It is observed that if first eggs are damaged before hatching or chicks die in first few days, they lay more than one clutch of eggs in a year. Mortality rate is constant with respect to age unlike other animals. The larger species reach breeding age at 2-3 years. The eggs of Peregrine are creamy pink to reddish-brown and are average of 53mm. long. It is observed that overall mean clutch-size recorded was 3.3. Generally 2-6 eggs are laid, incubation is 28-35 days, offspring fledged in 4-8 weeks and youngs stay with parents learning to hunt for 1-3 months. Average incubation period was 32.6 days. Details of fate of eggs laid by Peregrines were as: 57% hatched, 24% did not hatch even after extended incubation, 11% were damaged during incubation and 8% destroyed by the effect of pesticides. First two eggs hatched after an interval of 2.31 days on an average. Since incubation started with laying of first egg, eggs in a clutch hatched asynchronously. Average nestling and fledgling periods were 16.6 and 37.1 days respectively.

It was noticed that even though differences in size, there is no significant difference in the daily food intake of male and female nestlings for about the first 21 days. It is understood that female nestlings require a greater amount of food than do males, but because of greater growth efficiency, they need less than expected on the basis of body mass.

Pterylographic studies, study of plumage and moulting of falcons are indispensable features for research studies. The less availability and high cost make the falcons difficult to get for studies like this. The study is meant to acquire the maximum knowledge of taxonomic pterylographic patterns of feathers on body tracts of adults and nestlings. Falcons generally moult once a year. The moulting time is the resting period of falcons in captivity.

Pterylosis of young differs in some pterylae from that of the adults. The femoral tract in nestlings is not developed as in adults. It is noticed that after moulting, in the second year the colour of moulted feathers in wild falcons differ compared to falcons in captivity. The probable reason may be differences in nutrition. The colour of secondary feathers got changed in Peregrine and Gyr after two years of age, but the primary feathers will be same. It was observed; the relationship of plumage colouration was more or less not influenced in pairing. The season for moulting in all falcons coincides with breeding season. At the population level falcons moult primaries from March to October, secondaries April to November and retrices May to November. In the case of Peregrine falcons the moulting starts very late, from May and it lasts till next January.

The management of falcons in captivity requires highly sophisticated facilities. Temperature and humidity controllers are to be provided in captivity. Aviaries should be well lit and airy and faced away from cold prevailing winds. Nest ledges or boxes are to be placed in aviaries. In aviaries roofing materials are to be used with the purpose of preventing excess heat in summer and condensation in winter. In falcon aviaries the wet muddy substrate is a cause of hypothermia and poor perches is the reason of bumble foot disease. Falcons only breed in captivity when they feel convenience and comfortability. It is advised to leave alone enclosures from disturbance from egg laying to youngs have fledged.

In captivity food is not given to falcons in live condition and it can be advised that frozen food items are not to be given below 20°C. It is also recommended that food ledges are to be used for feeding falcons in captivity. Calcium supplements and vitamins are given if necessary. Youngs require more food than adults. In falcons dehydration is widely seen, so in captivity drinking water and bathtubs are to be erected.

In captivity management of falcons may not be perfect without caring the health and hygiene. Hence the topic health and healthcare was included in my studies. This includes documenting important preventive, promotive and curative measures taken in falcon hospitals and clinics for various diseases. Main objectives of study were to document the diseases caused by virus, bacteria, fungus, internal and external parasites and diseases by other agents and their preventive measures.

A large variety of viral, bacterial and fungal diseases are widely seen in falcons. Most diseases are not so critical if precautions and treatments are taken in proper time. Bacterial infections are not so dangerous as viral diseases in falcons. Most bacterial diseases and viral diseases are transmitted to falcons through their preys like pigeons. The endoparasites are protozoans and helminths. The study based on statistical field research showed that in captivity bumblefoot is seen widely, so it is advised to give the falcon training twice a day to reduce the morbidity rate.

As far as falcons are concerned the diseases are not fatal, except New Castle and Aspergillosis in late stages. Proper management, routine checkup, health awareness programmes and counseling will prevent almost all diseases.

Falconry is the traditional sport of the Arabian Gulf. Arab people constitute one-third of the total falconers in the world. Major species used for falconry comprises of Peregrine, saker, Gyr and their hybrids.

Skilled trainers train falcons to perfect the techniques of hunting. Today falconry is facing a serious threat by habitat destruction, pesticides and diseases. Falcon trappers catch them when they rest on the route during migration. Though falcon

population faces serious threats, man has made modern technological improvements to reduce the rate of destruction through captive breeding and falcon release project. Proper management, better hygiene, balanced diet and routine checkup will prevent almost all diseases to a certain extent.

The following recommendations are given:

- Since consumption of live specimens cause infectious parasitic diseases. A mixed food regime of frozen and live food is advisable. Feeding on stored food alone is not healthy and food frozen below 20°C may be avoided. Food supplements are necessary if the birds are fed on monotype food. Diverse food promotes healing wounds, immunity, hunting capacity, and proper casting.

- Fasting once in a fortnight facilitate proper casting. Ammonium chloride, used for purgation of falcon's alimentary system, kills them when given excessively.

- Old food items are to be removed from the cages regularly. The food items should be given in food ledges or in a clean place. Throwing food to falcons is not advisable.

- Food items should be checked before feeding to falcons. Attempts should be made to reduce the possibility of infected pigeons transferring trichomoniasis to falcons. Falconers should feed the falcons only after removing head, neck and internal organs of preys. Pigeon flocks should be medicated with antiprotozoal drugs to reduce the number of protozoan carriers.

- For artificial insemination the spermatozoa may be washed gently using water, immediately after collection, to clean it off the urine and other contaminations. Contaminations are likely to cause lower success.

- In aviaries roofing materials are to be used with the purpose of preventing excess heat in summer and condensation in winter.

- Falcons constantly forced to land on cold muddy floors are likely to have health problems and hypothermia. Bark or wood clips are not suitable substrate as they harbour spores of *Aspergillus sp.*

- It is advisable to change perches regularly. Changing the perches once in a while gives a stimulus to the raptors. Apart from perches, baths, feed ledges and hidden retreats are also necessary in the enclosures. Poor perches in aviaries are known to cause over 80% of the bumble foot disease. The talons should be cut and trimmed once a month especially during moulting season, otherwise it may cause bumble foot.

- Best time to remake nests and clean the cages and nest boxes is 6-8 weeks before the breeding season. Once egg laying commences it is best to leave enclosures undisturbed until hatching.

- The bathtubs of 4-6 inches of water depending on size and height of the individual falcons are deep enough for most birds for bathing. Bath water is not necessary for sick birds, although water for drinking must be available. Cleaning the bath at least twice a week especially during summer is necessary to avoid green algae and other noxious materials build up.

- Entering into aviaries should be with great care and feeding done carefully if pairs are showing behavior associated with breeding. It is better not to enter the cage until chicks are full fledged.

- Effective windshields are advisable to protect the birds during moulting season to speed up the moulting.

- Some of the diseases are fatal to falcons. However, proper management, better hygiene, balanced diet and routine check up will prevent to a certain extent almost all diseases affecting falcons.

CHAPTER 1

INTRODUCTION

The falcons have always been regarded as a very uncommon and shy bird, and they are very rarely met with by amateur birdwatchers (Ali 1968). Man has always regarded the falcon as a symbol of force and courage. Falcons are fast flying hunters, supremely suited for taking prey in the air. It is called '*Saqr*', in Arabic language, which means beating. They are long winged and tailed similar in shape to kites but with a greater sense of power.

History tells us of emirs, chieftains and nobles practicing hawking since millennium. Falconry is an important traditional sport of the Arabian Gulf. Opinions on origin of the sport and its subsequent development are highly debatable. Hunting with falcons, keeping them in captivity, their healthcare and use of advanced methods in training them were widely discussed in the period of the Omayyads and the khalifs of the dynasty (Schlegel & Verster 1979).

Falcon is the national bird of United Arab Emirates recognizing the importance of falconry in their tradition and culture. The Saker falcons and houbara are held in high regard, reminiscent of the desert life that is vanishing. Falconry, like camel racing and horse riding, is a traditional quest in UAE and the other countries of the Middle East. The primary purpose of falconry was hunting for fresh meat. Falconry, once an important means to supplement diet of the inhabitants of the Middle East desert, is now enjoyed as a traditional sport of hunting. The most popular hunting birds like Peregrine falcon and Saker falcon are conventionally trapped during their autumn migration used for hunting for the season and then released to the wild.

1.1 Taxonomy of falcons

The family *Falconidae* comes under the order *Falconiformes,* sub order *Falcones.* Two sub families, the first *Falconinae* that includes falcons and falconets (46 species) and the other *Poliborinae* that includes forest falcons (15 species) and

caracaras. *Falconidae* consists of 10 genera, 61 species and 149 taxa. Of these, 5 species are threatened and one species is extinct since 1600 (Cade 1979).

The genus *Falco* has 37 species, the largest of which are circumpolar Gyr falcons and Merlins. Kestrels are the smallest. Peregrine falcons are the most cosmopolitan in distribution. Caracaras do appear in the Arabian Gulf. The falcons are generally divided into 4 groups, (a) Large falcons (11 species) (b) Typical Hobbies (8 species), (c) Typical Kestrels (16 species) and (d) Merlins (2 species). Large falcons consist of two groups, namely (a) Gyr falcons and desert falcons (Lanner and Saker falcons) and (b) Peregrines (Peregrine and Barbary falcons).

The genus *Falco* contains a number of adaptive types, from large insect eating kestrels to the exclusively bird-eating Peregrine falcons. The Indian Peregrine falcon or Black Shaheen *Falco pergrinus peregrinator* (Plate 1.1), Saker falcon *Falco cherrug* (Plate 1.2), Gyr falcon *Falco rusticolus* (Plate 1.3), Luggar falcon *Falco jugger*, Barbary falcon *Falco pelegrinoides*, Sooty falcon *Falco concolor*, Lanner falcon *Falco biarmicus* and Arctic Peregrine falcon *Falco peregrinus calidus* are some of them. The Hobby group consists of species such as Eurasian hobby *Falco subbuteo*, African hobby *Falco cuvierii*, Oriental hobby *Falco severus*, Australian hobby *Falco longipeunis* and Eleonoras falcon *Falco eleonorae*. Among hobbies, the Brown falcon *Falco berigora*, New Zealand falcon *Falco novaeseelandiae*, Aplomado falcon *Falco femoralis*, and large falcons like orange-breasted falcon *Falco deiroleucus* and Prairie falcon *Falco mexicanus* are closely related to one another.

Another well-defined group comprises the Kestrels that include 16 species. Kestrel *Falco tinnunculus*, Lesser Kestrel *Falco naumani*, Indian Kestrel *Falco tinnunculus objurgathus*, American Kestrel *Falco sparverius* and European Kestrel *Falco tinnunculus tinnunculus* are some of them, and 2 species of Merlins are Merlin *Falco columbarius* and Red headed Merlin *Falco chicquera chicquera.*

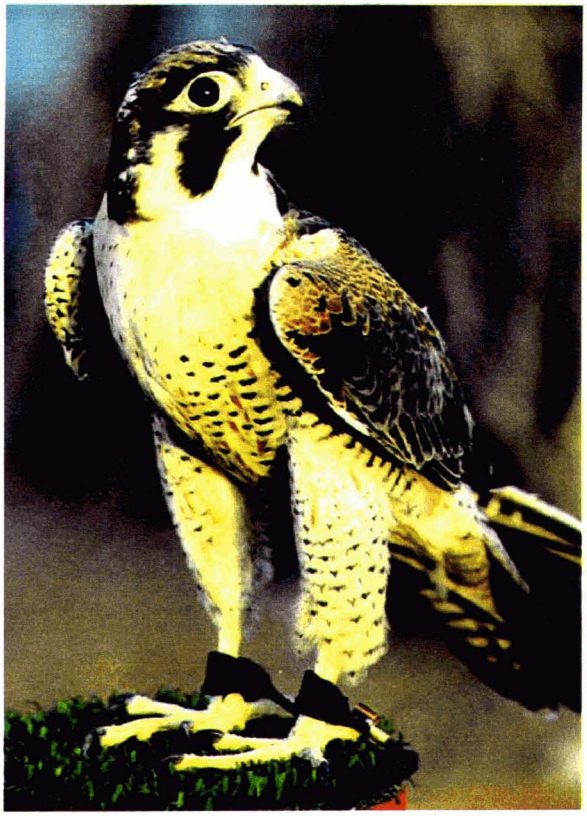


Plate 1.1 The Black Shaheen is a medium-sized dark Peregrine subspecies that breeds on the Indian Subcontinent

Plate 1.2 The Saker falcon is probably the most versatile houbara hunter and therefore the favourite among Arab falconers

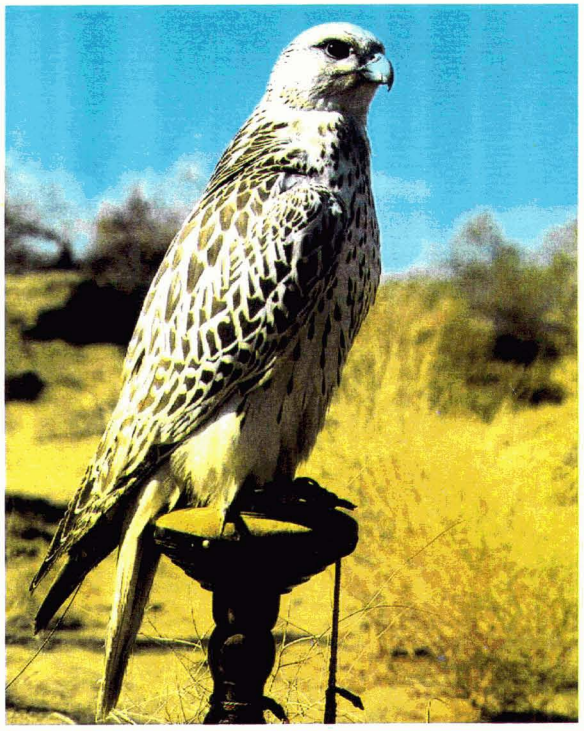


Plate 1.3 Gyr falcon with ptarmigan. This magnificent falcon is the most powerful and lethal of all aerial killers

Plate 1.4 The nostril of a falcon has a needle like projection, which helps for cutting the air for easy flight; they have the tomial tooth

1.2 Worldwide status of falcons

Falcons form a very well specialized and spectacular group of hunting birds and are exhaustively termed as 'hunting dogs of the skies'. The genus *Falco* is distributed almost worldwide. They are adaptable to nearly every latitude and climatic zones except Antarctica (Dottlinger *et al.*1999). It is seen in almost all places like tundra to desert, tropical forests and in all regions wherever prey is available. The Peregrine falcon is widely spread all over the world except Antarctica. Lesser Kestrels are limited to west Paleartic breeding species to middle latitudes and even boreal zones on northern fringe, although occurring in Asia upto an altitude of 1500m, and occasionally higher. Lowland species in Europe breed regularly not beyond 500 m (above MSL) and usually much lower, preferring foothills to mountains. Africa and its islands form the center of the distribution of kestrels. Although members of the genus are seen in a wide variety of habitats, particularly the large falcons, such as the Prairie falcon *Falco mexicanus* and the Saker *Falco cherrug* live in open terrain. The smaller falcons can live in enclosed countryside but as an exception, New Zealand falcons *Falco novaezeelandiae* inhabit heavily wooded areas.

All breeding species of *Falco* are migratory or partially migratory within west Palearctic region. Seven species are wholly or partially equatorial migrants. Of these, Sooty falcons are rarely seen in UAE during winter. They cross wide areas of water and passages like Mediterranean and Gibraltar. Falcons come into Arabia as migrants from Eastern Europe and central Asia, enroute their wintering grounds in Africa. There are two major migratory routes to Arabian Peninsula. The first route draws from Europe and Baltic States to Mediterranean through Syria, Lebanon and Red Sea. The second draws from the Caucasus, crossing Afghanistan, Pakistan and Iran, then into the Gulf area before dispersing into Africa. From September to November they move to the eastern and western coasts of the Arabian Peninsula, as this is the peak migration season of their prey species. Saker falcon, the traditional favourite of Arab falconers and a migratory visitor to the Gulf, breed in Eastern Europe and Asia. The Sooty falcon and Eleunoras falcon breed during late summer to early autumn around the Mediterranean and North Africa and migrate to Madagascar in winter.

Spring passages often are more conspicuous than that in autumn. Many falcons have breeding areas that are geographically separated from the ones they occupy during rest of the year. Tropical and sub-tropical species tend to occupy the same areas year round, with little migratory wanderings. To escape from the harsh northern winters, northern breeding species tend to migrate great distances. Arctic Peregrines of the Eastern Hemisphere migrate to Africa and those of the Western Hemisphere migrate to South America.

The falcons that nest in the American Arctic and Greenland migrate to central and South America, Argentina, while their counterparts in the Eurasian Arctic move south towards Europe, Africa, Middle East, India, China and south east Asia. Peregrines nesting in northern latitudes are highly migratory, while those nesting in mid latitudes and in Southern Hemisphere are much less. Large peregrines are seen in Great Britain, Northern Europe, Russian and Siberian Arctic (Brunell 1986). Some of the largest Peregrines used to breed in the eastern United States.

Falcons are diurnal, smaller species often traveling in loose flocks. Larger ones generally move as singles. Falcons occupy the top of biological pyramids. Hence, they are subject to serious ecological risks. Environmental contamination, bioaccumulation and biomagnifications of the contaminants are likely serious threats to the survival of this top avian carnivore. It is felt that Peregrine falcon is highly vulnerable species as per the IUCN criteria A2b, c, e; C2a; D1.

1.3 Aims and objectives of the present study

For the present study broadly five major objectives were identified and listed below.

- Examine feeding habitat and behaviour of falcons,
- Examine breeding and moulting in captivity,
- Document training and management of falcons,
- Study the healthcare practices for falcons in captivity and

- To briefly examine the status of the falcon population and role of captive breeding in their rehabilitation.

1.4 Significance of the study in view of earlier works

Falcons being migratory birds, their ecology, behaviour, falconry, food and feeding strategies in the natural environments are least studied. The falcons had complex interactions with man. It has been prized in falconry for at least four thousand years (Harting 1891); their eggs are highly prized by oologists, their spectacular hunting techniques have fascinated naturalists and have been a major target of gamekeepers and pigeon fanciers. The Peregrine falcon a rare resident of woods, and coasts, prey almost exclusively on birds (Brown and Amadon 1968). Though the Peregrines are uncommon, they can be found wintering in most states, but rarely breeding (Cade 1982).

Some of the most insidious threats to falcon's survival are the chemical contamination, bioaccumulation or biomagnification. Comparatively little research has been done on the dangers posed to falcons by these substances (Weidensaul 1996). The marked declines in several populations of Peregrine falcons have been ascribed to reproductive failures caused by DDE and poisoning by other organochlorine compounds (Ratcliffe 1980). The relationship between eggshell thinning and DDE was clearly demonstrated for the Peregrine falcons by Cade and co-workers (Cade *et al.* 1971). Predators of the American Kestrels *Falco sparverius* include large raptors such as great horned owl, golden eagles, and red-tailed hawks (Balgooyen 1976). In several areas, investigators have found that male kestrels tend to use woodland openings and edges, while females tend to utilize more open areas characterized by short or sparse ground vegetation, particularly during the winter (Mills 1975, 1976; Smallwood 1987). In other areas however, investigators have found no such differentiation (Sferra 1984, Toland 1987). Kestrels are more likely to use habitats close to centres of human activities than are most other raptors (Fischer *et al.* 1984). The Merlin *Falco columbarius* larger than Kestrel can be found in a variety of habitats but nests in open wooded areas (Cade 1982). The falcon population is decreasing recently because of their habitat destruction, illegal trapping, pesticide effects, accidental deaths etc. To

eradicate these threats, more studies are to be carried out in this field. If proper measures towards conservation and preservation of these royal birds are maintained, the extinction of this species can be avoided.

In the 1970s, there was a surge of captive-bred falcons in the Middle East. The high demand was for their demonstrated higher ability in hunting. But the locally captive-bred falcons were very few in numbers and hence they were imported to the Gulf countries mostly from Europe and other Western countries. For importing the birds a huge amount of money was spent. However, it was possible to get wild-bred birds at much cheaper rates from some of the eastern nations. It is likely that such a situation would have offered high pressure on wild population of the bird in their nations of origin. The sport of falconry is a national pastime in most Middle East countries. Arab people constitute $1/3^{rd}$ of the total falconers in the world. Capturing the birds from nature for training and falconry is not easy, may pose serious threat to wild population. Hence breeding in captivity and management of falcons are very essential although expensive.

1.5 Falcon species under study

a. Peregrine falcon *Falco peregrinus*

The Black Shaheen or Indian Peregrine is a medium-sized dark Peregrine subspecies that breeds on the Indian Subcontinent, hunts over all kinds of habitats, but prefers open spaces such as coasts, moors and fields.

b. Saker falcon *Falco cherrug*

Saker is the favourite among Arab falconers. This species is a raptor of vast open spaces such as steppes, cultivated plains, mountain plateaus and foothills.

c. Gyr falcon *Falco rusticolus*

Gyr falcon is the most powerful and lethal of all aerial killers. It breeds from Iceland to Asia, North America and Greenland.

The large size of eyes, which are relatively fixed within the skull in birds, permits only limited movement. To compensate this drawback, birds have at least twice the number of cervical vertebrae, this feature enabling them to turn their heads

upside down or to rotate their head on its axis almost 360 degrees. The eyes of falcons are directed forwards which helps in binocular vision. Many falcons have a dark streak under each eye; this helps to reduce the glare reaching the eye, so that they see more easily in bright light. The dark streak is the peculiarity of most sub species of Peregrine falcons. Nostrils of falcons set in cere typically rounded have a needle like projection, helps for cutting the air for easy flight (Plate 1.4).

In general a bird's hearing is equal to humans (Remple & Gross 1993) although they have higher ability to differentiate individual sounds much faster than humans do. All falcons possess a unique structure on the cutting edge of the upper mandible on each side known as '*tomial tooth*', with this it snap the cervical vertebrae of captured prey. Wing-beats are strong which have great powers of diving flight-'stooping'. Like many other migratory birds falcons are also migrates from their breeding grounds to wintering grounds and back.

1.6 Area of study

United Arab Emirates (Figure 1.1) was selected as the study area because the country has large number of falcons in captivity. The country also has free ranging falcons, although in very low numbers, in nature especially in winter. However, free ranging falcons belonging to peregrines, most wanted among the sportsman are not known from the country. Owing to the large number in confinement the study was mainly concentrated on falcons in captivity, breeding and research centres of different falcon hospitals in UAE. The country also has three falcon-releasing centres, situated 25km from the Abu Dhabi falcon research hospital in high terrain. Observations on feeding, roosting, breeding, moulting, casting, bathing, vocalization and other aspects in an intimate manner is only possible in captivity and not easy in nature.

The present study on the biology of the falcons was carried out in different parts of UAE concentrating in H.H. Sheikh Zayed Ibnu Sultan Al Nahyan Falcon Research Hospital, Abu Dhabi; Environmental Research and Wildlife Development Agency (ERWDA) Abu Dhabi; National Avian Research Centre (NARC), Sweihan; Dubai Falcon Hospital; Nad Al Shiba Avian Reproduction Research Centre, Dubai and Falcon Clinic, Sharjah. The study area falls between the latitudes 22° to 26.5°N and longitudes 51° to 56.5°E (Figure 1.2).

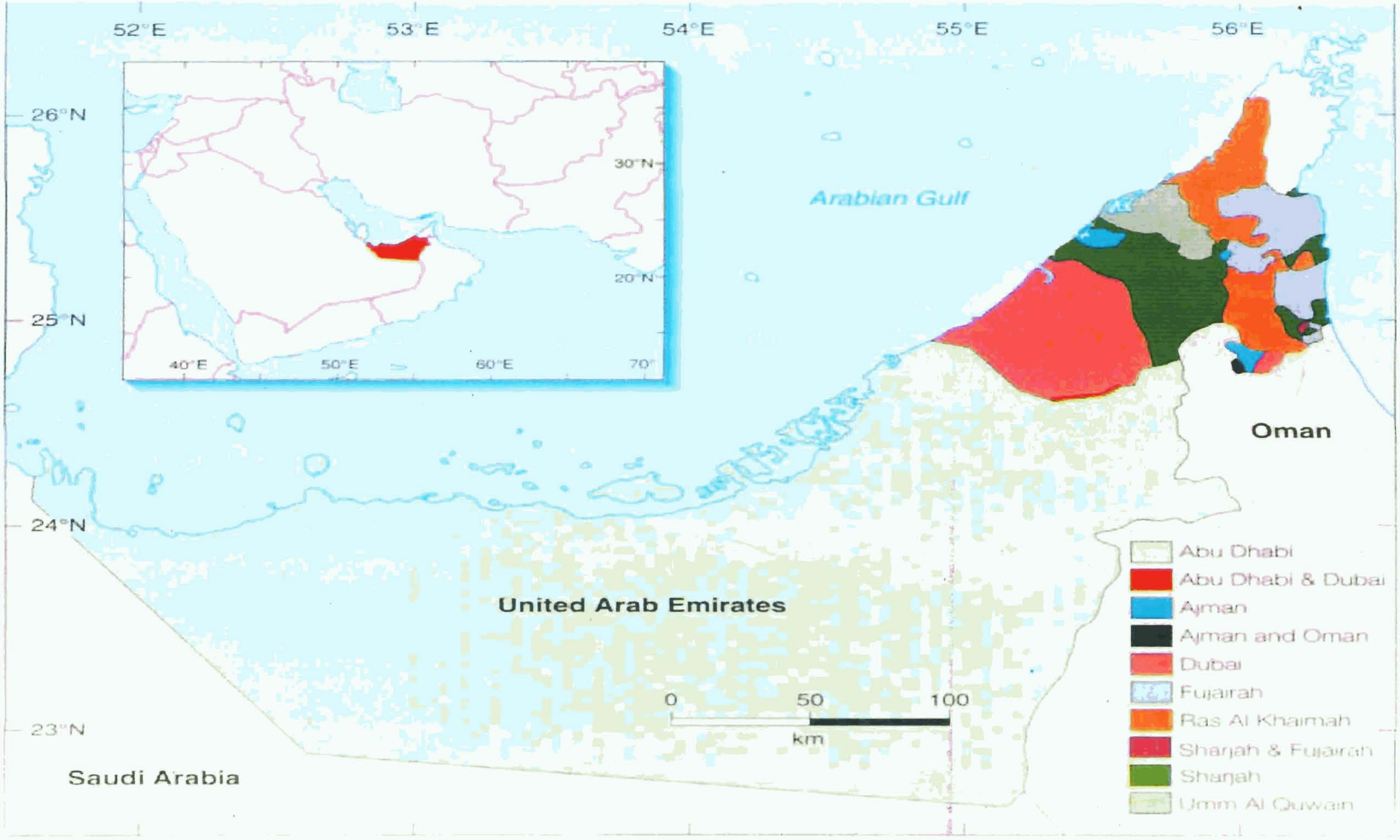


Fig. 1.1 The Map of United Arab Emirates

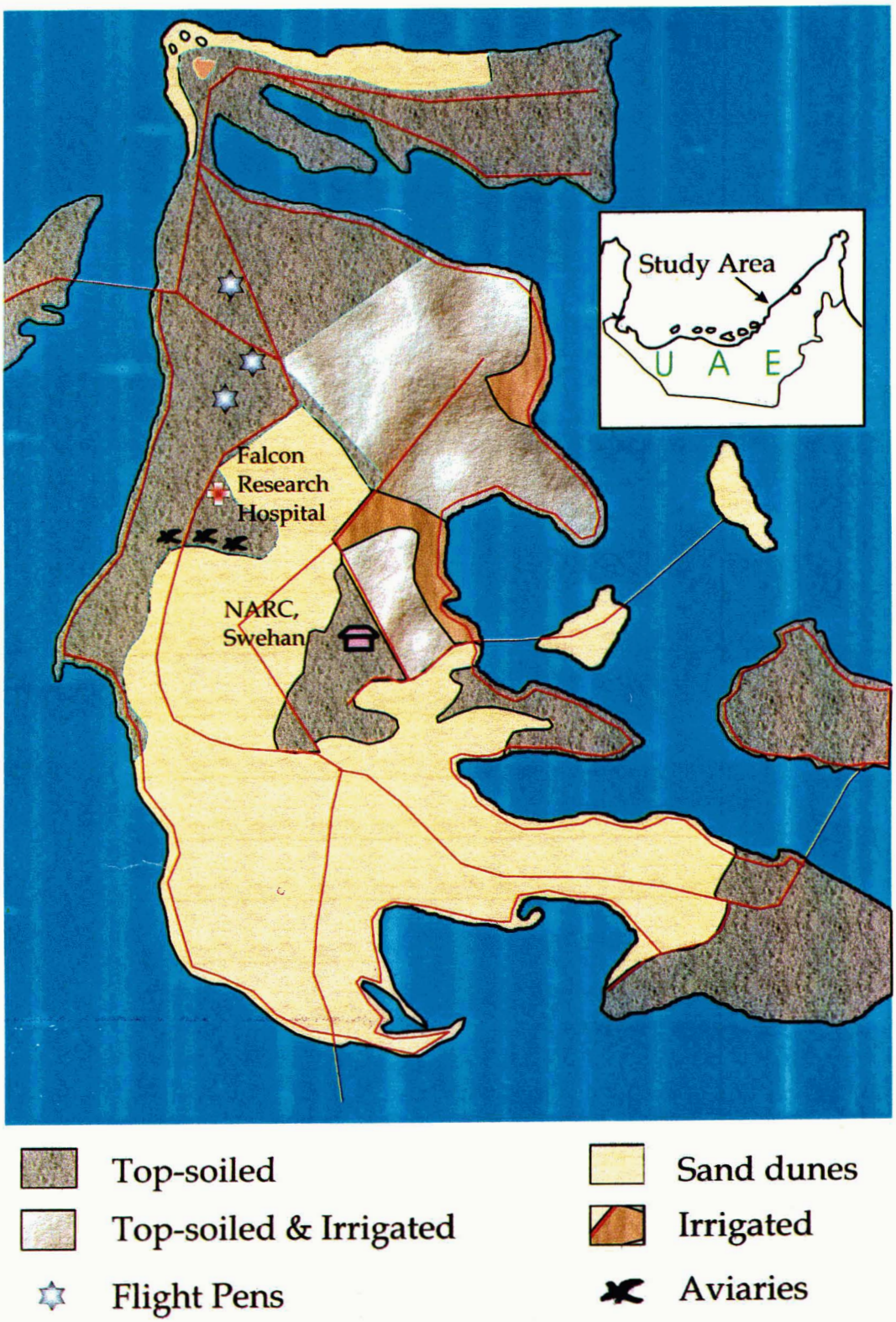


Fig. 1.2 The study area

1.7 Climate

The climate is hot and rainfall is low. However, the coastal humidity is high. It is hot and humid along the coast and drier in the inland. Most of the area is arid desert while the eastern mountains are somewhat cooler. Due to desert climate, vegetation is scarce and mostly formed of low growing shrubs.

1.7.1 Temperature

UAE has warm and sunny climate in winter, and hot and humid summer. Winter daytime temperatures average a pleasant 26°C, although nights are relatively cool, between 12-15°C on the coast, and less than 5°C in the depths of the desert or high in the mountains. Local northwestern winds (*'shamal'* in Arabic) frequently develop during winter, bringing cooler windy conditions. Summer is from May to October, and winter is from November to April. In summer temperature reach more than 45°C (Jones & Swinnertone 1995). Summer temperature along the coast remains below 33°C (Boer 1997). From December to February, the weather is pleasant, with temperatures averaging 28°C in daytime and 14°C at night. The highest mean temperature for the season was 26° C in November 1999 and the lowest, 18.1°C in January 2001. The mean monthly changes of temperature for the years 1999-2003 recorded at Abu Dhabi are summarized in Tables 1.1, 1.2 and 1.3.

In winter the minimum temperature recorded was 7.0° C in February 2002 (Table 1.2). The maximum temperature was recorded during the summer season. August was the hottest month during the first three years (1999-2001) and July in 2002 (Table 1.3).

Table 1.1 Mean daily temperatures (°C) recorded at Abu Dhabi during 1999-2003

Latitude: 24° 26,, 12, N. Longitude: 54° 39,, 03, E. Height: 27m A.M.S.L.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
1999	18.9	20.7	24.1	27.7	31.8	34.6	36.3	36.8	33.4	30.0	26.0	22.2	28.5
2000	19.7	22.1	22.7	28.4	31.1	34.6	35.6	37.6	33.9	30.1	25.9	21.1	28.6
2001	18.1	20.0	22.3	28.8	31.1	32.7	36.5	36.4	33.2	29.8	25.3	20.6	28.1
2002	20.5	19.6	23.5	27.0	32.4	33.0	35.7	35.3	33.2	29.5	24.6	23.4	27.9
2003	19.5	21.3	22.3	27.5	32.5	32.9	36.1	35.5	331	32.0	25.4	21.0	26.5

(Source: Abu Dhabi Meteorology Department)

During winter moderate temperatures were recorded. The highest temperature recorded during the last five summer seasons was 48.7°C in 2000 (Table 1.3).

Table 1.2 Minimum dry bulb temperatures (°C) recorded at Abu Dhabi during 1999-2003

Latitude: 24° 26,, 12, N. Longitude: 54° 39,, 03, E. Height: 27m A.M.S.L.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
1999	9.6	10.0	11.5	15.0	16.6	24.9	26.5	26.2	24.3	19.9	15.6	12.1	9.6
2000	9.5	12.6	11.6	16.0	20.0	23.5	25.6	28.8	24.8	20.2	15.3	10.5	10.3
2001	11.1	10.3	10.8	11.3	21.3	21.0	26.2	26.3	24.7	20.3	16.0	10.3	10.3
2002	7.9	7.0	12.1	16.2	19.7	22.1	25.2	25.2	24.3	18.8	14.9	15.0	7.0
2003	7.8	7.2	11.5	16.2	19.8	22.2	25.0	24.5	23.2	22.0	14.5	14.1	6.0

(Source: Abu Dhabi Meteorology Department)

Table 1.3 Maximum dry bulb temperatures (°C) recorded at Abu Dhabi during 1999-2003

Latitude: 24° 26,, 12, N. Longitude: 54° 39,, 03, E. Height: 27m A.M.S.L.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
1999	28.5	32.3	43.0	44.7	45.9	46.9	47.8	47.9	45.7	42.2	35.0	33.8	47.8
2000	31.0	35.6	40.5	42.7	46.2	48.5	48.7	48.6	47.7	41.8	37.9	30.9	49.2
2001	30.6	34.5	39.2	44.0	43.2	46.3	48.0	48.2	42.7	41.1	36.1	32.6	48.7
2002	27.6	34.0	38.8	41.1	46.2	46.0	47.6	47.3	44.7	41.7	35.7	33.4	48.3
2003	28.5	34.5	38.7	43.2	42.3	46.0	47.5	47.6	43.5	42.3	38.5	31.8	47.2

(Source: Abu Dhabi Meteorology Department)

1.7.2 Rainfall

In most years it rains during winter months usually in February or March. The rainfall is sparse and intermittent; winter rain is in the form of short sharp bursts. During the summer occasionally there will be thunderstorms. In winter such storms lead to extremely heavy rain. Sometimes almost the entire annual amount of rainfall happens in a day. The skies remain cloud-free for most of the year and with high temperatures, low humidity and long hours of sunshine leading to extremely high evaporation rates.

Some years are totally dry with no rain recorded in some locations for over three years, and it is only through the regular formation of dew that vegetation and wildlife survive. Generally, rainfall does not exceed 13cm a year. The maximum monthly rainfall recorded for the entire period 1999-2003 was in January 1999 (Table 1.4).

Table 1.4 Monthly total rainfall (mm) recorded at Abu Dhabi during 1999-2003

Latitude: 24° 26,, 12, N. Longitude: 54° 39,, 03, E. Height: 27m A.M.S.L.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
1999	68.1	45.7	2.7	Trace	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.2	119.7
2000	Trace	4.3	8.8	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	Trace	13.2
2001	0.0	0.0	Trace	0.0	0.0	0.0	0.0	0.0	0.0	Trace	Trace	4.3	4.7
2002	Trace	0.0	Trace	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	2.0
2003	0.0	0.0	0.0	2.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.7

(Source: Abu Dhabi Meteorology Department)

Rainfall was maximum during 1999 followed by 2000, 2001, 2003 and 2002. It rained few days in January, February, March and December in 1999, February and March in 2000, December in 2001, July 2002 and April in 2003 (Table 1.5). No rain was recorded during other months of these years.

Table 1.5 Monthly total number of rainy days (Rain >0.2mm) recorded at Abu Dhabi during 1999-2003

Latitude: 24° 26,, 12, N. Longitude: 54° 39,, 03, E. Height: 27m A.M.S.L.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
1999	9	4	1	0	0	0	0	0	0	0	0	2	16
2000	0	1	2	0	0	0	0	0	0	0	0	0	3
2001	0	0	0	0	0	0	0	0	0	0	0	1	1
2002	0	0	0	0	0	0	1	0	0	0	0	0	1
2003	0	0	0	2	0	0	0	0	0	0	0	0	2

(Source: Abu Dhabi Meteorology Department)

1.7.3 Relative humidity

Humidity in coastal areas averages between 50 and 60 %, touching over 90% in summer. Inland areas are far less humid. Fog and mist occur throughout the year, but lightly in winter and end of summer. Data on the monthly mean relative humidity recorded in the morning and the evening for the period 1999 and 2003 are tabulated. The most humid and least humid months were January 2000 and June 1999 (Table 1.6).

Table 1.6 Monthly mean relative humidity (%) recorded at Abu Dhabi during 1999-2003

Latitude: 24° 26,, 12, N. Longitude: 54° 39,, 03, E. Height: 27m A.M.S.L.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
1999	39	36	31	26	17	15	24	19	22	27	39	49	30.1
2000	51	36	27	18	21	19	26	16	27	29	37	41	27.6
2001	43	39	29	20	26	21	16	16	27	28	37	41	28.7
2002	41	37	30	21	18	21	23	17	25	30	36	40	28.2
2003	43	38	29	27	19	20	22	16	24	29	37	40	28.3

(Source: Abu Dhabi Meteorology Department)

1.7.4 Wind

Winds remain light in the Emirates for most of the year. Stronger winds can occur with the passage of a weather system, during *'shamal'*. The strongest winds occur in association with thunderstorms. Dust hazes are a common occurrence during the summer months and thick dust haze occasionally blow across from Saudi Arabia. The wind speed is high in summer, from March to September and low in winter between October and February (Table 1.7).

Table 1.7 Monthly mean maximum 10-minute wind speeds (knots) recorded at Abu Dhabi during 1999-2003

Latitude: 24° 26,, 12, N. Longitude: 54° 39,, 03, E. Height: 27m A.M.S.L.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
1999	16	17	17	17	15	16	16	16	14	14	12	11	15.0
2000	12	14	15	16	17	14	15	16	15	13	12	13	14.4
2001	13	14	15	14	15	14	17	16	15	14	14	12	14.4
2002	12	13	14	14	16	14	16	17	15	13	13	12	14.2
200	13	13	15	16	16	15	16	16	14	14	13	12	14.1

(Source: Abu Dhabi Meteorology Department)

1.8 Flora and fauna of the study area

1.8.1 Flora

In United Arab Emirates, in the study area, tree species are very few. Many annuals come up during the rainy season and disappear soon after rain. During the rest of the year the vegetation is mainly composed of grasses and date palms. *Tribulus arabicus, Cornulaca arabica, Cyperus conglomerates, Zygophyllum spp., Haloxylon salicornicum, Acacia tortilkica, Polycarpaea repens, Dipcati erythracum, Stripagrotis plumose, Zygophyllum mandavillei, Neurada procumbens, Conocarpus spp., Laguncularia spp., Spartina alferniflora, Coccoloba uvifera, Avicennia germinans, Laguncularia racemosa, Chrysobalanus icacao, C. icacao var.pellocarpus, Spartina atterniflora, Disticlis spicuta, Paspalum vaginatum (distichum), Philoxerus vermicularis, Spartina patens, Sporobolus verginicus, Conocarpus crictus, Conocarpus crictus.var.serica, Acrostichum danacifolium, Rhizophora mangle, Batis maritima, Sesuvium species, Jaquinia arborea, Savia bahamensis, Surriana maritima* are some of the common species of plants seen here (Sen & Rajpurohit 1982, Teas 1983 & 1984, Ahmad *et al.*1984, Ismail *et al.* 1990, Birkeland 1990, National Research Council 1990,

Nwaigbo & Adgebehin 1990, Hill 1973, Halwagy and Halwagy 1977, Batanouny 1981, Gauch 1982, Western 1989, Mandaville 1990, Boer and Warnken 1991).

Other wild plants of this area include *Ziziphus oenoplia* (Linn) Mill, *Ixora coccinea* (Linn). *Passiflora foetida* Linn. *Physalis minima* (Linn) and *Ceiba pentadra* (Linn) Gaertn. *Terminalia lenticulata* Roth, *Macaranga peltata* (Roxb) Muell.Arg *Ficus racemosa* (Linn). Rarely seen are *Argostemma courtellense* Arn., *Nymphoides parvifolium* (Griseb) Kuntze, and *Oldenlandia caerulea* (Wt & Arn), Gamb and *Exacum sessile* Linn. Herbaceous vegetation include *Chromolaena odorata* (Linn) King & Robinson, *Clerodendrum viscosum*Vent. *Lantana camara* (Linn) and *Croton bonplandianum* Baill. The residential areas of the campus have pockets of cultivation of date palms, banana etc. The greatest diversity of fruits and flowers occur during the period from November to April. Shrubs like *Lantana camara* and *Passiflora foetida* flower throughout the year.

Mangrove vegetation of the UAE coasts is represented mainly by *Avicennia marina*, which tolerates high water salinity and arid condition. The coastal geomorphology of UAE is characterized by many lagoons, providing a suitable habitat for mangrove growth (Embabi 1993).

1.8.2 Fauna

Many species of mammals, birds, reptiles, insects like grasshoppers and beetles are seen in the study area. Termites are commonly seen and a major soil organisms in the study area. Avian fauna includes 339 certain and 11 uncertain species (Appendix 1.1 & 1.2). Some of the species seen are Pallid Harrier *Circus macrourus*, Long legged Buzzard *Buteo rufinus*, Kestrel *Falco tinnunculus*, Houbara bustard *Chlamydotis undulata*, Stone curlew *Burhinus oedienemus*, Eagle Owl *Bubo bubo*, Little Owl *Athene noctua*, Black-crowned finch lark *Eremopteryx nigriceps*, Bar-tailed desert lark *Ammomanes cincturus* and Desert Lark *Ammomanes deserti* (Richardson & Aspinal 1998).

Forty-seven species of mammals are reported from here (Appendix 1.3). Of these, Ethiopian hedge dog *Hemiechinus aethiopicus*, Branhles hedgedog *Hemienchinus hypomelas*, Muscat mouse tailed bat *Rhinopona muscatellum*, Naked bellied tomb

bat *Taphozous nudiventrius*, Wolf *Canis lupus*, Red fox *Vulpes vulpes*, Ruppell's (sand) fox *Vulpus rueppellii*, Striped hyaena *Hayena hayena*, Wild cat *Felis silvestris*, Sand Cat *Felis margarita*, Leopard *Panthera pardus*, Arabian Tahr *Hemitragus jayakari*, Arabian Oryx *Oryx leucoryx*, Arabian gazelle *Gazelle gazelle*, Arabian Ibex *Capra ibex* are widely reported. Reptiles include *Phrenocephalus arabicus*, *Phrenocephalus maculatus*, *Trapelus flavimaculatus*, *Uromastyx aegyptius microlepis* are the commonly know ones (Harrison & Paul 1991).

CHAPTER 2

BIOLOGY AND GENERAL BEHAVIOUR

2.1 Introduction

Falcons begin the daily activity cycle at daybreak. Smaller falcons like Peregrines, especially those that hunt songbirds, generally start their day early. As the day winds down, a falcon heads for its nighttime shelter. The most important daily activity of falcons is hunting. As noted by Ali (1977) the falcon's body is a marvel of nature's engineering; wings are long and pointed, legs are strong, toes are long and claws are hooked and powerful. The falcons are extremely accomplished and swift fliers, generally killing their prey on the wing (Ali & Ripley 1983). Falcons seem to take great delight in bathing. Peregrine falcons wintering in England, bath daily, despite the chill, are choosing running water a few inches deep where the stream bottom matched the colour of their plumage (Baker 1967).

Birds have devised various means of energy conservation in every aspect of their life, to meet the vast amount of energy for flying. Their metabolism is the highest in the animal kingdom (Remple & Gross 1993). The flight muscles are specialized and modified breast muscles, which are well developed. The keel is enlarged and the bones are connected to air sacs, which helps to provide buoyancy. Oxygen is supplied to the lungs during exhalation from the air sacs by their unique breathing mechanism. The falcons spend a huge part of their time for gathering food and feeding to meet the high rate of metabolism.

Bird song performs a variety of functions (Ali 1996). In most passerine species song is the characteristic of the male and is used for territorial defense through advertisement and mate acquisition (Cooney and Cockburn 1995). Besides these two functions, birds also use the song to synchronize breeding behaviour, mate guarding, mate recognition, parent offspring recognition and neighbour stranger discrimination (Weary *et al.* 1992, Lambrechts and Dhondt 1995). The major functions of the song of the female include territorial defense, prevention of polygyny and intra pair communication. Vocalization of falcons helps them to

communicate with each other. Vocalization is the language by which birds communicate with and understand one another. The present study is undertaken with the major objectives listed below:

- Study foraging methods,
- Examine daily activity cycle,
- Observe the movements in the study area and
- Document various types of vocalizations.

2.2 Methodology

Falcons were observed in their natural habitat condition for about three years (2001-2003) to study various aspects of their biology and behavior in United Arab Emirates and data was collected on food and feeding, breeding moulting. Each day was divided into 3-5 hour shifts. 05.00 to 10.00, 10.00 to 15.00, 15.00 to 20.00 hrs. Observations were made on alternate shifts for two days in each month; falcons were followed for the whole day.

Foraging habits: The activities of the falcons in the aviary were recorded from morning till roosting in the evening concentrating on the time schedule.

Roosting habits: A pair of Peregrine falcon was closely followed from morning to evening hours during the period of 2001-2003 in the aviaries to observe the roosting habits. My practice was to reach the roost early in the morning before the birds wake up and move out of the roosts.

Timing: By observing the falcons the timing of activities such as awakening, first and last feeding, roosting and sleeping were recorded.

Movement in the study area: Three pairs of falcons were closely followed in the aviary and a full-day observation done to assess the movement in the aviary. A scale map of the area was used to record the positions and movement of the pair, from 05.00 to 19.00 hrs. The distance between the roost and the location of first feeding and the number of places on which the falcon perched after moving out of

the roosts before the first feeding were noted. The approximate distance between the location of the last feeding and the evening roost, the number of places perched on way to roost after the last feeding were observed.

Vocalization: Some pairs of falcons were followed for a full day in the aviary and various types of calls were noted using anthropomimetic notations. Observations were carried out in and around the aviaries, cages and flight pens near Abu Dhabi Falcon Research Hospital. Songs of male and female Peregrines, Saker, Gyr and some hybrids of falcons were recorded in September 2003 at Abu Dhabi Falcon Research Hospital using a JVC Zoom MZ-500 unidirectional microphone and a SONY CFS 1030S tape recorder. Proper care was taken to avoid human influences on the sound produced by individual birds.

Most signals were recorded at a distance of 2-5 m. Pre- and post signaling behaviour and circumstances in which signaling occur were observed to infer the meaning of the song. After editing cuts of high quality recordings (a few seconds duration) were used for physical analysis. The recorded sounds were converted to wave files using freeware audio grabber 1.83. The wave files were analysed for its characteristics using sonogram 2.2 Software. Because of background noises some of the calls recorded were not acoustically pure for analysis.

2.3 Results

All the falcons of the area makes morning calls and move out of their roosts, preened their feathers, moves from one roost to another and then glides down to start foraging. Sometime they drink water especially after food. The Peregrine falcons of the study area woke up between 05.49 and 06.41 hrs and started wandering from 06.00 to 06.50 hrs. For preening their feathers they take oil using their beaks from the pineal gland and swap it on the feathers.

2.3.1 Foraging

The falcons generally started foraging in the morning during 05.30 to 07.05 hrs and less often during the next half an hour (64% & 35% respectively). The entire period of my observation during 2001-2003, the falcon pair normally stopped

foraging from 17.00 to 17.30 hrs (22%), 17.30 to 18.30 hrs (76%) 18.30 to 19.30 hrs (2%). The falcons foraged in the morning twilight but not in the evening.

2.3.2 Roosting

They generally entered the roost at 17.30 hrs to 19.30 hrs (47% & 40%) and became silent between 18.30 to 19.30 hrs (69%) as given in Table 2.1. Even though there was a tendency to roost in the same nest, a change in the roosting was observed 11 times in 126 observations. The data suggest that this species is not rigid in its roost location in daytimes but at night it is rigid (Appendices 10 & 11). The Peregrine falcons, Saker falcons and Gyr falcons of the study area were early risers. During the course of observation, the pair awoke (N=119), flew out of the roost (N=87) and started foraging (N=76) before sunrise. In the evening they stopped foraging (N=112) and entered the roost (N=79) before sunset.

The members of a pair drift apart slowly as wandering progresses, but keep in touch with each other through contact calls. They do not roost at mid-day. They foraged vigorously from 17.40 to 18.30 hrs. Thereafter the tempo of feeding slowed down between 17.45 to 18.35 hrs. They proceeded to their nightly roosts, perching on several places on the way. They seldom approached the roosts directly, but covered the last 50-m slowly to roosts. Details of roosting and awakening behaviour of a pair of Peregrine falcons in the campus for 126 days are given (Table 2.1 & Appendices 2.1 to 2.3. The Peregrine falcon pair in my observation arose in the morning between 05.00 – 07.05 hrs during the different seasons. 68% of awakening took place between 05.30 and 06.30 hrs and 14% during 05.00 to 05.30 and 18% during 06.30 to 07.05 hrs (Table 2.1).

Generally the falcon pair often roosts together, even outside of the breeding season, and recently fledged siblings may roost close to one another for a period of time after leaving the nest. They generally moved out of the roost between 05.30 to 07.05 hrs and started foraging immediately. 71% of the roost-exit time was observed during 05.30 and 06.30 hrs, 27% during 06.30 - 07.05 hrs and 2% during 05.00 to 05.30 hrs.

Table 2.1 Frequency-occurrence of awakening and roosting of a pair of Peregrine falcons in the study area for 126 days in the course of 2001-2003

Activities of the falcons under observation	Time duration in hours and number of days carried out (Numbers in brackets show the percentage)		
	05.00– 05.29	05.30 – 06.29	06.30 – 07.05
Awakening time	18 (14)	85 (68)	23 (18)
Sunrise	-	94 (75)	32 (25)
Roost-exit time	2 (2)	90 (71)	34 (27)
First-feeding time	-	81 (64)	45 (35)
Activities of the falcons under observation	Time duration in hours and number of days carried out (Numbers in brackets show the percentage)		
	17.00– 17.29	17.30– 18.29	18.30– 19.30
Last-feeding time	28 (22)	96 (76)	2 (2)
Sunset	13 (10)	63 (60)	50 (30)
Roosting time	16 (13)	59 (47)	51 (40)
Sleeping time	-	39 (31)	87 (69)

2.3.3 Movement

Monthly variation in the daily distance traveled by a pair of Peregrine falcons is shown in (Table 2.2 & Appendix 2.4). The pair traveled an average distance of 850m per day. The rate of progression was the lowest during the first hour of observation (05.00 to 06.00 hrs). Thereafter the pair moved faster up to 15.00 hrs, then the rate was stepped up and it stayed high up to 18.00 hrs. The rate slowed down again during the last hour. The maximum distance covered in December and the minimum in September. The pair reached a quarter of the day-journey by 10.00 hrs, a half of the journey by 14.00 hrs. Thus on an average, it took 5 hrs to cover 1/4th part of the day's journey, 4 hrs for the 2nd quarter, 3 hrs for 3rd quarter and 2 hrs for last quarter (Table 2.2 & Fig. 2.1). Frequency distribution of progression rates in class intervals of 25m is given in Table 2.3.

The frequency (number of birds progressed)/percentage is as follows. The birds progressed up to 25m (10/6.02%), up to 50m (51/36.74%), up to 75 m (50/66.86%) up to 100m (30/84.93%). It is observed that 85% birds travelled up to 100m within 7 hours, from 0500 hrs. After 1400 hrs the bird's progression comes down (Table 2.3).

Table 2.2 Average daily distance travelled (m) by a pair of Peregrine falcons in the study area on a full-day (05.00 – 19.00 hrs)

Time (hours)	Average distance	Cumul. Average distance
05.00-05.59	3.8	3.8
06.00-06.59	59.3	63.1
07.00-07.59	51.8	114.9
08.00-08.59	53	167.9
09.00-09.59	62.1	230
10.00-10.59	62.6	292.6
11.00-11.59	56	348.6
12.00-12.59	48.3	413.2
13.00-13.59	64.6	477.8
14.00-14.59	61	538.8
15.00-15.59	85	623.8
16.00-16.59	81.8	705.6
17.00-17.59	98	803.6
18.00-19.00	67.1	870.7
Daily Distance	854.4	5654.4
Mean daily distance = 850m		

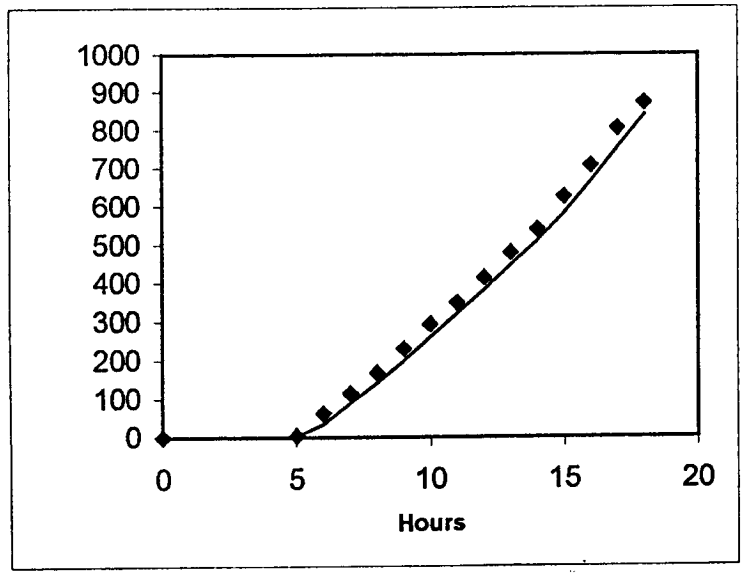


Fig. 2.1 Cumulative distance progressed during different hours

Table 2.3 Frequency of progression rates			
Progression rate (metre)	Time of the progression	Frequency (number of birds progressed)	Percentage
0-25	5.00-7.00	10	6.02
26-50	7.01-10.00	51	36.74
51-75	10.01-11.30	50	66.86
76-100	11.31-14.00	30	84.93
101-125	14.01-15.30	13	92.76
126-150	15.31-17.00	7	96.98
151-175	17.01-18.00	3	98.79
175-200	18.01-19.00	2	99.99

2.3.4 Vocalization

Raptors are generally a silent group compared to songbirds, but every species makes some sort of vocalization, from the piercing whistles of red-shouldered hawks to the hisses and grunts of New World vultures. The falcons have a "*hek..hek*" voice in their alarming calls, in single or repeated notes. The sonogram (spectrogram) of the notes of the call is shown in Figure 2.2. The peak frequency of the alarming call of the Peregrine falcon was 2239.45 Hz. and the peak time was 16.186 sec. The uttering call (detecting a danger) of Saker falcon was like a '*keiii...keiii..*' scream, the pitch of which depends on the size of the bird. The peak frequency of the uttering call of the Saker was 1701.12 Hz and peak time was 13.382 sec (Fig. 2.3).

The presence of Peregrine falcons, Saker falcons and Gyr falcons in an area could be easily detected by their cacking aggressive calls in "*kek kek*" voice. The peak frequency of the cacking call of Peregrine falcon was 3251.51 Hz. and the peak time was 0.838 sec. (Fig. 2.4). The peak frequency of the cacking call of Gyr falcon was 1571.92 Hz. and the peak time was 5.494 sec. (Fig. 2.5).

Peregrine falcons are unusually vocal near their nest and make alarm call sounding like '*schreee-schreee*' . They also make various vocalizations like screams and wails. Generally Saker falcons have voice similar to Peregrine and Lanner, but louder and harsher than the former, including distinctive scream. Gyr falcons have voice similar to Peregrines, but often distinctly gruffer, deeper and louder. The peak frequency of the alarming call of the Gyr falcon was 2164.09 Hz. and the peak time was 31.209 sec. (Fig. 2.6). These calls helped to spot the

falcons in the field and in the roost, the morning and evening hours. The types of calls of the falcons are summarized in Table 2.4. Contact calls are deep resonant "*kek kek*" calls in notes of 2 to 20, usually in duets, with the bills closed. As soon as one member of a pair of falcons started calling the other invariably joined in after a few notes. The peak frequency of the contact call of Gyr X Shaheen Hybrid falcon was 2024.12 Hz. and the peak time was 22.732 sec. (Fig. 2.7).

Table 2.4 Summary of vocalizations of the falcons in the study area

Sl. No.	Type of Vocalization	Description	Bill closed or opened	Remarks
1	Cacking call	"Kek...hek-ek-ek" (5 – 40 notes)	Open	Aggressive call- Potential predators including man.
2	Wailing call	"Kaa-aa-ack, Kaa-aa-ack" (2 – 20 notes)	Open	Between members of a pair, in duets. Any time of the day, food, copulation etc.
3	Alarming call	Hek-hek-hek	Open	In strange situations.
4	Creaking call	"Kleechip (male) Kleechup (female)." (Loudly)	Open	During breeding season. In the case of danger.
5	Challenge calls	"Kae kae" (Less than 10 notes)	Open	Between territorial opponents during breeding season.
6	Chupping call	"Chup or yapp"	Closed	Parental call usually by female when feeding the young.
7	Chittering call	'Hek-herrech-kerrech"	Open	During breeding season. By both sexes in captivity during pre-copulatory behaviour and copulation.
8	Whining call	"Eeyaik eeyaik". Quickly repeated 10 notes.	Closed	Exchange between partners
9	Alarming call	Chick-ik, chick-ik	Open	Call while caring chicks in the nest.
10	Alarming call	Schreeeee-schreeeee	Open	Call, while guarding nest.
11	Clicking call	"Pep-pep-pep"	Snapping of bills	Calls, when birds in roost.
12	Uttering call	"Keiiii.... keiiii"	Open	Calls, when danger was suspected.
13	Mobbing call	"Kwisss..." (Not so loudly)	Open	Wings opened. All seasons.
14	Contact calls	"Kek...kek"	Closed	Calls, usually in duets.
15	Territory calls	"Kae...kae" (5-40 notes)	Open	Calls, to keep territory.

Vocalization of falcons both adults and chicks could be grouped into two types, the long calls and short calls. The long notes were easily inscribable but the short

calls as their intonation and intensity had very little variation were very difficult to record. In the breeding season falcons make a variety of calls, which may attract and stimulate the opposite sex to mate or to do the courtship display. The breeding season starts from March and ends in October.

The rate of utterances of the major types of calls of the falcons during daytime is shown in (Table 2.5) whereas the contact calls were heard during all the day hours, the territory calls *"kae...kae"* were heard more often during the morning and evening hours. The peak frequency of the territory call of Saker falcon was 2304.05 Hz. and the peak time was 4.077 sec. (Fig. 2.8) and the peak frequency of the territory call of Peregrine falcon was 2046.65 Hz. and the peak time was 9.321 sec. (Fig. 2.9). The clicking calls were restricted to the early morning and late evening hours in aviaries in the study area.

During the breeding season the falcons uttered low *"kleechip"* (male) and *"kleechup"* (female) sounding calls with the bill open at the approach of a predator or when danger was suspected. This appeared to serve as an alarm call enabling the young birds to reach safe locations. The peak frequency of the creaking call of a male Peregrine falcon was 1485.79 Hz. and the peak time was 0.233 sec. (Fig. 2.10).

Clicking calls are low-pitched "*pep...pep*" sounding calls similar to the sounds produced by snapping of the bills. These are uttered when the birds are in the roost. The peak frequency of the clicking call of the Gyr falcon was 1679.59 Hz. and the peak time was 12.13 sec. (Fig. 2.11).

After descending to the ground the members of a pair drift apart as foraging progresses but keep in touch through wailing calls, sounds like "*kaa..kaa..ack*" "*kaa..kaa..ack*" calls with movement of head and neck, but with more notes (usually 5 to 40). The peak frequency of the wailing call of the Saker falcon was 1733.42 Hz. and the peak time was 20.237 sec. (Fig. 2.12). The peak frequency of the wailing call of the Gyr falcon was 2217.92 Hz. and the peak time was 1.352 sec. (Fig. 2.13).

Table 2.5 Frequency-occurrence of a few types of Vocalization by a pair of Peregrine falcons in the Study area. (Data for 12 days within a period of 6 months at the rate of two days per month are pooled)

Time duration (hrs)	Cacking calls	Creaking calls	Wailing calls
05.00 – 06.00	3	4	-
0600 – 07.00	12	5	9
0700 – 08.00	8	14	-
0800 – 09.00	9	7	1
0900 – 10.00	3	6	-
10.00 – 11.00	22	4	2
11.00– 12.00	18	3	-
12.00 – 13.00	14	8	-
13.00– 14.00	12	1	22
14.00– 15.00	24	-	-
15.00– 16.00	8	-	12
16.00– 17.00	10	2	-
17.00– 18.00	12	4	1
18.00– 19.00	8	1	-
Total	163	59	47

Whereas the members of a pair produce the contact calls, members of different pairs utter the territorial calls in sequence. Just before the completion of the call by one member of a pair, other member repeats the call immediately.

Challenge calls are quickly repeated "*kae..kae*" calls of generally less than 10 notes uttered during the breeding season between territorial opponents. The peak frequency of the challenge call of the Gyr X Saker Hybrid falcon was 1658.06 Hz. and the peak time was 14.606 sec. (Fig. 2.14). The neighbours face each other near the boundary or occasionally on boxes on vantage points near the boundary and challenge each other by 'counter calling'. Actual fights between the neighbours have been observed. Rarely one bird chased the territorial intruder into the latter's territory. While mobbing predators on the ground or around the released area the adult falcons produced a "*kwiss...kwiss*" sound with bills and wings open, and tail fanned up and down. The peak frequency of the mobbing call of the Saker falcon was 1399.66 Hz. and the peak time was 0.292 sec. (Fig. 2.15).

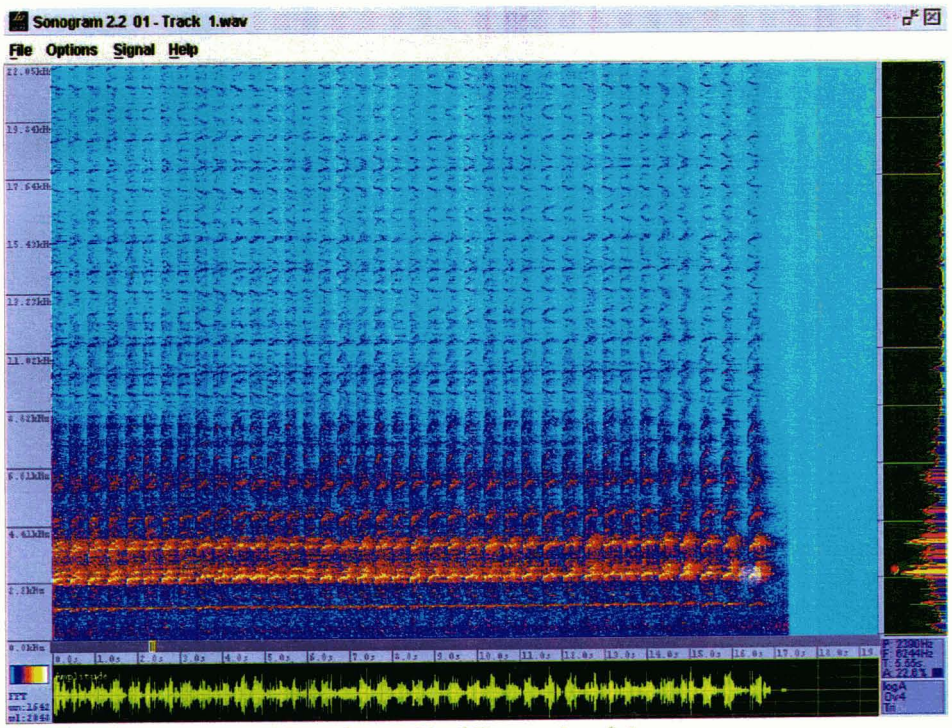


Fig. 2.2 Sonogram – Alarming call of Peregrine falcon
Peak frequency – 2239.45 Hz. Peak time – 16.186 sec.

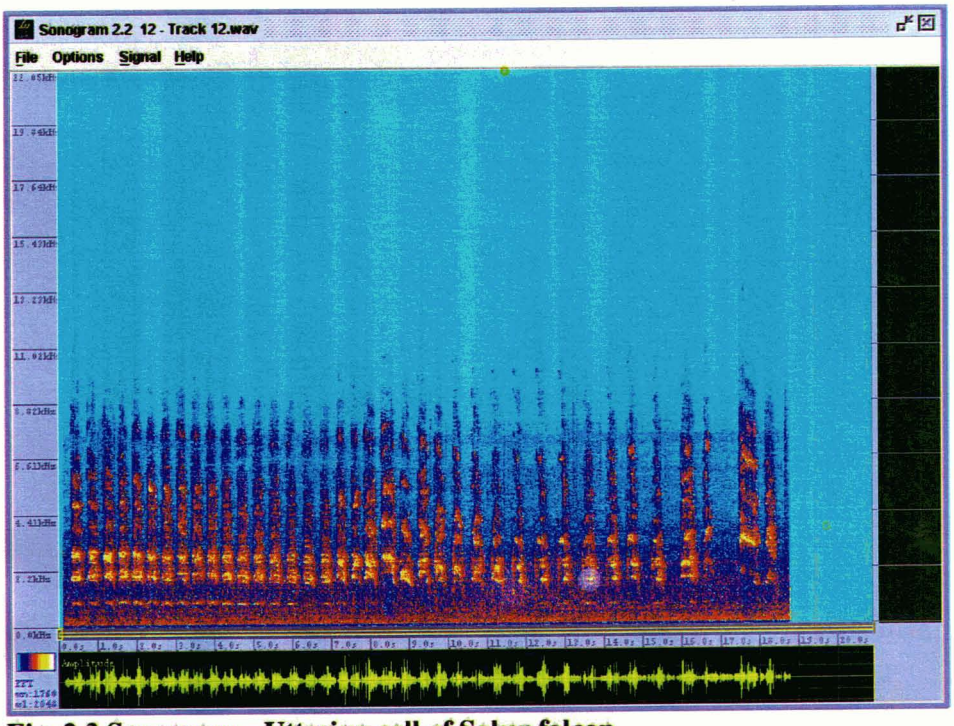


Fig. 2.3 Sonogram – Uttering call of Saker falcon
Peak frequency – 1701.12 Hz. Peak time – 13.382 sec.

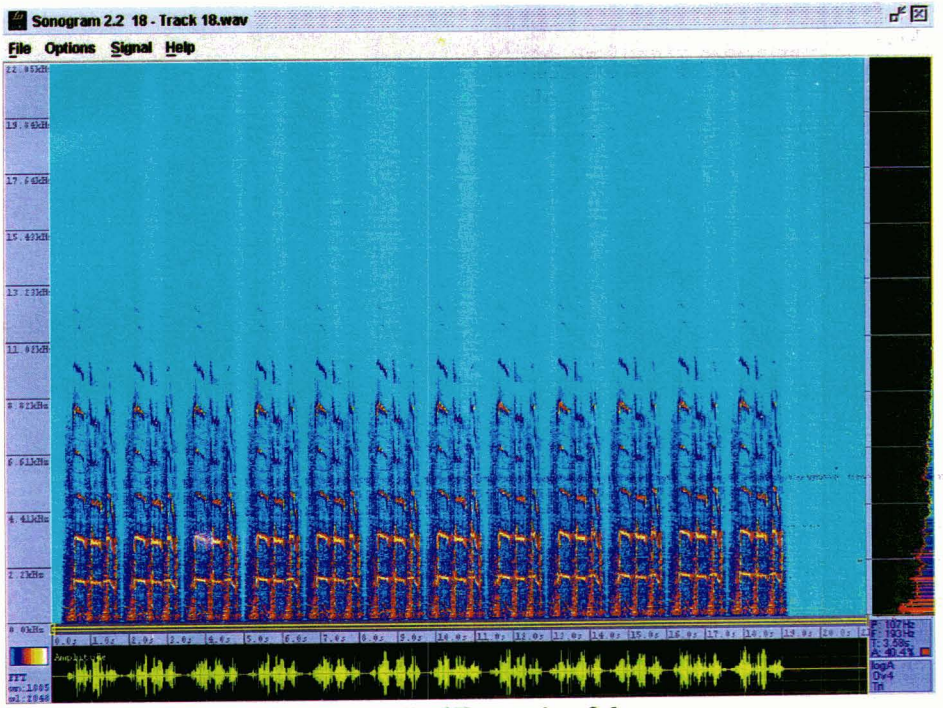


Fig. 2.4 Sonogram – Cacking call of Peregrine falcon
Peak frequency – 3251.51 Hz. Peak time – 0.838 sec.

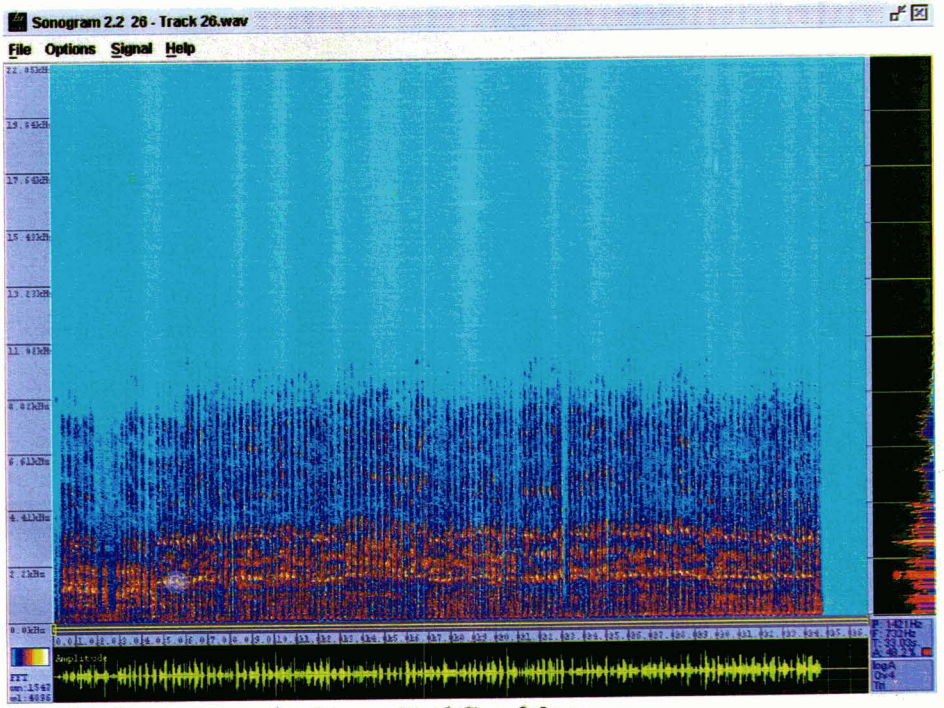


Fig. 2.5 Sonogram – Cacking call of Gyr falcon
Peak frequency – 1571.92 Hz. Peak time – 5.494 sec.

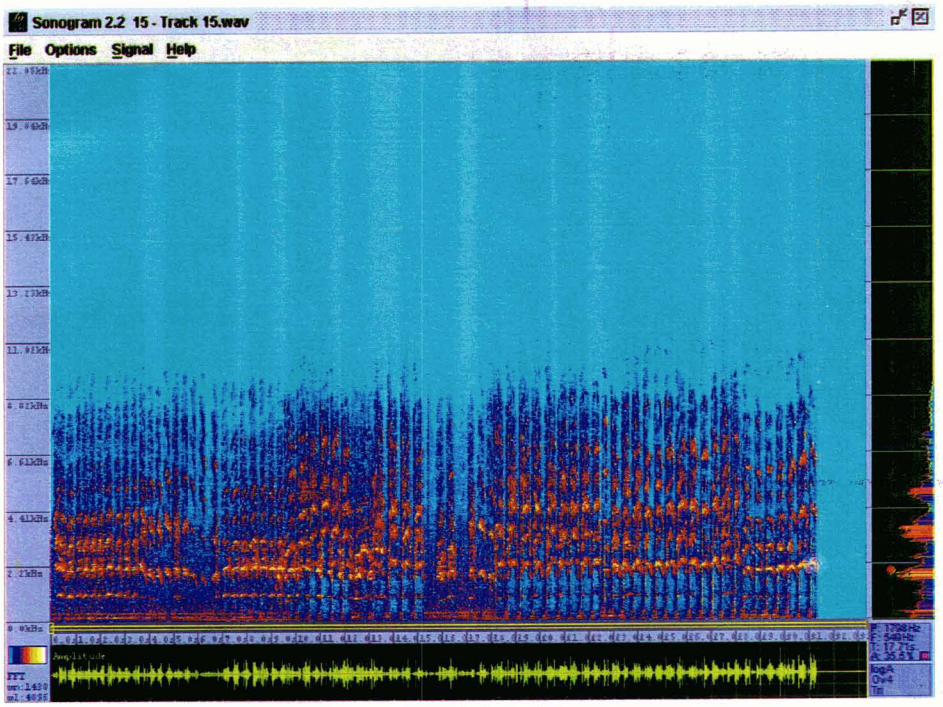


Fig. 2.6 Sonogram – Alarming call of Gyr falcon
Peak frequency – 2164.09 Hz. Peak time – 31.209 sec.

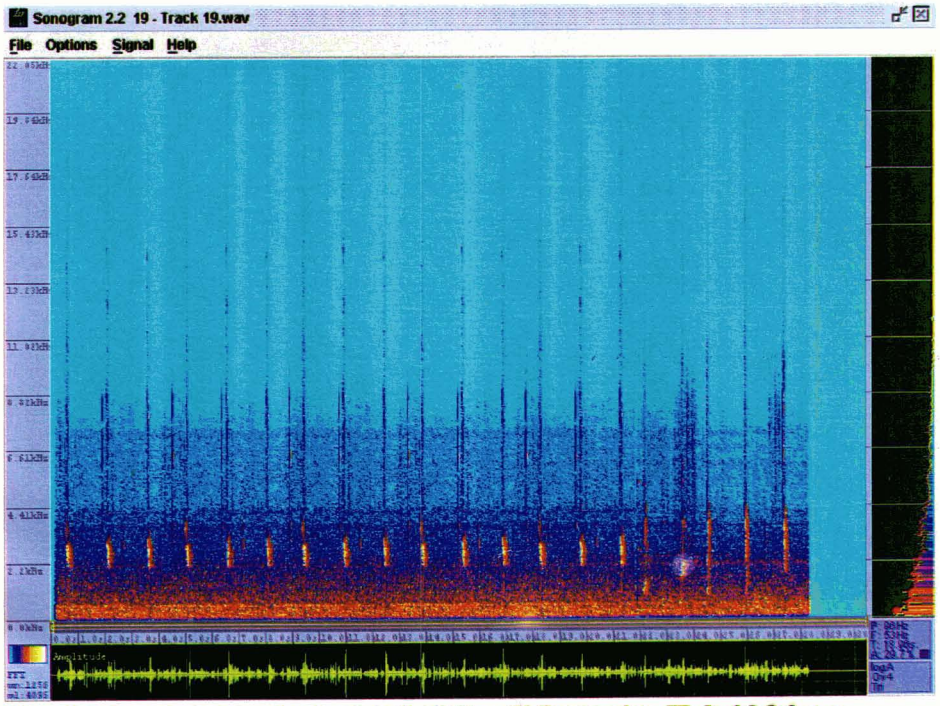


Fig. 2.7 Sonogram – Contact call of Gyr X Peregrine Hybrid falcon
Peak frequency – 2024.12 Hz. Peak time – 22.732 sec.

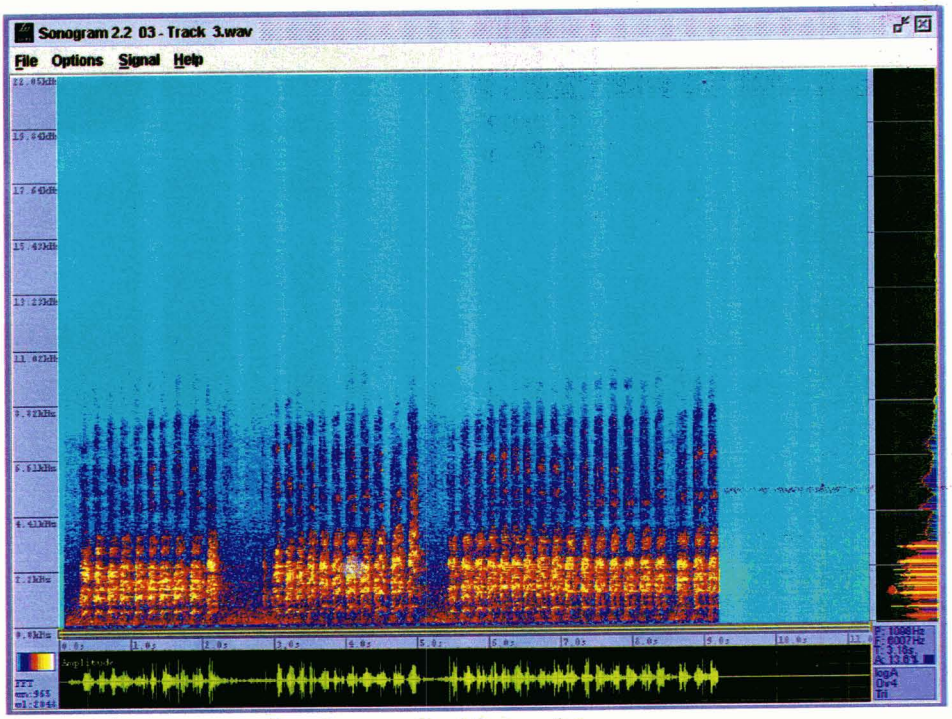


Fig. 2.8 Sonogram – Territory call of Saker falcon
Peak frequency – 2304.05 Hz. Peak time – 4.077 sec.

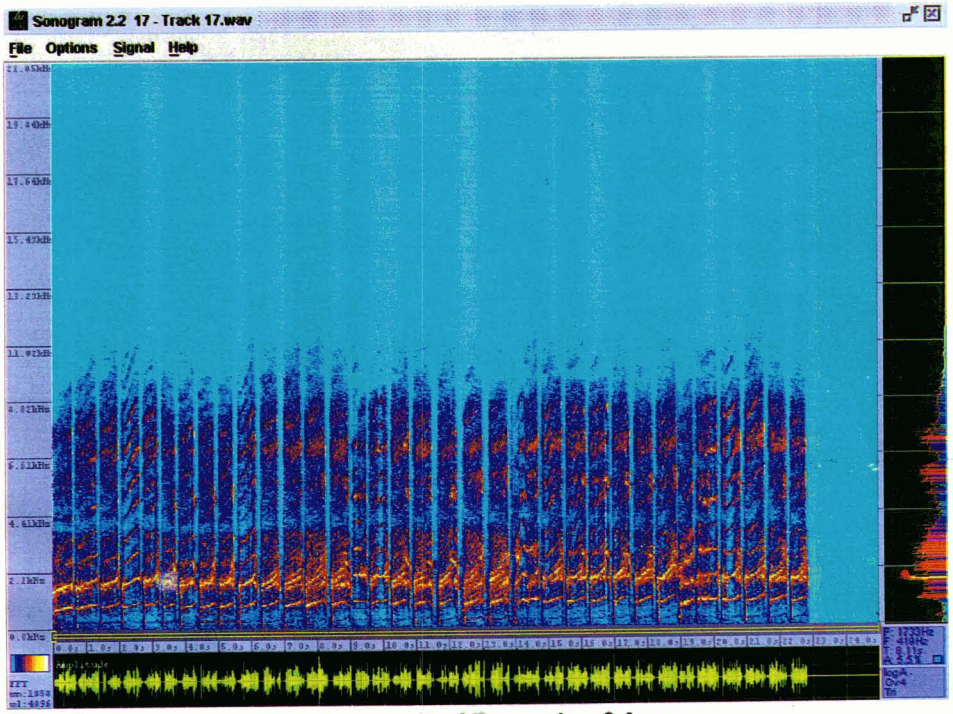


Fig. 2.9 Sonogram – Territory call of Peregrine falcon
Peak frequency – 2046.65 Hz. Peak time – 9.321 sec.

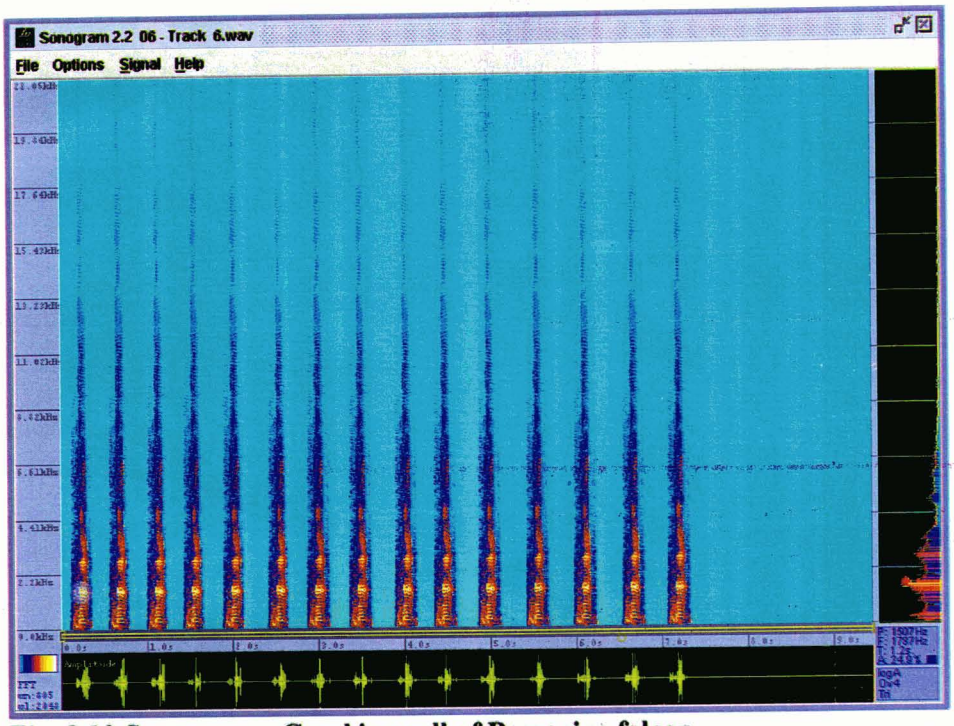


Fig. 2.10 Sonogram – Creaking call of Peregrine falcon
Peak frequency – 1485.79 Hz. Peak time – 0.233 sec.

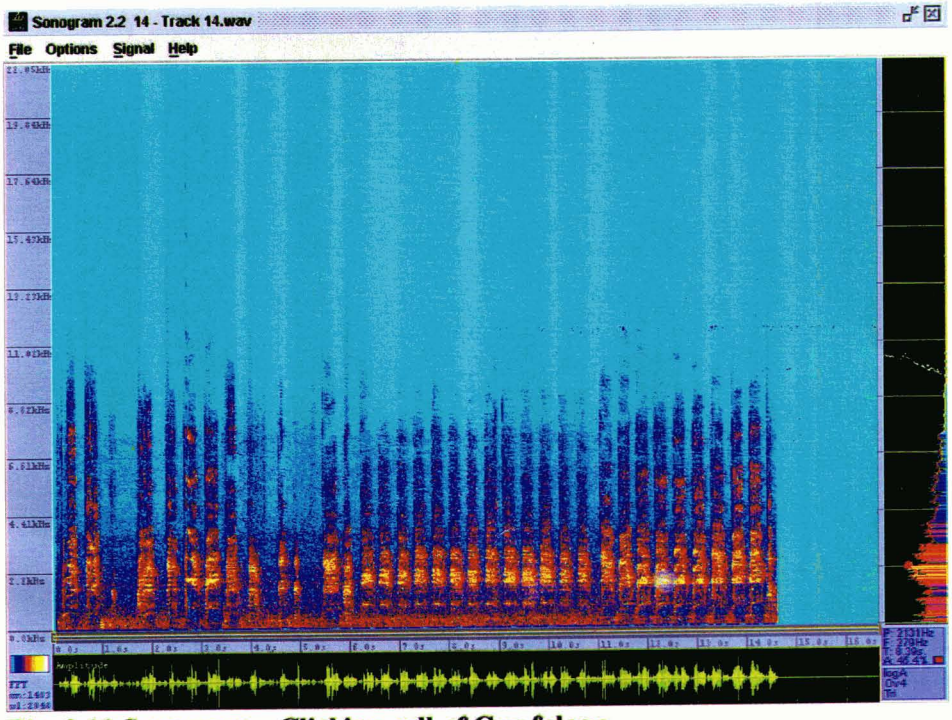


Fig. 2.11 Sonogram – Clicking call of Gyr falcon
Peak frequency – 1679.59 Hz. Peak time – 12.13 sec.

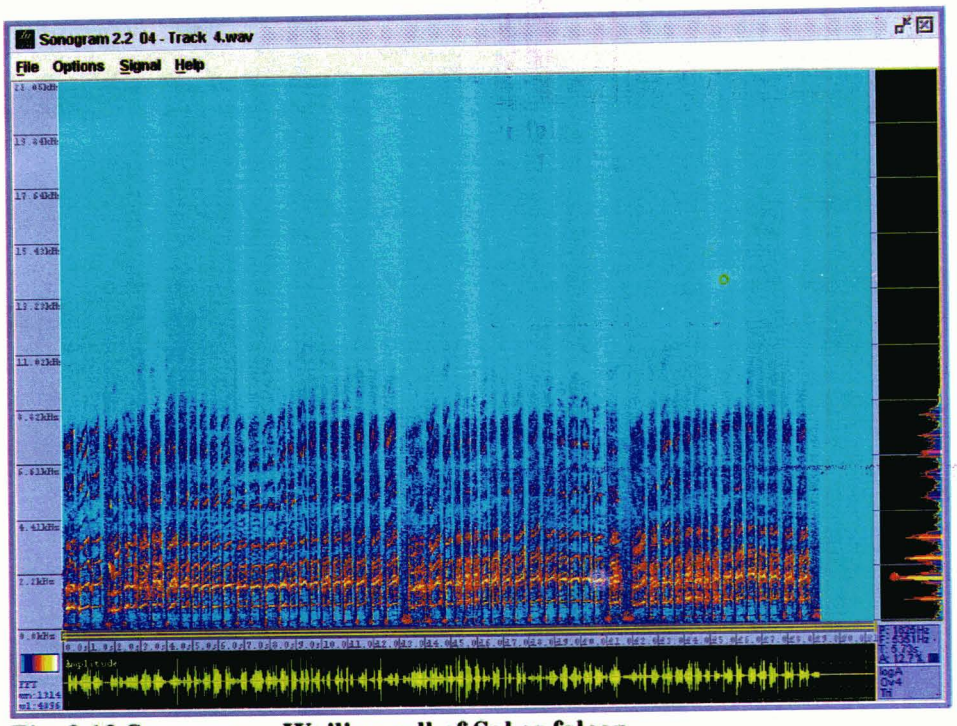


Fig. 2.12 Sonogram – Wailing call of Saker falcon
Peak frequency – 1733.42 Hz. Peak time – 20.237 sec.

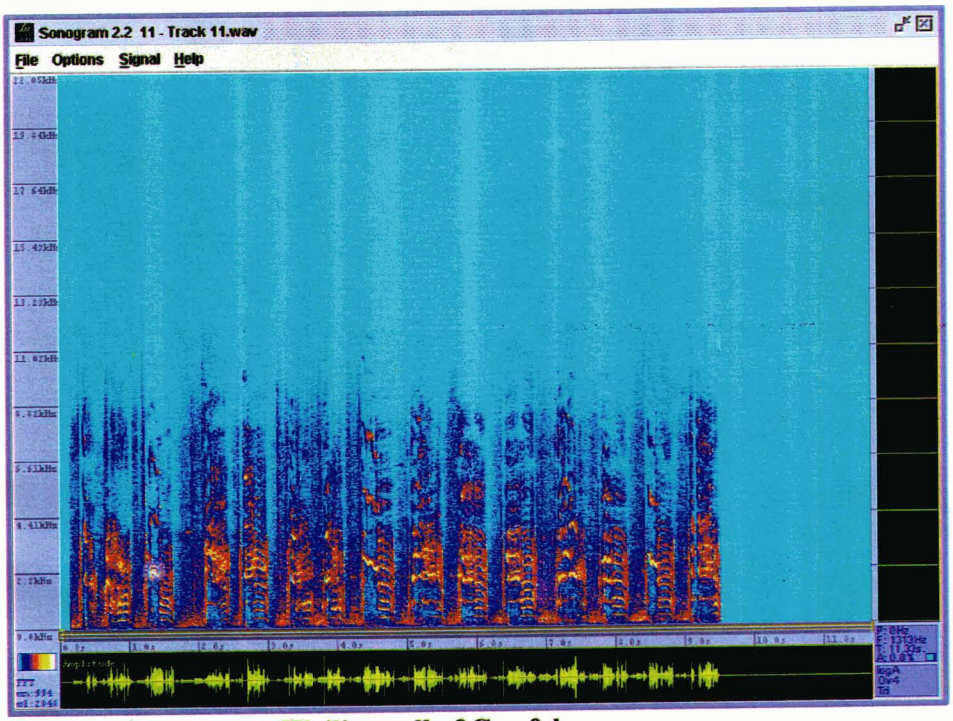


Fig. 2.13 Sonogram – Wailing call of Gyr falcon
Peak frequency – 2217.92 Hz. Peak time – 1.352 sec.

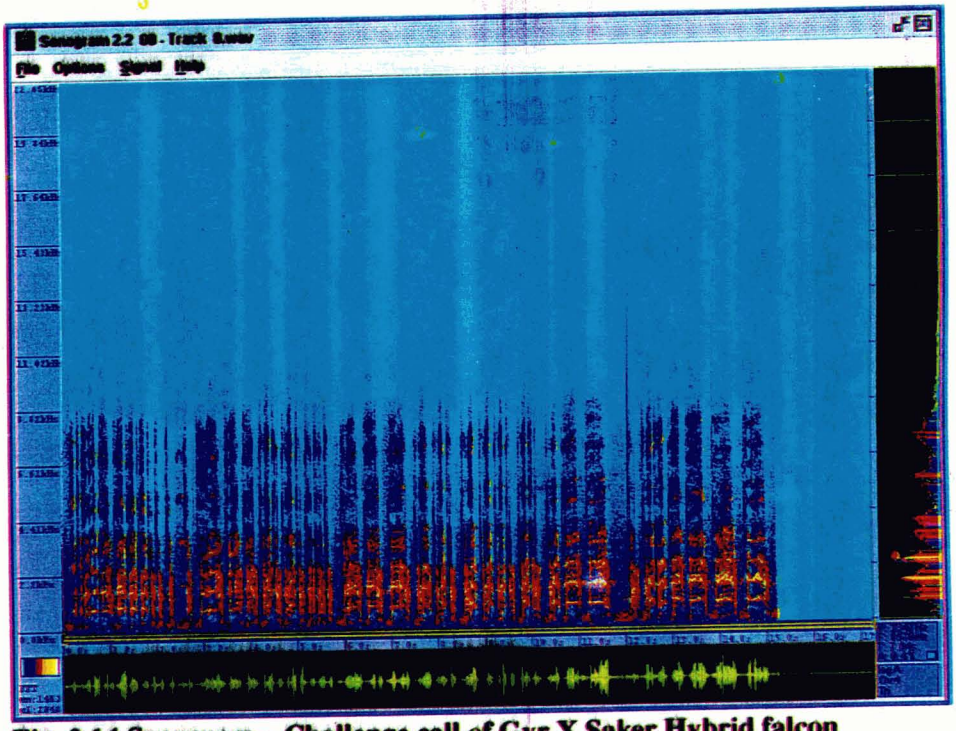


Fig. 2.14 Sonogram – Challenge call of Gyr X Saker Hybrid falcon
Peak frequency – 1658.06 Hz. Peak time – 14.606 sec.

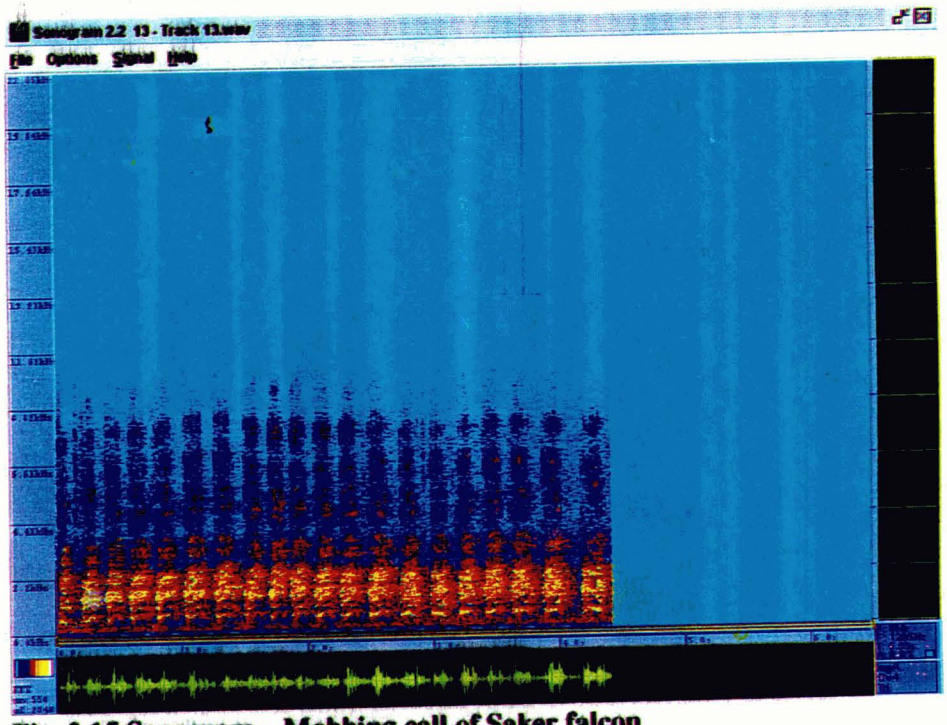


Fig. 2.15 Sonogram – Mobbing call of Saker falcon
Peak frequency – 1399.66 Hz. Peak time – 0.292 sec.

2.4 Discussion

In the study area the falcons are early risers and they forage preferably in the morning twilight but less so in the evening. May be thus the falcons could avoid competition for food with other predators. The falcons are highly adaptive to take maximum advantage of its prey. They are also capable of protecting themselves from predators. The slow indirect and stealthy movement between the roost and the foraging areas and the habit of changing roost from time to time are also meant to achieve this.

All the falcons of the area made morning calls while they moved out of their roosts, preened their feathers, moved from one roost to another before glide down to start foraging. The daily activity cycle of majority (68%) of falcons starts between 5.30 to 6.30 and they (47%) go roosting between 17.30 to 18.30hrs. The major daily routine activity was foraging and lowest time was spent for resting. Falcon is very aggressive and an active bird. The male bird wanders for food when the female is in breeding. Captive falcons are confined within the aviaries for roosting for which small boxes are provided. Falcons exhibit extra ordinary sense in identifying own roosts. It was observed that they also defend their cages when other falcons try to intrude and sometimes end up in serious fighting.

Generally the falcon pair often roost together even outside of the breeding season and recently fledged siblings may roost close to one another for a period of time after leaving the nest. They generally moved out of the roost between 05.30 to 07.05 hrs, and started foraging immediately.

It was observed that the Peregrine falcon pair traveled an average distance of 850m per day. The rate of progression was the lowest during the first hour of observation (05.00 to 06.00 hrs). Thereafter the pair moved faster up to 15.00 hrs, then the rate was stepped up and it stayed high up to 18.00 hrs. The rate slowed down again during the last hour. The maximum distance covered was in December and the minimum in September. Frequency distribution of progression

rates in class intervals of the birds is tabulated in Table 2.3 & Fig. 2.1. It was observed that 84.93% of falcons traveled up to 100 m.

It is observed that a hungry falcon attacked even other falcons in the aviary for food. It is also noted that after regular feeding of the falcons, they do not attack or kill stray birds that intruded into the aviary even though they were very close. Only parts of the aviary are utilized for foraging each day. The wide home range and its careful utilization ensure adequate supply of food for the species throughout the year. When falcons in captivity are fed regularly and not left hungry, they exhibit high adaptiveness and adjust with other species of birds.

During the study of Jenkins and Benn in 1989-1994, two adult males and two adult female Peregrine falcons were radiotracked in adjacent territories on the Cape Peninsula, South Africa. The objective of the study was to determine the spatial and habitat requirements of Peregrines and their ranging behavior. They observed that male occupied larger home ranges than females. The females were more sedentary, spending over 50% of their time at the nest. The home ranges of neighboring birds overlapped by about 20%, but neighbors tended not to forage in the same area on the same day.

Falcons especially Peregrines are aggressive hunters. They fly at incredible speed. The Peregrine, which is the most versatile aerial specialist, probably flies about 100 km/hr. The stooping velocity of the falcon in a dive is amazing which makes it the world's fastest creature. The documented speed of a Peregrine's stoop is over 320 km/hr (Cade 1980). Incidentally it may be noted that they have needle like projection in their nostrils that are likely to help in reducing the air resistance and drag during their fast flight. Raptors have two regions of the retina in their eyes, the deep fovea and the shallow fovea, that are specialized for acute vision (Tucker 2000). They can focus their vision at distant object even during their stooping flight. The falcons have high capacity for sideways vision and they effectively use it to track their preys.

An optical tracking device recorded the three-dimensional paths of dives by a Gyr Falcon trained to dive to the falconer, shows that each dive consists three phases,

the acceleration phase (upto 500 m), the constant-speed phase and deceleration phase (Tucker *et al.* 1998). The Arctic Gyr falcon far outdoes the level flight speed of a Peregrine. Although slightly less speedy in a dive than a Peregrine, the Gyr is capable of sustained level flight at a speed of approximately 160 km/hr. This ability enables the Arctic Gyr falcon to eventually catch ptarmigan grouse after long exhaustive chases.

During the stooping falcons are not merely falling from the sky. They control their speed in three phases. Several authors have estimated that diving falcons reach speeds of more than 200 km/hr. and wild falcons may reach such speeds when they make long, steep dives upon birds flying high in the air. Hantage (1968) timed the maximum speed of Peregrine falcon as 270 km/hr. Orton (1975) using mathematical formula for the acceleration of a free-falling body has calculated that Peregrine stoop with a vertical fall of 1524m would reach 230-240 km/hr and suggested that more normal strikes at prey reach around 190-240 km/hr. Conservative estimates show that while stooping the Peregrine falcon exceeds 160 km/hr (Baker 1967), while Cade (1980) asserts that 300 km/hr is entirely possible.

In most of the falcon, males are larger than females. Small males are better protectors of their nests than are large females (Andersson & Wilkund 1987) and the large females are better protectors of their nests than small females (Storer 1966). The Gyr falcons are thought to be a close relative of Saker falcons for their hunting methods are similar. They are very sensitive to direct exposure to the midday sun. The climbing power and flying speed of the Gyr falcon is unequalled. Its prey species includes lemmings, arctic hare, ptarmigan, waterfowl and other large birds.

Falcons are migratory birds from their breeding grounds to wintering grounds and back. The migration speed of falcons was calculated by NARC using satellite telemetry data for autumn and spring. In autumn, migration speed was slower in Europe than in the Middle East and Africa. In spring migration speed was faster in Africa as birds left their wintering grounds than in the Middle East.

Falcons use a variety of vocalizations in their routine activity. They communicate with others by loud territorial calls to alarm dangers and as a defense from predators. Broadly the vocalization of falcons both adults and chicks could be grouped into two types, the long and short calls. Their amplitude are also very low making it difficult to correctly decipher in anthropomimetic terms or even to record, except probably by continuos recording that needs higher level of logistics. Different calls of the falcons and the context in some cases are recorded. Male Marsh Wrens in Washington State have about 115 different song types (Verner 1975). Male Northern Mocking birds may sing 100 to 200 different song types (Wildenthal 1965), and the Brown Thrasher, may have as many as 2,000 different songs in each male's repertoire (Boughey and Thompson 1981).

The song plays a critical role during breeding (Brockway 1969). It probably stimulates the female's breeding behavior and also aids in spacing breeding males (Marler 1956). Similar songs may be made within the aviary also (Falls 1969). Apart songs there are variety of sounds produced by individuals, probably more than the level of syllables or word in human languages. The phonetic units used in birdcalls apparently communicate the message fast and hence have got evolved through the course of evolution. In the breeding season falcons make a variety of calls. As mentioned above in the case of bird songs, such calls may attract and stimulate the opposite sex to mate or to do the courtship display. It is likely that such calls may function to alarm other competitors. The broadcasting of taped calls is a tool in attracting and locating resting raptors in woodland settings (Fuller and Moscher 1981). Kestrels are not highly territorial (Village 1990), and hence their response to playbacks was relatively high compared to other diurnal raptors (Penteriane 1992). In the present study Peregrine's cacking call was of the highest frequency (3251.51 Hz) and its peak time was short (0.838 sec). This sound is produced when a larger aggressor appears close to the bird. The intention of producing such high frequency sound may be to drive away the aggressor. The sound with highest peak time (31.209 sec) was the alarming call of Gyr falcon intended to communicate the impending threat. The call having shortest duration was creaking call of Peregrine fall. The peak time of the call was 0.233. This call also has the lowest frequency. The creaking call is made during the breeding season and the aim of the vocalization is apparently communicating to the mate.

The Peregrine falcons wake up before sunrise and immediately utter loud "*kek kek*" territorial calls repeatedly. In the evening they stop foraging and perch on different places on their return to the roosts. They produce "*kek kek*" calls during the evening hours too. These calls appeared to be some kind of a social releaser synchronizing the behaviour of all the falcons of the study area. The loud and impressive territorial calls of the species perhaps ensure a better defense of their territories and compensate to some extent for the very fast flight and generally fast movements of the species.

2.5 Summary and Conclusion

Falcons are aggressive birds, moving widely in search of prey. They have high adaptations to locate and capture prey species. Even in captivity they show regular movements and the median distance travelled in day by a captive individual within its large pen was about 50-75m. The falcons foraged in the morning twilight than evening twilight. The daily activity cycle of majority (68%) of falcons starts between 5.30 to 6.30 and they (47%) go roosting between 17.30 to 18.30hrs. The major part of their daily routine was involved in foraging activity. The lowest time was spent for resting.

They are parochial about their roosting sites. They vocalize loudly if an intruder approaches the sites. Falcons are found to have complex vocalization that could be classified in to long calls and short calls that could be distinguished based on the duration, intonation and intensity. In the breeding season falcons make a variety of calls, which may attract and stimulate the opposite sex to mate or to do the courtship display. Common types of vocalizations are cacking call, alarming call and mobbing call etc. for communicating among the members in their day-to-day life. The vocalizations help them to maintain their territories. Falcons usually do not forage in the evening.

CHAPTER 3

FOOD AND FEEDING

3.1 Introduction

Falcons are carnivorous, migratory birds with wide distribution all over the world. The Peregrine Falcon *Falco peregrinus* is the most widespread species among the raptors (Ratcliffe 1980). Despite widespread distribution of the species, little information is available on its food and feeding behaviour. Ali & Ripley (1983) have mentioned birds as the chief food of falcons along with and rodents, large insects and small ground animals. Although qualitative information on the food is available no serious study providing quantitative data from any part of India or abroad is available.

Though many studies have been made (Cramp & Simmons 1980, Anderson & Norberg 1981, Ali & Ripley 1983, Temples 1985, Bijlsma *et al.* 1988 and Vyas 1993) adequate knowledge is wanting regarding the food and feeding habits of falcons. In this study it is attempted to develop a picture of diet, relative proportions of various food items and feeding habits of falcons. With this perspective the major objectives identified for study are:

- Study the various methods of feeding in the field,
- Examine types of food in the field and in captivity and
- Critically examine the present feeding strategy in captivity

3.2 Methodology

About 1500 hours were spent to observe the feeding behaviour of various falcons. The different types of food, feeding habits and foraging behaviour were noted. Some observations are also carried out at Sweihan 35 kms west of the study site, the Abu Dhabi Falcon Research Hospital. The later has more or less the same type of physiography and vegetation as the main study site. About 48 adult falcons were observed over this period at a monthly rate of four birds in 2001-2003.

The quantitative and qualitative changes of the availability of vertebrate food in the study area were monitored regularly. The falcons were observed in the field with binoculars and telescopes to ascertain the types of food they take. The falcons brought to hospitals by *bedouins* were examined and the food items they consumed were documented.

3.3 Results

3.3.1 Hunting and feeding behaviour in the field

All falcon species hunt for food and will defend the area against other intruders, and attempt to drive it off, uttering aggressive cackles –"*kek-kek-kek*" or some species-typical variant thereof. Many species of falcons make a habit of catching food, and will defend the area near the catch against intruders. If the intruder persists and finds the quarry and lands on it, the falcon will usually break off its attack and depart, should the intruder be a large bird.

Falcons attack their prey in the air. If the quarry is too large to carry, the falcon will leave it and fly in pursuit of other preys. The most favourite prey of falcon is Houbara Bustard. Unlike falcons the female houbara is smaller than the male. In the ground struggle of prey capture, the houbara will never allow the falcon to take off after it, and houbara shoots a thick, slimy discharge at the falcon called '*taml*'- a slimy '*tam*' missile (Remple & Gross 1993). The falcon can't fly because its feathers get glued together and has to be cleaned immediately to fly again. The houbara can twist and turn whilst flying at a great speed. Falcons are capable of doing so when they are trained well.

Houbara's wing and tail feathers are nearly twice the length of a falcon, which often help them climb in air faster. The long wings of falcons help to occupy more air and consequently they can fly swiftly and powerfully. The wing feathers are arranged in rows and layers. This peculiar arrangement helps in controlling body balance and also helps to press the wings to the body to avoid the air resistance while stooping. The aeronautical shapes of the wing help to move fast and glide

swiftly in air. The tail controls the body balance while flying, at the time of take off and landing. The shape of the beak is sharp and curved at the end and sides of the beak are semi flattened which help to avoid the air resistance while flying.

3.3.2 Food of falcons in the field

The vertebrates in the food items of falcons are houbara, desert hare, sand grouse, kairowan, rat, pigeon, quail and doves (Table 3.1).

Table 3.1 Monthly abundance of prey items of falcons in the field

Item of food	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Stone curlew	25	88	24	9	16	10	8	58	86	126	160	78
Houbara	9	14	-	1	1	10	13	18	32	18	60	22
Sand grouse	54	86	90	102	69	28	10	50	70	90	108	85
Desert hare	4	3	6	5	8	9	7	5	4	5	12	28
Rat	14	25	15	12	31	26	12	2	3	4	15	12
Lizard	4	5	8	7	16	21	12	14	2	4	14	29
Pigeon	12	14	12	4	13	5	8	9	14	17	19	15

However, the prey species that are traditionally pursued by Arab falconers for hunting are three in number. All are 'catchable' by falcons flown straight from the hand and all offer the bonus of the meat for the cooking pot. They are the Houbara Bustard *Chlamydotis undulata macqueenii* (Plate 3.1), Stone Curlew or Kairowan *Burhinus oedicnemus* (Plate 3.2) and Arabian Hare *Lepus capensis* (Plate 3.3). In United Arab Emirates the Collared Dove *Streptopelia decaocto,* chestnut bellied Sand Grouse *Pterocles exustus* (Plate 3.4), Turtle Dove *S. turtur*, Palm Dove *S.senegalensis*, Rock Dove *Columbia livia,* Grey Quail *Coturnix coturnix*, Sand Partridge *Ammoperdix heyi*, Grey Francolin *Francolinus pandicerianus,* Chukar *Alectoris chukar* all found in scattered abundance, and all potential quarry for falconry. As noted earlier houbara is an important quarry. There are two species of houbara bustards namely, North African Houbara Bustard *Chlamydotis undulata undulata* and Asiatic Houbara Bustard *Chlamydotis undulata macqueeni*.

a. Asiatic Houbara Bustard *Chlamydotis undulata macqueeni*

One of the main preys of falcons is houbara. The one entity, more than any other factor that has influenced, defined and molded the way of Arab falconry is the houbara or Macqueen's bustard *Chlamydotis undulata macqueenii*. The 'houbara' relentlessly sought-after prey forms the virtual core of Arab falconry and the entire tradition revolve around its pursuit.

Male Houbaras have an average weight ranging from 1800-3200 gms and females 1200-2500gm. Adult is 55-65cm in length having a wingspan of 137-170cm. In contrast one of its predator the adult Peregrine falcon has a wingspan of 80-120cm. The houbara bustard prefers harsh, arid plains with little cover except scattered shrubs. An omnivorous bird, it exists on a variety of desert plants and insects. In the winter-feeding areas shoots of shrubby, aromatic plants and grubs are the preferred food items. Small lizards and mammals occasionally supplement their diet. Much of the migratory traveling and feeding is done at night.

The size and weight of the houbara varies across its migratory range. The Asiatic sub-species are the largest. The houbara is very cryptic when it freezes or flattens itself on the ground; even the falcon's eye may be unable to detect it. Bush circling of houbara is an evasive behavioural pattern the bird uses to avoid capturing i.e. circling a low bush so as to keep the bush between itself and the predator. The strut is a particular movement of houbara i.e. with its body parallel to the ground and its head held vertically, the bird moves forward slowly.

The pace is gradually increased accompanied by occasional turns. The houbaras are found frequently in UAE from September to mid November. Again they are seen in March, while they return to their breeding grounds in Central Asia. The bird is known to nest in Egypt upto outer Mangolia, and migrates into Arabia, Iran, Pakistan and India from late November until March. The Nag valley in Balochistan is a breeding ground of the resident population of the houbara in Pakistan

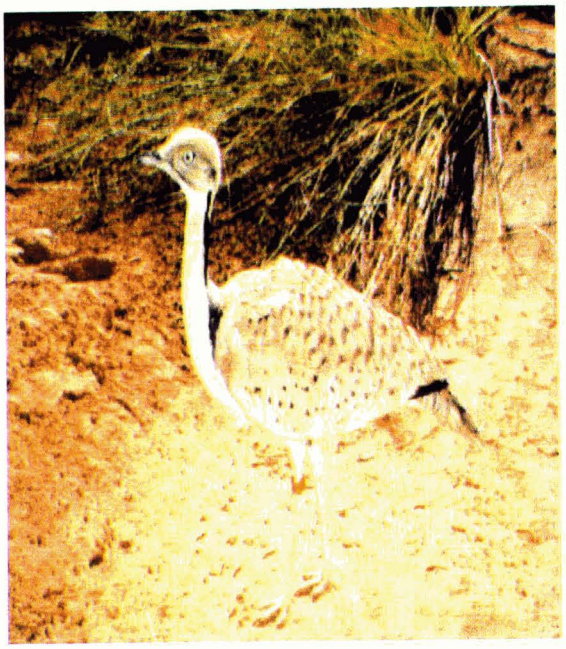


Plate 3.1 Prey of falcons. Houbara bustard *Chlamydotis undulata macqueenii*

Plate 3.2 Stone curlew or Kairowan *Burhinus oedicnemus*

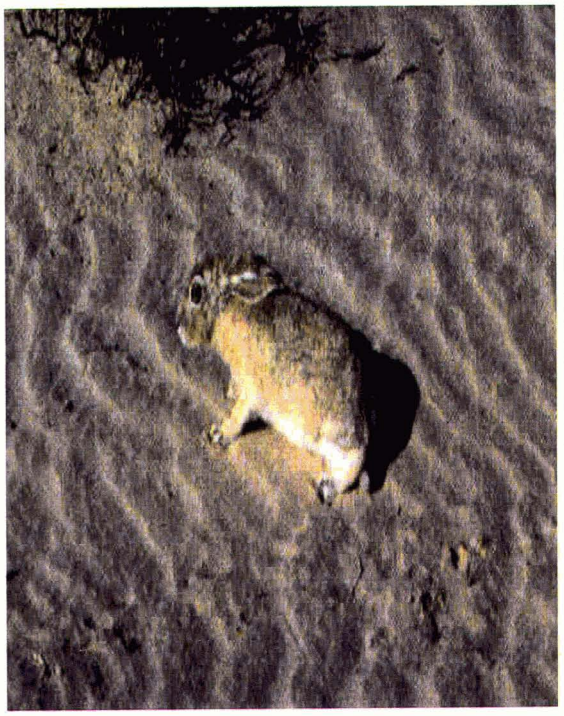


Plate 3.3 Arabian hare *Lepus capensis* or desert hare is a quarry for falconry

Plate 3.4 Sand grouse *Pterocles exustus* exist in scattered abundance in deserts

b. Stone Curlew or Kairowan *Burhinus oedicnemus*

Due to the size of the Houbara, the importance of the Kairowan, as a quarry of Arab falconry, is greatly overshadowed. The kairowan has flight characteristics and feeding habits similar to the houbara and therefore, is caught by the use of same falconry techniques and methods used to catch houbara. But unlike houbara, stone curlews are related to plovers, they are typically plover sized birds, and hence their importance as food quarry, for hunters, is greatly diminished. Their diet consists of insects, plant shoots and small reptiles. Unlike houbara, stone curlews are vocal when they arrive at feeding area. Their plover-like '*kleee-kleeuu*' often alerts camping falconers to their location-where they will be found sleeping during the day.

c. Arabian Hare *Lepus capensis*

The Arabian hare is much a smaller version of the European hare. They are only about one-third the size of the European species, and weigh approximately 1.5kg. The strikingly large ears of the species are thought to act as 'radiators' to help rid the body of excess heat. Like the houbara and kairowan, the hare is largely nocturnal in its feeding habits. Much of their day is spent crouched under a bush or rock to avoid the heat. As Peregrines normally loath to engage in a ground tussle, especially with something that kicks, Saker falcons are best flown at this quarry. In UAE this hare was nearly hunted to extinction with firearms.

3.3.3 Quantitative estimation of the food items preyed in the field

Vertebrates like sand grouse, kairowan, desert hare and rats are found in all season, but houbara is found during hunting season and other items less often. Monthly occurrence of food items in stomach-contents of the falcons is listed (Table 3.2).

The falcons are let out in the field to catch their prey. It is found that falcons, which are in larger size, prefer to hunt the bigger preys. The smaller falcons try to catch the small preys comparable to larger falcons. Like hawks the prey capture of falcons is largely dependent on the biomechanics of the hindlimbs, and both limb

size and grip forces potentially determine the size of prey (Norberg 1981). Occasionally falcons take bats. The young Peregrines are also known taking flying insects. Some of the important preys of Peregrine falcons in the field are houbara bustard, pigeon, lizards and rabbit. Of these the major food items in the field are sand grouse (31.3%), stone curlew (24.8%), houbara bustard (13.5%) and desert hare (10.3%). Occasionally the falcons are known to consume rats, pigeon, duck, lizard, quail etc. (Table 3.3 & Figure 3.1).

Table 3.2 Monthly occurrence of food items in the stomach-contents of falcons in the field (N=48)

Item of food	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Stone curlew	16	9	4	5	3	2	3	9	15	15	15	20
Houbara	4	6	-	-	-	-	2	3	16	11	11	8
Sand grouse	8	14	29	16	14	2	2	12	16	12	8	9
Desert hare	2	3	4	2	3	1	2	3	2	3	4	3
Rat	8	6	5	4	-	1	-	6	5	2	3	1
Lizard	1	2	-	1	-	1	-	1	-	1	-	1
Pigeon	9	8	6	5	7	2	4	2	5	4	7	6
Frozen quail	-	-	-	8	12	21	18	7	-	-	-	-
Frozen lamp	-	-	-	3	4	11	4	2	-	-	-	-
Frozen chicken	-	-	-	4	5	7	13	3	-	-	-	-

Table 3.3 Consumption of prey items of the falcons in the study area

Items of food	Numbers observed	Percentage
Stone curlew	156	24.8
Houbara bustard	85	13.5
Sand grouse	197	31.3
Desert hare	65	10.3
Rat	25	3.97
Lizard	21	3.33
Pigeon	65	10.33
Duck	15	2.38
Total	629	100

3.3.4 Diet of falcons in captivity

In captivity, during summer falcons are fed in the morning around 7'o clock. In the winter the food is given at the time of training in the morning or in the evening before sunset. As noted earlier that the wild falcons eat different kinds of preys and

probably the diversity of food consumed may be the reason for the distinct yellow colour of legs and beak acquired from the second year onwards.

The amount of food eaten varies with body size. It is observed that the food intake of a male Peregrine falcon is about 113gm per day of frozen quail or pigeon, while female consumes an average 141gm. Intake of a freshly hatched Peregrine nestling is 80gm per day. As it grows almost 33 days old, the food intake is recorded to reach almost 300gm per day.

Although different in size, there is no significant difference in the daily food intake of male and female nestlings for about the first 21 days. After that period the growth of male nestlings become slow than females and female nestlings require a greater amount of food than males. Puppets can be used to assist young chicks for feeding. Most species learn to pick up food for them when they are about 10 days old. The chicks can go without food for almost a day. Some food items of falcons in captivity are quail, pigeon, lamb-meat etc. In the moulting season falcons are fed frozen meat. Fasting once fortnightly facilitates proper casting, the eviction of accumulated bolus of undigested materials such as hair, feathers, bones and stones.

On feeding falcons with boneless lamb meat daily, cause calcium deficiency affecting the growth of hard tissues such as bones, claws and beak. This also may result in improper casting (Table 3.4).

Table 3.4 Effect of feeding the falcons with boneless meat continuously in captivity (Observation during the month of June 2002)

Days	Peregrine falcon	Saker Falcon	Gyr Falcon	Symptoms
Sat – Mon	Lamb meat	Lamb meat	Lamb meat	Digestion decreases
Tue –Wed	Lamb meat	Lamb meat	Lamb meat	No casting
Thu – Fri	Lamb meat	Lamb meat	Lamb meat	Faeces not normal
Sat – Sun	Lamb meat	Lamb meat	Lamb meat	No casting
Sun – Mon	Lamb meat	Lamb meat	Lamb meat	Digestion decreases
Tue – Wed	Lamb meat	Lamb meat	Lamb meat	No casting
Thu – Fri	Lamb meat	Lamb meat	Lamb meat	Digestion decreases
Result after two weeks	Diminutive growth of the beak and talons	Diminutive growth of the beaks and talons	Diminutive growth of the beak and talons	

Falcons if provided with preys such as quail, pigeon, duck and rat, completely consume it including bones and feathers of the prey. That makes the falcons obtain almost all-essential nutrients (Table 3.5). Observations show that mixed food is essential for the proper growth and health of falcons in captivity. Diverse food is expected to promote the healing of the wounds, immunity, healthiness, hunting capacity and resistance against diseases.

Table 3.5 Effect of feeding falcons with different types of food in captivity (Observation during the month of June 2002)

Days	Peregrine falcon	Saker falcon	Gyr falcon	Symptoms
Sat - Mon	Pigeon	Pigeon	Pigeon	Normal casting
Tue -Wed	Quail	Quail	Quail	Excretion normal
Thu - Fri	Quail	Quail	Quail	Normal excretion
Sat - Sun	Lamb meat	Lamb meat	Lamb meat	Excretion normal
Sun - Mon	Pigeon	Pigeon	Pigeon	Casting normal
Tue - Wed	Fasting - quail	Fasting - quail	Fasting-quail	Normal excretion
Thu - Fri	Quail	Quail	Quail	Excretion normal
Result after two weeks.	Normal growth of the beak and talons	Normal growth of the beak and talons	Normal growth of the beak and talons	

However, it may be noted that feeding falcons with live pigeons, quails and ducks may cause diseases due to contagious microorganisms, virus and bacteria present in the blood of these birds (Table 3.6). When live specimens are provided to falcons higher bacteria are found in their fecal matter. The fecal matter can become free from bacteria after 2-3 days of treatment.

Table 3.6 Effect of feeding falcons with different types of food (live specimens only) in captivity (Observation during the month of June 2002)

Days	Peregrine	Saker	Gyr	Symptoms
Mon	Pigeon	Pigeon	Pigeon	Bacterial stomatitis, Neo castle disease virus
Tue	Rat	Rat	Rat	Bacteria, virus present in the fecal matter
Wed	Quail	Quail	Quail	Trichomonas, bacteria, virus present in faeces
Thu	Pheasant	Pheasant	Pheasant	Micro organisms present in the fecal matter
Fri	Duck	Duck	Duck	Parasites, bacteria, virus present in the faeces
Sat	Quail	Quail	Quail	Bacteria, virus, protozoa present in the faeces
Sun	Rat	Rat	Rat	Protozoa, bacteria, virus present in the faeces

During training the falconer train the bird to catch prey using live pigeons that the falcons eat after capturing them. Hence, 60-70% of falcons undergoing training of this sort are observed to contain microbes in their excreta. If they are fed live

intermixed or on alternately with frozen specimens the chance of getting such pathogenic infections will be low (Table 3.7).

Table 3.7 Effect of feeding falcons with different types of food (live and frozen) in captivity (Observation during the month of June 2002)

Days	Peregrine	Saker falcon	Gyr falcon	Symptoms
Mon	Live pigeon	Live pigeon	Live pigeon	Presence of bacteria, protozoa in the faeces
Tue	Frozen quail	Frozen quail	Frozen quail	Decreases the number of bacteria in faeces
Wed	Live rat	Live rat	Live rat	Presence of micro organisms in the faeces
Thu	Frozen quail	Frozen quail	Frozen quail	Micro organisms decreases in faeces
Fri	Pheasant	Pheasant	Pheasant	Presence of protozoan, bacteria in faeces
Sat	Frozen quail	Frozen quail	Frozen quail	Decreases the number of bacteria in faeces
Sun	Live pigeon	Live pigeon	Live pigeon	Presence of bacteria, protozoa in faeces

3.3.5 Food supplements

Supplementing food with vitamins and calcium is found very useful for the birds. Multi vitamin supplement is regularly added in the food. Calcium has to be used carefully. Sterilized bone flour, as a supplement can cause imbalances in phosphates. If the falcons are fed exclusively frozen food, additional vitamin is very essential.

3.3.6 Digestion, casting and casting materials in falcons

A raptor's digestive system, especially that of a falcon, is capable of dissolving bones completely. Like many of the granivorous birds, members of the *Falconidae* also have adaptations for grinding. The digestive system of falcon is capable of grinding bones and feathers. Feeding boneless meat regularly causes no casting. Falcons excrete a viscous white fluid that quickly dries to a chalky consistency - the 'whitewash' that is frequently seen around falcon roost.

Falcons are rather fussy eaters, and most ingest relatively roughage-bones, fur and feathers from their prey. The powerful gastric juice in a raptor's digestive system can usually dissolve what is swallowed, but any indigestible bits will be regurgitated as a pellet (Plate 3.5).

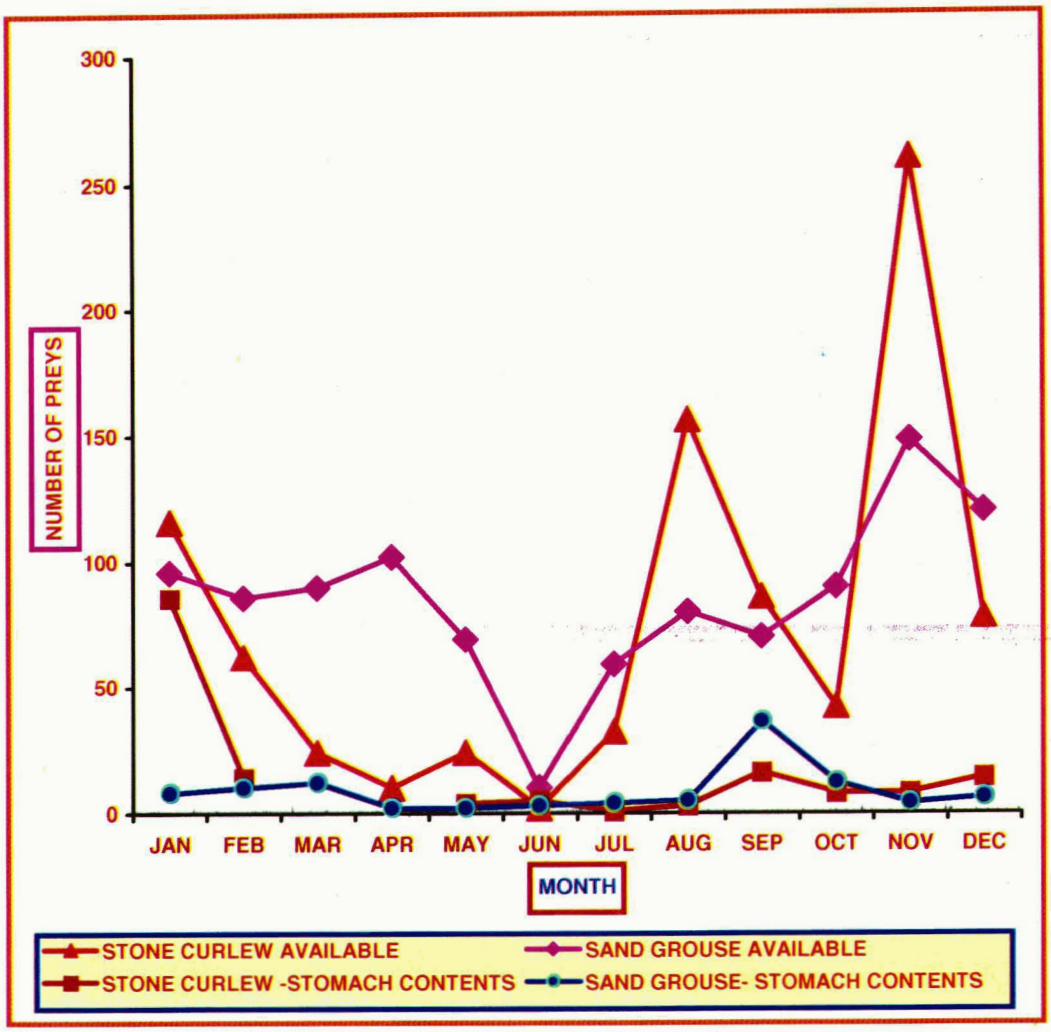


Fig. 3.1 Monthly abundance of stone curlews and sand grouses in the study area and in the stomach-contents

Plate 3.5 The 'castings' of falcons

The size of the pellet depends on the species and size of the prey, but generally pellets are an inch or two long, oblong and dark grey. They must have cast before eating a new meal. Falcons usually cast after 12-15 hours of a meal before a new meal.

Observations of captive falcons show that pellets are regurgitated on an average of about 18 hours after a meal but in wild raptors a pellet is expelled roughly once a day, usually early in the morning. In the Arab world, it is still common to feed ammonium chloride (*Shenadra* in Arabic) to the falcon to purgate its stomach. Giving ammonium chloride may however lead to destruction of the stomach lining, killing the falcon. At Falcon Clinic Sharjah, one falcon was brought with severe dysentery and anaemia for treatment. The falcon, when examined was found to be fed with excess ammonium chloride. Although the bird was attended by experts it could not be saved.

It is much better to use 6-8 small stones of 15 gm and 3-5 mm in size, often-called rangles. These stones are given to the falcon in the evening after it has a light meal without or with very little casting. The stones clean the stomach overnight and in the morning are casted. If there is no proper digestion spraying water is recommended on face and thoracic part of the body.

3.4 Discussion

Falcons are exclusively carnivorous birds, feeding on a variety of prey species such as houbara bustard, quails, pigeons, sand grouse and hares in nature. Simmons (1970) stated that food supply plays an important role in determining the breeding biology, dispersion pattern and social system of a species through natural selection. In captivity they are given frozen meat of quail, pigeon and lamb and rarely live specimens. In the field they hunt small animals and birds. In captivity additional nutrition is provided for their proper health.

Falcons appear well adapted to live in highly modified cages. When they are fed the same type of food, it affects the health and therefore they should be supplemented

with vitamins and minerals especially in training, stress and moulting period. Spraying of water or sugar solution on facial and thoracic region of falcon speed up the defecation and if the falcons are not taking food properly they are given juice of meat mixed with necton powder.

Most falcons are heavy-wing loaded raptors, the larger the falcon the heavier the loading. Falcons are large broad winged raptors with high hunting capacity. The hunting is closely related to certain aspects of predator size (Norberg *et al.*1983) and behavior like breeding, moulting and migratory activities. Falcons are capable of fast, sustained flight and high maneuverability, which enable them to catch flying prey that would elude most other raptors. Falcons are opportunistic hunters and hunt by either the 'stoop and glance blow' or the mid-air 'chase and grab' (Cade 1960). The method chosen by the falcon will depend either on the size, or elusive flight capabilities of the prey being sought, or the opportunity that presents itself at the time of hunt. Large gallinaceous prey (pheasant, grouse etc.) generally are faster in flight than a pursuing falcon, but speedy prey lack maneuverability, therefore the stoop is the most successful method for catching the prey. However the highly maneuverable houbara bustard can easily elude a diving falcon with a simple dodge. Therefore the greater flying speed will favour the falcon in an attack on the houbara and a series of spectacular chase will prove to be the successful method.

The food intake of male and female nestlings of falcons was compared in order to investigate parental resource allocation to their highly size-dimorphic offspring (Boulet *et al.* 2001). It was noticed that even though differences in size, there is no significant difference in the daily food intake of male and female nestlings for the first 21 days of the nestling period. It is understood that female nestlings require a greater amount of food than do males, but because of greater growth efficiency, they need less than expected on the basis of body mass (Allen 1982). Prey captures of owls and hawks are largely dependent on the biomechanics of the hindlimbs, and both limb size and grip forces determine the size of prey (Ward *et al.* 2002). Falcons use the talon closure by two discrete mechanisms that function together in an alternate fashion.

Falcons are basically of aggressive dispositions like other raptors. Sometimes they happen to contend with members of other raptorial species and antagonistic with individuals of their own species. Even advanced nestlings respond with aggressive defence to intruders. These encounters often result in disputes over captured prey, nest-sites, and favourite perches or roost areas. This aggressiveness often helps to self-defense against predators such as eagles, large hawks and other falcons.

One peculiar feature displayed by all falcons is the formation of pellets known as castings (Remple & Gross 1993). Several castings sometimes represent a single prey item, which are formed from indigestible material in the ventriculus and later regurgitated. The casting is essential for its proper defecation. If the casting stays too long inside the crop and if it is not passing out, bacteria may develop inside the crop and in worst case it may affect the life of falcon.

It was observed that falcons affected with casting problems are to be fed with boned meat to cast properly. On the other hand single type of boneless meat like lamb meat will result indigestion and this may adversely affect casting. It was noticed that in Dubai Falcon Hospital, falcons without proper casting were made to fast once in 15 days. After this they began to cast properly. So fasting once fortnightly is recommended for proper casting of falcons.

Summer diet of Lesser Kestrel has been investigated quantitatively in Spain, France and Australia (Cramp & Simmons 1980, Bijlsma *et al.* 1988). Although fresh food is best for falcons, sometimes frozen food is unavoidable. Freezing the meat for a long period reduces the vitamin content in the food, so additional vitamin supplement is to be provided. There is a correlation between the food abundance in the field and that in the stomach contents. Stone curlews were the most abundant prey item found in the analysis of both monthly food abundance and stomach-contents, observed in the study area (Fig 3.1).

Feeding Falcons with ammonium chloride *(Shenadra)* to clean its stomach are well practiced in Arabian countries. This may however lead to destruction of the

stomach killing the falcon (Samour 1995). Although falcons do not drink a great deal of water, when they are young they drink water in summer. Factors such as availability, vulnerability, palatability, size and weight of prey, individual variations in hunting in Peregrines and development of specific choice may all play a part in prey selection (Ambrose 1988). It was noticed that when the niche breadth is varied ensuring availability of various species of preys, falcons prefer to catch the most favourite preys like houbara bustard.

3.5 Summary and Conclusion

Falcons are carnivorous species, well adapted to live in highly modified habitats. It is found that the larger falcons have a tendency to hunt bigger preys than smaller ones. The important prey species are houbara bustard, sand grouse, kairowan and desert hare. The major food item in the wild is kairowan. In captivity falcons are fed with quail, pigeon, lamb meat, beef and ducks. Females apparently consume more food than Males as indicated by their body size. The food intake of male and female nestlings is same till 21 days after hatching. The falcons drink water especially in summer to compensate with temperature.

The falcons are sensitive to stored food during their breeding. When falcons take the boneless food regularly casting does not occur properly. To avoid such complications both boned and boneless food needs to be supplied routinely in a mixed manner. Fasting once in a fortnight facilitate proper casting. Ammonium chloride, used for cleaning falcon's stomach, kills them when given excessively.

Consumption of only live specimens may cause infectious parasitic diseases. Feeding on stored food alone also is not advisable. A food regime with frozen and live food in a mixed manner is recommended for their proper health.

CHAPTER 4

BREEDING BIOLOGY IN PEREGRINE FALCONS

4.1 Introduction

Falcons do not make nests for themselves; they prefer old stick nests of other birds on trees or on cliffs. They are solitary and live in an environment far off from the nuisance and reach of human beings. Hence capturing wild falcons was very difficult and risky. As a result, the falconers turned to the captive-breds and hybrids. In this situation breeding centres began to flourish in the Middle East countries especially in UAE. Riddle and Remple (1994) estimated that there might be 8600 Saker and Peregrine falcons in captivity in the Middle East. No estimation has been made about the captive population of falcons worldwide.

In India only a small population is seen in certain northern states. Hence no significant studies have been made about falcons in India. The Indian Peregrine or Shaheen falcon *Falco peregrinus peregrinator* is a rare breeding bird found in scattered population throughout the Indian Union (Baker 1967, Ali & Ripley 1968). Despite its widespread geographic occurrence, no information has been published on its present day reproduction success rate. North temperate Peregrine falcon *Falco peregrinus* have experienced drastic population declines resulting from the use of certain pesticides such as DDT (Peakall 1976). Such pesticides were widely used in many parts of India (Karla & Chawla 1981).

Cade (1978) has examined earlier attempts to propagate Peregrine falcons and one of their conclusions is that falcons taken into captivity as nestlings are much more likely to reproduce as adults. Most breeding centres are situated in European, American & Middle East countries from where we get a profound knowledge of breeding and various aspects of behavior. Some studies are reported on breeding and successful nesting Peregrine falcon and/or Shaheen falcon *Falco peregrinus peregrinator* (Gurney 1879, Dodsworth 1913, Livesey 1933, Loke 1947, Osman 1979 & 1983, Bell 1990). In one of our surveys we have located Shaheen falcon nest in the Silent Valley forest at Neelikkal dam site in Kerala. Nevertheless data

and studies on the breeding of falcons and related aspects remain insufficient (Cooper 1979, Ratcliffe 1980, Remple 1988). Moreover, many of these studies are partial and insufficient. Hence, in the present study an attempt is made to collect more information on the breeding activities of Peregrine falcons.

The present study on breeding biology of falcons in UAE was undertaken from August 2001 to March 2003. The main objectives identified for the study are the following:

- To examine the resource requirements for breeding in captivity,
- To observe the courtship, mating and egg-laying behaviour,
- To study hatching and development,
- To document artificial insemination and related aspects and
- To document the growth of nestlings.

4.2 Methodology

In captivity the birds are kept in custom made enclosures with specially designed nest ledges and perches. These cages are well equipped with regulated temperature (15°-20°C) and humidity (below 80%) to match with species-specific requirements. The pens are periodically monitored for various aspects and care is taken to maintain the optimum. In the pens since both male and female birds are kept together in the breeding season it is very likely that they start courtship behaviors. These activities were observed and recorded during the present study. Female birds selected for artificial insemination are kept isolated.

Night and day observations were done to get details of various breeding events like courtship behavior, pair formation and parental care. The cages were visited daily to record the progress in various aspects of breeding biology. Nest activities were monitored following Cooper and Afton (1981). Eggs, immediately after laying, and nestling, at frequent intervals, were weighed close to the cages using a torsion balance. The dimensions of eggs and chicks were measured with vernier calipers.

Eggs were collected for artificial incubation. Attempts were also made to allow for natural incubation by some mother birds. While handling the eggs thin rubber gloves were worn to avoid contamination. For removal of eggs for safe transport two persons were appointed, one to remove the incubating bird with a net and the other to carefully handle the eggs. During the exercise the birds may become aggressive, even by damaging their eggs during the violent actions. So utmost care has to be taken while removing the eggs and the mother bird. Sometimes even dummy eggs were placed in the nest to avoid nuisance.

In captivity males and females are not normally allowed to mate. The breeding exercise is mostly by artificial insemination. For artificial insemination male falcon is wrapped in a towel and placed breast down on a foam pillow in a well-lighted room. Three persons were involved in the work. Falcon was held very safely by a person and the other two concentrated on massage and semen collection. Massage also done on lower back belly and sides with both hands. The collected semen is stored in a temperature-regulated freezer. Later artificial insemination is done by injection of the collected semen to the cloaca. The eggs laid were collected and kept in incubator at a temperature of 99°F (37°C). Observation on hatching was done with species-specific regulated intervals. The chicks were reared in breeding chambers. The chicks were observed in a routine manner and growth of different nestlings was documented:

4.3 Results

The breeding season is defined as the period elapsed from the date of building of the first nest to the date of fledgling of the last chick. The falcons have a unique breeding cycle. In breeding season the falcons show more aggressiveness to intruders, but are tolerant with keepers because of familiarity. Falcons also show ritualized courtship displays and activities. Peregrine falcons breeds once annually and live with same mate for the lifetime.

4.3.1 Breeding plumage

The most spectacular changes in plumage are seen just before the onset of the breeding season, February – March to August-September. It is usually the male

bird that is more colorful, which helps to attract the females and repels rival males. The brood patches are seen on breast side of falcons in the breeding period.

4.3.2 Pair formation

Pair selection is the process of selecting female by male by aerial display and courtship displays. It is the first stage in the breeding cycle of the falcons. Activities among monogamous species like falcons assist in forming and strengthening the pair bond and synchronizing mates for readiness in reproduction. The birds may repeat them indefinitely in association with advertising displays and copulation and later with nesting.

4.3.3 Courtship display and courtship feeding

In the courtship pairing male falcon display a dance before the female. If the female bird is receptive and ready to mate she reciprocates by a dance. The aerial display incorporates some special aerobatic move, such as a slow landing swoop up to a perch near the female with the feet conspicuously extended in flight. The display involves standing up with downward tail and legs extended, sometimes arching the neck and lowering the head, or hitching the wing butts above the plane of the back, and staring intently at the female (Plate 4.1).

The courtship feeding (Plate 4.2a) is observed before mating, where the male will catch prey and present it to female. Vocalizations during pair formation, copulation etc. which lasts only a few seconds, vary greatly even among the same species, but usually both the male and the female vocalize, and the female's wailing calls are unusually loud and persistent. It was noted that as male produced courtship call, the reply from female was followed by courtship display.

4.3.4 Mounting

The female falcon indicates her readiness to mate by turning away from the male and by bending forward and elevating her tail at about 45 degree or less above her back, assuming a kind of stationary bow. The male mounts on female directly from an extended flight in some cases or from a nearby perch. Sometime he jumps to her back from a standing position by her side. As he thus mounts on her back, she lifts her tail to one side, and he depresses his tail down between her wing and

tail to achieve cloacal contact, and apposition while balancing himself on his tarsi and closed toes by flapping his wings, which are usually held high above his body (Plate 4.2b). Close observations of mating in captivity reveal that only some of the copulatory mountings result in actual cloacal contact with the possibility of insemination.

4.3.5 Nesting, nests and nest site selection

Once the pair bond is established, the male searches several potential nest sites and the pair select the most suitable one. In some cases, the pair will alternate between two or three closely spaced nests over a period of three years, but more often a pair uses the same nest repeatedly.

In some birds like Passerines, once a pair of birds establishes a territory, they customarily remain on it until the young are independent (Michell 1990, Nolan 1978, Best 1977, Darley *et al.* 1977, Potter 1972, Zimmerman 1971, Hickey 1969, Southern 1958, Gullion 1953, MacQueen 1950, Kendeigh 1940 & Erickson 1938).

Falcons commonly nest on cliffs or high rising towers of churches, top of the buildings, bridges etc. It was reported by Dodsworth (1913), Bell (1990) & Uthaman (1991) that the Shaheen falcon nests were situated on a ledge on the cliff face in the tree. No particular material is necessarily needed for nesting for falcons although they prefer lonely atmosphere.

Though generally falcons do not make nests the Peregrine scratches out with its feet a shallow bowl in a soily ledge or appropriate the unused nest of another cliff nesting bird. I noticed a nest of a falcon at Musaffa Bridge on the way from Abu Dhabi to Al Ain. The nest was made up of old sticks on the top of the pillar of the bridge. In nature the falcon nests are not common in UAE.

4.3.6 Egg laying and clutch size

Peregrine falcons lay eggs in February – March in N-temperate zone, April-May at N-high latitude, August-October in S-hemisphere and June-December at Equator (Ratcliffe 1980). Peregrine egg ranges from creamy pink to reddish-brown in colour and are on an average 53 mm long (Table 4.1).

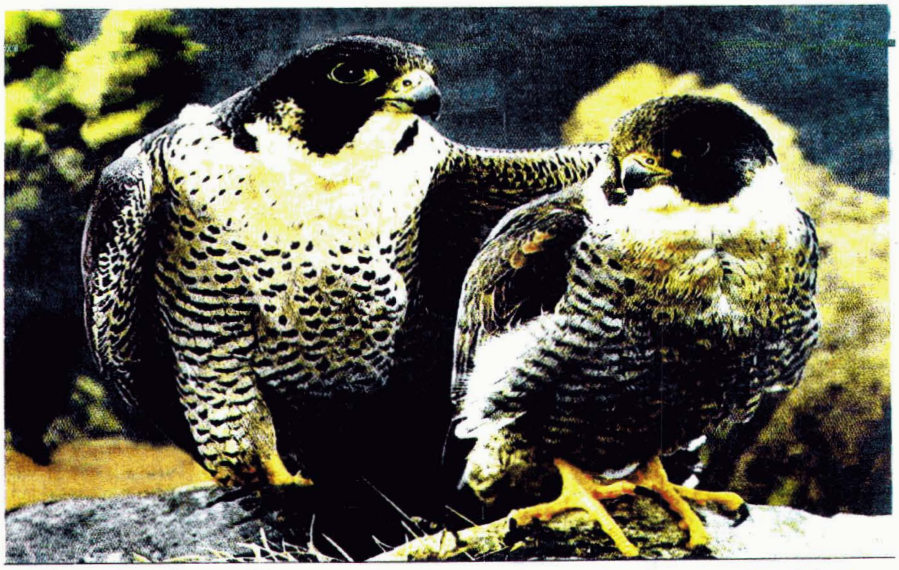


Plate 4.1 Courtship precedes the roosting and subsequent mating

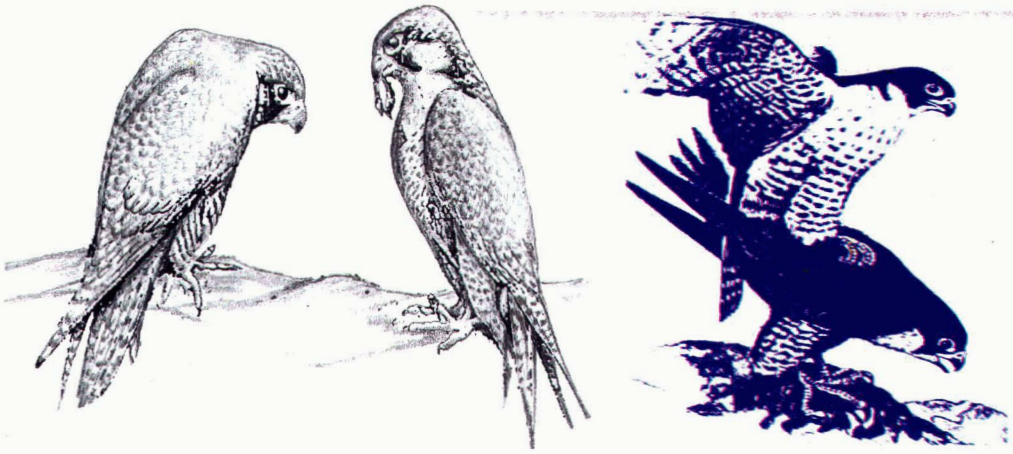


Plate 4.2 (a) Courtship feeding of falcons, (b) Mounting in falcons

Plate 4.3 Peregrine falcons normally lay three or four eggs

Table 4.1 The mean of the Peregrine eggs measured in the lab (2001-2003)	
Sl. No.	Eggs of Peregrine falcons (mm)
1	53.5
2	52.8
3	54.1
4	53.4
5	53.7
6	53.2
7	51.9
8	52.5
9	52.3
10	52.6
Mean	53

The colour of the eggs tends to be paler as each subsequent egg is laid and the last egg in larger clutches is almost white because of gradual decrease of pigments in their body. It is observed that mean clutch size is 3.3 (Table 4.2). An average nest contains 3-4 eggs (Plate 4.3). Young pairs often only have 2 eggs in their first breeding season, and then increase to 3 or 4 eggs in subsequent years.

Some Peregrines regularly produce 3 or 4 eggs, and rarely as many as seven. The eggs are usually laid with a gap of one or two days and are left rarely unattended until the last or second-last egg has been laid, at which point incubation begins.

It is necessary to monitor nest sites some time before egg laying occurs. Often the most difficult thing to measure is the fresh eggs weight (FEW). Unless each egg is weighed as it is laid, it is impossible to know the FEW of a clutch of eggs. Eggs begin to lose weight as soon they are laid. Brunham (1947) has reported a relation between the length and breadth of the eggs that is given below.

$W = Kw (LB^2)$ where W = fresh weight

Kw = observed weight coefficient for Peregrine eggs (0.0005474)

L = length of egg (mm)

B = breadth of egg (mm)

The computed FEW, as per the equation, can have error of 2%. Although this formula has been worked out for Peregrines, it seems to work well for other species also.

4.3.7 Incubation and egg manipulation

Falcons especially Peregrines accumulate excess food during the breeding season beginning with incubation. During incubation females attend the nest more than males. As nesting cycle progressed female's visit gradually reduces. Eggs are brooded almost continuously by the female for the first 7-10 days. Parents attended the nest area less during early morning and late evening, which are prime hunting periods.

Table 4.2 Details of clutch sizes of the Peregrine falcons in the lab (2001-2003)

Clutch size	Clutches		Total	%	Total number of eggs	%
	2001	2002				
2	5	4	9	20%	18	13%
3	8	7	15	34%	45	31%
4	4	16	20	46%	80	56%
Total	17	27	44	100%	143	100%
Overall mean clutch-size = 3.3						

Falcons are capable of incubating, hatching and rearing without assistance but the inexperienced pairs may need some assistance in the first few seasons. If any breakage of eggs happens in the nest the remaining eggs should be removed and if a second clutch is not required, dummy eggs can be substituted to continue incubation. Otherwise the parent birds hesitate to continue incubation. The wooden eggs make excellent dummies. One falcon incubates the eggs while the other perches nearby.

Unlike many other birds, falcons begin incubation after the first egg itself. The first two eggs were laid after an average of 1.44 days gap (Table 4.3). The eggs generally hatch on successive days, but occasionally two hatch on the same day, or a day or two passes between individual hatchings. During incubation, the eggs are rarely left unattended for more than a minute or two, although on very warm days the adults may stay off them for somewhat longer periods. The role of sexes in incubation on falcons is variable. The female incubates mostly, but male takes

over for several short shifts through the day so that the female can get off and hunt for herself.

Table 4.3 The intervals between the laying first and second eggs in Peregrine falcons in captivity (2001-2003)

Interval (days) = N	Frequency (f)		Sum of frequency (Σf)	Interval x sum of frequency (N x Σf)
	2001	2002		
1	2	3	5	5
2	2	2	4	8
3	-	-	-	-
4	-	-	-	-
5	-	-	-	-
Total	4	5	9	13
Overall mean period between the laying of the first eggs and the second eggs = 1.44 days				

Incubation period ranges between 28-36 days. Incubation once begun usually continued until the last egg is hatched. The average incubation period of the Peregrine falcon in the study area was 32.6 days (Table 4.4).

Table 4.4 The incubation periods in Peregrine falcons in the lab (2001-2002)

Incubation Period (days)=N	Number (f)	N x f
29	2	58
30	6	180
31	10	310
32	29	928
33	18	594
34	19	646
35	8	280
Total	92	2996
Overall mean period of incubation =N x f / f = 2996 / 92 = 32.6 days		

When eggs fail to hatch, falcons continue to incubate for a longer period. There was a case when falcons continued incubating upto 36 days, although the egg did not hatch (Appendix 4.1). Afterwards the bird deserted the egg.

4.3.8 Artificial insemination and semen collection

The imprinted falcons are familiar to humans, which are mostly captive-bred ones. In captivity semen is collected from birds trained and habituated to human beings and they are injected to the females. The insemination is done within six hours of laying an egg. In actual practice it is likely that the first chance for artificial

insemination is missed if the egg is laid during night. Forced insemination should not be attempted later than 16 hours post laying as the chances of bursting an egg and premature laying are high. The spermatozoa may be washed gently using water, immediately after collection, to clean it off the urine and other contaminations. Contaminations are likely to lower success.

4.3.9 Artificial incubation

Falcon eggs are hatched in incubators at varying temperatures at 99.5°F (37.5°C) and 30-35% relative humidity. The RH may be adjusted if the eggs are found loosing too much weight. Bird's eggs lose 18% of its weight when they hatch, 15% of this weight loss occurred by the pipping time.

Normally in falcon breeding centres at least 2 or 3 incubators are maintained. Of these one is for incubating the eggs, the 2nd for actual hatching and 3rd as a backup for mechanical breakdown or disinfecting the incubators in operation. This type of an arrangement is used to handle eggs of different clutches. To handle eggs of different species, separate incubators may be used.

4.3.10 Egg storage and egg handling

If there is dirt on eggs they are cleaned properly. Candling of eggs is to be done to check the health of the egg, to confirm that the egg is hatchable and not infected. During incubation the eggs need to be turned 180 degrees, but with great care, on alternate days. Once eggs have passed through initial stages of incubation, approximately for a week, and are proved to be infertile by candling they should be removed from the incubator to prevent cross infection of other viable eggs. Peregrine falcon eggs are stored only if proper storage conditions are available. Eggs should not be stored for more than one week; otherwise hatchability will decline at about 8%. Eggs should be kept in a dry stable room.

4.3.11 Hatching

By hand turning on a regular basis pipping eggs can be spotted soon after the shell cracking. The first crack of dark coloured eggs may be difficult to spot; however it can usually be felt by finger. After pipping of the egg it was shifted into another incubator. Once the embryo starts to turn within the egg the hatching process

should start within ten minutes to an hour. If the hole in pipping area becomes enlarged and the membrane starts to dry out, spraying of water is suggested to wet the membrane and get the foetus loosened. The pipping hole can also be covered with damp tissue or even a tiny piece of micropore tape. Details of fate of the eggs laid by the Peregrines in the study area for 2001-2003 were summarized in Table 4.5. Of the total eggs laid for hatching, 57% hatched, and 24% remained unhatched even after extended incubation period. Meanwhile 8% eggs were destroyed by shell breakage. The eggs (24%), which did not hatch even after extended incubation, were the first laid ones (Appendix 4.2).

Table 4.5 The fate of the eggs laid by the Peregrine falcons in the lab (2001-2003)

	2001	2002	Total	%
Number of eggs laid	34	40	74	100
Number of eggs hatched	19	23	42	57
Number of eggs which did not hatch even after prolonged incubation	7	11	18	24
Number of eggs destroyed by breakage of shells	3	3	6	8
Number of eggs damaged	4	4	8	11

Spraying the foetus with a propelled spray may be avoided. It is advisable that moistening may be done with a cotton bud or clean tissue. The Peregrine falcon chicks take 24-72 hours to hatch (Plate 4.4), after shifting the eggs to the hatching incubator. Since incubation started with laying of first egg in Peregrine falcons, eggs in a clutch hatched asynchronously (Plate 4.5), and the youngs are different in size. The first 2 eggs in the study area hatched after an average interval of 2.31 days (Table 4.6).

Table 4.6 Hatching intervals between the first and second eggs in the Peregrine falcons in captivity

Hatching interval (Days) = N	Number (f)		Total (Σf)	N x Σf
	2001	2002		
1	5	3	8	8
2	2	2	4	8
3	1	1	2	6
4	2	1	3	12
5	1	1	2	10
Total	11	8	19	44
Overall mean period between the hatching of first and second eggs = Σ(N. Σf) / Σf = 44/19 = 2. 31 days				

Plate 4.4 Newly hatched Peregrine falcon chick

Plate 4.5 Asynchronous hatched Peregrine falcon chicks

Plate 4.6 The female falcon feeds the young ones until they are full grown

The eyes of falcon chicks will open within three to four days after hatching. A newly hatched chick has an oddly shaped head, bulbous neck and very protruding eyes. These characters will disappear within 24-48 hours. Care should be taken to ensure that the egg-laying falcons are not suffering from infection or egg binding. Such incidences of egg binding were seen during the study period.

Some eggs will be difficult to hatch than others and needs human help. It is found that after pipping in certain eggs the foetus will not able to break open the eggshell and release itself from the egg membranes. Human assistance can save the hatching in most cases.

Pipping happens at the wider end of the egg adjacent to the air sac. The air sac of the egg could be seen and the exposed membrane will have blood vessels. When the vessels are closed and contain no blood, it is advised to remove the foetus at the earliest. If blood is still flowing, cover the hole as discussed above and place it in an air incubator. It is observed that on exposure to air the embryo is likely to get dried up and that has to be avoided.

4.3.12 Development and care of young

Newly hatched chicks were placed in an air incubator at 95°F. This temperature can be reduced by a degree a day until they return to parents or foster parents. Temperature is measured at all times. A steady temperature in the brooder room makes the rearing of young much easier while overheating leads to weak and ill young ones. It is not advisable to have young in the same room with incubating eggs to prevent cross infection and need to be shifted to a different cage. Both parents feed the chicks (Plate 4.6) and there are several feedings per day with an interval of 2 hours (5-7 times/day).

Chicks: The falcon chicks grow rapidly. By the time they are six weeks old they have already grown to full adult size and are starting to fly. As the chicks develop the parents allow them to become independent, and each week the appearance and behaviour of the chicks changes considerably. Falcon being a ferocious bird it was very difficult to approach the chicks for close observations.

When the chicks emerge, they look like helpless bundles of white down with oversized feet (Plate 4.7). Their eyes stay closed for the first two days. Towards the end of their first week they begin to stumble around the box and make attempts to preen themselves with their beaks. In this week they make low calls.

Over their second week (Plate 4.8) the chick become less willing to sit under the adults, producing hissing calls and begins to spend more time moving around the nest. At this age the chicks need more food. By the end of the week the adults leave the chicks alone at times and both adults hunt in order to satisfy the hunger of the growing chicks.

In the third week (Plate 4.9) the chicks are seen with flight feathers beginning to grow and they start to flap wings. During this time they also become more proficient at preening themselves. The 15-20 days old nestling shows cowering behaviour and sink to base of the cage (Plate 4.10 & Figure 4.1).

By fourth week the chicks are grown up almost to adults in weight. They gain strength but remain somewhat clumsy. The leg bands are being put on the chicks for identification. This is usually done during their fourth week, when their legs are fully grown (Plate 4.11).

The chicks become restless and begin to flap wings regularly. The adults no longer feed the chicks (Plate 4.12); instead they drop off carcasses for chicks and let them tear the food themselves. Even if they are hungry the chicks do not fight each other for food, but instead wait for their turn.

The down feathers of the chicks begin falling out on a regular basis (Plate 4.13) and they spend much of their time actively trying to pull it out. The chicks are old enough to take their first flight at this time and spend hours running in the nest ledge and flapping their wings until they can take off.

Fledging: Fledging is the time when the young chicks fledge out of nest and are able to fly independently.

Plate 4.7 Second day of hatching chicks

Plate 4.8 Ten days old Peregrine chicks

Plate 4.9 Twenty days old young ones

Plate 4.10 Four weeks old falcon chicks

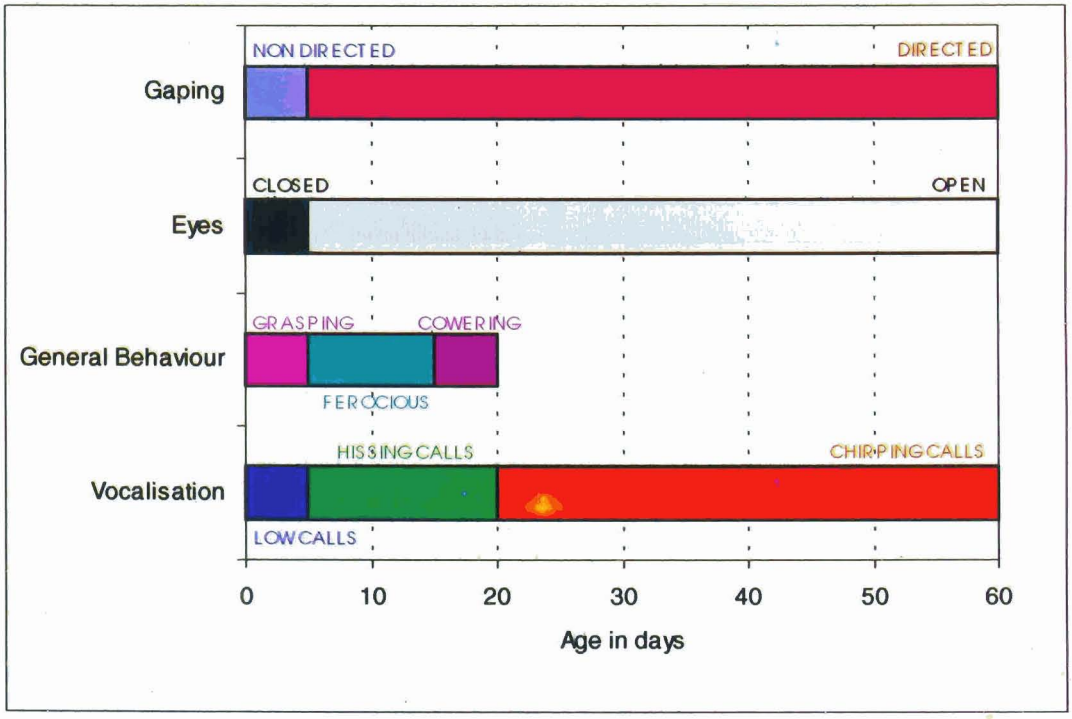


Fig. 4.1 Some milestones in the development of the Peregrine falcons in captivity

There is a great deal of variation in the time at which chicks leave the nest for their first flight. After a month they begin to hunt on their own. All nestlings achieve mature plumage in their first moult.

Table 4.7 Nestling periods in the Peregrine falcons in captivity (2001-2003)

Nestling periods (days) = N	Frequency (f)		Total (Σ f)	N x Σ f
	2001	2002		
12	1	1	2	24
13	1	1	2	26
14	2	2	4	56
15	2	3	5	75
16	3	4	7	112
17	2	2	4	68
18	1	2	3	54
19	2	3	5	95
20	1	1	2	40
21	2	1	3	63
Total	17	20	37	613
Overall mean nestling period = Σ (n. Σf) / Σf = 613 / 37 = 16.6 days				

Generally the offsprings are fledged in 4-8 weeks. On rare occasions they take off as early as 33 days after hatching, while some linger for over 50 days. Majority of chicks leaves between 38 and 45 days. Females stay in the nest longer, for they need long time to develop flight muscles. The average nestling and fledgling periods of the falcons in the study area were 16.6 and 37.1 days respectively (Table 4.7 & 4.8). In the days before fledging the chicks often spend hours looking over the ledge, often parents encouraging them to take off. Some chicks try to fly even before they are strong enough.

4.3.13 Growth and general development of behavior

The chicks open its mouth on the first day itself. When handled immediately after feeding, 1-4 days old chicks eject a thin-covered fecal sac with foul smelling. At the time of fledging, the young weighing 440gms on an average were about 70% of the adult weight (Table 4.9). The young stay with the parents learning to hunt for 1-3 months. By observing the weights of Peregrine, Gyr and Saker falcons the different age levels are recorded (Appendix 4.3). In addition, other related falcons are maintained in UAE, and the weights of Barbary, Luggar and Lanner falcons in relation to different age levels were also appended (Appendix 4.4).

Table 4.8 Fledging periods in the Peregrine falcons in captivity (2001-2003)				
Nestling periods (days) = N	Frequency (f)		Total (Σf)	NΣf
	2001	2002		
34	1	2	3	102
35	4	5	9	315
36	6	3	9	324
37	2	2	4	148
38	3	3	6	228
39	4	1	5	195
40	-	1	1	40
41	2	1	3	123
42	1	1	2	84
43	-	-	-	-
Total	23	19	42	1559
Overall mean fledging period = Σ (N.Σf) / Σf = 1559 / 42 = 37.1 days				

Table 4.9 Weight of the young Peregrine falcons at the time of fledging		
Weight (gm) = x	Frequency (f)	X / f
400 - 490	11	4370/11=440
Overall mean weight on the day of fledging = xf / f = 4370/11 = 440gm		

4.3.14 Food for the young

In captivity, most nestlings died by overfeeding than by any other causes like predation and diseases. The youngs weighing less than 10 grams at hatching, is best left without food for at least twelve hours and sometimes longer if a chick is showing no signs of hunger. Newly hatched chicks that look distended with fluid should be left without food until the stomach is flaccid and soft to touch.

4.3.15 Breeding success

Only about half of the nestling Peregrine falcons fledged (Table 4.10). The others perish due to diseases, starvation or unknown reasons. Details of the breeding success of the Peregrine falcons in the study area are shown in Table 4.11. The average breeding success defined as the percentage of the eggs producing flying ones, was 33%.

Table 4.10 Fate of the nestlings of the Peregrine falcons in captivity				
	2001	2002	Total	%
Number of nestlings fledged	12	10	22	42%
Number died due to diseases	5	17	22	42%
Number died due to starvation	1	-	1	3%
Number died due to unknown reasons	4	3	7	13%
Total number of nestlings	18	24	52	100%

Table 4.11 Breeding success of the Peregrine falcons in captivity			
	2001	2002	Total
Number of cages observed	10	12	22
Number of eggs laid	36	44	80
Number of eggs hatched	18	20	38
Hatching success (%)	50%	45%	48%
Number of youngs fledged	10	10	23
Fledging success (%)	55%	50%	60%
Breeding success (%) *	27%	23%	33%
Number of nests producing at least one flying young	3	4	7
Nest success (%)♦	30%	33%	32%

* - Percentage of eggs producing flying young

♦- A nest is considered to be successful if at least one young survives to the usual time of departure.

4.3.16 Foster Parents and Monitoring

Although falcons rear other chicks, they show concern for the size of the chicks. Some species really need their own kind as parents or fosters. Once youngs are accepted by fosters they are monitored. If a chick becomes sick, it should be removed.

When the chicks are transferred to the foster parents there is possibility for quarreling, so monitoring is necessary to ensure that all are being fed. It is found that Peregrines are given not more than four chicks to care unlike Prairie falcons, which are provided with as many as nine youngs to care.

4.3.17 Natality, Longevity and Mortality

Natality is the reproductive rate of population and is expressed as the number of young produced per unit time. Natality rate of Peregrine falcons was 54% in 2001 & 2002. Falcons are considered to be mature at two years of age, although some breed after they are one year old. Average age of Peregrine falcons is 10-12 years. They lay eggs once a year until throughout their life. Mortality is the death rate of a population and results in decrease in population density. The mortality rate was 7% during the study period (2001-2003).

4.4 Discussion

The falcon breeding in captivity is interesting. Peregrine falcons breed once a year in their life span and live with same mate. The life span of Peregrine falcons is as high as 10-12 years. Captive birds frequently live even longer and there are also records of a few wild falcons, have nested for as many as 17 years (Perrins & Birkeland 1983). Peregrines generally mate for life, but will readily accept a new partner if their mate dies (Newton 1990).

In Peregrines and large falcons males apparently reach sexual maturity on an average, about a year later than females (Cade 1978). In captivity the youngest bird to show sexual maturity and to lay eggs were one year old and the oldest was six years old.

The pre-copulatory displays are self-assertive and male achieves dominance over the female. In flight pens the courtship displays and courtship feeding were seen. The courtship call is produced by male and female replies by courtship display. Courtship feeding by males named as *"production-feeding"* and *"supplementary feeding"* by Newton (1979), which emphasizes the nutritional purpose for females and is supposed to strengthen the bond. This behaviour is observed in captivity also. A number of false mountings are also seen, so that the male's mounting attempt is successful while the female is ovulating (Simmons 1980). In the Herring Gull *Larus argentatus* both partners give begging calls and head-tossing movements (Tinbergen 1953, Klopman 1962).

There are some intrinsic control such as hormonal and extrinsic factors like environmental factors that influence the allocation of time to breeding behaviors, nest attendance and time-activity budgets of Peregrine falcon's breeding (Palmer *et al.* 2001). In successful breeding most important factor is the adequate supply of food for the young (Perrins 1970). The first year mortality of falcons ranges from 60% to over 80%. This can be overcome by captive breeding, habitat improvements, establishing protected areas (D'Aloia *et al.* 2000). High facilities are to be provided for their proper breeding in captivity.

The falcons nest in mid-April through May. The females attend the nest more than males. Both parents incubate and possess paired brood-patches on their breasts, although the male's patches are relatively less developed than females. In most species of birds prior to incubation one or more incubation patches develop on the ventral surface of the body (Nice 1937, Bailey 1952). As per Dementiev (1951) there are three brood-patches, while Cramp and Simmons (1980) reported only a single median brood-patch in falcons. In the present study 2-3 brood patches were seen in both of Peregrine falcons.

Falcons are not making nests, but uses nests made and used by others. They may utilize hawk and eagle tree-nests (Rosenau 1972 & Cade 1982). Some reasons that cause mortality rate in tree-nests are (a) most nests are small and in poor condition leading to ineffective incubation and (b) falls from the nest. Most birds species characteristically lay only one clutch a year since the time remaining in the breeding season, after the young are reared, is not long enough for repeating the nesting cycle. For a few species of large birds whose young develop at an exceptionally slow rate, even one year is not long enough for one nesting cycle. This is the case with the Wandering Albatross *Diomedea exul* and California Condor *Gymnogyps californianus*, which nests every other year (Tickell 1968, Koford 1953 & Stonebous 1960).

Falcons show good parental care. It was reported that Gyr falcons fed their young on the ground after their tree-nest collapsed (Poole & Bromley 1985). Falcons are very aggressive if intruder comes inside the cages. It was observed that the females attended the nest more than males and as the nesting cycle progressed,

female attendance decreased to levels similar to those of males. The parents attended the nest area less during early morning and late evening, which are prime hunting periods. Although females typically performed most of incubation, the division of labour between males and females during incubation differed among pairs.

The female falcons reach their heaviest seasonal weights during the laying period, and then tend to lose some weight but remain relatively heavy through incubation and into the nestling period (Newton 1990). The heaviest weight of female Peregrine falcon during the breeding season was 1150gm. The average incubation period of the eggs of falcons in the study area was 32.6 days. The first two eggs of falcons in the study area hatched after an interval of 2.31 days on an average. Since incubation started with laying of the first egg in Peregrines, the hatching was asynchronous. Ratcliffe (1980) also made such observations.

Ricklefs (1965) suggests that this is of selective advantage to species living in the environments where the food supply between hatching and fledging can be predicted at the time eggs are laid particularly in species with long incubation and fledging periods. During my study the overall mean clutch-size recorded is 3.3, the first two eggs of these hatched after an interval of 2.31 days on an average. Cade *et al.* (1988) reported that the interval between the first two eggs was 3.

The average nestling and fledgling periods of the falcons in the study area were 16.6 and 37.1 days respectively. One problem to be watched for is egg lethargy in falcons. Often they seem to be sick just prior to egg laying. This may lead to the confusion on the real state of the female. So care should be taken to ensure that the egg laying falcons are not suffering from infection or egg binding. A number of such incidences of egg binding were seen during the study period. Bouts of cold weather cause egg binding, particularly in enclosures facing chill winds (Newton 1990).

There are many theories proposed for the evolution of clutch-size. The larger species reach breeding age at 2-3 years and lay 2-6 eggs. Relatively few eggs are

as distinct as the species producing them. Within species there can be remarkable diversity in color (Harrison 1975, 1978). The falcon eggs are brown in colour.

Among all bird species the role of the sexes in incubation is subject to every conceivable variation (Kendeigh 1940, 1952 & Skutch 1957). In no species of birds is incubation periods normally shorter than 11 days; authenticated periods of fewer than 11 days are very rare (Nice 1954, Frith 1962).

Incubation is 28-35 days and offspring are fledged in 4-8 weeks, the youngs stay with parents learning to hunt for 1-3 months. Natural selection favours the falcons which produce clutches and leave the largest numbers of youngs (Lack 1968). Although Lack's theory is generally accepted it has been found that the commonest clutch size was smaller than most productive one (Klomp & Furness 1970, Perrins & Moss 1975).

The greater the characteristic size of a clutch in a species, the greater the variation. Nice (1943) showed that clutch size in the Song Sparrow *Melospiza melodia* is influenced by the age, weather conditions and time of season. Young females may lay smaller clutches during the first season. Cold weather may reduce the size of a clutch (Lack 1990). Smaller clutches may be laid at the end of the season by birds that have laid larger clutches earlier (Howard 1967).

It is observed that in the study area the mean clutch size of the Peregrine falcons was 2.8, which is lower than the most common clutch-size (3). There is no evidence to show that this is the ideal clutch size, although it will be difficult to feed a larger brood, especially in nature, as there is much competition for food. In falcons artificial insemination requires large doses of high-quality spermatozoa and sterilization is needed to maximize fertility (Blanco *et al.* 2002). It is found that immediately and gently washed spermatozoa give better results.

The nestling mortality is notable in falcons. According to Ratcliffe (1993) pesticides such as DDT are likely causes. However, in captivity the roles of pesticides in nestling mortality need to be further ascertained. It is likely that the prey obtained from the market have pesticides residues. Even pharmaceutical

residues may add on to such mortality (Arun and Azeez 2003). Because of pesticides that interfere with calcium metabolism and eggshell formation eggshells are thinned causing hatching problem. Hence, it is suggested that the prey items be scanned for artificial residues prior to feeding the falcons. Prey contaminated by pesticides and destruction of natural habitats in the Lesser Kestrel's breeding range has been suggested as the main factors responsible for decline (del Hoyo *et al.* 1992, Tucker & Heath 1994).

The average breeding success of Peregrine falcons in captivity is 33% in the year 2001-2003. This low percentage is due to the inexperienced flight of chicks leading to death by falling on the ground. The juvenile mortality is probably one of the reasons of declining population in nature. It is important that all remedies to be taken to help the birds survive their first year. During the present study only about half of the nestling Peregrine falcons fledged successfully while the rest died due to diseases, starvation or some unknown reasons.

Although females are larger than males, it is difficult to identify their sex by reversed size dimorphism due to large weight, and also the weight of most falcons appears to be midrange. Breeders are known to use sex by karyotypes and laproscopy. Molecular DNA-based technique is a more reliable alternative. According to D'Aloia & Marie-Ann (2000) DNA genetic fingerprinting is also the most conclusive way for breeders and law enforcers to prove parentage of birds. Proper sexing helps aviculturists, avian veterinarians, poultry scientists, ecologists and diagnosticians to understand sex differences in developmental rates and susceptibility to diseases (Cortes *et al.* 1999).

4.5 Summary and Conclusion

Peregrine falcons reach breeding age at 2-3 years old and live paired for life. The courtship behaviour is rarely observed in cages while they are seen in pens and larger enclosures. The male produces courtship calls and female replies with a display, followed by courtship feeding by male.

Artificial insemination is commonly done in captive falcons. Sometimes the insemination may not be fully successful due to the contamination of the semen. In falcons the egg length and breadth are minimum in first breeding and slightly higher till middle age of the mother birds. The size then decreases gradually over the years.

Generally in a clutch 2-6 eggs are laid. Incubation period is 28-35 days and offspring fledge in 4-8 weeks. The youngs stay with parents for 1-3 months learning to hunt. The average breeding success of Peregrine falcons in the study area was 33%.

CHAPTER 5

PTERYLOSIS, PLUMAGE AND MOULTING

5.1 Introduction

The study of pterylography is useful in taxonomic investigations. By comparing the pterylosis of apparently similar species it is often possible to determine whether or not a close relationship exists. The works by Compton (1938), Berger (1960) Ames *et al.* (1968) and Heyman and Morlion (1980) illustrate how the pterylography can be applied to taxonomy. One of the earliest pterylographic studies was on House Sparrow *Passer domesticus* (Clench 1970, Humphrey and Clark 1961, Lucas and Settenheim 1972, Morlion and Vanparjis 1979 and Wetherbee 1957), they suggested "the pterylosis of the House Sparrow must not be considered the standard or typical pattern for all birds, as there is no typical pattern. If possible, study and compare the pterylosis of several widely different species of birds, adult as well as natal forms".

The plumage distinctions of different falcon species ie, Peregrine, Saker and Gyr are given by Ali (1953). The various age groups of falcons can be recognized based on their plumage. The study of plumage and moult can be used as a method to identify the different ages of falcons. The moulting of falcons is a sequential orderly system, which permits a few of the major flight feathers to be shed at a time. Moulting and breeding, both highly energy consuming processes, occur simultaneously. Whittow (1984) stated that the replacement of feathers consumes a great deal of energy in a variety of different ways.

The feathers of falcons moults once a year and overlaps the breeding season. There is considerable change in the plumage from immature to adults. The juvenile and adult plumages are different. The immature plumage is replaced by adult plumage after one year.

Usually the process of moulting of falcons lasts for 5-7 months. In American Kestrels females begin their moult during incubation and complete it by the end of the breeding season. Males, who are responsible for capturing most of the prey for the family, do not begin their moult until near the end of the breeding season (Smallwood 1988). Because of their late moult, males migrate and arrive at the wintering grounds later than females or immatures (Smallwood 1988).

The study has been taken as an essential prerequisite to follow the sequence of moult and also to get knowledge of pterylographic pattern. The observations of pterylography, plumage and moulting were carried out for about three seasons during 2001-2003 at various falcon hospitals and falcon breeding centres throughout UAE. The important objectives of the study are following:

- To know the relative lengths of different flight and contour feathers
- To document pterylosis in the nestlings and adults of Peregrine falcons,
- To document pterylosis and plumage patterns in different stages of development in Peregrine, Saker and Gyr falcons and
- To study the moulting sequences of Peregrine, Saker and Gyr falcons.

5.2 Methodology

Pterylosis: Methodology of studying pterylography is the one adopted by Naik (1965). One adult Peregrine falcon was used for studying pterylographic pattern of adult and one Peregrine nestling was examined for studying pterylographic pattern of nestling. The feathers of the adult preserved Peregrine falcon were examined for moulting and the pattern of follicle arrangements was observed.

The formalin-preserved specimen was washed thoroughly in water for many hours and dried. The number and lengths of principal feathers of the wing 1-12 of the wing and tail 1-6 were noted. The wings were stretched well to study the upper and under surface and to count the feathers. The feathers were then clipped close to their bases

to determine and confirm the number of feathers in each row. The feathers of body tracts were also similarly clipped close to their bases. They were counted and the distribution of feathers in each tract studied.

Plumage: Description of plumage was based on 10 nestlings, 12 fledglings and 20 adult Peregrine, Saker and Gyr falcons each. The information of plumage in different age groups of falcons is documented by making observations during 2001-2003.

The plumage development was closely followed to maximum possible period through their fledgling, juvenile, one-year-old and adults. Colour rings were put on individuals for recognition. All types of feathers were measured. The relative length of primary, secondary and retrices are methodically obtained by computing the mean length of 10 numbers of each type of feathers.

Moulting: Moulting in falcons was studied by recording by individual primaries, secondaries and tail feathers of 40 birds of Peregrine, 20 each of Saker and Gyr falcons by noting sequence of moulting in captivity at Abu Dhabi Falcon Research Hospital. In captivity the moult of the fledglings, juveniles and adults were documented by regular observations on ringed falcons during moulting season in 2001-2003.

The feathers are measured from the base of the quill to its tip. The covert flight feathers are measured from the point of emergence to its tip and the body feathers from level of the skin surface to the tip of feathers. Of the 25 Peregrine nestlings ringed for individual identification (2001, 2002 & 2003), 6 were followed through the first annual moult and one through the second and third annual moult. Following the scoring system adopted by Miller (1928) each flight feather is given a score in the following order. Old feather = 0, feather missing or in small pin stage = 1, feather in large pin or brush stage = 2, feather brush to half-grown = 3, feather half to three-quarters grown = 4, feather three quarters to full-grown = 5.

5.3 Results

5.3.1 Pterylosis

The arrangement and distribution of feathers in feather tracts is meant here as pterylosis (Pettingill 1985). Pterylosis of the young Peregrine falcon differs in some pterylae from that of the adults. Pterylographic result shows that the body tracts are capital, spinal, humeral and femoral tracts on the dorsal side and ventral tract on ventral side in nestlings and adults. In nestlings the dorsal region is connected at interior end to interscapular region, continued at posterior end as the pelvic region consisting of two bands of feathers enclosing the pelvic apterium. In nestlings the femoral tract is not developed as in adults. On each side of the nestlings alar tract consists of 10 primaries and 12 secondaries. It is noticed that there are 6 pairs of shorter retrices at caudal tract.

Some differences are observed in the pterylae of adult falcons and youngs. In adult Peregrine falcon the capital tract is divisible into frontal, coronal and occipital regions and feathers of these tracts are arranged in transverse rows. The cervical region of adult resembles in shape as an inverted pyramid. The spinal tract extends from the pineal gland upto the upper tail covert and bounded by a series of apteria, lateral cervical, intrascapular and pelvic. The ventral tract of adult is divided into inter-ramal, sub-malar, cervical, sternal, accillar and abdominal regions and extends from the base of the bill to the cloaca.

In ventral tract at anterior region there are 2-3 pairs of feathers, 4-5 pairs in central region, 7-8 pairs posterior to thoracic apteria and 2 pairs at posterior region. Humeral tract is connected with alar tract and dorsal tract. The femoral tract is separated from spinal and crural tract. The crural tract is separated from femoral tract by femoral apterium. The caudal tract consists the tail feathers and anal circlet.

a. Pterylosis of the nestling

The following description of pterylosis is based on a single specimen of 10 days old nestling of Peregrine falcon (Figure 5.1 & 5.2).

Capital tract: The capital tract of the nestling covers the upper half of the head from the base of the bill posteriorly to the base of the skull where it is continued as the spinal tract.

Spinal tract: The spinal tract consisted of cervical, interscapular, dorsal and pelvic regions. Cervical region consisted of eight transverse rows, each four pairs of feathers, arranged in the form of an inverted cone. Interscapular region consists of a triangular shaped band of feathers. There is a large apterium separating the interscapular region from the cervical region. The dorsal region consists of two bands of feathers enclosing a dorsal apterium, which continued posteriorly as the pelvic apterium. At the anterior end the dorsal region is connected to interscapular region and at posterior end they continued as pelvic region consisting of two bands of feathers enclosing the pelvic apterium. The two bands of the pelvic region joined posteriorly to form a single band at that end just at base of pineal gland. An apterium separates pelvic region from crural tract on each side.

Ventral tract: The ventral tract of the young consists of the inter-ramal, submalar, ventral cervical, sternal and abdominal regions. Axillar region is lacking. The ventral cervical region consists of six rows of feathers. The outline of the sternal region resembles a parallelogram. It has five oblique rows of feathers on sides separated by a large sternal apterium.

Humeral and crural tracts: The humeral and crural tracts of the nestling are similar to those of the adult. The crural tract is not developed on the ventral side and the humeral tract is only two-feather thick in nestlings.

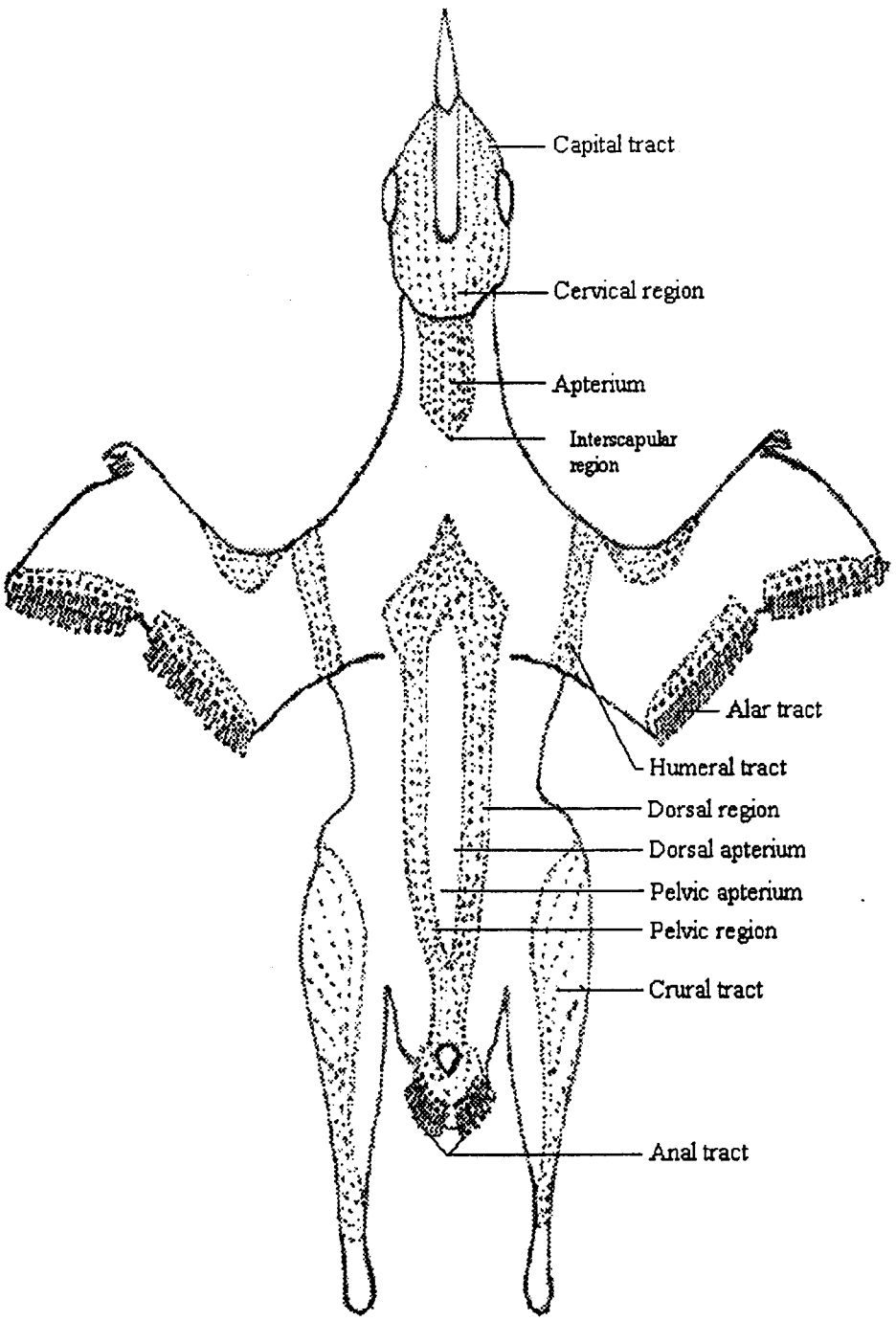


Fig. 5.1 Pterylosis of a nestling of Peregrine falcon (dorsal view)

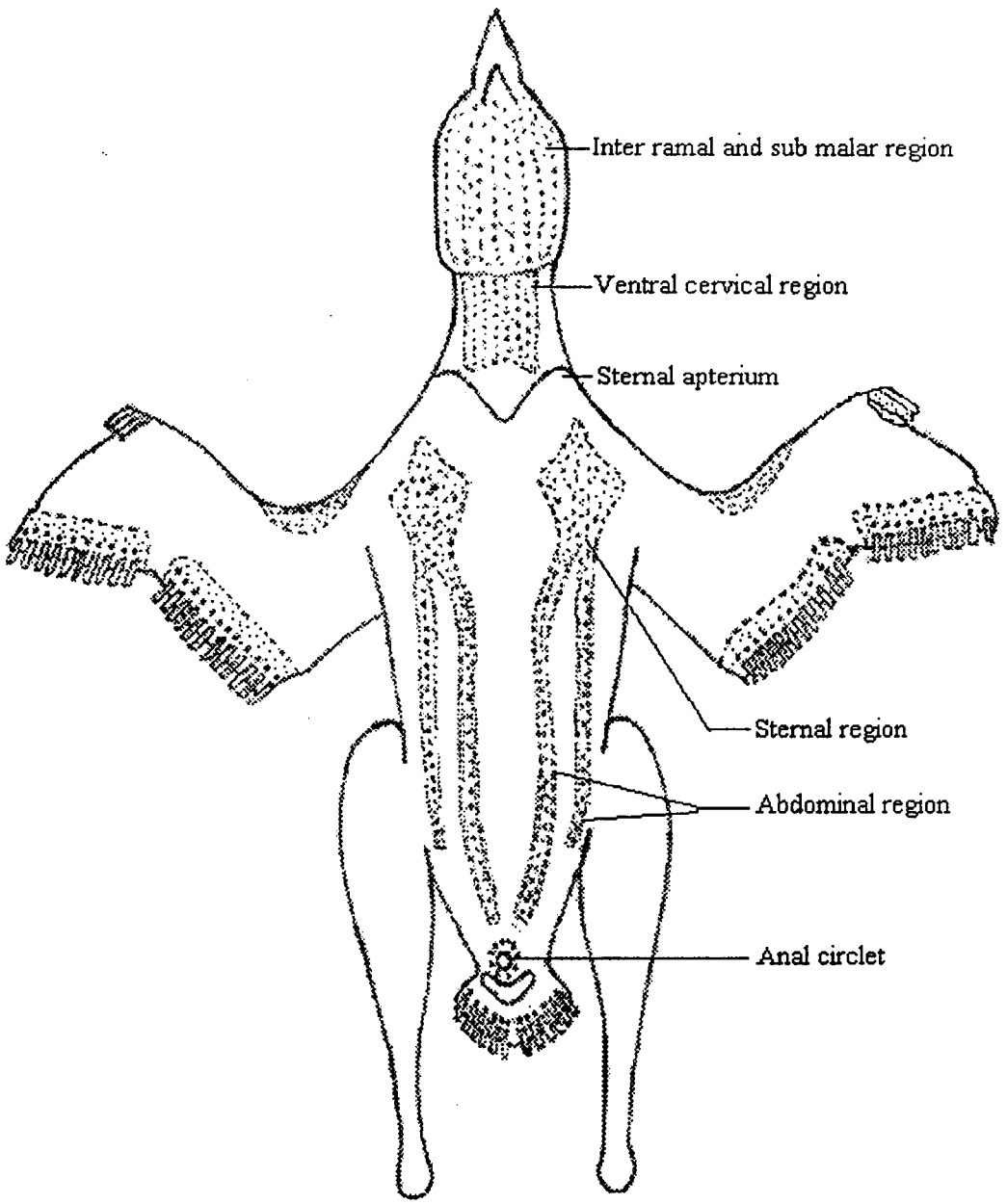


Fig. 5.2 Pterylosis of a nestling of Peregrine falcon (ventral view)

Femoral tract: The femoral tract is not developed in the young. The abdominal region consists of two longitudinal rows on either side united at the anterior end. The inner rows were longer and terminated a little distance in front of the anal circlet.

Alar tract: The alar tract on each side consists of 10 primaries, 12 secondaries, one row each of the major upper primary coverts, major and median under secondary coverts and fewer under and upper marginal coverts. Alular feathers are four in number.

Caudal tract: The caudal tract of the nestling consists of six pairs of retrices which are comparatively shorter, two rows are of each upper and lower tail coverts and a single row of anal circlet.

b. Pterylosis of the adult

This description of pterylosis is based on a single specimen of an adult falcon (Figure 5.3 & 5.4). The pterylosis of adult falcons differs in some pterylae from that of the youngs. The body tracts are the capital, humeral, spinal and femoral tracts on dorsal side and ventral tract on ventral side.

Capital tract: The capital tract covers the upper half of the head from the base of the bill. It is divisible into frontal, coronal and occipital regions. The frontal region towards the external nares, covers the lateral sides of the maxilla and encloses a frontal apterium which is a featherless area at the base of the upper mandible behind the posterior end are stiff and small. Feathers of the capital tract are arranged in transverse rows.

Spinal tract: The spinal tract extends at pineal gland and upper tail coverts. Laterally it is bounded by a series of apteria, the lateral cervical, the intrascapular and the pelvic. The cervical region resembles in shape as an inverted pyramid. It is bounded laterally by the lateral cervical apterium.

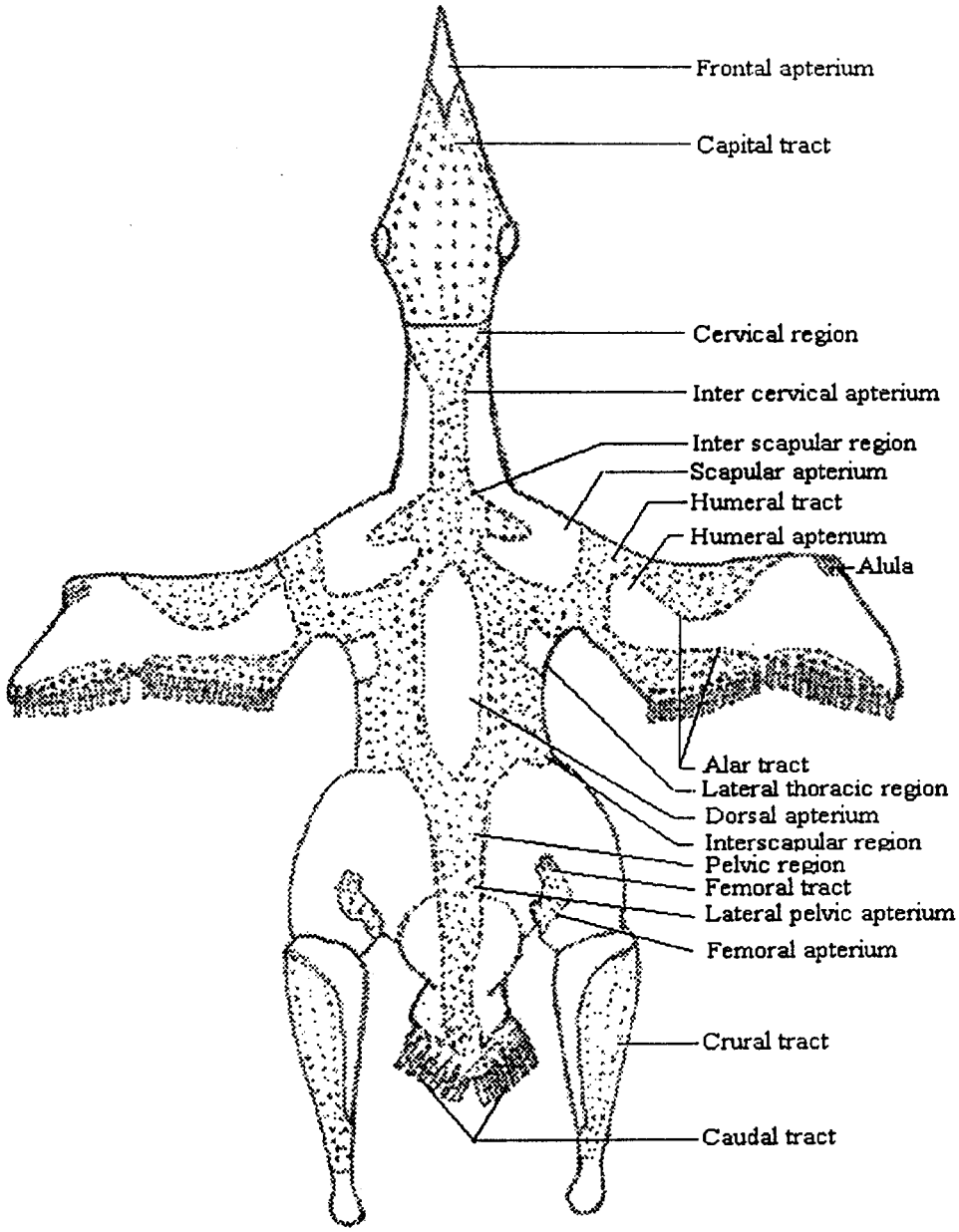


Fig. 5.3 Pterylosis of an adult Peregrine falcon (dorsal view)

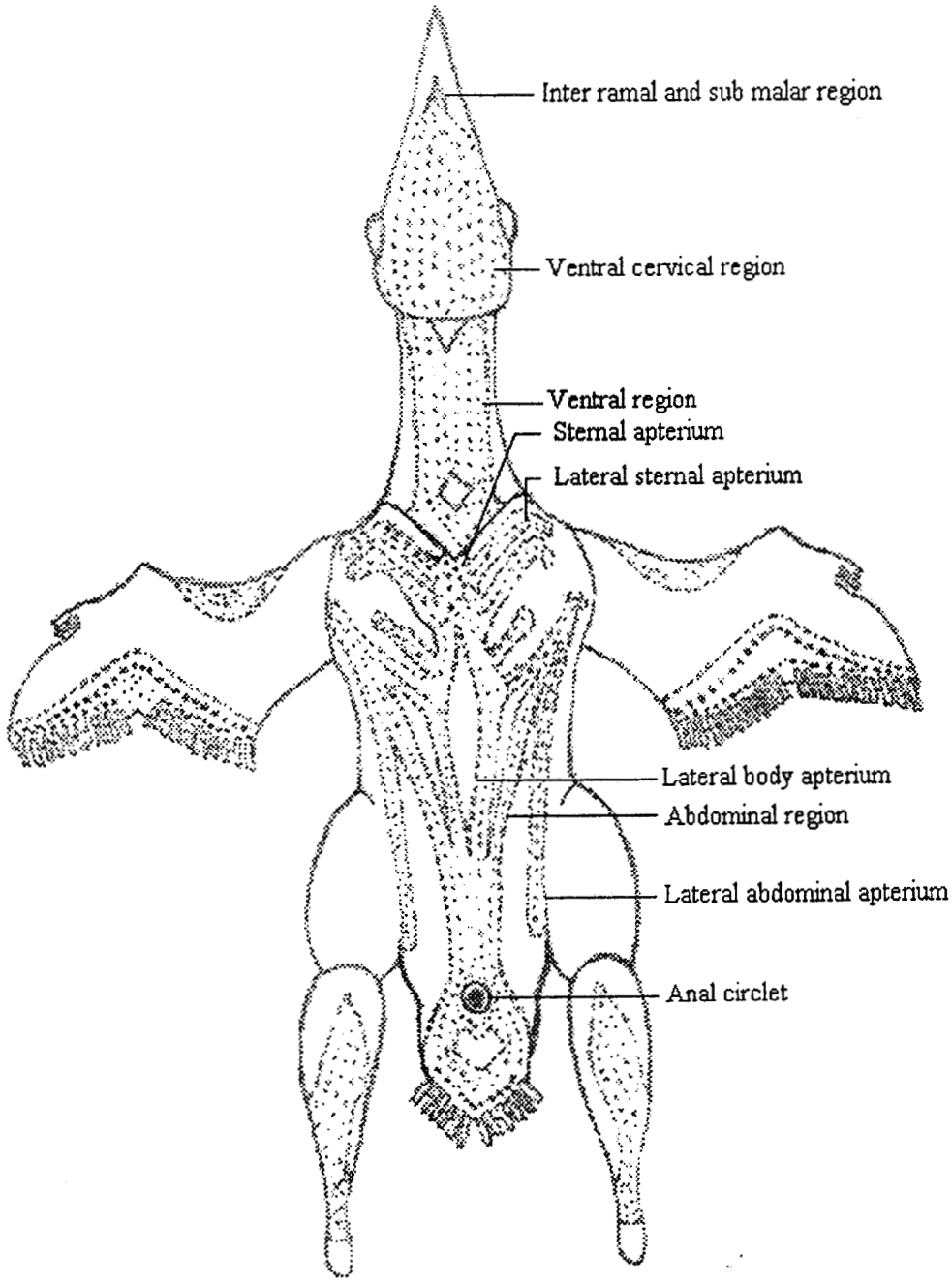


Fig. 5.4 Pterylosis of an adult Peregrine falcon (ventral view)

The intrascapular region is shield-like in outline with a tapering anterior end consisting of a pair of feathers, a broader centre of five to eight pair of feathers and a median posterior end consisting of two to three pairs of feathers. It is bounded laterally by the scapular apterium, which is a continuation of lateral cervical apterium. The dorsal region occupies central position in spinal tract, has a shield-like outline and encloses a central apterium.

Ventral tract: The ventral tract of the adult falcon consists of the feathers of the under parts exclusive of the humeral and femoral tracts. It extends from the base of the bill to the cloaca and it is divided into inter-ramal, submalar, cervical, sternal, axillar and abdominal regions. It extends from the intrascapular to the pelvic regions and is bounded in its antero-lateral sides by lateral thoracic apteria.

There are 2-3 pairs of feathers on the anterior regions, 4-5 pairs in central region adjacent to lateral thoracic apteria, 7-8 pairs posterior to it and 2 pairs at its posterior most region. Extended, as an elongated longitudinal band posterior to dorsal region is the pelvic region. It consists two pairs of feathers except at the posterior region where there is only one pair. Feathers of the pelvic region are arranged like an arrowhead.

On the dorsal side of the wing there is a row of upper major primary and upper minor primary coverts and 4-6 rows of upper marginal coverts. The ventral cervical region is bounded at lateral sides by lateral cervical apteria and at its posterior end by central cervical apterium. The sternal region is bounded at its anterior end by ventral cervical apterium, its lateral sides by lateral sternal apteria and its mid-posterior side by the sternal apterium.

Each lateral sternal apterium has 3 finger like extensions inward and encloses 4 pairs of feather rows. The sternal region is continued latero-posteriorly as the axillar region consisting of 1-2 rows of feathers on either side. The abdominal region consists of 3 pairs of longitudinal bands of feather rows enclosing of a total 5-apterial coverts,

median primary coverts, major secondary coverts, median secondary coverts and 1 or 2 rows of marginal coverts.

Humeral tract: This tract is a narrow band of 2-3 rows of feathers beginning at shoulder and extending across dorsal surface of the wing to elbow. It is connected at sides anteriorly and posteriorly with alar tract and on inner posterior ends with dorsal tract, separated from alar tract by scapular apterium.

Femoral tract: The femoral tract is separated from the spinal tract by the lateral pelvic apterium and from the crural tract by the femoral apterium

Crural tract: The crural tract consists of a few rows of feathers covering the lateral, medial, anterior and posterior surfaces of the shank. They are a single midventral abdominal apterium, a pair of median abdominal apteria, and a pair of lateral abdominal apteria. The abdominal apterium is a continuation of the sternal apterium and is bounded by lateral body apteria and by femoral apteria. The middle and inner rows of feather regions of both sides join with the anal circlet.

Alar tract: The alar tract consists of the remiges and their coverts and the alula. Each wing has four alular feathers.

Caudal tract: The caudal tract consists of feathers of the tail and their coverts, and anal circlet. The dorsal tail coverts consist of a single row of 6 pairs of coverts on dorsal side of the tail. The under tail coverts consist of 6 pairs of coverts, under major coverts, 2 pairs each of median and minor coverts. The anal circlet consists of a circular row of coverts around the cloaca.

5.3.2 Plumage

Observations on plumage of falcons show differences in the plumage between the different age groups. Based on the plumage falcons can be differentiated whether it is mature or immature. Raptors have a dark phase and a pale phase with an intermediate

one in their plumage like many other birds. During the studies it was observed that the pairing of various species of falcons were more or less neutral to plumage colouration in captivity. In Peregrine, Saker and Gyr falcons there are 10 primaries (P1-P10) numbered from the outer (distal) end to the inner (proximal). Secondaries were 12 pairs (S1-S12) and retrices were 6 pairs (T1-T6), both numbered in the same sequence as primaries (Plate 5.1).

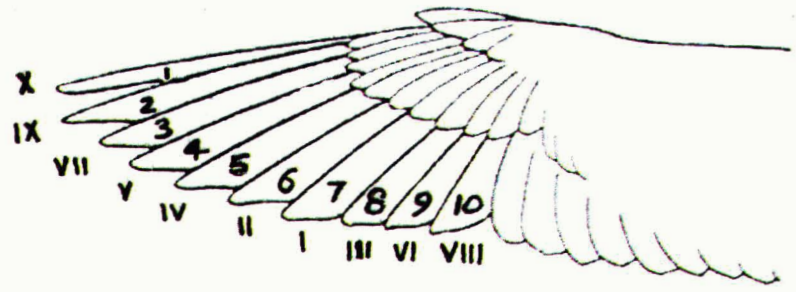
The stray feathers that are located between two primaries and small in size, in Saker and Peregrine falcon are seen, but rarely. This reported to affect the normal flight of the falcons. While hunting the chances of breaking feathers are high that may decrease flight efficiency. To mend this handicap imping (gluing an exact feather taken from another bird) is resorted to.

In Peregrine falcons second primary is comparatively longer than first and third. The average lengths of the primaries varied between 145 and 249 mm. The primaries 6, 7, 8, 9 and 10 had mean lengths below 200 mm while the others were longer. The second secondary is the longest having a mean length of 144 mm and the mean lengths ranged between 106 and 144 mm. There are 6 pairs of tail feathers T1-T6 from outside. The mean lengths of retrices ranged from 186 and 207 mm. The 5^{th} and 6^{th} tail feathers have the same length (Appendices 5.1 to 5.3). A comparison of the primary, secondary and tail feathers of three falcon species is shown in the Figures 5.6 to 5.8 & Appendices 5.1 to 5.9).

In the case of all the feathers the order with respect to the lengths were Peregrine < Saker < Gyr, corresponding to their weight and size. The plumage peculiarities of different species of falcons, i.e. Peregrine, Saker and Gyr in juvenile and adult stages are described below.

Plate 5.1 Falcon has 10 primaries, 12 secondaries and 6 tail feathers in the wings

Peregrine Falcon



Saker Falcon

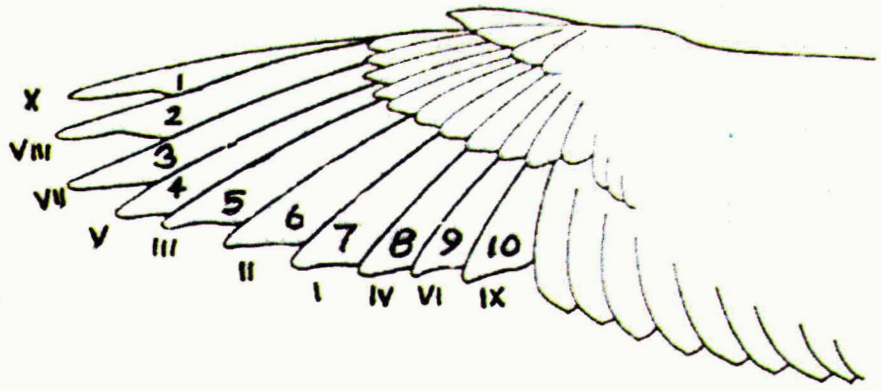


Fig. 5.5 The moulting sequence of primary feathers of Peregrine falcon and Saker falcon

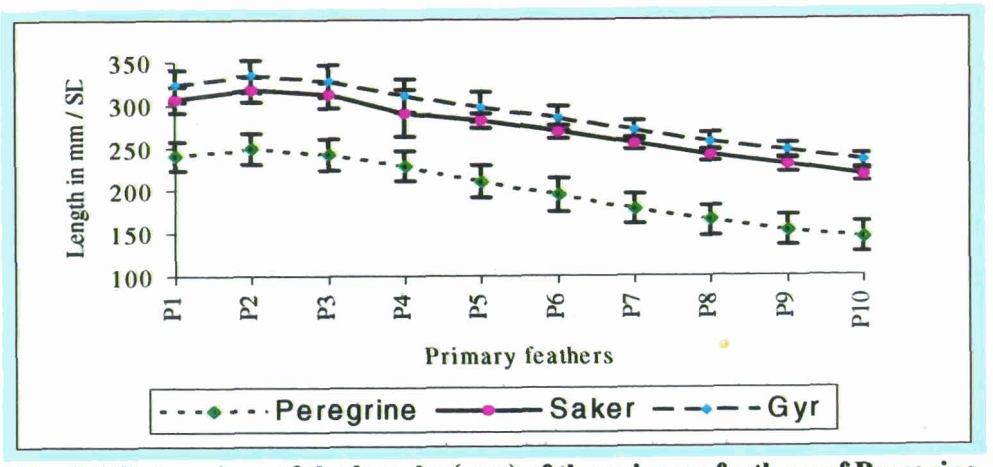


Fig. 5.6 Comparison of the lengths (mm) of the primary feathers of Peregrine, Saker and Gyr falcons (2001-2003); Error bars indicate standard deviation

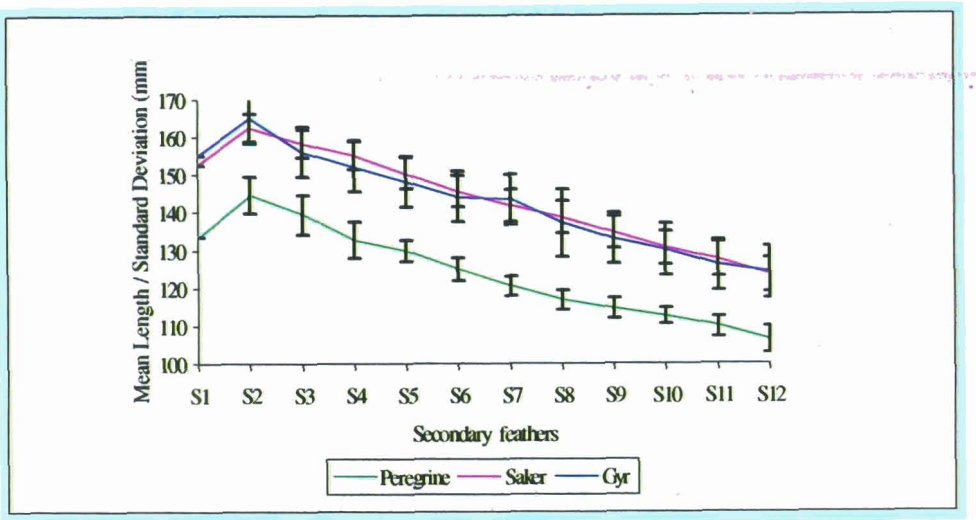


Fig. 5.7 Comparison of the lengths (mm) of the secondary feathers of Peregrine, Saker and Gyr falcons in the study area (2001-2003); Error bars indicate standard deviation

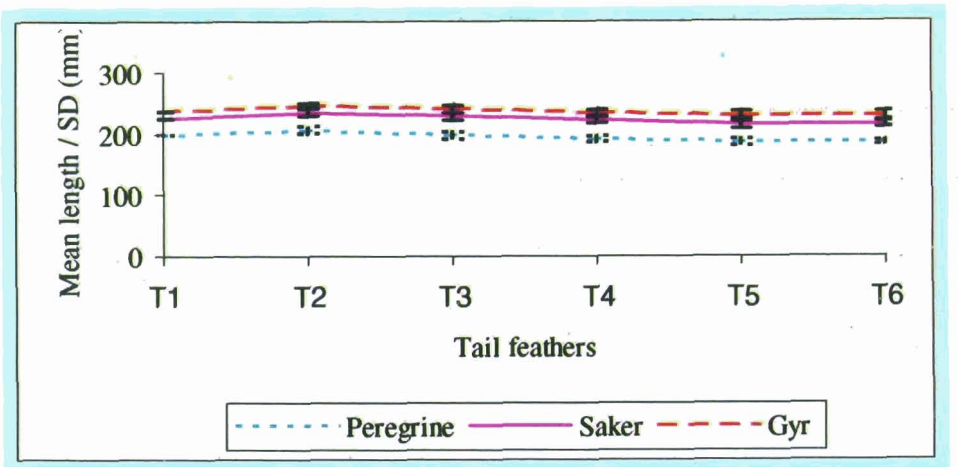


Fig. 5.8 Comparison of the lengths (mm) of the tail feathers of Peregrine, Saker and Gyr falcons in the study area (2001-2002); Error bars indicate standard deviation

Juveniles of Peregrine falcon are characterized by brownish upper parts and streaked under parts and shorter wings and long tail than adults and hence more similar to other large falcons. Adults are grayish above and white with dark underneath.

Sparsely spotted breast, more distinctly barred secondaries below and more sparsely patterned underwing covers are typical of adult Saker falcons. Juveniles are darker and more heavily marked on breast and have darker underwing covers and plainer grey secondaries below.

Gyr Juveniles are brownish-grey above with fine creamy tips and tail shows creamy bars. The under parts are streaked with bolder markings on flanks. Adults are grey above with dark barring and under body are spotted on mid-breast but yellow barred on flanks. White plumaged Gyr falcons are found to get more tired than black Gyr falcons.

5.3.3 Moulting

Birds moult periodically ie. shed the feathers and renew their plumage. Almost all fully adult birds renew their feathers at least by the postnuptial moult, and many birds renew twice a year by the additional prenuptial moult (Pettingill 1985). Every species normally exhibits a definite sequence of plumages and molts. The sequence of plumages and molts in each species proceeds in a relatively consistent manner, so consistent that the successive plumages and intervening molts can be identified and named.

In falcons primary moult, secondary moult and moult of retrices occur simultaneously. There is an overlap between the moult and breeding. The last month of the breeding seasons was the month of maximum moulting. It appears moulting takes a quick completion towards the last stages of breeding when food is abundant and photoperiod maximum. The falcon species appear to moult once annually, from April to October especially in Saker, Gyr and hybrids but it is delayed in Peregrines. Moult of feathers of various body tracts is shown in Table 5.1 and Appendices 5.10 &

5.11). The monthly distribution of the number of Peregrine falcons showing moult of primaries, secondaries and tail feathers are shown in Table 5.2. The moulting sequence of Peregrine, Saker and Gyr falcons are shown below.

Table 5.1 Month wise distribution of the number of moulting feathers of Peregrine falcons (N=40)

Month	J	F	M	A	M	J	J	A	S	O	N	D	Total
Sampled numbers	1	1	0	0	0	0	5	6	7	6	7	7	40
No. of moulting body feathers	1	-	0	0	0	0	4	5	6	5	6	5	32
Capital tract	-	-	-	-	2	3	4	2	1	2	1	-	15
Spinal tract													
Cervical region	1	-	-	-	-	1	2	3	4	1	-	-	12
Interscapular region	-	-	-	-	-	-	3	2	4	5	-	-	14
Dorsal region	1	-	-	-	2	1	1	-	1	2	1	1	10
Pelvic region	-	-	-	-	-	1	-	3	4	5	-	-	13
Humeral tract	1	-	-	-	3	4	3	2	3	3	-	-	19
Femoral tract	-	-	-	-	2	2	4	-	5	3	-	-	16
Crural tract	1	-	-	-	-	2	3	1	3	4	-	-	14
Ventral tract													
Inter-ramal and submalar	1	-	-	-	1	1	-	-	1	2	-	-	6
Cervical	-	-	-	-	-	-	3	2	-	4	-	-	9
Rest of ventral	-	-	-	-	3	1	4	3	2	1	-	-	14
Alar tract													
Greater wing covert	-	-	-	-	4	4	1	2	3	2	-	-	16
Middle wing covert	1	-	-	-	-	-	1	1	2	-	-	-	5
Lesser wing covert	-	-	-	-	1	1	1	4	3	-	-	-	10
Under wing covert	-	-	-	-	2	2	-	1	-	1	-	-	6
Alula	-	-	-	-	-	-	1	-	1	-	-	-	2
Caudal tract													
Upper tail covert	1	-	-	-	1	1	2	3	3	2	-	-	13
Under tail covert	1	-	-	-	-	-	1	3	1	3	-	-	9
Anal circlet	-	-	-	-	1	1	-	1	-	1	-	-	4

Peregrine falcon: In Peregrines generally the moulting starts in May-June months and completed by November-December when photoperiod is minimum in which the primary feather take 128-185 days to complete moulting. The moulting begins early in females during egg-laying or incubation period, but it is late in males. In juveniles moulting starts with body plumage as early as late winter, beginning with rump, mantle and scapulars. Moult of remiges starts earlier than in adults and is completed by early autumn.

Saker falcon: The annual moulting completes in Saker falcons between April and September. In juveniles a partial body moult begins during winter during which feathers of head, neck, upper breast and mantle are moulted to a variable extent. In adult Saker females the moult begins from early April to May during egg laying and is completed during late September to October. It was found that although adult males begin to moult a month later than females they complete the moulting almost at the same time. It is observed that captive birds complete their primary feather moult in 110-128 days.

Table 5.2 Monthly moult of primaries, secondaries and retrices of the Peregrine falcons (N=40)

Month	J	F	M	A	M	J	J	A	S	O	N	D	Total
No. sampled	1	-	-	3	5	5	4	5	6	4	5	2	40
Primaries													
No. of moulting primaries	1			3	5	5	4	5	6	4	5	2	40
No. moulting													
P1	1	-	-	-	-	-	-	-	-	-	-	-	1
P2	-	-	-	-	-	-	-	-	-	-	-	2	2
P3	-	-	-	-	-	-	-	-	-	4		-	4
P4	-	-	-	-	-	-	-	-	6	-	-	-	6
P5	-	-	-	-	-	-	-	5	-	-	-	-	5
P6	-	-	-	-	-	5	-	-	-	-	-	-	5
P7	-	-	-	-	5	-	-	-	-	-	-	-	5
P8	-	-	-	-	-	-	4	-	-	-	-	-	4
P9	-	-	-	-	-	-	-	-	-	4	-	-	4
P10	-	-	-	-	-	-	-	-	-	-	5	2	7
Secondaries													
No. moulting secondaries	1	-	-	3	5	5	4	5	6	4	5	2	40
No. moulting													
S1	-	-	-	-	-	-	-	-	-	-	5	-	5
S2	-	-	-	-	-	-	-	-	-	-	-	2	2
S3	-	-	-	-	-	-	-	-	-	4	-	-	4
S4	-	-	-	-	-	-		5	-	-	-	-	5
S5	-	-	-	-	-	-	4	-	-	-	-	-	4
S6	-	-	-	-		3	-	-	-	-	-	-	3
S7	-	-	-	-	3	-	-	-	-	-	-	-	3
S8	-	-	-	-	-	2	-	-	-	-	-	-	2
S9	-	-	-	-	-	-	-	-	6	-	-	-	6
S10	-	-	-	-	-	-	-	-	-	-	4	-	4
S11	-	-	-	-	-	-	-	-	-	-	3	-	3
S12	-	-	-	-	-	-	-	-	-	3		-	3
Retrices													
No. moulting retrices	1	-	-	3	5	5	4	5	6	4	5	2	40
No. moulting													
T1	-	-	-	-	-	-	-	-	-	6	-	-	6
T2	-	-	-	-	-	-	-	-	5	-	-	-	5
T3	-	-	-	-	-	-	-	4	-	-	-	-	4
T4	-	-	-	-	-	5	-	-	-	-	-	-	5
T5	-	-	-	-	3	-	-	-	-	-	-	-	3
T6	-	-	-	-	-	-	5	-	-	-	-	-	5

Gyr falcon: Similar to the above two species in Gyr falcons also moulting is completed during breeding season. In juveniles partial body moult start during the first winter with new feathers appearing on mantle, scapulars and rump.

Table 5.3 The correlation matrix of lengths of primary feathers of Peregrine falcon in moulting

	I	II	III	IV	V	VI	VII	VIII	IX	X
I	1									
II	0.98817	1								
III	0.95290	0.97619	1							
IV	0.94353	0.97273	0.98775	1						
V	0.90247	0.93426	0.91166	0.93454	1					
VI	0.90024	0.93173	0.91057	0.92912	0.98162	1				
VII	0.85446	0.89571	0.89663	0.91107	0.94162	0.97178	1			
VIII	0.81427	0.84854	0.84113	0.85720	0.90744	0.94529	0.97984	1		
IX	0.76231	0.78308	0.77229	0.78494	0.84928	0.89822	0.94396	0.97946	1	
X	0.75499	0.77824	0.77654	0.78525	0.86087	0.89919	0.91732	0.92636	0.93452	1

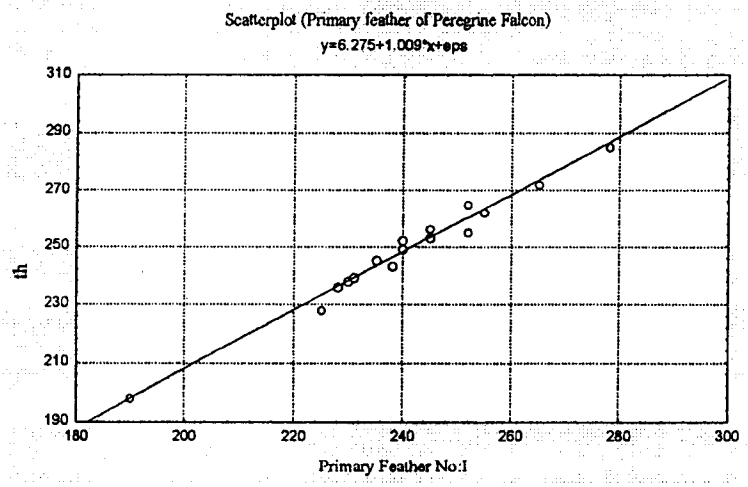


Fig. 5.9 Correlation between mean length of Primary feathers No. I & II of Peregrines

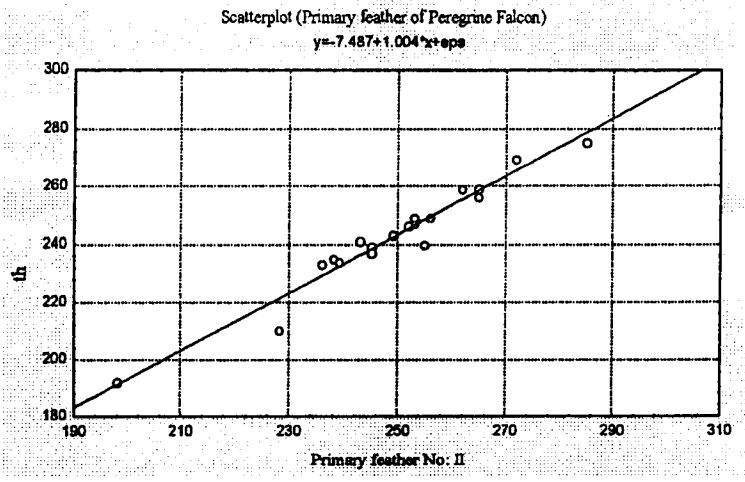


Fig. 5.10 Correlation between mean length of Primary feathers No. II & III of Peregrine falcons

The moult is completed earlier than adults. Adult females start to moult in April-May during egg laying or incubation period and the primary moult of females is completed in 115-135 days. Moulting in males happens later than females. The pattern of association between I and II is almost same as that of II and III. Hence there does not exist any association between sequence of moulting and length of primary feathers of falcons. But no significant correlation could be found between the primary feather length and the sequences of molting. No notable correlation could be found between the intermittent feathers in terms of their length, although most of them molt simultaneously, shown in Table 5.3 and Fig. 5.10 & 5.11.

5.4 Discussion

Pterylosis of the young and adult Peregrine were studied and various tracts were identified. Differences are observed in the pterylae of adult falcons and youngs. In adult Peregrine falcon the capital tract is divisible into frontal, coronal and occipital regions and feathers of these tracts are arranged in transverse rows. On each side of the nestlings alar tract consists of 10 primaries and 12 secondaries. It is noticed that there are 6 pairs of shorter retrices at caudal tract.

With the help of the pterylographic studies we can follow a series of plumages of birds of known ages, which, in turn enables researcher to develop keys for aging wild-caught specimens by plumage characters. Ultimately, the Pterylographic procedure enables researcher to ascertain the age composition of a population at certain times of the year (Aldrich 1956, Mewaldt 1958, Holmes 1966, Foster 1967 and Ohmart 1967).

Falcons have different plumages in juvenile and adult periods. In addition to normal plumages the birds of prey and some other birds frequently have a dark phase and pale phase with an intermediate one (Ali & Ripley 1983). Unlike large falcons American Kestrel is sexually dichromatic and its dorsal barring in juvenile males has been used as a sexual aging criteria (Smalwood *et al.* 1999). Both body size in males and dorsal barring increases with increasing north and south latitudes. On theoretical

grounds it was conjectured by Stoutjesdijk (2002) that birds with white plumage might experience higher heat load than the black birds. The observation made during the present study that white Gyr falcons get more tired than black ones of equal weight also suggest such a hypothesis. However since white reflects higher proportion of radiation than black this hypothesis, which appears contrary, needs further investigation. Moreover Wolf and Walsberg (2000) also suggest that darker colour absorb more radiation, a hypothesis contrary to what is referred earlier.

It was noticed that when white Gyr falcons came after flight, they had higher body heat than black Gyr falcons. Matics *et al.* (2002) reported a study during 1998-2000 of 64 breeding birds of Barn Owl in Hungary for plumage coloration. No relationship between the colour morphs of partners was found. It was observed in the present study that the plumage colouration was more or less independent of pairing.

Humphrey and Parkes (1959) name the molt from the incoming plumage and confine the word "plumage" to a single generation of feathers acquired by a specific moult. They also suggest a useful term, definitive for any plumage that will not change further with age. Thus, the plumage of the Bald Eagle *Haliaeetus leucocephalus* is definitive when, after four or more years, the head and tail feathers, are completely white (Humphrey & Clark 1963).

In albino falcons melanin pigments are completely absent. Albinism in falcons may have a genetic basis and be inherited. In the three species under the study albinism appears in one-year-old individuals. This may be genetic and environmental. About 50% of Gyr falcons turn white in one year. This pigment loss also need further study. It may also be spontaneous, developing in an individual as a result of some physiological disturbance. Frazier (1952) reported that of an American Robin *Turdus miigratorius* with normal plumage when banded turned partially albinistic when recovered two years later.

The colour of secondary feathers of falcons especially Shaheen and Gyr will change after two years of age, but the primaries will be remaining as before. Juvenile Peregrines are much similar to other large falcons because of shorter wings and long tail than adults. The adult Saker has spotted breast, but in its juveniles the breast plumage is heavily marked. The adult Gyr falcons are grey above, but juveniles are brownish-grey. Turcek (1966) found that the relative weight of the plumage is lighter in heavier birds despite an increase in the absolute number of feathers.

Hutt and Ball (1938) demonstrated that a small bird has more feathers per unit of body surface than a large bird and that among the land species the number of feather per unit of bird surface is actually increases with decreasing body weight. The basis for the phenomenon is that the amount of heat lost by a bird is directly proportional to surface areas of its body.

In captive falcons, moulting occurs early in Saker and Gyr falcons than in Peregrines. In UAE the moulting occurs in Saker and Gyr falcons during March to October. In Peregrines it starts in May and cease in January. So falconers prefer mostly Saker and Gyr falcons earlier for hunting than Peregrines. For moulting studies in falcons usually the primary, secondary and tail feathers are numbered inwards, from distal to proximal. But Streseman (1960) has reported that some authors numbered these feathers in reverse order. In the present study the former pattern is used.

In moulting process, the growth of new feathers will be completed within 4-6 months, depending on the bird's health. During the study it was observed that moulting of primary feathers was completed in 128-185, 110-128 and 115-135 days in Peregrines, Sakers and Gyr falcons respectively. It was noticed that moulting begins early in females than males. Though males begin to moult a month later than females both complete moulting in the same period. This may be related with the egg formation in females and with the role each bird takes in incubation, as the females take higher role in the early stages of incubation.

In falcons moult starts in primaries with 7th feather from outer side. This set apart them from Accipitridae (Stressmann 1960). However the pattern of moulting is almost the same. The moulting period coincides with breeding time and both parents go for hunting after hatching the eggs. If moulting delays it affects the flight capacity of the bird and its ability for hunting. It is felt that this may be a reason for completing the moult of both parents at the same time. In Gyr falcons the moult of juveniles is completed earlier than adults. It was observed the moulting was highest in the last month of breeding season, i.e., when food and photoperiod are maximum and flight requirement is minimum.

The standard metabolic rate or energy expenditure increases during moulting, i.e. the efficiency of extracting energy from food is high during moulting. The loss of feathers causes an increase in heat production and heat loss. In this period they are provided with more food to compensate the loss of energy and body heat. The maximum increase in metabolic rate coincides with the regeneration of the flight feathers.

Breeding is also energy demanding especially in females. In falcons, the breeding and moulting overlaps (Cade 1978). It was observed that in captivity, when moulting and breeding occurs simultaneously, although the moulting in peregrines do not get completed in breeding seasons and its extends almost a month more, the feathers may delay shedding for a while in both sexes. Because breeding as well as moulting requires a lot of energy when these two processes coincides the falcon may not get adequate energy, a probable reason for the delay of shedding feathers.

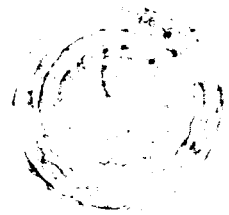
As noted above breeding and moulting processes are energy consuming and as a result the birds take more food. Towards the end of the breeding season the accumulated energy helps the falcon to moult maximum. Moulting is associated with an increase in thyroid activity, which is probably one of the causes of the increase in metabolic rate (Cade 1982).

The energy demanding activities of falcons such as migration, moulting and egg laying occur sequentially, so that the total energy requirement tends to be uniform throughout the year. Naturally falcons migrate from one place to another because of climatic variation and food availability. But in captivity even though these facilities are provided the falcons have tendency to migrate if released from the cages. It indicates that the reasons for migration are not fully environment or resource related; some inborn factors may also be influencing the seasonal migration.

5.5 Summary and Conclusion

The pterylography is used to get an accurate taxonomic knowledge of plumage pattern. Pterylosis of young differs in some pterylae from that of the adults. The colour of secondary feathers got changed in Peregrine and Gyr falcons after two years of age, but the primary feather remains same. In the case of falcons, in captivity, the plumage colouration did not effect pairing. However, it is to be ascertained under natural condition.

In falcons the moulting period coincides with breeding season and seems controlled by photoperiod and hormonal mechanisms. Falcons moult primaries from March to October, secondaries during April-November and retrices in May- November. In the case of Peregrine falcons the moulting starts very late, begins from May and lasts till January.



CHAPTER 6

MANAGEMENT OF FALCONS IN CAPTIVITY

6.1 Introduction

Presently the raptor population is apparently facing serious threat to their survival in the nature, because of habitat destruction, pesticide effects, illegal trapping, accidental deaths etc. Pharmaceutical residues and other modern chemicals have started having their impacts on species occupying top of the food web. Because of the falcon's position high up in the tropic level their natural number is low, and any further threat to the population is likely to have irreparable damage to their survival. Hence pro-active steps for the preservation of this species are necessary. In earlier times birds for falconry came from nature and capture of birds from wild population would have caused serious decline. Though it is not easy to catch them from nature to impart training for falconry.

Unlike other birds falcons are difficult to be bred in captivity because they need a lot of amenities due to their high sensitivity to human activities. In breeding season their courtship displays often involve dizzying aerial maneuvers and other activities that are difficult even in the roomiest cage. However they are seen to perform courtship displays, in pen in which they are habituated for considerable time of their life. Captive breeding often involves sophisticated manipulation of reproductive biology, using techniques like artificial insemination and multiple-clutching.

Breeding falcons in captivity is a complex and expensive process that had not been successful until recently (Allen 1982). It requires individual territories and separate enclosures for each potential pair. Some species of falcons will not breed if seen by other adults of own species. Falcons often partake in aggressive territorial disputes between enclosures if other individuals are in close proximity. Falcons are responsive to disturbances during the breeding season and can injure themselves in the enclosure on disturbances. Some falcons are very aggressive when others approach nest sites. To enable the falcons to feel secure the

enclosures are to be built so that the falcons can't see any approachers. To solve all the above problems in captivity, acute care and good rearing experience are essential. The Peregrine Fund and other organizations are attempting to breed a wide variety of endangered raptors in captivity to replenish their natural population. In this context, the present study attempts to document:

- The environmental needs of managing falcons in captivity,
- Various food and nourishment requirements for maintenance of falcons
- Aspects of breeding and behaviour in captivity.

6.2 Methodology

The study in United Arab Emirates at Abu Dhabi Falcon Research Hospital in 2001-2003 concentrated on biology and behaviours, food and feeding habits, healthcare, training and hunting. The facilities available in the breeding centres, their management strategy and drawbacks experienced were documented by personal observations and also interviewing the experts. During breeding season the falcons in cages were monitored through spy holes or glasses for observation.

6.3 Observation

6.3.1 Environment

When the climate becomes colder and less conducive the falcons migrate to wintering grounds. Although falcons withstand a cold environment, they can also survive warmer weather conditions as is shown by hunting captive birds in UAE. In wild they move to tackle the weather changes, but a captive bird cannot and hence the aviary must have air-conditioning and enough light and air for which nets are provided on lateral sides. Aviaries built up with more ventilation appear to have reduced risk of infection (Page 105). Almost all aviaries in various centres of UAE were with wire roofs; these wire roofs were erected with intention of preventing fog. It is suggested that plenty of sheltered areas in these enclosures be provided. Aviaries should be faced away from cold winds.

6.3.2 Basic needs

6.3.2.1 Enclosures

Enclosures are designed to ensure good ventilation. When keepers approach aviaries falcons may get disturbed and aggressive. To minimize such disturbance the passages are made dark by no ventilation and the doors large enough to allow easy access. A double door system for the entrance avoids bird fleeing out of the enclosure and for ensuring their security. While constructing enclosures some facilities are to be provided to prevent disturbances from outsiders, this may provide maximum comfort to the falcons.

Dimensions

The following are the sizes of enclosures recommended by Peregrine Fund for falcons

Large falcons – wingspan 1m – 1.5m
Enclosures – 6.5m length x 3.25m width x 4m height
Preferred – 6.5m length x 6.5m width x 4m height
Small falcons – wingspan 500mm – 950mm
Enclosures – 4m length x 2.5m width x 3m height
Preferred – 4m length x 4m width x 3m height

In general as a minimum standard the enclosure sizes should be approximately three times of the size of the wingspan. Welded mesh with a hole of 50mm X 50mm diameter is suitable for all falcons. But small falcons such as kestrels are provided with 50mm x 25mm diameter mesh. Very small mesh of 10mm x 10mm should be used only for the tiny raptors such as Merlins, American kestrels or Pigmy falcons. It was noticed that when a Gyr falcon was put in an enclosure with a mesh of 10mm x 10mm diameter, the talon of falcon got entrapped in the wire injuring its toes.

a. Roof

Falcon aviaries are roofed well; because falcons fly well in aviaries and if it is not roofed properly they may escape (Plate 6.1). In aviaries roofing materials are to be used with the purpose of preventing excess heat in summer and condensation in winter. When finer mesh such as the chicken wire mesh is used for roofing, there are incidences of falcons getting entangled in the net when flying high in the aviary. Hence, such enclosures made by chicken wire are not advisable. Similarly certain aviaries were found roofed with chain links, that would also harm or kill the falcons.

In all aviaries and falcon cages boxes or nest ledges are placed for perching (Plate 6.2). At Nad Al Shiba Avian Reproduction Research Centre in Dubai, it was observed that falcons were not so enthusiastic as that of the aviary of Abu Dhabi Falcon Research Hospital, where falcons are more active and always flying around in the aviary probably because numerous perch boxes were placed alternatively at upper and middle areas of the aviary with very good ventilation at Abu Dhabi hospital than the research centre in Dubai. This may be the reason why the falcons of Abu Dhabi hospital are more active.

b. Substrates

Substrates of aviaries where indigenous undergrowth is allowed to grow unchecked can be dangerous to falcons in wet cold weather. If a natural substrate is required there are some specific grass species adapted for slow low growth. However, further investigations into these would be advisable. Falcons constantly forced to land on cold muddy floors are likely to have health problems and die for hypothermia. When examined a falcon at Falcon clinic in Sharjah brought by a Bedouin, it was noticed that the falcon was affected by hypothermia. On further inquiry the enclosure was in constant wet condition. Though floors are made in different types such as muddy, sand, concrete and tree-bark. The sand is the most suitable substrate for breeding enclosures. Bark or wood clips are not suitable as they harbour spores of *Aspergillus sp.*, which can lead to aspergillosis.

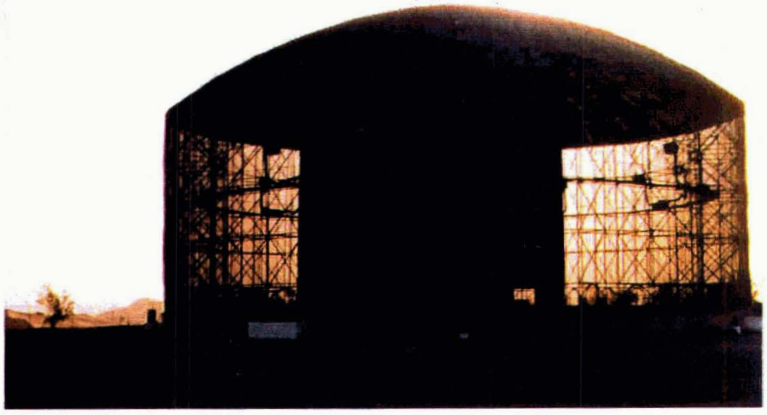


Plate 6.1 Aviary in Abu Dhabi

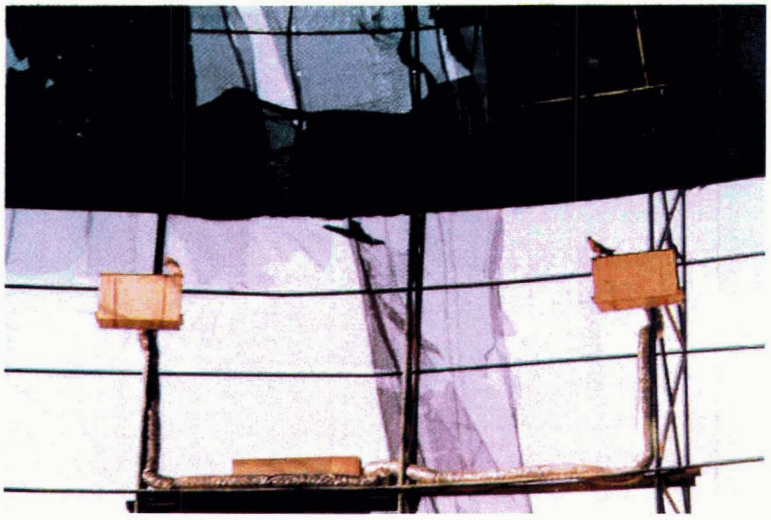


Plate 6.2 Nest ledges or boxes should be placed in Aviary

Plate 6.3 The folded skin of a falcon's leg due to dehydration

Concrete with no covering over is unsuitable especially for larger species to land on. Fine gravel is acceptable, but not easy to keep clean and maintain as sand covered floor. The sand bed absorbs droppings well, is easy to clean and will drain rainwater fast. Sand also prevents the problem of rats colonizing the enclosure floors.

c. Perches

Perches or nest ledges are resting places of falcons in the aviaries. It also provides essential gripping exercise for the bird. The perches should be placed in proper position. Perches placed in corners are not suitable, because when the bird fly to the corners flight feathers are likely to damage. Besides that, bird droppings can fall on the walls. Aviaries where the perches are located away from walls are apparently cleaner and the inmates have better feather condition.

Over the years wooden perches and walls of pens get dirty. The hardened perch causes foot damage. It is found that bumble foot disease is caused over 80% by poor perches in aviaries. It is advisable to keep an eye on perches and change them regularly. Changing the perches in a while gives a stimulus to the raptors. Apart from perches, baths, feed ledges and hidden retreats are also necessary in the enclosures. To breed falcons successfully in captivity a certain amount of privacy should be given to pairs.

6.3.2.2 Maintenance of enclosures

Daily cleaning of enclosures of falcons negatively affects the birds in side making them feel intrusion into their own territory, which can lead to breeding failure. Each enclosure should be completely cleaned out once a year. 6-8 weeks before the breeding season is a good time to remake nests and clear nest boxes. Once egg laying commences it is best to leave enclosures until hatching.

In summer months the falcons are seen frequently infected in captivity. When enquired about this it was found that bath in the aviary was left uncleaned more than two weeks and it was full of algae. Cleaning the bath at least twice a week

especially during summer is necessary to avoid green algae and other noxious materials build up.

6.3.3 Drinking and bathing

Although falcons do not drink a great deal, all of them drink at some time of the day, especially when young, in hot weather or if ill. Dehydration is sometimes serious for falcons. Water evaporates from the falcon's buccal lining and skin surface, causing dehydration (Plate 6.3). Especially in times of hunting period falcons need additional water. Then the falcons are given a bath, sprayed it with water or dipped the food slightly in fresh water. It was noticed that when a falcon was brought for checking in the hospital, the upper part of the skin on its leg was folded most probably because of dehydration. On rehydration by water spraying the folding of the skin disappears if the dehydration is not serious. So there should always be clean fresh drinking and bathing water available. The bath should be large enough to give sufficient room, but fairly shallow with a non-slip surface. Too deep a bath can lead to drowning particularly of young ones. 4-6 inches of water depending on the species is deep enough for most birds. Bath water is not necessary for sick birds, although water for drinking must be available.

6.3.4 Food and Nutrition

Falcons are carnivorous and quail, rats, mice, rabbit and beef or mutton meat used in a feeding regime for falcons make good diet. Use of same item of food type regularly is not advisable. Boned and boneless mixed diet is most suitable for proper casting and defecation of falcons in captivity. Food should always be as fresh as possible, even if from frozen stock. In captivity the food is not given in live condition to falcons. They are preferably not to be given food items frozen below 20°C. The prey items are dressed up and kept in refrigerator after removing feathers, alimentary canal and internal organs. Providing food for falcons has several conservation applications. There may not be enough natural food to support the falcons; in such case supplementary food may promote the population to increase.

6.3.4.1 Method of feeding

Except during breeding season falcons can be fed once a day. In the breeding season they need to be fed twice a day. Feeding can be done at anytime, although a specific time is easier for the keepers. Feeding at least twice a day once young are hatched is vital. Hand feeding can be resorted to feed youngs. For cleanliness in enclosures, well cleaned gutted and butchered pieces of meat are advisable. Old food items are to be removed from the cages regularly. The food items should be given by putting in food ledges or in a clean place. Generally the falcons sit on stand (*waqr* in Arabic) in cages. Throwing food to falcons is not advisable. Food can be put on the *waqr*, however it is likely that it falls on to the floor and the birds may consume it with sand, leading to health problems. It is suggested that the food ledges be used for feeding falcons in captivity.

6.3.4.2 Supplementary and special dietary requirements

There are a number of multivitamin supplements available today. Only one supplement is used at a time, and possibly on the advice of a veterinarian. Vitamins may be provided if required and not for a long period. Calcium supplements can be useful for egg laying birds. But calcium phosphate is not always a good supplement for other falcons as it can cause an imbalance. Young falcons require more food than adults. Falcons on high protein diet (from chicks to quail) appear to gain a higher fertility.

To sick falcons, that decline to take food properly, liquid food through a crop tube is given. Usually 20-30 ml/kg is given every two hours until the bird shows signs of recouping and develops good appetite. In one incidence we could revive a sick and weak falcon suffering from indigestion and unable to take food by giving the juice of quail with Necton powder using crop tube for two days.

6.3.5 Breeding behaviour of falcons in captivity

The falcons are aggressive during breeding season. Entry into the aviaries should be with great care and caution and feeding done carefully if pairs are showing behavior associated with breeding. In breeding season the female falcons do not

go to collect her food and allow the male to access the food first. She may call him for food, chase him begging for food, and if he is unresponsive, take food from him. This is normally the stage when pair bonds are established. If males are not responsive, the females start chasing, terrorizing, or even injure or kill him. If a male is showing signs of fear, injury or unacceptable levels of stress he should be removed without delay. Generally, females are more aggressive because of larger size. If males are aggressive and female shows signs of fear, she should be removed from the cage. In these cases a significant level of knowledge and experience is required in dealing with aggressive falcons to find out incompatibility of pairs and to handle the problems. Aggression towards intruders can continue until young birds are fledged well. So it is advised that better not to enter the cage until chicks are full fledged.

Generally falcons are not much social animals, other than pairing with a single bird, either just for breeding or for life. In captivity juvenile birds can sometimes be left in-groups until they reach adult plumage, although they should be monitored to spot any potential bullying. All species of falcons are meat eaters and majority hunters and they can be very aggressive to other species. It is not a good to consider falcons suitable for sharing enclosures with other species.

Mating of falcons can occur at anytime; it may be very obvious to the onlooker. If the falcons are put in a favourable atmosphere the mating can be encouraged. Higher quality food can be given prior to the breeding season to stimulate breeding activity.

6.3.6 Nest Areas

Some falcons prefer to nest on ledges, while others prefer cliffs. In captivity the size of the nest area is quite important while building ledges or boxes. All nest areas should be easily monitored with minimum disturbance and easily accessible to facilitate the removal or replacement of eggs and youngs. Spy holes, one-way glass and painted glass windows are must where breeding occurs and access doors will be more helpful in nest areas. As eggs are fragile it is advisable to have a soft substrate material on nest ledges.

6.4 Discussion

Because of the distruction of habitats the falcon population in the wild is facing serious threats. Lesser Kestrel *Falco naumanni*, Teita Falcon *Falco fasciinucha* New Zealand Falcon *Falco novaeseelandiae*, Mauritius Kestrel *Falco punctatus*, Grey Falcon *Falco hypoleucos* are declared as endangered species of falcons in latest version (2003) in Red Data Book. Unfortunately many others that face similar threats are not yet included. It is felt that urgent steps are to be taken for their inclusion in the list and steps have to be initiated for their conservation in their natural habitat.

The falcon is a symbol of royalty and dignity and it is also very expensive to maintain in captivity. Further, it is easier to train falcons bred in captivity. It demands these royal hunters of skies be bred in captivity by investing huge amounts. Although the captive breeding requires high skill and highly advanced facilities, it is worth the effort. However, the attempts may not be very fruitful in many breeding centres. This is because the birds are very sensitive and also aggressive. Unlike most of the other birds they do not have a strict social structure other than to its mate. Falcons like privacy in aviaries especially in breeding season and when intruders approach the aviary it violently resists.

When falcons are brought to the desert climate the temperature should be maintained in captivity similar to its natural habitat using air conditioners. During shifting falcons from one place to another, extreme care has to be paid. Falcons require a medium humidity level for its healthy survival. Means for humidifying the air are necessary in certain conditions.

It is observed that prevailing and prominent wind in Abu Dhabi is coming from northwest direction. When birds are exposed continuously in open atmosphere or in aviary it is suggested to provide effective windshields to protect the birds during moulting season as well as to speed up the moulting. Although birds of prey do not drink a great deal all of them drink at some time especially when young in summer, or if ill. So clean fresh drinking and bathing water are very essential for them (Loke 1947).

It is observed that falcons are sensitive to various diseases in captivity. The falcons especially Gyr are avoided from common pens and need specialized enclosures. They are very susceptible to bumble foot and aspergillosis. The substrate of aviaries is to be covered with sand. If the muddy floor becomes wet regularly it may cause hypothermia. The enclosures are to be constructed with good ventilation. In winter months in certain aviaries water get condensed and in summer excessively hot. The roofing materials are to be selected keeping this in mind. The perch boxes placed alternatively upper and middle areas of aviary will help falcons to become agile. Bumblefoot disease is seen in aviaries where perches are not in a good condition.

The falcons are not fed with live specimens in captivity, but they can be provided with frozen food stuffs not below 20°C. Live specimens are avoided to contain parasitic infections. The food items should be given by putting in food ledges or in a cleaned place. Cleanliness is very essential to avoid many infections and also building up of pathogenic organisms in the enclosures.

In UAE, captive breeding is the main reproductive practices performed by highly expensive and sophisticated facilities. Breeding stocks are carefully selected from the finest falcons available worldwide. Falcons are brought from North America, Canada, United Kingdom, Germany, Austria, Iraq and Saudi Arabia. For selective breeding in captivity, Gyr with Peregrines, Saker with Gyr and Saker with Peregrine are commonly adopted.

Artificial insemination is practiced in some breeding centres. Although the climatic condition is unfavorable for breeding in UAE the breeding success in captivity is notable. Success of a breeding centre depends on a number of factors such as facilities, maintenance, experienced hands and the breeding stocks.

Good breeding centers have sophisticated biosecurity system to prevent disease entering and all the stocks are vaccinated and undergo regular health check ups. The falcon breeding centres have a state of the art of the incubation facility and

use the latest computer software to manage its incubation and all the breeding stocks.

As the falcons are highly sensitive to the certain conditions of food and environment, the government and falconers are providing necessary helps and facilities of modern standard. It is felt that captive breeding with international co-ordination, especially from nations with natural populations of falcons and countries that fall on the migratory routes, can refurbish the natural population. An international body with that mandate to coordinate the activities and to initiate research programmes, especially on natural population may facilitate the whole activities.

6.5 Summary and Conclusion

Captive breeding, demonstrated to an extent in some of the breeding centres is one of the ways to refurbish natural populations of falcons, the royal hunters of the sky. It was found that being very sensitive and aggressive birds with very specific environmental requirements the captive breeding exercise needs high-tech facilities experienced persons and financial resources. The present chapter discusses many of such minute but critical requirements. Some of the current practices in the enclosures that meddle with the healthy sustenance of the birds are elaborated. It also highlights some of the unnoticed problems, that are carelessly handled leading to unhealthy conditions of the birds ultimately leading to less effective captive breeding.

It is attempted here to discuss many problems such as development of hypothermia, malformations in the foot, pathogenic infections, fungal infections in view of the conditions and maintenance of the enclosures. Necessary means to avoid such issues, that hamper successful breeding in captivity, are elaborated.

CHAPTER 7

HEALTH AND HEALTHCARE OF FALCONS

7.1 Introduction

A large variety of infectious diseases are prevalent in falcons. The majority of these infections are transmitted through their natural preys. It is possible that wild falcons due to their acquired immunity may be resistant to some of the infectious agents. The primary role of disease prevention in falcons should involve optimizing the conditions in captivity to meet all the animal's natural requirements.

Falcon is a royal and costly bird especially in Middle East nations. As discussed in the earlier chapter, notable infrastructure is developed in these countries for better healthcare and management of diseases of various natures. Among the Middle East nations UAE can boast of the best health care and management facilities for falcons. It is doubtful whether any country other than UAE provides such huge amount of money, material and manpower for preservation and conservation of these birds.

Falcons are sensitive to specific diseases majority of which is acquired through food. Health care management includes all measures employed in an effort to restore the birds' health. This includes plain cage rest, providing nourishment or simple rehydration techniques. Maintaining these birds, that occupy special status in the trophic chain and are highly sensitive to local environment, healthy deep knowledge and experience are needed. Realizing the importance of properly documenting details of health care and to critically examine the current practices the topic health and health care was included in the present study. This chapter examines the important preventive, promotive and curative measures taken in the falcon hospitals and clinics. The present study attempts to address the following objectives:

- To document the viral, bacterial and fungal diseases of falcons,

- To document the diseases caused by internal and external parasites and
- To document other diseases by non-biological agents in falcon species.

7.2 Methodology

The study aim to diagnose and classify the diseases and injuries affected on falcons for various reasons. The methodology adopted to collect information and data was to visit the hospitals and clinics, observe the individuals and document their health status and examine individuals that are ill or inactive. The medical history of the individual birds of interest was collected. The management strategy adopted by the clinics or hospitals in each case was studied and documented. Experts handling the cases were also met and discussed about the technical details.

The data and other relevant information were collected from falcon hospitals, clinics and breeding centers, in Abu Dhabi, Dubai, Sharjah and Al Ain in the United Arab Emirates. I had actively involved in treatment of falcons brought in the hospitals by falconers, trainers, breeders, local people and Bedouins of UAE. In cases where detailed examination of the birds is required they are anesthetized, using isoflurane gas. The study was conducted during 2001-3 and was compared with disease occurrences during 1999-2003. The major diseases caused by viruses, bacteria and funguses were widely seen in falcons in captivity all over UAE. The fecal samples, pharyngeal swabs and blood samples were tested for presence of microbes. In certain cases methods of X-ray tests, biopsy and endoscopy were also used.

7.3 Observations

During 2001-2003 several diseases of falcons have been traced in my study period in various falcon hospitals, falcon clinics and breeding centers. The infectious diseases seen in falcons are viral, bacterial, mycoplasmal, chlamidial and fungal diseases. The common internal parasites are protozoans and helminths such as trematodes, cestodes and nematodes. The external parasites include arachnids such as ticks, fowl mites, red mites, quill mites and epidermatid mites and insects

such as feather lice, feather flies and blowflies. Some unidentified endoparasites were also noticed during my work of microscopy.

The data on frequency of prevalence of three species of falcons, brought in hospitals for treatment in 1999-2003, during the course of my study is presented (Appendices 7.1 to 7.3). The symptoms of major diseases and effects are discussed afterwards (Table 7.4). It was found that the common diseases equally affect both the wild and captive-bred ones (Tables 7.1 to 7.3 and Figure 7.1).

Table 7.1 Percentage of diseased captive bred and wild falcons brought in the Abu Dhabi Falcon Research Hospital for treatment during 1999-2003

Diseases	1999			2000			2001			2002			2003		
	P	S	G	P	S	G	P	S	G	P	S	G	P	S	G
Viral	61 (10)	70 (11)	63 (18)	53 (10)	61 (9)	58 (9)	56 (6)	51 (10)	50 (9)	54 (15)	50 (12)	69 (12)	48 (9)	70 (13)	48 (7)
Bacterial	29 (10)	27 (12)	34 (9)	29 (9)	40 (10)	29 (9)	38 (9)	26 (8)	35 (9)	40 (12)	44 (11)	39 (10)	36 (7)	33 (8)	33 (9)
Fungal	23 (5)	25 (6)	31 (6)	32 (7)	35 (5)	19 (3)	40 (5)	24 (6)	32 (5)	21 (3)	16 (3)	32 (5)	40 (8)	25 (6)	38 (6)
Protozoa	102 (31)	89 (20)	91 (23)	85 (25)	91 (23)	77 (13)	91 (21)	75 (19)	76 (18)	86 (16)	70 12)	85 (14)	95 (13)	77 (15)	85 (19)
Helminths	220 (58)	225 (65)	218 (60)	235 (69)	227 (46)	229 (52)	227 (59)	220 (50)	212 (54)	206 (49)	246 (69)	248 (68)	235 (63)	221 (59)	237 (57)
Bumble foot	47 (9)	48 (10)	58 (12)	52 (11)	49 (10)	59 (13)	57 (12)	48 (10)	42 (9)	56 (10)	52 (9)	54 (11)	49 (8)	50 (9)	53 (10)

P - Peregrine falcon, S - Saker falcon, G - Gyr falcon

Table 7.2 Percentage of diseased captive bred and wild falcons brought in the Dubai Falcon Hospital for treatment during 1999-2003

Diseases	1999			2000			2001			2002			2003		
	P	S	G	P	S	G	P	S	G	P	S	G	P	S	G
Viral	62 (14)	81 (19)	66 (19)	52 (12)	62 (18)	43 (11)	78 (21)	65 (18)	50 (13)	56 (14)	40 (13)	81 (19)	51 (12)	67 (20)	59 (18)
Bacterial	40 (10)	36 (9)	35 (8)	40 (11)	44 (12)	30 (10)	26 (8)	24 (8)	27 (6)	40 (9)	33 (8)	47 (9)	31 (10)	33 (9)	28 (8)
Fungal	21 (8)	31 (9)	31 (7)	32 (6)	37 (8)	20 (4)	39 (6)	23 (5)	27 (6)	21 (5)	13 (4)	35 (8)	45 (13)	46 (14)	42 (12)
Protozoa	81 (19)	98 (21)	90 (18)	88 (17)	89 (19)	89 (16)	93 (17)	80 (15)	95 (19)	83 (19)	76 (17)	92 (19)	103 (23)	104 (21)	109 (25)
Helminths	222 (52)	240 (56)	225 (51)	223 (50)	238 (53)	228 (52)	242 (58)	228 (49)	210 (45)	195 (42)	220 (46)	227 (47)	227 (46)	228 (45)	218 (43)
Bumble foot	42 (9)	56 (10)	52 (11)	54 (10)	49 (9)	50 (8)	53 (9)	48 (10)	42 (9)	56 (10)	52 (9)	54 (11)	49 (9)	57 (8)	48 (7)

P - Peregrine falcon, S - Saker falcon, G - Gyr falcon

However it may be noted that the wild-bred individuals were under captivity for some period and hence it is likely that the observed disease frequency is due to captivity. In India falcons are not kept in captivity. Nevertheless a comparative study of the case history of some diseases diagnosed and treated in Delhi Charity Bird Hospital and Shadra Bird Hospital, New Delhi are appended (Appendices 7.4 & 7.5).

Table 7.3 Percentage of diseased captive bred and wild falcons brought in the Sharjah Falcon Clinic for treatment during 1999-2003

Diseases	1999			2000			2001			2002			2003		
	P	S	G	P	S	G	P	S	G	P	S	G	P	S	G
Viral	56 (13)	57 (12)	67 (13)	48 (11)	74 (20)	50 (13)	54 (14)	72 (17)	63 (15)	46 (12)	69 (14)	66 (13)	65 (14)	50 (12)	43 (11)
Bacterial	30 (8)	34 (7)	39 (9)	31 (8)	31 (9)	33 (8)	37 (9)	36 (10)	35 (9)	31 (7)	28 (6)	31 (7)	31 (8)	37 (8)	38 (9)
Fungal	30 (9)	28 (8)	34 (10)	22 (5)	38 (8)	21 (6)	37 (8)	26 (6)	18 (4)	27 (9)	38 (10)	27 (12)	35 (13)	35 (14)	34 (13)
Protozoa	91 (26)	72 (19)	89 (23)	83 (22)	87 (23)	91 (25)	82 (20)	93 (24)	103 (26)	90 (22)	95 (24)	102 (27)	104 (26)	101 (25)	85 (21)
Helminths	230 (62)	222 (61)	233 (63)	219 (59)	231 (62)	232 (64)	202 (57)	210 (58)	231 (62)	233 (65)	255 (70)	224 (60)	217 (59)	231 (62)	214 (57)
Bumble foot	58 (17)	52 (14)	49 (15)	59 (18)	57 (16)	48 (14)	42 (15)	56 (18)	52 (16)	54 (17)	49 (16)	50 (17)	53 (18)	41 (14)	43 (15)

P - Peregrine falcon, S - Saker falcon, G - Gyr falcon

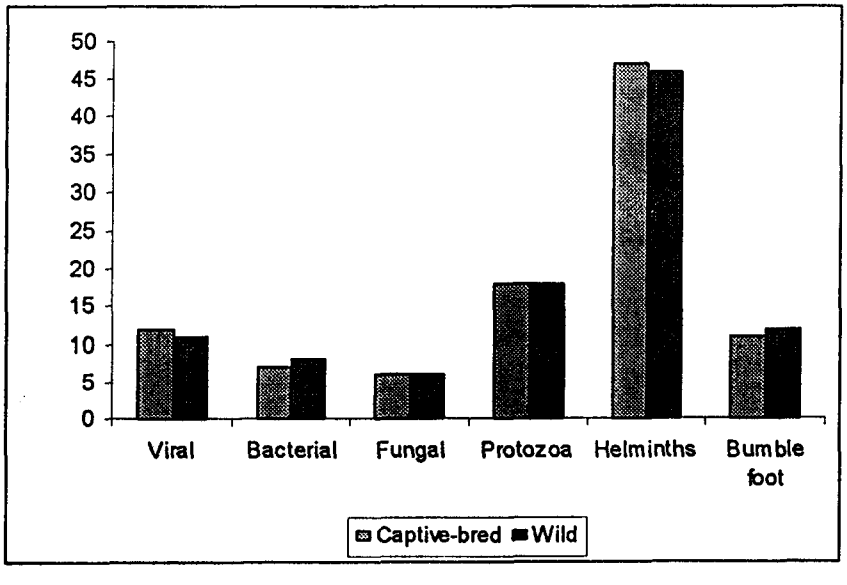


Fig. 7.1 Graphical representation of the percentage of various diseases affecting the pure-bred and captive falcons during 1999-2003

Table 7.4 Some diseases affecting falcons, their symptoms, pathogens and medicines for treatment

No	Diseases	Symptoms	Pathogen	Medicines given	Remarks
1	Viral Diseases a. Viral Pox	Pinhead sized papules develop on the unfeathered areas of the skin, feet and eyelids.	*Avipox falconi*	No specific treatment. Supportive treatment (broad spectrum, antibacterial and anti fungal therapy).	Prevention by vaccination and protecting falcons from mosquito bites.
	b. Newcastle disease	Mild neurological signs, gentle tremors, severe ataxia.	*Paramyxovirus*	No specific treatment, but supported treatment	Prevention by vaccination.
2	Bacterial diseases a. Chlamydiosis	Discharge from eyes and nose, diarrhea, weight loss etc.	*Chlamydia psittaci*	Antibiotics like doxycycline, Enrofloxacin are affective.	Avoid feeding ducks, turkeys and pigeons affected with this disease.
	b. Salmonellosis	The falcons were depressed, dehydrated and had greenish urates.	*Salmonella.sp.*	Enrofloxacin, Tetracycline etc.	Avoid feeding pigeons affected with this disease.
	c. Mycoplasma	Respiratory dysfunction, air sacculitis, pneumonia and tracheitis.	*Mycoplasma. sp.*	Enrofloxacin, tylosin.	Avoid feeding pigeons affected with this disease.
3	Fungal diseases a. Aspergillosis	Weakness, exercise intolerance and dyspnea with open mouth and abdominal breathing.	*Aspergillus fumigatus*	Treatment is successful if given earlier. Flucytosine, Amphotercin etc are effective.	Optimal nutrition, good management and maintenance of body condition etc.
	b. Candidiasis	Reduced food intake, yellowish white plaque on the oral mucosa.	*Candidia albicans*	Broad-spectrum antifungal drugs.	As per above
4	Protozoan diseases a. Trichomoniasis	Yellowish caseous leisions develop in the oral cavity, and on tongue. And foul necrotic odor.	*Trichomonas gallinae*	Carnidazole is successful and supplementation of vitamins.	Maintaining healthy disease resistant birds
	b. Coccidiosis	Weight loss, lethargic, depressed and changes in fecal consistency.	*Caryospora.sp*	Clazuril, toltrazuryl etc. are very effective.	Hygienic measures are important
5	Helminthes a. Trematodes	Severe infection, diarrhea and weakness	Flukes	Fenbendazole, praziquantel are effective	Rare in captivity
	b. Cestodes	Diarrhea and weakness.	Tape worms	Praziquantel is effective	Rare in captivity
	c. Nematodes	Weight loss, depression, yellowish deposits on the mucus of the pharynx etc.	Capillaria, *Serratospeculum sp.*, Ascarids etc.	Fenbendazole is very effective.	Serratospeculum may be removed endoscopically.
6	Bumble foot	Inflammation and swelling on foot, advanced case may lead to death.	Secondary bacterial infection	Therapy directly dependant on stage of disease	Commonly seen in captive birds

7.3.1 Viral Diseases

Viral infections have always been an important cause of disease of falcons in captivity. The viral diseases, which are common in falcons, are Newcastle disease, Raptor pox and Falcon herpes virus.

Newcastle disease (Paramyxovirus infection) threatens birds throughout the world. The symptoms generally relate to the digestive tract, respiratory system and nervous system. Once the infection is contracted it is often fatal and there is little chance for recovery. The virus is spread between falcons in the same way as influenza. Transmission of virus to falcons in captivity is possible at any time via consumption of day old chicks and pigeons. One-day-old chicks are given to falcons that are not well.

Saving infected falcons are difficult in the case of New Castle disease. During my study despite all attempts to save the falcons, in all the cases the infected individual died because of permanent CNS damage. As a precautionary measure vaccination that protects against virus for almost a year is advised. It is also suggested that day old chicks and pigeons may be avoided from the menu for captive falcons.

Raptor Pox infection is a viral infection transmitted by mosquitoes generally causing ugly sores or scabs on face and legs of falcons (Plate 7.1). In Saker, Peregrine, Gyr and Luggar falcons there were many cases of the pox during my study period. It is noticed that the viral pox because of the scabs on face and legs disturb the activities of falcons badly. By vaccination this disease can be prevented effectively.

Falcon herpesvirus affects almost all species of falcons, especially Gyr. During the present study there were no reports of this disease. Falcons affect herpesvirus disease through consumption of the virus-affected pigeons. If affected the falcons appear depressed and unresponsive, refuse to eat and produce lime green urates. Feeding falcons with diseased pigeons should be avoided to prevent contagion.

Influenza A virus also affect falcons. Some cases have been reported of Influenza A virus during the present study. The infected birds are unable to stand. A Peregrine falcon affected by influenza A virus, presented to the Al Safa Falcon Clinic in Dubai, died after four hours despite supportive care and calcium disodiumedetate treatment. The carcass was submitted to the Central Veterinary Research Laboratory in Dubai where it was subjected to postmortem examination. Investigations resulted in the isolation of influenza A virus, which proved to be highly pathogenic for chickens. The routine check up of falcons can prevent this kind of happenings to a certain extent.

Chronic superficial keratitis, an infection of the cornea of the eye, is a viral disease. It is rare among falcons, but a case has been reported in Saker falcon for which grid keratectomy was performed. Grid keratectomy is a simple and cheap procedure for the treatment of chronic superficial corneal ulcers in falcons. As a result vascularization of the cornea and epithelial adhesion to the stroma was achieved. The cornea healed within the next ten days.

7.3.2 Bacterial Diseases

Bacterial infections are not so dangerous as viral diseases in falcons. Most of the bacterial diseases are transmitted through preys such as pigeons. In falcons use of antibacterial medicines is critical to successful treatment of such diseases. The common bacterial diseases in falcons are Chlamydiosis, Salmonellosis, Avian tuberculosis and Mycoplasma. Many cases of these diseases were reported in the period of 2001-2003.

Chlamydiosis (Psittacosis or Ornithosis) infection has been reported in various falcons and this is not very common in UAE. The discharges from the eyes and nose, diarrhea and weight loss are the common symptoms of this disease. Antibiotics are effective for treatment, for minimizing the risk of infection. Avoiding feeding ducks, turkeys and pigeons affected with these diseases is also recommended.

Salmonellosis is minor disease affecting falcons. Pigeons are best carriers of the *Salmonella sp.* In 2001-2002, a total of 190 samples of biological materials from the falcon breeding centres in UAE were examined. 26 strains of Salmonella were isolated from 110 eggs, young birds, faeces and organs of kept animals, whereas 12 strains were isolated from 35 samples of animals used as food, in 45 samples no Salmonella species were found. In two cases the source of Salmonella for falcons originated from food animals like mice.

Avian tuberculosis is widespread among falcons particularly in captivity. It is observed that diarrhoea and weight losses are some symptoms of this chronic disease. This is a potentially zoonotic disease. This disease spreads among birds such as pigeons, quail and chicken and hence these food items should be checked before providing to falcons.

Mycoplasma infection of falcons by *Mycoplasma sp.* is difficult to find out through culture from the infected birds, although few cases of this disease have been reported. Pigeons are known carriers of several *Mycoplasma sp.* Respiratory dysfunctions; pneumonia and tracheitis are described as clinical signs of mycoplasmal infection in raptors. Antibiotic treatment is effective.

7.3.3 Fungal Diseases

Fungal infection is an important cause of disease in falcons. Gyr and Merlin falcons from far northern climates are more susceptible to these diseases. Poor management and stress play an important role in the development of fungal disease. The antifungal drugs are used to cure these diseases. The common fungal diseases seen in UAE are Aspergillosis and Candidiasis.

Aspergillosis is a prevalent mould that is caused by *Aspergillus fumigatus.* It affects respiratory tract, although not confined to it. Hence, respiratory signs alone are not helpful in diagnosis. The symptoms are weakness and exercise intolerance. The falcon caught by Aspergillosis shows dyspnea with open mouth and abdominal breathing towards end of the disease. Treatment is difficult and success is only possible if therapy is conducted in early stage. On an occasion a bedouin brought a falcon with acute breathing problem to Dubai Falcon Hospital. By

inspection it was understood that the falcon was in severe condition of Aspergillosis and surgery was conducted. However, the bird died the next day.

Candidiasis is an opportunistic fungal disease affecting primarily oropharyngeal mucus membranes and oesophagus of falcons. It is relatively easily treated with broad-spectrum antifungal drugs.

7.3.4 Parasitic Diseases

Parasitic organisms live on their host as ectoparasites or inside the host as endoparasites. The diseases caused by these parasites are more or less dangerous. The common endoparasites that are seen in falcons are classified as protozoans and helminths. Diarrhoea, weakness, depression and respiratory problem are common symptoms of these diseases. The common ectoparasites are ticks, mites, lice, louse flies, blowflies and feather flies. Good management, better hygiene and supply of vitamin are effective to prevent these diseases in greater level.

a. Protozoan Diseases

The protozoan diseases affecting falcons are Trichomoniasis, Coccidiosis and Babesiosis. Weight loss, diarrhea and depression are the symptoms and the treatment can cure these diseases.

Trichomoniasis is one of the most well known parasitic diseases in falcons caused by a protozoan parasite that lives in upper digestive tracts of pigeons and other birds. The symptom of this disease is presence of leisions on tongue (Plate 7.2). In falcons this disease is seen due to the consumption of infected pigeons, for this reason the local Arab falconers call this as the 'pigeon disease' or *'gurha fie lissan'* in Arabic which means mouth canker. The disease has fatal results, but it is treated with trichomonacidal drugs.

Plate 7.1 A case of viral pox in an immature Peregrine falcon

Plate 7.2 Trichomonas infection in a Saker falcon

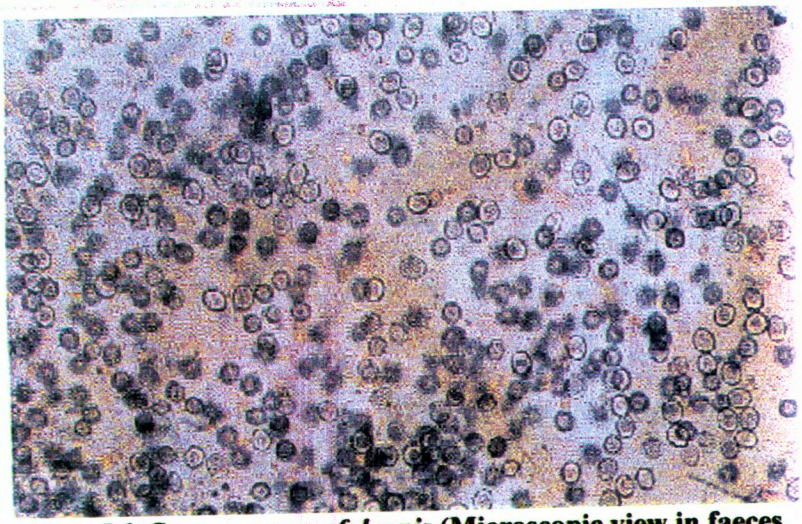


Plate 7.3 *Caryospora neofalconis* (Microscopic view in faeces of Peregrine falcon with Coccidiosis)

It is a well-known fact that more than 50% of pigeons in UAE are infected with this protozoan. It has been observed that Trichomoniasis in falcons has increased in a significant number recently.

Coccidiosis is the most frequently diagnosed pathological parasitic infestation in Gulf. Coccidia (*Caryospora sp.*) are unicellular protozoans. The completion of the parasite's life cycle results in destruction of the intestinal cells, which in turn interferes with food absorption. This disease is diagnosed by checking the fecal matter (Plate 7.3). Affected falcons show weight loss and other stresses when they are trained, making them vulnerable to infection and disease. During my studies in different falcon hospitals and clinics all over UAE, I could find a number of falcons showing weight loss, lethargy and diarrhoea. Most of the falcons with these symptoms were affected by coccidia and drugs were supplied to eliminate this disease.

In falcons this disease is seen due to the consumption of infected pigeons, for this reason the local Arab falconers call this as the 'pigeon disease' or *'gurha fie lissan'* in Arabic which means mouth canker. The disease has fatal results, but it is treated with trichomonacidal drugs. It is a well-known fact that more than 50% of pigeons in UAE are infected with this protozoan. It has been observed that Trichomoniasis in falcons has increased in a significant number recently.

Babesiosis is caused by a tick-borne protozoan blood parasite. As ticks act as vectors, falconers are advised to provide acaricide to eliminate ticks if found on birds in cages where falcons are kept. In UAE there is no report on Babesiosis in falcons during my study period.

b. Helminths

Helminthes are internal parasites and consist of Nematodes (round worms), Trematodes (flukes), and Cestodes (tapeworms).

Nematodes constitute Capillaria, Serratospeculum, Ascarids, Filarial worms etc. Ascarids are the most common nematode parasites found in falcons in captivity. Weight loss and depression are seen in infected birds.

Capillaria species are common in raptors. These long worms live in falcon's intestine, oesophagus or oropharynx. The eggs can be detected in fecal samples and washes from the oral cavity and oesophagus.

Serratospeculum, the lungworm, are of nine species of which the *Serratospeculum seurati* is most commonly found in falcons in Middle East. Falcons are often placed in the sand or grass during hunting season, where they have the chance to eat insects and beetles, which are infected and serve as intermediate host. Inside the falcons, the larva moves from stomach, where the beetle is digested, to the airsacs. There these worms grow into adults.

The worm eggs move to trachea and are coughed up by falcon. The bird then swallows these coughed up eggs. The eggs move out along with faeces. Insects and beetles within which the eggs develop from filaria to larva eat these contaminated faeces. When falcon eats this beetle, the larva goes from the stomach to the air sac and becomes an adult worm. Then the vicious cycle (Fig. 7.1) starts again.

Filarial nematodes are difficult to treat successfully because their location within the air sac makes them relatively immune to medical therapy and the dead worms will remain in the respiratory system and cause problems as they decay. For these reasons it is recommended that these parasites be endoscopically removed. During my study in Abu Dhabi and Dubai Falcon Hospitals I found that the endoscopic removal of these parasites is effective.

Trematodes: In raptors flukes reside primarily in the small intestine causing severe infections. Diarrhea and weakness are main symptoms.

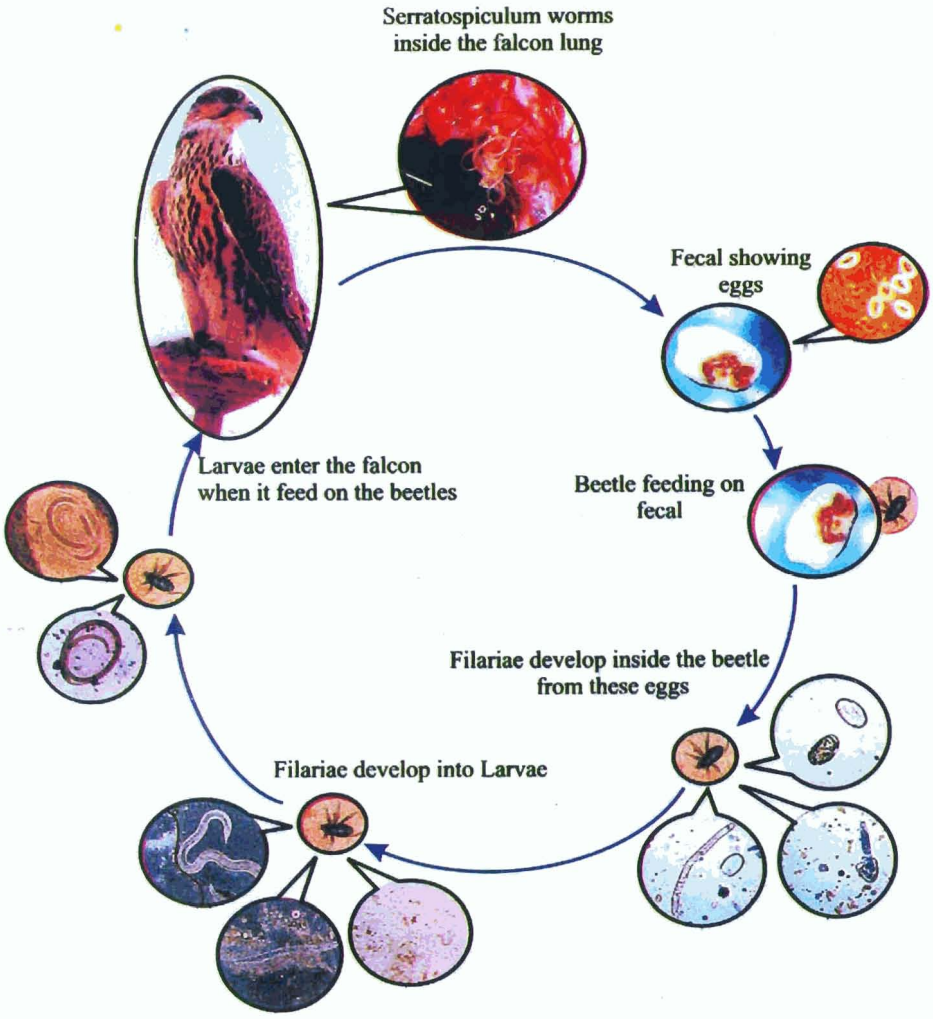


Fig. 7.1 Life Cycle of *Serratospeculum seurati*

Plate 7.4 The feet of a Saker falcon infected with Bumblefoot

These are probably rare under normal captive condition. Recent studies reveal that 71% of Saker falcons and 46% of Peregrine falcons in UAE are carrying these parasites.

Cestodes: Tapeworms are well adapted to their hosts and only rarely cause clinical disease. I observed that falcons imported from warmer climates are sometimes heavily infected and require treatment for cestodes. Tapeworms are easily ridded from their host with the aid of a single tablet taken orally.

c. Ectoparasites

Ticks, mites, lice, louse flies, blowflies and feather flies are common ectoparasites seen in falcons. Ticks and mites causes anemia, lice cause skin irritation and feather damage. Very heavy infestation of feather flies may cause enough damage to impair a falcon's flying capacity. It is observed that the healthy falcons infected with these ectoparasites appear not to be much irritated like other falcons.

7.3.5 Nutrition deficiencies and metabolic disorders

In falcons' nutrition deficiencies and metabolic disorders occur only when the falcons are not offered a balanced diet and environment. It is believed that falcons have a higher requirement for vitamin A than do mammals. Vitamin A deficiency is seen falcons in captivity and is managed by providing vitamin supplements. Inadequate levels of certain vitamins in the diet can result metabolic disorders (Table 7.5).

Inadequate levels of calcium and phosphorous may cause rickets in growing falcons or osteomalacia in adults. Providing constant supply of chopped rats may prevent rickets in growing falcon. Boned meat consumption will stop osteomalacia in adults. Whole animal diet can keep away the deficiency diseases successfully. In case of treating the diseases using artificial food supplements in the form of tablets, they are to be placed in the digestive tract carefully for the bird to guide to the stomach. In few occasions during my studies falcons had breathing problems due to chocking of the nostril track, which required immediate medical attention.

Table 7.5 The role of vitamins and deficiency diseases in falcons in captivity		
Vitamin	Effect	Deficiency
Vitamin A	Protection of mucous tissue Resistance against infection	Lesions on beak and talons, Eye problems, Poor hatching, high chick mortality predisposing factor for visceral gout of respiratory and alimentary tract
Vitamin B, B1, B2	Important for nerve system	Biotin=>feather and skin problems Biotin=> necessary for good skin
Vitamin C	Wound healing	Level reduced in times of stress like training, transport and Prolonged wound healing
Vitamin D, D3	Balance of calcium and phosphorous, Gets by sunlight=>45min sunlight daily	Weak bones, rickets etc.
Vitamin E, K	Immunity, protective effect on stress, stored in liver, blood-clotting factor.	Low immune system, easily contracts by diseases and bleeding.

Gout is a disorder in which uric acid; a nitrogenous waste product normally secreted by the kidneys is improperly deposited in various parts of the body. Vitamin A deficiency and dehydration are the helping factors to gout. Affected falcons are reluctant to fly, flying slowly and resting frequently.

7.3.6 Bumblefoot

In falcons it is a disease affecting the plantar metatarsal pad of the foot. It is a necrotic situation developed primarily because of the being confined onto a perch and not moving around. The total strain of the body weight is concentrated on the sole for most of the time for long duration, probably limiting blood circulation. In moulting period falcons rest almost all the time in captivity, and hence is more prone bumble foot development.

The growth of the talon in to the sole may also cause bumblefoot. So it is advisable that cutting or trimming the talon and putting the birds in flight pen for

exercise to decrease the chances of the foot deformation. It may be noted that if the birds develop the bumble foots few times then the birds' capacity to hunt is highly hampered. If once it is developed severely (Plate 7.4), surgery will have to be conducted. It takes more than a month for the sole to heal and get to normal.

7.3.7 Injuries to eyes and keel

It was reported that 15% incidents of eye diseases in falcons are by accidents. 50% of that is a result of traumatic injury, primarily from automobiles, gun shot wounds etc. Avian skin is extremely thin and tears easily. The edges of wound dry out quickly making repair more difficult. I got some experiences of traumatic injury of eyes and keel of falcons. The keel injury happened while the falcon was stooping for its prey, which was on the ground.

7.4 Discussion

There are several diseases affecting falcons, and the present discussion is intended to cover the common pathological conditions and illness. The widely seen diseases are viral, fungal, bacterial and parasitic diseases. Newcastle disease, raptor pox, falcon herpesvirus and influenza A virus are common viral diseases. Heidenreich (1976) states that 14% of falcons' death is due to viral diseases; while in 30% of the cases antibodies to various viruses were present. Falcons are prone to infections and it is reported recently that some dead Peregrine falcons are found to carry H5N1 bird flue virus, some strains of which are also contagious to human beings (New Scientist 2004 and The Hindu 2004).

New Castle disease caused by virus mostly is fatal to the bird. Raptor pox disease affects falcon's activities, but is not fatal. Herpes virus and influenza A virus are also seen. Chronic superficial keratitis is a viral infection of cornea, rare among falcons, but a case has been reported in Saker falcon for which grid keratectomy was performed. Grid keratectomy presents a promising, simple and cheap procedure for treating chronic superficial corneal ulcers in birds (Lierz & Lierz 2003).

Chlamydiosis, Salmonellosis, Mycoplasma and Avian tuberculosis is the common bacterial disease seen in falcons. Because mycoplasmas are low in infectivity close contact is necessary for horizontal transmission. While Avian Tuberculosis is common in captive falcons, other diseases are not seen widely. These are diseases caused by consuming preys of affected bacteria especially pigeons. These bacterial diseases are not so fatal as that of viral diseases. During 2001-2002, it is observed that some falcons tested in UAE had Salmonella infection originated from food animals like mice.

The common fungal diseases are Aspergillosis and Candidiasis. These are widely seen in Gyr and Merlin falcons of far northern climates. Aspergillosis is one of the most common and potentially fatal diseases of captive falcons (Forbes 1991). This is an infection, influenced by environmental hygienic factors and the animal's resistance to infection. Though Aspergillosis can be cured by surgery, success in advanced stage is difficult. Candidiasis is a fungal disease affecting oesophagus and easily treated with antifungal drugs.

Like almost all animals falcons are also carriers of parasites. The diseases caused by parasites are more or less dangerous and common. Endoparasites included protozoan and helminths. Better hygiene and good management is effective to prevent these diseases. The protozoan diseases occurred in falcons is Trichomoniasis, Coccidiosis and Babesiosis.

Trichomoniasis is protozoan disease that affects falcons through the infected prey especially pigeons. Pepler & Oettle (1992) reported a serious outbreak of Trichomoniasis in various raptor species in South Africa. Attempts should be made to reduce the possibility of infected pigeons transferring trichomoniasis to falcons. Increased health awareness programmes could decrease the prevalence of trichomoniasis further. In addition to this, falconers should feed the falcons only after removing head, neck and internal organs of preys. Furthermore pigeon flocks should be medicated with antiprotozoal drugs to reduce the number of protozoan carriers.

A study in Bahrain about Trichomoniasis by Samour *et al.* (1998) reveals that the practice of chilling or freezing pigeons before feeding them to falcons is not a custom among Arab falconers and this may help to explain why Trichomoniasis is a very common disease of falcons in Middle East. So it is recommended that before feeding falcons with pigeons, quails etc. it should be freezed or chilled at least for 24hrs, so this inactivates the trichomonads and might therefore reduce the risk of infection of falcons. It is observed in my studies that more than 50% of pigeons in UAE are infected with this protozoan. Di Somma (2002) has also reported considerable increase of Trichomoniasis in falcons of Dubai.

Coccidiosis is the most commonly seen disease all over the world as well as in Gulf. Coccidiosis and intestinal inflammatory disorders can reduce the uptake of B vitamin in falcons (Ward 1971, Stauber 1973). The completion of the parasite's life cycle results in destruction of the intestinal cells. One of the Coccidian infective species *Caryospora neofalconis* was first detected in Gyr falcons suffering from diarrhoea and lethargy by Pavlik *et al.* (1991). In my study period, it was noticed that the falcons showing weight loss, lethargy and diarrhoea, were mostly affected by Coccidia.

The Helminths are Nematodes, Trematodes and Cestodes. Ascarids, Serratospeculum, Capillaria and Filarial worms are Nematodes seen in falcons. *Serratospeculum seurati* is a common parasite with an intermediate host in falcons especially during hunting season and widespread in Middle East. These species are parasites of respiratory system. Saker falcons, which are caught from wild in their countries of origin, are infected with these parasites. Such falcons already have lungworms in their airsacs when they are brought to UAE or other GCC countries. During the present study it was found that coccidian eggs are very common in falcons caught from wild, while they are lesser in captive bred individuals indicating that the infection is only possible in the field if they consume the vector beetle.

Various species of worms belonging to *Filaridae* can occur in falcons from tropical climates. Many of the wild caught birds used for falconry in Arab country carry these parasites. It is observed that in Falcon hospitals in Abu Dhabi and

Dubai during my practice, the falcons were treated with this disease by endoscopic removal of these parasites. Trematodes are flukes residing in small intestine of falcons causing severe infections. Studies reveal that 71% of Saker falcons and 46% of Peregrine falcons in UAE are carrying these parasites (Greenwood 1984).

Insufficient nutritional diet makes falcons in captivity metabolic disorders. Vitamin A deficiency and dehydration may cause gout in falcons. Organophosphates, carbonates, polychlorinated biphenyles, chlorinated hydrocarbons, which are present in a variety of fungicides; herbicides and insecticides are badly affecting falcons. Lead-induced mortality appears to have been a major factor in the decline of the California Condor (Carpenter *et al.* 2003). There was a significant relationship between lead shot ingestion in falcons and consumption of waterfowl during the hunting season (Mateo *et al.* 2001), indicating that waterfowl can be an important source of lead intoxication in falcons.

The pressure and temperature of the feet increases at the time of moulting and it may cause the bumble foot. Sometimes the talons may grow more and pierce the sole and result injury. In captivity the falcons are tied in *'waqr'* and it increases chance for bumble foot. Poor perches in aviaries are known to cause over 80% of the bumble foot disease. In 1990s, bumblefoot posed a major health problem to the falcons in the United Arab Emirates (Muller *et al.* 2000). Traumatic injury is a big reason for death of falcons. Raptors with traumatic injuries need emergency stabilization (Heatley *et al.* 2001). It was reported that 15% incidents of eye diseases in falcons are by accidents. 50% of that is a result of traumatic injury, primarily from automobiles, gun shot wounds etc.

7.5 Summary and Conclusion

A large variety of viral, bacterial and fungal diseases are widely seen in falcons. Most of the diseases are not so critical if precautions and treatment are taken in proper time. The common viral diseases, which are seen in falcons, are Newcastle disease, raptor pox, falcon herpesvirus and influenza A virus. The common

bacterial diseases seen in falcons are Chlamydiosis, Salmonellosis, Mycoplasma and Avian tuberculosis. Bacterial infections are not so dangerous as viral diseases in falcons. Most of the bacterial diseases and viral diseases are transmitted to falcons through their preys.

The common fungal diseases are Aspergillosis and Candidiasis. Parasitic organisms can live on their host as ectoparasites or endoparasites. The common endoparasites that are seen in falcons are protozoans and helminths. The protozoan diseases occurring in falcons are Trichomoniasis, Coccidiosis and Babesiosis. The helminths are Trematodes, Cestodes and Nematodes. Ticks, mites, lice, louse flies, blowflies and feather flies are common ectoparasites.

The study based on statistical field research showed that in captivity wild falcons need a training frequency of twice a day to reduce the bumblefoot morbidity rate. In captive falcons nutrition deficiencies and metabolic disorders are directly related to the quality of the food and environment provided. Proper management, better hygiene, balanced diet and routine check up will prevent almost all diseases to a certain extent.

CHAPTER 8

FALCONRY IN MIDDLE EAST REGION

8.1 Introduction

Falconry, believed to have been in practice in the Middle East for more than 1400 years, is a popular sport in UAE as well as other countries. The sport is practiced with fervor and passion in these countries as a symbol of their traditions and as a cultural heritage. An Arabic account attributed to Huraira (710), the distinguished rapporteur of *hadiths* – saying of Prophet Mohammed - holds that the first falconer was a king of Persia, Hariz Ibnu Mu'aviah, who watched a wild falcon capturing a passing bird. He was fascinated by the grace and beauty of the bird and ordered his men to secure the falcon. The king is said to have always kept the bird on his wrist and learned many lessons from the falcon and got converted from a violent king to a wiser ruler. Generally the falcons are strong hunters and they attack the prey many times bigger than falcon.

Holy Qur'an (5:4) approves falconry and legitimizes hunting by falcons for human consumption of the trophy. The Holy Qur'an says "If the hunting dog or bird of prey (like falcon) catches any prey, it is permitted to eat even when some part of the prey was eaten by them: if you send the hunting animal pronouncing the name of God". According to Khalid (1996) well-known Arabic interpreters of 13th and 14th century such as Saad bin Abi Waqas, Abdullahi Ibnu Amr, Salmanul Farisi and Abu Huraira (710) and two of the four cardinal imams – religious authorities - *Imam Shafi* and *Imam Malik* interpreted this verse to support falconry.

Falcons are hunting birds and as such are forbidden for consumption (Azeez 1998). But, it is rightful that man can use these birds to hunt and utilize the capture according to sayings of Prophet Mohammed (Peace Be Upon Him - PBUH) and Islamic traditions.

Falconry has played a remarkable role in the Arab community. The bird was widely quoted metaphorically by a number of intellectuals and poets. Iqbal (1905) says "You are the falcon Shaheen, Prosperity is your aim, the sky that wide infront of you, the tombs of Sultans are not your residence, you are Shaheen, reside on the top of the mountain". Another celebrated Persian poet Gibran (1900) says, "I like loneliness to avoid seeing the cruel faces of the people like Falcons-hunting the innocent birds".

Arabs have acquired knowledge of catching, manning and hunting with falcons through generations. The falconry had influenced Arabs before 7th century at a greater level. Falcons have occupied a covetous position in the cultural history of Middle East civilization. "Abu Huraira (710) reported that Prophet Mohammed (PBUH) mentioned an incident happened at funeral of Prophet Davood; ie, Prophet Sulaiman asked his falcon to provide shade by its wings to Davood's body. Even though traditionally the sport of falconry was practiced to use the trophies as meat, today, as the people of Emirates live in a modern world dominated by impersonal and contractual relations, falconry has changed radically from its original objectives.

The exact period at which hawking was introduced in the world is elusive. Firdousi, in the 10th century AD names Shah Thimuraz, third king of Persia as the first monarch to hunt with cheetah and the falcon (Glasier 1986). Falconry is one of the old sports on earth and has become an integral part of the Arabian culture and heritage. Great effort has been made by UAE government and other private agencies to ensure the overall well being of the falcon, the national bird of UAE.

The first record of falconry from the East, ie, Japan is reported around 720 A.D. and in the late 16th to 17th centuries Samurai warriors received a military manual that included a section of falconry (www.scottishfalconry.co.uk). The sport probably existed in Persia and Arabia at a much earlier time than Japan, although a very few written records have been found supporting the belief. As trade increased between Arabia, Europe and the Far East, so did the interest of falconry. It is believed to have reached the Mediterranean by 400 A.D., where an elderly author (Schlegel 1979) related his desire as a youth to have "a swift dog and a

splendid hawk". Germanic tribes acquired the sport around the sixth century A.D. It was practiced widely through Western Europe and Saxon England. The period of 500 A.D. to 1600 A.D. was the peak of interest in falconry. It became a highly regulated, revered and popular sport among nearly all-social classes in Europe. In Western Europe and Great Britain, falconry went beyond being a sport of royalty or being practiced as a necessity. Instead, its popularity became what sociologists would term a craze for fad, and became a status symbol in medieval society. A detailed history of falconry related legal aspects are provided by www. falconry.co.uk .

Edward III had thirty falconers with him when he invaded France (Schlegel & Verster 1979). They noted that in England the first laws aimed at protecting birds of prey were created there at this time and the punishments for harming falcons were often very strict. To destroy a falcon's eggs meant one year's imprisonment, to poach a falcon from the wild was reason enough for the criminal's eyes to be poked out. In all societies where falconry was popular, harming them, their aeries, eggs, hatched young, was viewed as a greater or lesser crime, with corresponding penalties, that some suggest that the notion of conservation of wildlife in western world might have been originated during this period.

Maintaining falcon's health was expensive, thus falconry was reserved for nobles. Such retained falconers accompanied their masters on both diplomatic missions and military campaigns. Master falconers were often highly paid to work for kings and other nobles as a sport, and as an art. The Golden Age of falconry ended several centuries ago. Soon after the invention of firearms, falconry quickly declined in popularity, although it never disappeared.

In many countries in the Middle East and parts of Asia, falconry remains a popular sport of the nobility. Middle Eastern falconers, who can back their interest with virtually unlimited wealth from the oil industry, have been the primary supporters of the falconry market. They often purchase by spending more than $100,000 for a wild caught falcon. In the early 20th century, there was a resurgence of interest in falconry in some European countries. Since World War

II, falconry has dramatically increased in popularity in the United States. Falconers today increasingly turn toward captive-bred raptors for hunting birds.

The present study attempts to examine the contemporary practice of falconry in the context of its historical development. The main objectives are:

- To have a picture of the various species and breeds of falcons used for falconry,
- To document the different methods of hunting and training practices, and
- To examine the major reasons for falcon's extinction and their possible remedies.

8.2 Methodology

Surveys were conducted to collect information on various aspects of falconry and their methods of hunting practices and desert life of Arabs who continue hunting with falcons. The authorities of Environmental Research and Wildlife Development Agency (ERWDA), Abu Dhabi; National Avian Research Centre (NARC), Sweihan; Federal Developmental Agency (FEA), Abu Dhabi and their subordinate institutions were contacted and different aspects related to falcon population, its threats, maladies, accidents and conservation of falcons were discussed.

Data on different species of falcons and their cross breeds were collected by participating in hunting and training trips to deserts. Training falcons in the morning and evening in hunting season were closely observed. Information were also gathered by participating in workshops and seminars conducted for the falconers about the threats, accidents, pesticide effects and gunshots on falcons and for building awareness about the conservation and preservation of these royal birds.

8.3 Observations

The main falconry region of Arabia lies within the Arabian Gulf region of the peninsula and extends well into the interior of Saudi Arabia. It extends from the

UAE in the southern Gulf, northward through Qatar and Bahrain into Kuwait. Its southern limits extend from northern edge of the Empty Quarter to Medina. The region becomes patchy and gradually diminishes in the north toward Iraq. Only little known and scattered pockets still exist in and around Syria and Jordan without falconry.

Falconry is not widely practiced in Yemen. Falconry is a very important cultural activity in UAE. Their interest in falconry is very much reflected in the importance for the falcons in their cultural heritage. Nowadays for various reasons falcons are facing some threats such as traumatic injury, effects of pesticides and hunting. In addition to this, destruction of habitats, gun shot and infectious diseases also causing for dangers.

8.3.1 Species used in falconry

In UAE falcons are generally used for hunting as well as sporting as heritage. Peregrine, Saker, Gyr and hybrids are the major species, which are used commonly. Peregrine is famous for its quick attack on its preys.

a. Peregrine falcon is specialized in catching medium-sized birds in the air. When suitable prey spotted goes into a long steep glide, sometimes-terminating impressive vertical stoop with folded wings.

b. Saker falcon which is smaller than Gyr falcon but larger than Peregrine. Most hunting carried in open steppe areas, but wide variety of techniques used to capture prey.

c. Gyr falcon preys mostly in medium sized birds with coastal populations feeding on waders, ducks, gulls and auks while inland birds rely mainly on willow grouse and ptarmigan.

d. Hybrids (Crossing)

The best hunting falcons are produced by selective breeding, i.e., cross breeding of Gyr falcon with Peregrine hybrid, white Gyr with Saker hybrid, black Gyr with

Saker hybrid by the captive breeding programmes. Captive-bred falcons are proving their worth for hunting, strong and fast falcons well suited for desert life. The hybrids are more aerial and easily trained and managed than a purebred falcon. Hybrids are less expensive than purebreds. Hybrids possess hybrid vigor and are superior to the pure species in many aspects. Artificial insemination techniques have considerably improved production hybrids from all three falcons. The characteristics of some hybrids are given in App. 8.1 – 8.6 and plate 8.1).

8.3.2 Falcon quarry

Quarry refers to prey species that are pursued by falcons. In United Arab Emirates the Collared Dove *Streptopelia decaocto,* Turtle Dove *S. turtur*, Palm Dove *Streptopelia senegalensis*, Rock Dove *Columbia livia,* Quail *Coturnix coturnix*, Sand Patridge *Ammoperdix heyi*, Grey Francolin *Francolinus pandicerianus*, Chukar *Alectoris chukar* and Chestnut bellied Sand grouse *Pterocles exustus* are available in plenty. The major three species of quarry, which are traditionally pursued by Arab falconers, are the Houbara Bustard *Chlamydotis undulata macqueenii*, the Stone Curlew or Kairowan *Burhinus oedicnemus* and Arabian hare *Lepus capensis*. A successful hunt provides a delicious feast for the falconers in the desert (Plate 8.2). The overall aim of breeding houbara in captivity is to provide a sustainable quarry resource for falcons in hunting season.

8.3.3 Training

Each bird is trained by highly skilled trainers using live and dummy birds to perfect the hunting skills. High power radio transmitters having range upto 50 kilometers are used to avoid loosing the costly birds during training and hunting.

The primary aim of training is to impart tameness and obedience. As falcons and quarry arrive in the Gulf at about the same time and will be available only for short period; Arab falconers at this time are under pressure to make the most of the situation. Until recently, it was difficult to retain a falcon from one season to next. It was impractical for the nomadic falconer to keep falcons year-round in the hot season, because of lack of food and suitable environment.

Plate 8.1 Black Gyr X Shaheen, White Gyr and Saker X Shaheen hybrids

Plate 8.2 The falconers cook and eat the houbara caught by the falcon

Plate 8.3 Sealing is a painless procedure, calms falcon after capturing

Therefore, most falcons, except best hunters were released at the end of a hunting season. When a falcon first comes into the hands of a trainer its eyes are usually 'sealed' by stitching the eyelids together using a thread (Plate 8.3). This procedure makes taming easier. Major progress in taming is achieved during the sealed period as falcon comes to accept sounds and tactile sensations of captive new world. At this stage the thread is removed, to restore the full sight. The sealing period may last less than a week, but the falcon is most likely to emerge from this short experience in a totally tame, yet unstressed state of mind. While moulting the falcons in captivity will revert back and forget hunting techniques that was acquired during the training and hence, after moulting the trainer will have to re-train the bird for hunting, but it will be easier than a new bird.

8.3.4 Hunting

The objective of falconry is to hunt and catch quarry with trained falcons. Commonly female falcons are used for hunting. The falcon must be rewarded when her efforts are successful; therefore she is usually allowed to eat a portion of the quarry that she has caught (Plate 8.4), while falconer usually retains the remainder. The falcon takes the advantage of height and stoop down over the prey and rakes it with talons. The targeted bird tries to escape from the attacker. Sometimes the falcon tries to snatch other bird's booty. Falcons generally exhibit two types of hunting techniques, the high-speed stoop, and the chase and grab. Saker flies low, 'search and chase' method of hunting, enables to catch mammals and birds. The Saker has long legs but lacks the extended, bird-catching toes of the Peregrine. The large body size and wings of Saker falcon is more suitable for desert hunting.

In struggles with its preys Saker's feathers are not so damaged as that of Peregrine. Once a houbara has taken flight, it presents a challenge to the falcon's endurance. A healthy, well-muscled falcon going all out can initially 'close the distance gap', but she expends great effort and energy in doing so.

Gyr falcon is bigger than Saker and hunt larger preys. The ultra-light wing-loaded houbara, with her gull-like maneuverability and razor-sharp turning ability,

usually escapes initial closing efforts of falcon. At just about the time a falcon attempts to grab a houbara in flight, she will suddenly find herself going in the opposite direction of her intended meal. At the same time the houbara emit a thick slimy discharge 'taml'. This glues the wings of falcon and helps houbara to escape.

8.3.5 Furniture

Furniture means the equipments necessarily used for the daily maintenance of falcons. Always there must be a means of restraining falcons, to prevent from flying off. The means of restraint is a strong, lightweighted tether fitted to each ankle, these tethers or jesses, are known as *'subuq'*, made of leather. The free ends of these are then brought together and tied to a single cord. This piece is fastened to a brass or steel swivel, which is attached to another cord. This comprises of a *'mursil'* leash components and *'midwar'* a swivel.

The place on which a falcon stands is called a *'wakir'* (Plate 8.5a). The traditional form of protection for a falconer's hand or arm is a leather glove or *'mangalah'* (Plate 8.5b). As a security measure the end of mursil can be fastened to the mangalah when it is not fastened to the wakir. The *'burqa'* or hood functions as a blindfold for falcon (Plate 8.5c). A falcon's world is mainly what is visualized, therefore this has the effect of psychologically removing the bird from any vision that would stimulate or upset it. The *burqa* assist in transforming a nervous agitated or emotionally upset raptor into a pseudohypnotized bird.

The object used to exercise the falcon during training, or retrieve the falcon after an unsuccessful flight is called the *'tilwah'* (Plates 8.6a & 8.6b). In Western terminology it is referred to as the 'lure'. The typical Arab *tilwah* is made of the wings of dead Houbara. The wings are tied to form an attractive bundle. The device when swung by a long cord attracts the attention of falcon at great distances and can be used to recall an errant falcon.

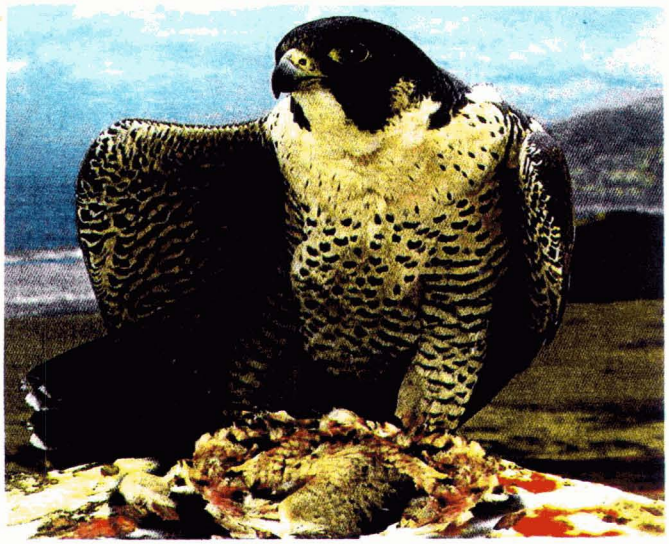


Plate 8.4 Peregrine with houbara. Falcon can sustain themselves for days together with a good meal

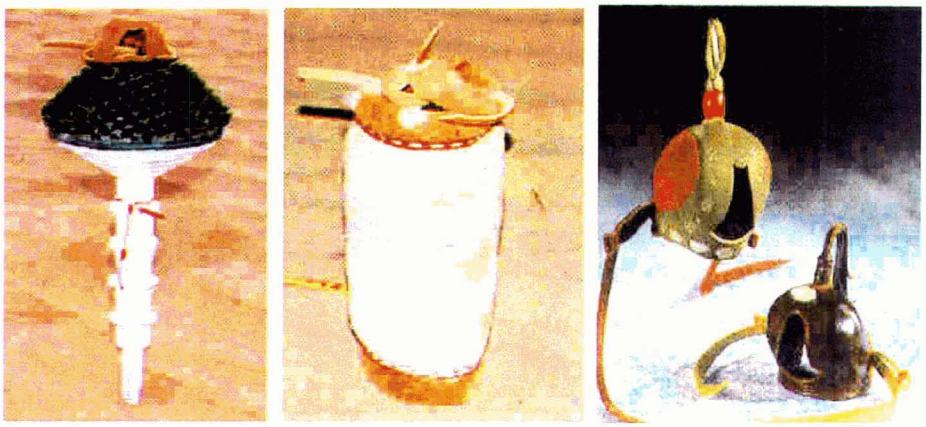


Plate 8.5. (a) Place on which a falcon stands ('waqr'), (b) Leather glove or 'mangalah', (c) Leather head cover or hood ('burqa')

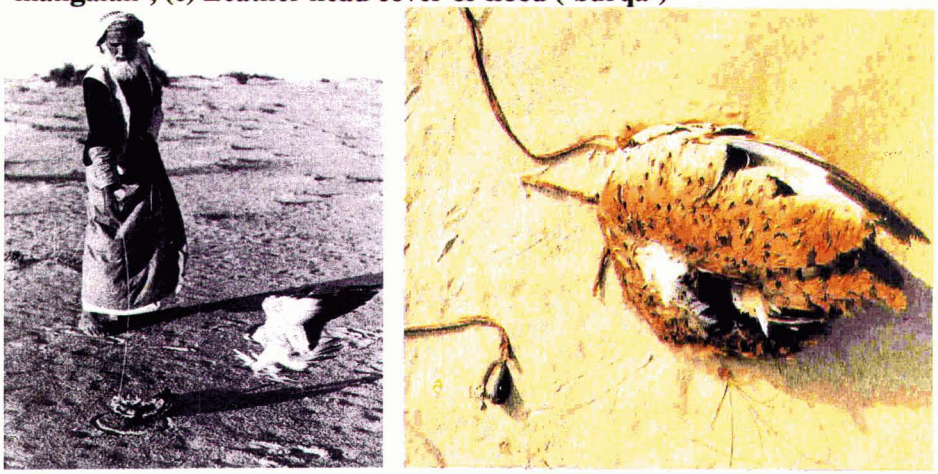


Plate 8.6 (a) A falcon trainer trains the hunting technique to a falcon, (b) *'Tilwa'* a training and retrieving device made of Houbara wings

8.3.6 Falcon trapping

Raptors and their prey birds migrate from September to November across Arabia from Eastern Europe and Central Asia to their southern wintering areas. The shorter northern days and chill in the air signals the onset of migration and each cold snap sends a new wave of raptors on their great annual journey. Waiting for their arrival over Syria, Iran, Pakistan and Arabian Gulf will be the falcon trappers (Remple 1993).

The first method of capturing falcons is luring method; pigeon is used as bait for this purpose. The second method, a bait bird with its noose frame attached, is thrown from a moving vehicle when a falcon is spotted. Care should be taken to throw the pigeon opposite the falcon. The object of this is to conceal any association of the pigeon with the trapper; as though the vehicle has struck the pigeon. The falcon, if all goes as planned, will alight on top of the pigeon and during killing and eating the bait ensnare its long toes in one or more of the nooses.

Third method is of 'little worth' to catch more valuable ones. Luggar falcon is retained for this purpose. Sealing is carried out to make the falcon prevent from seeing the ground when it flies. A lightweight feather bait decoy is attached to the leg of 'bizzuar', the lesser falcon. In the west the bizzuar is referred to as 'barak hawk'. When a desirable falcon is sighted, the bizzuar is thrown into the air. Since its downward vision is impaired, it cannot see the land and flies upward carrying its decoy. To another falcon the opportunity to rob the lesser one proves irresistible. In this instance it is not the lesser falcon that is attacked but rather the decoy it carries. When the larger falcon becomes ensnared, continued flight for either is impossible, and both flutter to the ground uninjured.

The most intriguing method of catching a falcon is the 'hide', or 'dig' in approach, a method known to falconers worldwide. When a stationary falcon is sighted a good distance away, a hole is quickly dug in the sand and a trapper is buried except for his head and gloved hands. A basket or some such item is camouflaged with grass and placed over the man's head, so that the trapper can see out. A

pigeon is tied to his wrist. He then repeatedly tosses the pigeon in the air to attract the attention of the falcon. When the falcon kills and begins to eat, the trapper slowly catches the legs of falcon. Once a falcon is caught, by whatever method, a head-cloth is quickly thrown over the excited and frustrated bird to prevent injury to it and the trappers. A hood is placed over the head. Finally, it is wrapped in an *'abba'*, a type of straightjacket.

8.3.7 Mortality factors of falcons

A large percentage of falcon's death especially of inexperienced and young ones is by accidents. Many raptors are killed or injured simply by flying into objects. When they fly and dive at high speed they cannot see utility line or a barbed-wire fence against a cluttered background. Hazard in the wild are also recorded and many wildlife rehabilitators treat raptors that have been injured by collision with branches, sticks, tree-trunks and even cliffs. Starvation is another mortality factor. Falcons have comparatively few natural predators, as informed by many workshop seminar participants and falconers.

8.3.7.1 Effects of Pesticides

According to the falconers, falcons especially Peregrines are facing a serious risk of population decline due to many reasons like pollution and poisoning together with changes in habitat; mainly due to direct exposure to pesticides like DDT, eldrine and dieldrine or indirectly eating preys affected by such pesticides. With each step up the food chain from sprayed grass, to grass hopper, to prey species, to falcon ie, in the biomagnification process the pesticides get concentrated and the falcon gets the largest dose of all.

DDT causes a decrease in the thickness of eggshell, and as a consequence, eggs are either crushed under the weight of incubating mothers, or they undergo an excessive evaporative water loss, and the embryo die. This is a serious side effect of 'high-tech' agricultural methods. Until this problem was recognized and there was a ban on DDT and DDT-like poisons in Western countries, several species of raptors nearly became extinct. It is interesting today that in many underdeveloped countries, which do not have access to 'high-tech agricultural methods, raptor

population remain healthy (Cade 1980). However, DDT is still in use to kill malaria-carrying mosquitoes and crop-eating insects, and has come into widespread use in overpopulated, developing countries. The raptors that was free of this threat before may now be affected.

8.3.7.2 Other mortality reasons

The falcon population is affected due to inadequate care and treatment by poachers and trappers. Falcons are poached in large numbers because of its high cost. Many farmers kill falcons to protect their game birds, poultry etc. by shooting. Raptors have been targeted by many gamekeepers, poultry farmers, pigeon fanciers and hunters, who simply can't resist the temptation of shooting a big easy target. In spite of protecting them well many falcons continue to be slaughtered.

Destruction of nesting habitat has critically affected many species. In their natural habitat Peregrines require huge hunting expanses to satisfy their food needs, and tall, inaccessible cliffs to meet their nesting requirements. When people transformed their habitat to agricultural lands, falcons began to dwell in cities and taken up residence on skyscrapers. In Europe, many egg collectors endanger the lives of falcons. In a quest to enrich their collections, the strict laws protecting falcons and their eggs do not deter most collectors.

8.3.8 Feather damage and imping

Majority of falcon accidents involves damage to their wings and tail feathers. The feathers are expose to injury during tussles with large quarry. The loss of a single feather from each wing does not noticeably affect flight, but it does jeopardize the adjacent feathers, therefore, when a major feather breaks, it must be repaired by imping. Feathers are repaired with an intrafeather shaft splint (imping needle). Once they are fully-grown and hardened, feathers are 'dead' appendages; therefore they can be cut at any point without any sensation by the bird. Unlike hair-growth, cut feathers do not grow back until the feather (stump) is dropped during the regular moulting.

8.3.9 Transportation

All falcons are transported in completely dark boxes with air holes on either side and with adequate space. Falcons are very susceptible to heat stress and so boxes should never be placed in sun. Transporting birds during excessively hot spells should be avoided it be in the early morning or late evening and falcons should be moved singly. I observed that in August 2002, the peak summer in UAE, two Gyr falcons died due to sunstroke, while the owner left the bird outside the cabin unattended during the transferring from transport cabin to its cage. During the study period I observed at Umm-Al Quwain that one falcon died due to hit injury at a glass window, when the falconer freed it in front of a bird selling shop that unlucky falcon flew to catch the pigeon kept behind a glass plane. Falcons should be removed from boxes in secure areas where accidental escape is not possible and away from areas of glass windows. Trained falcons can be moved hooded, but never be left in view of the public or left near another bird within one and half times their wingspan distance. They are never left unsupervised, and never transported hooded after being fed.

8.3.10 Falcon release and rehabilitation

UAE is paying keen attention to overcome the problems of possible extinction of falcons and introduced many schemes to rehabilitate falcons by breeding them in captivity and by releasing falcons to the wild where favourable natural breeding places exists in countries like Pakistan and Afghanistan. The released falcons are fitted with satellite transmitter. Satellite telemetry makes possible worldwide automatic location of falcons. Sakers are fitted with a battery size of 30gm and Peregrines with a battery size of 20gm. Mapping the routes of migration of these birds helps to ascertain the distance travelled and the location of falcon after they are released. Thorough health check up is done to select healthy birds that can survive in wild before they are released with plenty of pigeons as their preys.

The falcon release project is an integral part of a programme launched by the UAE President H.H. Sheikh Zayed Bin Sultan Al Nahyan in 1995, to conserve falcons in the wild. Through this project it was possible to gather information on the survival rate of falconry birds, their readaptive ability in the wild and in their

migratory routes. The details of released falcons under this project during 1999-2003 are given in Table 8.1.

Table 8.1 Falcons released under the H.H. Sheikh Zayed Falcon Release Project Abu Dhabi during 1999-2003

Year Released	Area	Falcons released	Remarks
1999	Baluchistan, Pakistan	107	Saker 65, Peregrine 35, others 2
2000	Gilgit, Pakistan	86	Saker 35, Peregrine 32
2001	Baluchistan, Pakistan	59	Saker 34, Peregrine 25
2002	Kyrgystan	98	Saker 55, Peregrine 43
2003	Kyrgystan	57	Saker 35, Peregrine 22

8.3.11 Safety, law and enforcement

As a rule most birds of prey will endeavor to get away from humans rather than attack them. Imprinted falcons can be extremely dangerous to both keepers and the public, if imprinted in the wrong way. Great care should be taken to ensure that these birds are not within reach of public unless under control by a trained keeper. Mentally stable birds are usually aggressive towards their keepers only during the breeding season. While handling falcons regularly, particularly the larger species, bites and scratches are inevitable. The trainers and keepers should make sure that they are up to date with inoculations such as tetanus and that any cuts are cleaned and bandaged as soon as possible.

Convention on the International Trade in Endangered Species of wild fauna and flora (CITES) regulates international trade in species of wild fauna and flora. The UAE government is a signatory of CITES agreement and was admitted in 1990. All falcon captive breeding centres in the UAE are registered with the CITES management authority, and hence certificates of origin for the captive bred falcon should be kept in the breeding centre. Authority can issue ownership certificates and falcon passports that will enable the owner to travel with their certified falcon. The passports are issued for a period of three years.

8.3.12 PIT micro-chipping & ID chip

Microchips (Passive Integrated Transponder - PIT) are being used in a scheme to tag wild and captive falcons and follow their movements in detail. PIT tag and ringing recoveries are stored in the Middle East Falcon Research Group's PIT central database and recoveries are now giving an insight into the movements and trade in wild falcons. Rings can become illegible or may have to be removed in case of injury; implanted Identification chip - ID will make the bird easily identifiable to those with a reader. The ID chip is implanted under the skin of the pectoral muscles.

8.4 Discussion

The falconry began to supplement the nomad's diet, but gradually evolved into a gentleman's sport since long period. Arabs use falcon for hunting purpose. 'Baz' and 'Shaheen' are called falcons. The large expanse of the desert, its relative lack of protective cover and the demanding long-range flight of quarry such as the houbara bustard, desert hare and stone curlew all clearly favours the use of falcons. Shooting has been recently banned in several Arab countries, and there is growing interest in programmes to propagate houbara for release to the wild. The laws and regulations have assured the survival of the sport in the west and Arabia.

The favourite prey of falcons is houbara bustard. "The meat of houbara bustard is very tasty and considered as of high medicinal value for which there is no scientific evidence. It is also believed as an aphrodisiac and energizer. Bahavudheen (1967) give the picture of the combat between falcon and houbara, its quick stoops on houbara struggle in the atmosphere to escape and to defeat.

The houbara species have suffered a massive decline in numbers during the present century and especially during the past 30 years as native grass lands have been increasingly converted to cash crops (Rahmani & Shobrak 1987). Nowadays, fewer and fewer houbara visit the UAE, the reasons behind their fast declining needs to be well studied to know how to halt this decline before the houbara becomes extinct in the UAE.

"The Peregrine falcon is one of the noblest and most romantic birds in the world; beautiful, bold, fearless, so swift in flight that it is master of the air and falls on its prey like a thunderbolt from the sky" (Murphy 1963). "Peregrine may be regarded as the most perfect type of combined strength, speed, and destructive power in birds. The proportions are such as could not be altered with any advantage" (Michell 1990). The temperament of the Saker suggests that she may indeed be more intelligent than Peregrine. What Saker lacks in speed, but it makes up by tactical hunting skills. Falcons, hawks and eagles such as peregrines that attack distant prey from high-speed dives face a paradox (Tucker 2000).

The Saker can be a difficult bird to tame, and her initial unwillingness to accept captivity is testimony to her intelligence. The Peregrine comes second to Saker in popularity and is preferred by some Arab falconers. The falconers treat their falcons with high esteem. They also present the rings, ornaments to their falcons to praise their hunting ability" (Annazi 1980).

Predator and prey attack-escape performance is likely to be the outcome of an evolutionary arms race. Predatory birds are typically larger than their prey suggesting different flight performances (Hedenstrom & Rosen 2001). There are three idealized attack-escape situations between predatory and prey birds: climbing flight escape, horizontal speeding, and turning and escape by diving. Generally a smaller bird will out climb a larger predator and hence out climbing should be a common escape strategy. Applied some potential prey species, this analysis indicates that the falcon usually wins against the prey species, ie, hunting facilities are not common.

The Peregrine is faster and more aerial than Saker and it can be easily trained. These are the reasons that have helped the Peregrine as the falcon ideal for traditional falconry. Shaheen is strong hunter and their talons are sharp and piercing. They live in mild temperate areas. They do not make nest but reside in others nests. Iqbal (1905) wrote, I am Shaheen, the poor among the avian world, as Shaheen does not make nests.

Generally Gyr is similar to Peregrine and becomes a friend and a companion. Unlike Peregrine, it is typically resident within breeding area. They are considerably affected by fluctuating prey populations in many areas. Moulting the falcons in the captivity they will become wild and forget the hunting techniques, it is easier to train again than a new bird. Majorities of falcons used for hunting are females.

Falcons are facing a serious risk of extinction due to many reasons. Mainly due to direct exposure to pesticides like DDT, eldrine, dieldrine etc. or indirectly eating preys affected by such pesticides. Because of biological magnification pesticides get concentrated and the falcon gets the largest dose of all. DDT was first widely used in the late 1940s, aldrin and dieldrin in 1950s. The breakage of the eggshell during incubation was not discovered till 1960s. Aldrin and dieldrin are highly toxic, and they kill embryos and adult falcons (Ratcliffe 1980). A high DDE concentration was found in the Peregrine eggs (Mateo *et al.* 2001) although a number of organochlorine and Mercury contaminants were found in eggs of other species, were below known toxic levels.

The use of organochlorine pesticides has had adverse effect on wild bird population by means of two mechanisms; increase of mortality and reproductive failure (Newton 1979). Reproductive failures have been mainly associated with the use of DDT and DDE which produces a decrease of egg shell thickness (Ratcliffe 1980), a fact described up to now in 18 bird families (Blus 1995).

The Peregrine falcon has played a central role in the studies of the effect of pesticides on wildlife. The reasons for this are based on the complete interactions of this species with man. The marked declines in several populations of Peregrine falcons have been ascribed to reproductive failures caused by DDE and poisoning by organochlorine compounds (Ratcliffe 1970). The membrane extraction technique allows the case of museum preserved eggshells for the determination of chlorinated hydrocarbons pollutant levels. This could not be attempted in this study due to the non-availability of tissues.

The use of pesticides has made severe damages to the nature and has also affected preys like quail, pigeon etc. siphoning the pesticide residues to their predator.

Since 1945, some use has been made of trained Peregrine falcons to reduce bird-strike hazards to aircraft on military airfields, such as RAF Lossiemouth. Service and civilian falconers have been employed to manage these bird-scaring operations with falcons. The technique had somewhat indifferent success, and has been superseded by more cost-effective methods (Ratcliffe 1980). Due to the long distance to be travelled during migration many falcons fail to reach their destination due to natural calamities, hitting tall objects like trees, flying objects and food shortage, scarcity of water etc.

There is an estimated population of 3500 Saker falcons in captivity in Middle East (Samour 1996). The DNA fingerprinting is used to estimate annual survival rates in the released Saker falcons (Wink *et al.* 1999). It is assumed that approximately 2500 Luggar falcons are trapped each year mostly from Pakistan, and 90% of these dies during the trapping. A series of workshops to improve the care and management of captive falcons were organized by the Falcon Foundation International (FFI), Pakistan for falcon trappers in the rural areas of Punjab (Bailey *et al.* 1998). Today, modern technological man is the dominating influence on earth, for better or worse, and the destiny of falcons like other all-wild animals, is now inextricably bound by the actions of men (Oystein & Mortensen 1999).

Altogether falcons face several severe problems of decrease of shrinkage of habitat and viable area, viable population, isolation and fragmentation of habitats, and population leading to gradual genetic isolation, inbreeding depression etc. The condition is further complicated by problems of environmental stochasticity factors that may wipe away genetically effective population size in the next 100 years (Shaffer 1981, Ralls *et al.* 1979, O'Brien *et al.* 1985, Franklin 1980, Frankel & Soule 1981).

Even though the Peregrine Falcon *Falco peregrinus* is of world wide distribution the habitat and population are highly fragmented and going on decreasing at a rate

of 20-50% in a decade and the primary cause of this decline of population is habitat destruction, pesticide effects, pollution and exhaustive trapping by pigeon fanciers and falconers. The additional major threats are human interference, shooting and stoning by pigeon farmers, illegal smuggling and trade. Other natural / man induced threats are heavy mortality during migration (because of shooting also), diseases in the wild and in captivity decline of its prey species especially Houbara Bustard which itself is a migratory and fast declining bird. The captive populations are seriously affected by pathogens; fast decline of captive population occludes chances of re-introduction into the wild.

Political unrest especially in Pakistan, Afghanistan, Iraq and Iran leave falcon population unprotected in the absence of enforcement of conservation laws. So clandestine trade of this protected species proliferating beyond leaps and bounds. In the last 10-12 years the global population of Peregrine falcon is less than 10,000 and it is declining at a rate of almost 10% in 10 years (Remple & Gross 1993, Bell 1990 & D'Aloia & Ann 2000). Habitat is also subjectively estimated to be less and shrinking at a rate of 10% in 10 years. The captive breeding programmes to rebuild the population in captivity and wild are not yet successful even though attempts are going on.

8.5 Summary and Conclusion

Though the falconry was the nomad's means of diet eventually it transformed into gentleman's sport. Today falconry is facing a serious threat by habitat destruction, pesticides and diseases. There are many species of falcons as well as hybrids that are used in falconry. Major species used for falconry comprises of Peregrine, saker, Gyr and their hybrids.

Captive-bred falcons are strong and fast, well suited for desert life. The hybrids are cheaper, more aerial and easily trained than a purebred falcon. Skilled trainers train falcons, the main aim of hunting is to catch quarry. Trappers catch falcons when rest on the route during migration. Though falcon population faces a variety of threats mainly man made modern technological improvements helps to arrest the rate of decline through captive breeding and falcon release projects. Satellite

telemetry makes possible worldwide automatic location of falcons and their migratory routes.

All captive breeding centres in UAE are registered with CITES which issues ownership certificates, falcon passports, and monitors illegal trafficking. Even though governments and various authorities take fruitful steps, the status of falcon population is highly vulnerable likely to be endangered in the next 100 years. This can be overcome through appropriate combination of captive breeding and release, improving habitat quality and by establishing and conserving breeding population centers in intensively managed and protected areas.

REFERENCES

Afsar M (1988) A Contribution to the biology of Houbara-some observations in 1983-1984 wintering populations in Baluchistan. J. Bom. Nat. Hist. Soc. 85(1): 68-72.

Ahmed R, Ismail S and Khan D (1984) Use of highly saline water for growing plants at coastal sandy belt of Pakistan. 3rd Annual Research Report, Saline Agriculture and Afforestation Research Project, Karachi University and PARC.

Aldrich EC (1956) Pterylography and molt of the Allen Humming bird. The Condor. 58: 121-133.

Alexander W B (1955) Birds of the Ocean. Putnam, London.

Ali S (1927) Moghul Emperors of India as Naturalists and Sportsmen. J. Bom. Nat. Hist. Soc. 31(4): 32-34.

Ali S (1945) The Birds of Kutch. Oxford University Press, Bombay.

Ali S (1949) Indian Hill Birds. Oxford University Press, Bombay.

Ali S (1949) The Satpura trend as an ornithological highway. Proc. Nat. Inst. Sci. India. 15: 379-386.

Ali S (1953) The Birds of Travancore and Cochin. Oxford University Press, Bombay.

Ali S (1962) The Birds of Sikkim. Oxford University Press, Madras.

Ali S (1967) Field Guide to the Birds of the Eastern Himalayas. Oxford University Press, Delhi.

Ali S (1968) The Birds of Kerala. Oxford University Press, Madras.

Ali S (1977) The Book of Indian Birds, Bombay Natural History Society, Mumbai.

Ali S (1996) The Book of Indian Birds, Bombay Natural History Society, Mumbai.

Ali S and Ripley D (1968-1974) Handbook of the Birds of India and Pakistan together with those of Bangaladesh, Nepal, Sikkim, Bhutan & Srilanka. 10 Vols. Oxford University Press, Bombay.

Ali S and Ripley D (1983) A Pictorial Guide to the Birds of the Indian Subcontinent. Bombay Natural History Society, Oxford University Press, Bombay.

Allen M (1977) Falconry in Arabia, Orbis Publishing, London, UK. Pp. 251-260.

Allen M (1982) Falconry in Arabia. Orbis Publishing Ltd, London. Pp. 185-210.

Amadon (1964) American.Mus. Novit. Orbis Publishing. London. Pp. 214-251.

Amadon D (1959) The significance of sexual differences in size among birds. Proc. Am. Phil. Soc. 103: 531-536.

Ambrose T (1988) Population ecology of infectious diseases. Nature. 280: 361-367.

Ames PL Heimerdinger MA and Warter SL (1968) The anatomy and systematic position of the *Antpipits Conopophaga*. Peabady Mus. Postilla. Pp. 215-218.

Amman GA (1937) Number of contour feathers of Cygnus and xanthocephalus. The Auk. 54: 201-202.

Anderson DW & Norberg RA (1981) Egg shell changes in North American birds. Int. Orni. Congress. E.J. Brill, Leiden. Pp. 514-540.

Andersson S and Wilkund CG (1987) Sex role partitioning during offspring protection in the Rough-legged Buzzard Buteo lagopus. Ibis. 129: 103-107.

Annazi A (1980) The Book of falcons in east and west. Rabath, Morocco. Pp. 91-97.

Armstrong EA (1963) A study of bird song. Oxford Univ.Press. London. Pp. 145-152.

Arnold C (1985) Saving the Peregrine falcon. Lerner Publishing Group, In: The UAE Formative years 1965-1975, Edited by Bhatia A (2000) Motivate Publishing, Dubai. Pp. 75-82.

Arun PR and Azeez PA (2003) Residues of Therapeutics in the Environment; An Environmental Hazard to Blame for the Population Decline of White-Backed Vultures *Gyps Bengalensis* of Southern Asia? Indian Environment Congress 2003, Coimbatore.

Augspurger T and Boynton A (1998) Organochlorine and mercury in Peregrine Falcon eggs from western North Carolina. J. Rap. Research. 32(3): 251-254.

Aviler JM, Sanchez JM and A Sanchez (2000) Breeding biology of the Eurasian Kestrel in the Steppes of Southern Spain. J. Rapt. Research. 34: 45-48.

Azami M (1977) Studies in Hadith Methodology and Literature, Islamic Teaching Centre, Indiana. Pp. 258-265.

Azeez T (1998) Islam-Charity and Culture. Yuvathe Book House, Calicut Vol. 3: 246.

Azeez T (2001) Islam-History & Development. Yuvathe Book House, Calicut. Vol.3: 687-689.

Badie KAM (1996) Assaid be Ssuqoor fi ma Yawakib al Usoor. Doha Qatar, Arabian Gulf. Pp. 25-35.

Bahauddin M (1967) Faid al Barane, Rabath publishing. Egypt. Pp. 65-67.

Bailey RE (1952) The incubation patcho99f passerine birds. The Condor. 54: 121-136.

Bailey TA, Fox NC, Mukhtar A, Toosi A, and Samour JH (1998) Reconciling conservation interest with health and medical issues of the Lugger falcon *Falco jugger* in Pakistan. In: 3rd International Raptor Biomedicine Conference, South Africa (4-11 August 1998 EP-0171). Raptor Biomedicine. 3: 275-279.

Bailey TA, Samour Jaime H, and Bailey TA (1998) Hunting by falcons, protected by falconry: can the Houbara bustard fly into the 21st century? Journal of Avian Medicine and Surgery, 12: 190-201 EP-0183.

Bailey, Their, Samour, Jaime, Bailey, Tom and Remple (1998) Trichomonas sp. and falcon health in the UAE In: 3rd International Raptor Biomedicine Conference, S. Africa, (4-11 August, 1998, EP-0177). Raptor Biomedicine 3: 53-57

Baker ECS (1917) Notes on the nidification of some Indian Falconidae. Ibis. 45: 5-35.

Baker JA (1967) The Peregrine, Harper & Row. New York.

Baker MC and Mewaldt LR (1978) Song dialects as barriers to dispersal in Passerine birds Evolution. 31: 83-91.

Baker MC and Mewaldt LR (1981) Response to "Song dialects as barriers to dispersal: A re-evaluation." Evolution. 35: 189-190.

Balgooyen TG (1976) Behaviour and ecology of American Kestrel *Falco sparverius* in the Sierra Navada of California. Uni. Calif. Publ. Zool. 103: 1-88.

Banasch U and G Holroyd (1996) Peregrine falcon. Hinterland Who's Who series. Ottawa: Canadian Wildlife Service. Pp. 151-168.

Baranes SJ, Baharad A, Alpert A, Berthold P, YomTov Y, Dvir Y, Leshem Y (2003) The effect of wind, season and latitude on the migration speed of white storks

Ciconia ciconia, along the eastern migration route. Blackwell Munksgaard, Copenhagen, Denmark. The Condor. 104 (8): 715-721.

Barrows SZ and O'Brian SE (1984) Clinical Management of Injured Birds of Prey. The Condor. 46: 123-130.

Barton NW and Houston DC (1996) Factors influencing the size of some internal organs in raptors. J. Rapt. Research. 30(4): 219-223.

Batanouny (1981) Birds of the Middle East and N. Africa. T&A Poyser, Staffordshire, UK. Pp. 210-245.

Baumel JJ, King AS, Lucas AM, Breazile JE and Evans HE (1979) Nomina Anatomica Avium: An annotated anatomical Directory Birds. London: Academic Press. Pp. 175-192.

Baumgart W (1980) Der Sakerfalke. Wittenberg, Lutherstadt. Pp. 85-96.

Baylis JR (1981) Mimicry. In: Acoustic communication in birds, vol.2, Kroodsma DE and Miller EH (Eds.). New York: Academic Press. Pp. 142-156.

Beer RE (1970) Ectoparasites of birds: A brief review. In: Ornithology in laboratory and Field, Appendix I, Pettingill OS Jr (Ed.) Minneapolis. Burgess. Pp. 76-81.

Bell DA (1990) A successful nesting of Peregrine falcon in Tamil Nadu. J. Bom. Nat. Hist. Soc. 87(2): 291-292.

Bell DA and Gylstorff I (1987) Diseases of Falcons J. Bom. Nat. Hist. Soc. 69(3): 242-245.

Berger AJ (1960) Some anatomical characters of the Cuculidae and the Musophagidae. Wilson Bull. 72: 60-104

Best LB (1977) Territory quality and mating success in the Field Sparrow *Spizella pusilla*. The Condor. 79: 192-204.

Bhatt D, Kumar A, Singh Y and Payne RB (2000) Territorial songs and calls in oriental Magpie Robin, Copsychus saularis. Curr.Sci: 78(6): 722-728.

Bijlsma RG (1998) Predation by large falcons on wintering waders on the Banc d' Arguin, Mauritania. Ardea. 78: 75-82.

Bijlsma S, Hagemeijer EJM, Verkley GJ and Zollinger R (1988) Ecological aspects of the Lesser Kestrel Falco naumanni in Extremadura (Spain). Rapport. 28: 25-36.

Bildstein KL (1992) Causes and consequences of Reversed Sexual Size Dimorphism in Raptors. J. Rapt. Research. 26(3): 115-123.

Bilefeldt J, Rosenfield RN and Papp JM (1992) Unfounded assumptions about diet of the Cooper's Hawk. The Condor. 95(4): 427-436.

Birkeland (1962) Causes of mortality in the Mute Swan on the river Thames. J. Zool. 198: 15-25.

Birkeland C (1990) Caribbean and Pacific coastal marine systems: similarities and differences. In: UNESCO, Nature and resources. Managing the coastal environment. Parthenon Publishing Group, Lancs and New Jersey. Pp.3-12.

Blanco JM, Gee GF, Wildt, DE and Donoghue AM (2002) Producing progeny from endangered birds of prey: Treatment of urine-contaminated semen and a novel intramagnal insemination approach. Journal of Zoo and Wildlife Medicine, 33(1): 1-7.

Blus LJ (1995) Organochlorine Pesticides. In: Handbook of Ecotoxicology, Hoffman DJ, Rattner BA, Burton Jr GA, Cairns Jr J (eds.), Lewis Publishers, CRC Press, Inc., Boca Raton, Florida, Pp. 275-300.

Boer (1997) Birds of the Middle East and North Africa. T&A Poyser, Staffordshire, UK.

Boer and Warnken (1991) Birds of the Middle East. T&A Poyser, UK. Pp. 85-9

Bondesen P (1977) North American bird songs. A world of music. Klampenborg, Denmark: Scandinavian Science Press Ltd. Pp. 25-26.

Bouch (1992) Bald Eagle survival and population dynamics in Alaska after the Exxon Valdez oil spill. J. Wildl. Management. 59: 317-324.

Boughey MJ and Thompson NS (1981). Song variety in the Brown Thrasher *Toxostoma rufum*. Z. Tierpsychlo. 56: 47-58.

Boulet M, Olsen P, Cockburn A and K Newgrain (2001) Parental investment in male and female offspring by the Peregrine Falcon. Emu. 101(2): 95-103.

Boyer H (1982) Wild fowl and other water birds found dead in England and wales in 1962. Ann. Rep. Wildfowl. Trans. 15: 20-22.

Boyer H (1990) Duck numbers in the USSR, The Western Palearctic and North America 1967-1986. The Condor. 41: 171-175.

Brockway BF (1969) Roles of budgeregrations in integration of breeding behavior. In: Bird Vocalizations, Hinde A (Ed.) Cambridge University Press. Pp. 145-156.

Brodkorb P (1949) Number of feathers in some birds. Quart.J. Flrida. Acad. Sc. 12: 1-5.

Brodkorb P (1955) Number of feathers and weights of various system in a bald Eagle. Wilson Bull. 67: 142-143.

Brown L and Amadon D (1968) Eagles, hawks and falcons of the world. Vol.2, McGraw-Hill, NY. USA. Pp. 125-152.

Brunell S (1986) Hybrid Falcon Overview. The Condor. 25: 43-47.

Brunham B (1947) A Fascination with falcons. Hancock House Publishers Ltd. Zero Avenue, Surrey. Pp. 48-56.

Brush AH (1978a) Feather Keratins. In Chemical Zoology,Vol.10. AH Brush (Ed.). New York. Academic Press. Pp. 25-29.

Brush AH (1978b) Avian pigmentation. In chemical zoology, Vol. 10 AH Brush (Ed.). New York. Academic Press. Pp. 142-145.

Brush AH (1978c) Structural aspects of the speculum of Mallard *Anas platyrhynchos*. Ibis. 120: 523-526.

Bryant EH, Vackus VK, Clark ME and Reed DH (1999) Experimental tests of captive breeding for endangered species. Conservation Biology. 13(6): 1487-1496.

Buchanan JB (1996) A comparison of behaviour and success rates of Merlins and Peregrines when hunting dunlins in two coastal habits. J. Rapt. Research. 30(2): 93-98.

Burnham W, Sandfort C and Belthoff JR (2003) Peregrine Falcon eggs: Egg size, hatchling sex and clutch sex ratios. The The Condor. 105(2): 327-335.

Burton SR (1951) Falconry in the valley of the Indus. John Van Voorst, London.

Cade T J (1960) Ecology of Peregrine and Gyr falcon in Alaska. University of Caliifornia publication in Zoology, 63(3): 151-290.

Cade T J (1978) The Gyr falcon and falconry. Living Bird. 7: 237-240.

Cade T J (1979) The falconry. Living Bird. 6: 153-155.

Cade TJ & SA Temple (1977) The Cornell University Falcon Programme. In R.D. Chancellor (ed.), Report on Proceedings. World Conference on Birds of Prey, Vienna 1975, International Council of Bird Preservation. Pp. 353-369.

Cade TJ (1980) Population ecology of Raptors by Iwan Newton J. Wildl. Management Pp. 73(4): 120-123.

Cade TJ (1982) Falcons of the World. Cornell University Press, Ithaca, New York. Pp. 190-245.

Cade TJ (1987) Falconry and Art. Sotheby's, London. Pp. 80-120.

Cade TJ and Bird DM (1979) Peregrine Falcon *Falco peregrinus* nesting in an urban environment: a review, Canadian Field. Nat. 104: 209-218.

Cade TJ and Weaver JD (Eds.) (1983, 1985, 1991) Falcon Propagation. The Peregrine Fund Inc.

Cade TJ, Enderson JH, Thelander CG and White CM (1988) Peregrine Falcon Populations: their management and recovery. Boise, Idaho, The Peregrine Fund. Pp. 190-210.

Cade TJ, JL Lincer, CM White, DG Roseneau and LG Swartz (1971) DDE residues and egg shell changes in Alaskan falcons and hawks. Science. 172: 955-969.

Cade TJ, Kokimies P and Nielsen OK (1998) Gyr Falcon Birds of Western Palearctic update, Oxford university Press, Oxford, UK. Pp. 80-124.

Canadian Peregrine Foundation (1998) Ontario's Endangered Wildlife: Student's Guide to the Peregrine falcon. Toronto: Canadian Peregrine Foundation adapted with permission from a publication by the Alberta Environmental Protection Education Branch. Chamerlat. Pp. 20-35.

Carole S and Griffith (1994) The Falconinae, The Condor. 96(1): 127-140.

Carpenter EJ (1972) Plastics on the Sargasso sea surface. Science. 175: 1240-1241.

Carpenter FL (1980) Food abundance and territoriality. To defend or not to defend. American Zoology. 27: 387-399.

Carpenter FL (1983) Territoriality and abundance of prey. American Zoology 13: 154-156.

Carpenter JW, Pattee OH, Fritts SH, Rattner BA, Wiemeyer SN, Royle JA and Smith MR (2003) Experimental lead poisoning in turkey vultures (Cathartes aura), J. Wildlife Diseases. 39(1): 96-104.

Castellanos A (1996) Peregrine Falcon Recovery Along The West Central Coast of the Baja California Peninsula, Mexico. J. Rapt. Research. 30 (1): 31-38.

Chandler AC (1916) A study of the structure of feathers, With reference to their taxonomic significance. Univ. Calif. Publ. Zool. 13: 243-446.

Charles SGM & Burt ML (1990) A Supplement to Distribution and Taxonomy of Birds of the World. Yale University Press, London. Pp. 356-379.

Charles SGM & Burt ML (1993) A Supplement to Distribution and Taxonomy of Birds of the World. Yale University Press, London. Pp. 42-43.

Clark WS and Wheeler BK (1987) A field guide to hawks of North America. Peterson Field Guide series 35. Boston: Houghton Mifflin. Pp. 110-128.

Clench MH (1970) Variability in body pterylosis, With special reference to the genus Passer. The Auk. 87: 650-691.

Cody ML (1966) A general theory of clutch size. Evolution. 20: 174-184.

Combreau O, Launay F and Bowardi MA (1999) Outward migration of houbara bustard, from two breeding seasons in Kazakistan. The Condor. 101(1): 159-164.

Compton LV (1938) The pterylosis of the falconiformes with special attention to the taxonomic position of the Osprey. Univ. Calif. Publ. Zool. 42: 173-212. & A comparative study of feather arrangement. The Condor. 69: 1-12

Conover MR and MillerDE (1979) Rictal Bristle function in Willow Flycatcher, The Condor 82: 469-471.

Cooney R & A Cockburn (1995) Territorial defence is the major function of female song in the superb fairy-wren Malurus cyaneus. Anim. Beha. 49: 1635-1647.

Cooper JA & Afton AD (1981) A multiple sensor system for monitoring avian nesting behavior, Wilson Bull. 93: 325-333.

Cooper JE (1979) Clinical Changes in Captive Birds of Prey. Pp. 102-112.

Cortes O, Barroso A and Dunner S (1999) Avian sexing: an optimized protocol using PCR-SSEP. J. Vet. Diagn. Invest. 11: 297-299.

Craig W (1943) The song of the Wood Pewee *Myiochanes virens.* A study of bird music. New York State. Mus. Bull. No. 334.

Cramp S & Perrins CM & DJ Brooks (1993) Handbook of the birds of Europe, Middle East and North Africa. The Birds of Western Palearctic. Vol. 8. Crows of finches, Oxford University Press, Oxford, UK.

Cramp S & Simmons KEL (1970) Birds of Western Palearctic, Vol. 1, Oxford University Press, Oxford. Pp. 145-152.

Cramp S & Simmons KEL (1980) The Birds of Western Palearctic. Vol.2. Hawks to bustards, Oxford University Press, Oxford. Pp. 154-160.

D' AbuQa-sim MJF (1983) Al-Farid Fi Taqyid Ash Sharid Wa Tawcid Al Wabid, Morocco. Pp. 20-23.

D'Aloia and Marie-Ann (2000) DNA-based sex identification of falcons: a collaboration between the NARC, ERWDA and Pro Falcon, Al Ain. ERWDA International Research Report. Pp. 9-10. EP-0241.

D'Aloia Marie-Ann, and Eastham (1998) DNA-based sex indication of several falcon species and its use in wild studies and captive breeding. ERWDA Internal Research Report: No. 19, Pp. 9-13.

D'Aloia, Marie-Ann and Eastham CP (2000) DNA-based sex indication of falcons and its use in wild studies & captive breeding. Zoology in the Middle East. 20: 25-32.

Damiri S Kamaluddin (1940) Hayatul Hayawanul Kubra. Lebanon, Beirut. Pp. 213-215. (printed Abdul Hamid Hameed Hanafi, Egypt).

Darley JA, Scott MM and Taylor NK (1977) Effects of age, sex and breeding success on site findelity of Gray Catbirds. Bird-banding. 48: 145-151

David H Ellis, Beth Ann Sabo, James K Fackler and Brian A Millsap (2002) Prey of the Peregrine Falcon (Falco peregrinus cassini) in Southern Argentina and Chili. J. Rapt. Research. 36(4): 168-171.

David L, Harrison DL and Paul PJ (1991) The Mammals of Arabia. Printed by Lakeside Printing, 5 St Botolophs Road, Savenoaks, Kent, TN13 3AJ, England. Pp. 180-192.

Dawson WR and Evans FC (1957) Relation of growth and development to temperature regulation in nesting nestling Field and Chipping Sparrows. Physiol. Zool.30: 315-327.

Day MG (1966) Identification of hair and feathers remains the gut and faeces of stoat's weasel. J. Zool. 148: 201-217.

De Kiriline L (1954) The voluble singer of the treetops. Audubon Mag. 56: 109-111.

De Weese LR, Pillmore RE and Richmond ML (1975) A device for inspecting nest cavities. Birds-banding. 46: 162-165.

del Hoyo J, Elliot A and Sargatal J (1992) Handbook of the birds of the World. Vol. 1. Lynx editions, Barcelona, Spain. Pp. 105-121.

del Hoyo J, Elliott A and Sargatal J (1994) Handbook of the birds of the World. Vol. 2. New World Vultures to Guineafowl. Barcelona: lynx Edicions. Pp. 230-245.

Dementiev GP (1951) Der Gerfalke, Zeimsen Verlag A, Wittenberg Lutherstadt. Determination of by radio telemetry. J. Rapt. Research. 31(4): 333-338.

Demong NJ and Emlen ST (1975) An optical scope for examining nest contents of tunnel-nesting birds. Wilson Bull. 87: 550-551.

Di Somma A (2002) A considerable increase in Trichomoniasis. Dubai Falcon Hospital Report. P.10.

Dodsworth PTL (1913) Some notes on the nesting and plumage of the Shaheen Falcon *Falco peregrinus peregrinator* Vel. The black-cap Falcon *Falco atriceps* J. Bom. Nat. Hist. Soc. 22(3): 629-630.

Donald CH (1907) Nest of Indian Hobby *Falco severus*. J. Bom. Nat. Hist. Soc. 17(3): 841-842 & J. Bom. Nat. Hist. Soc. 14(3): 608-609.

Dottlinger H, Thilo and W Hoffman (1999) The Status of the Black Shaheen or Indian Peregrine Falcon *Falco peregrinus peregrinator* in Srilanka J. Bom. Nat. Hist. Soc. 96(2): 239-43.

Ehrlich PR, Dobkin DS and Wheye D (1988) The Birder's Handbook: A field guide to the natural history of North American birds. New York: Simon & Schuster. Pp. 210-241.

Ellis DH, Ellis MH and Tsengec PU (1997) Remarkable Saker falcon *Falco cherrug* breeding records for Mangolia. J. Rapt. Research. 31(3): 234-240.

Ellis DH, Moon SL and Robinson JW (2001) Annual movements of a Steppe Eagle-Summering in Mangolia and wintering in Tibets. J. Bom. Nat. Hist. Soc. 98(3): 145-148.

Elman R (1990) The Complete Book of Hunting. Abbeville Publishers, New York. Pp. 154-175.

Embabi NS (1993) Environmental aspects of geographical distribution of mangrove in the United Arab Emirates. Motivate Publishing, Dubai. Pp. 35-42.

Enderson JH and Craig GR (1997) Wide ranging by nesting Peregrine Falcon. The Auk. 25: 190-245.

Enderson JH and Kirven M (1983) Movements of Peregrine Falcon determined by telemetry. J. Rapt. Research. 17: 33-37.

Enderson JH, Heinrich W, Kiff L and White CM (1995) Population Changes in North American Peregrines. In: Trans. 60th North American Wildlife and Natural Resources Conference. Wildlife Management Institute, Washington, DC, U.S.A. Pp. 140-161.

Erickson MM (1938) Territory, annual cycle, and numbers in a population of Wren-tits *Chamaea fasciata.* Univ. Calif. Publ. in Zool. 42: 247-334.

Erskine AJ (1959) A method for opening nesting holes. Bird-banding 30: 181-182.

Falls JB (1969) Individual recognition by sound in birds. In: Acoustic communication in birds, Vol. 2, Kroodsma DE and Miller EH (Eds.) Academic Press, New York.

Falls JB (1982) Individual recognition by sound in birds. In Acoustic communication in birds, Vol.2. Kroodsma DE and Miller EH (Eds.). Academic Press. New York. Pp. 175-185.

Farabaugh SM (1981) The ecological and social significance of duetting. In Acoustic communication in birds, Vol.2, Kroodsma DE and Miller EH (Eds.) Academic Press. New York. Pp. 54-61.

Fautin RW (1941) Development of nestling Yellow-headed Blackbirds . The Auk. 58: 215-232.

Ferguson-Lees J and Christie DA (2001) Raptors of the World. Houghton Mifflin Company, 215 Park Avenue South, New York. Pp. 325-350.

Fischer DL, Ellis KL, Meese RJ (1984) Winter habitat selection of diurnal raptors in central Utah. Rap. Research. 18: 98-102.

Fisher HI (1966) Hatching and the hatching muscle in some North American ducks. Trans. Illinois State Acad. Sci. 59: 305-325.

Flood NJ (1990) Aspects of the breeding biology of Audubon's oriole. J. Field Ornithol. 61: 290-302.

Forbes NA (1991) Wing tip oedema and dry gangrene of raptors. Vet. 128: 575-576.

Forsman D (1999) The Raptors of Europe and Middle East, A Handbook of Field Identification. T & AD Poyster Ltd, Oval Road, London. Pp. 429-567.

Foster MS (1967) Pterylography and age determination in the Orange-crowned Warbler. The Condor. 69: 1-12.

Fox DL (1976) Animal biochromes and structural colours: physical chemical distributional physiological features of coloured bodies in the animal world. 2nd ed Berkeley Univ. of California. The Condor. 25(6): 65-68.

Fox DL (1980) The pterylosis in the genera Pycnonotus and Andropadus. Gerfaut. 70: 225-244.

Frankel OH & Soule ME (1981) Conservation and Evolution. Cambridge University Press. Pp. 125-135.

Franklin IR (1980) Evolutionary change in small populations. In: Conservation Biology: An Evolutionary – Ecological Perspective, Soule ME, Wilcox BA (Ed) Sundereland, Massachussets, Sinauer Associates. Pp. 135-149.

Frazier FP (1952) Depigmentatin of a Robin. Bird-Banding. 23: 1114-1115.

Freeman P and Salvin K (1985) Falconry, its Claims, History and Practice. T & AD Poyster Ltd, Oval Road, London.Pp. 356-382.

Friis NT (1995) Some recommendations concerning primary isolation of *Mycoplasma suipneumoniae* & *M. flocculare*. The Condor. 27: 337-339.

Frith HJ (1962) The Mallee-fowl: The bird that builds an incubator. Sydney: Angus & Robertson. Pp. 356-362.

Fuller JL and Thomsun WR (1960) Behaviour Genetics. John Wiley & Sons Publication, Wesleyan University, U.S.A. Pp. 110-125.

Fuller MR and Mosher JA (1981) Methods of detecting the counting raptors; a review. CJ Ralph & JM Scott (Eds), Estimating number of terrestrial birds. Stud. Avian. Biol. 6: 25-36.

Furr PM, Cooper JE, Tailor and Robinson D (1977) Isolation of Mycoplasmas from three falcons The Auk. 100: 72-73.

Fyfe RW (1988) The Canadian Peregrine Falcon Recovery Programme 1967-1985 in: Cade TJ, Enderson, C Thelander CG and White C (Eds.) Peregrine Falcon Populations: their management and recovery. The Peregrine Fund, Boise ID, U.S.A. Pp. 599-610.

Gaines D (1974) A new look at the nesting riparian avifauna of the Sacramento Valley , California. Western Birds. 5: 61-80.

Gallagher M and Woodcock M (1980) The Birds of Oman. Quarter Books, London. Pp. 241-245.

Gary B, Enderson J and Magro AJ (1992) Home range, habitat use and behaviour of Prairie falcons wintering in East Central Colorado. J. Rapt. Research. 26(1): 13-14.

Gauch S, Hollom K, Porter PAD, Christensen S and Willis M (1988) Birds of the Middle East and N. Africa. T&A Poyser, Staffordshire, UK. Pp. 321-335.

Gensbol B (1984) Collins Guide to the Birds of Prey of Britain and Europe, North Africa and Middle East. Collins, London. Pp. 180-201.

Gibbons LM, Samour JH and Bailey and Theresa (1998) Serratospeculum from the falcons of Arabian Peninsula. Proc. Conference of International Institute of Parasitology. United Kingdom, Pp. 10-12.

Gibran K (1900) In the lesson 'Why do I like loneliness' in the book Al Munthakhabath by Sayyid Gazanfar Zaidi. Pp. 13. Al Hilal Publications Beirut, Lebanon. Pp. 32-34.

Gish SL and Morton ES (1981) Structural adaptations to local habitat acoustics in Carolina Wren songs. Z.Tierpsychol. 56: 74-84.

Glasier P (1978) Falconry and Hawking. Charles T Bradford Co, Newton Centre, Massachussets, USA. Pp. 150-184.

Glasier P (1986) Falconry and Hawking. R.J. Acford Ltd, Fitzhardinge. Pp. 250-62.

Goodsman SM and Hynes CV (1989) The distribution, breeding season and food habits of the Lanner falcon from the Eastern Sahara. Nat. Geogr. Res. 5: 126-131.

Goodsman SM and Hynes CV (1992) The diet of the Lanner falcon *Falco biarmicus* in a hyper arid region of the Eastern Sahara. J. Arid Environ. 22: 93-98.

Govindakrishnan, PM (1979) in Karnataka. J. Bom. Nat. Hist. Soc. 75 (2): 487-489.

Green EE (1902) Hobby protecting Bulbul nest. J. Bom. Nat. Hist. Soc. 14(3): 608-609.

Greenwood A (1984) The role of diseases in the ecology of Raptors. Bird Study. 24: 259-265.

Greenwood PJ (1983) Mating systems and evolutionary consequences. In: IR Swingland & PJ Greenwood (Eds.) The ecology of animal movement Carendon Press, Oxford, UK. Pp. 116-131.

Grezegorz K (2002) Food of the Lesser Kestrel *Falco naumanni* in its winter quarters in South Africa. J. Rapt. Research. 36(2): 52-56.

Gross AO (1940) Eastern Nighthawk. In Life histories of North American cuckoos, goatsuckers, humming-birds and their allies. Bent AC, U.S.Natl. Mus. Bull. 176: 206-234.

Grossman ML and Hamlet J (1964) Birds of Prey of the World. Clarkson N Potter Inc, New York Grzimeks, Tierleben DTV: Vogel, Vol 7 Pp. 140-155.

Gullion GW (1953) Territorial behavior of the American Coot. The Condor 55: 169-186.

Gurney (1879) Some details on 'stray feathers' of less common Shaheen falcon in comparing Peregrine and *Falco atriceps*. SF. 8: 423-437.

Halwagy H & Halwagy (1977) Birds of the Middle East and N. Africa. T&A Poyser, Staffordshire, UK.

Hanbal Ahamed (710) The Book Musnad Ahamed, In: Hayatul Hayawanul Kubra, Lebanon, Beirut. Pp. 231-232. published by Abdul Hamid Hameed Hanafi, Egypt.

Hantage E (1968) Zum Beuteerwerb unserer wander-falcen. Orn. Mitt. 20: 211-217.

Harrison BW (1994) Avian Medicine, Principles, Application. T&A Poyser Ltd. Pp.1053-1060.

Harrison C (1978) A field guide to the nests, eggs ands nestlings of North American birds. London and Toronto: Collins. Pp. 190-235.

Harrison HH (1975) A field guide to birds' nests of 285 species found breeding in the United States east of the Mississippi River. Boston: Houghton Mifflin. Pp. 110-125.

Harrison HH (1978) A field guide to western birds' nests of 520 species found breeding in the United States west of the Mississippi River. Boston: Houghton Mifflin. Pp. 50-75.

Harting JE (1891) Bibliotheca Accipitraria. A catalogue of books ancient and modern relating to falconry. Bernard Quaritch, London. Pp. 112-125.

Hartshorne C (1973) Born to sing. Bloomington: Indiana Univ. Press. Pp. 245-260.

Hassan Ali Ibn Al Romi (1405) In: Hayatul Hayawanul Kubra, Lebanon, Beirut. Abdul Hamid Hameed Hanafi, Egypt. Pp. 230-231.

Health and Hygiene (Pvt.) Ltd. South Africa (2001) Review of biosecurity of the operations of the National Avian Research Center and Abu Dhabi Falcon Hospital in February 2001. ERWDA International Report. 8(79): 85-89.

Heatley JJ, Marks S, Mitchel M and Tully T (2001) Raptor emergency and critical care: Assessment and examination. Compendium on Continuing Education for the Practicing Veterinarian. 23(5): 442-450.

Hedenstrom and Rosen AM (2001) Predator versus prey: on aerial hunting and escape strategies in birds. Behavioral Ecology. 12(2): 150-156.

Heidenreich M (1976) Birds of Prey: Medicine and Management, Oxford: Balckwell Science, Pp. 131-153.

Henny CJ, Galushin VM, Dudin PI, Khrustov AV, Mischenko AV, Moseikin VN, Sarychev VS and Turchin VG (1998) Organochlorine pesticides, PCBs and mercury in hawk, falcon, eagle and owl eggs from the Lipetsk, Voronezh, Novgorod and Saratov regions, Russia, 1992-1993., J. Rap. Research. 32(2): 143-150.

Heyman R and Morlion ML (1980) The pterylosis in the genera Pycnonotus and Andropadus. Gerfaut. 70: 225-244.

Hichey JJ (1940) Territorial aspects of the American Redstart. The Auk. 57: 255-256.

Hickey JJ (1969) Peregrine Falcon Populations: their biology and decline. Madison, Wisconsin, University of Wisconsin Press. Pp. 121-154.

Hill (1973) Birds of the Middle East and N. Africa. T&A Poyser, Staffordshire, UK. Pp. 213-220.

Hinde RA (1969) Bird vocalizations: Their relations to current problems in biology and psychology. Cambridge: Cambridge Univ. Press. Pp. 125-168.

Hoffmeister DF and Setzer HW (1947) The postnatal development of two broods of Great Horned Owls (Bubo virginianus). Univ. Kanas Publ. Mus. Nat. Hist. 1: 157-173.

Hohn EO (1977) The "snowshoes effect" of the feathers on ptarmigan feet. The Condor. 19: 380-382.

Hohn EO (1980) Molt cycle of the red-backed sandpiper *Calidris alpine* in western north America. The Auk. 83: 512-533

Holcomb LC (1966a) The development of grasping and balancing co-ordination in nestling of seven species of altricial birds. Wilson Bull. 78: 57-63.

Holcomb LC (1966b) Red-winged Blackbird nestling development. Wilson Bull. 78: 283-288.

Holmes RT (1966) Molt cycle of the Red-backed Sandpiper *Calidris alpina* in western North America. The Auk. 83: 517-533.

Holroyd GL and Banasch U (1996) Raptor Research Foundation. J. Rapt. Research. 30(3): 145-156.

Holy Qur'an (22:31) Translated by Moudoodi A a'ala (1988) Tharjumane Qur'an, Malayalam Translation, published by Islamic Publishing House, Kozhikode. Pp. 442-443.

Holy Qur'an (24:41) Translated by Moudoodi A a'ala (1988) Tharjumane Qur'an, Malayalam Translation, published by Islamic Publishing House, Kozhikode. Pp. 468-469.

Holy Qur'an (5:4) Translated by Moudoodi A a'ala (1988) Tharjumane Qur'an, Malayalam Translation, published by Islamic Publishing House, Kozhikode. Pp. 141-144.

Howard DV (1967) Variation in the breeding season and clutch-size of the Robin in the north-eastern United States and the Maritime Provinces of Canada. Wilson Bull. 79: 432-440.

Howell TR (1964) Notes on incubation and nestling temperatures and behavior of captive owls. Wilson Bull. 76: 28-36.

Humphrey PS and Clark DA Jr (1961) Pterylosis of the Mallard Duck. The Condor. 63: 365-385.

Humphrey PS and Clark KC (1963) Comments on the study of plumage succession. The Auk. 80: 496-503.

Humphrey PS and Parkes KC (1959) An approach to the study of moults and plumages. The Auk. 76: 1-31.

Huraira A (710) In: Musnad Ahamed by Ahamed Ibnu Hanbal. Lebanon, Beirut. Abdul Hamid Hameed Hanafi, Egypt. Pp. 215-217.

Huraira A (710) In: Musnad Ahamed by Ahamed Ibnu Hanbal. Lebanon, BeirutAbdul Hamid Hameed Hanafi, Egypt. Pp. 221-222.

Hutt FB and Ball L (1938) Number of feathers and body size in passerine birds. The Auk. 55: 651-657.

Ibnu Hajr (1393) Hadith Fathhul Bari, the interpretation of Saheehul Bukhari, Hadith No. 3988. Chapter 'Magazi' Published by Al Thurash Publications Cairo, Egypt. Pp. 752-773.

Iqbal AM (1905) Bale Gibreel, Collection of Iqbalian Poems. Educational Book House, Aligarh Muslim University. P. 457.

Iqbal AM (1905) Bankedara, Collection of Iqbalian Poems. Educational Book House, Aligarh Muslim University. P. 342.

Ismail S, Malcolm and Ahmad R (1990) A bibliography of forage halophytes and trees for salt-affected land: their use, culture and physiology, University of Karachi.

Jackson JA (1976) How to determine the status of a woodpecker nest. Living Bird. 15: 205-221.

Jaison EA & Mathew DN (2002) Structure and comparison of two bird communities in the Southern Western Ghats. J. Bom. Nat. Hist. Soc. 99(1): 8-25.

Jellis R (1977) Bird sounds and their meaning London: British Broadcasting Corporation. The Condor. 21(5): 76-83.

Jenkins AR & Benn GA (1998) Home range size and habitat requirements of Peregrine Falcons on Cape Peninsula South Africa. J. Rap. Research. 32(2): 90-97.

Jenkins AR (2000) Characteristics of Peregrine and Lanner Falcon nesting habitats in South Africa. Ostrich. 171(3): 416-424.

Jennings MC (1981) Birds of the Arabian Gulf. Printed by Biddles Ltd, Guilford, Surrey, Great Britain. Pp. 25-32.

Johansson C, Linder ET, Hardin P and White CM (1998) Bill and body size in the peregrine falcon, north versus south. Journal of Biogeography. 25(2): 265-273.

Johnsgard P A (1990) Hawks, Eagles and Falcons of North America, T & AD Poyser Ltd, Staffordshire, UK (1990) biology and natural history. Washington DC: Smithsonian Institution Press. Pp. 85-102.

Jones CG & Swinnertone KJ (1995) A summary of the conservation status and research for the Mauritius Kestrel *Falco punctatus*, Pink pigeon *Columbus mayeri* . Dodo J.Jersey wildl. Preserv. Trust. 33: 72-75.

Jowhari (1005) In: Hayatul Hayawanul Kubra by Damiri, S Kamaluddin., Lebanon, Beirut. Abdul Hamid Hameed Hanafi, Egypt. Pp. 214-216

Karen Steenhof, Mjichael N Kochart, Leslie B Carpenter and Robert N Lehman (1999) Long term Prairie Falcon population changes in relation to prey abundance, weather, land uses and habitat conditions. The Condor. 101(1): 28-29.

Karla, RL & Chawla, RP (1981) Impact of pesticidal pollution in the environment. J. Bom. Nat. Hist. Soc. 78(3): 1-15.

Kellogg PP and Hutchinson CM (1963) The solar eclipse and bird song. Living Bird. 3: 185-192.

Kendeigh SC (1937) The relation of metabolism to the development of temperature regulation in birds. Jour. Exp.Zool. 82: 419-438.

Kendeigh SC (1940) Factors affecting length of incubation. The Auk. 57: 499-513.

Kendeigh SC (1941) Territorial and mating behavior of the House Wren. Illinois Biol. Monogr.18: 1-20.

Kendeigh SS (1952) Parental care and its evolution in birds. Illinois Biol. Monogr. Pp. 1-356.

Kenward RE, RH Pfeffer, MA AlBowardi, NC Fox, KE Riddle, EA Bragin, A Levin, SS Walls and KH Hodder (2001) Setting harness sizes and other marking techniques for a falcon with strong sexual dimorphism. J. Field. Ornith. 72(2): 244-257.

Khalid (1996) The Hunting with falcons. Motivate Pubishing, Arabian Gulf. Pp .125-152.

Khazweeni (1995) Wonders of Creatures and Animals and superfluous of beings. Motivate Pubishing, Arabian Gulf. Pp.35.

Kiff LF (1988) Changes in the status of the Peregrine Falcon in North America: an over view. Pp 123-139 In: Cade TJ, Enderson C, Thelander B and White C (Eds.), Peregrine Populations: their management and recovery. The Peregrine Fund, Boise ID U.S.A.

King AP and West MJ (1977) Species identification in the North American Cowbird: Appropriate responses to abnormal song. Science. 195: 1002-1004.

King AS and McLelland M (1984) Birds, Their Structure and Function, Bailliere Tindall, Philadelphia, U.S.A. Pp. 170-185.

Kirchhoff H and Rosengarten R (1994) Isolation of a motile Mycoplasma (International J. Gen. Microbio. 130: 2439-2445.

Klomp NI & RW Furness (1970) Nonbreeders as a buffer against environmental stress: declines in numbers of Great Skua on Foula, Shetland and prediction of future recruitment. J. Applied Biology. 29: 341-348.

Klopman RB (1962) Sexual behavior in the Canada Goose. Living Bird. 1: 123-129.

Klutch B (1994) Past and present of the Peregrine falcons in Estonia In: E Kumari (Ed) Estonian wetlands and their life, Tallin, Valgus. Pp. 230-253.

Koford CB (1953) The California Condor. The Auk. Batl. Audubon Soc. Res. Rept. 12: 123-132.

Konishi M (1963) The role of auditory feedback in the vocal behavior of the Domestic Fowl. Z.Tierpsychol. 20: 349-367.

Kostrzew R and Kostrzewa R (1990) The relationship of spring and summer weather with density and breeding of the Buzzard, *Buteo buteo*, Goshawk, *Accipiter gentilis* and Kestrel *Falco tinnunculus*. Ibis. 132: 550-559.

Kostrzew R and Kostrzewa R (1991) Winter weather, spring and summer density, and subsequent breeding success of Eurasian Kestrels, Common Buzzards and Northern Goshawks. The Auk. 108: 342-347.

Kotani H (1985) Identification of Mycoplasma colonies by immunobinding. Journal Clinical Microbiology. Pp. 783-785.

Krebs JR (1976) Habituation and song repertories in the Great Tit. Behav.Ecol.Sociobiol. 1: 215-227.

Krebs JR, Ashcroft R and Webber MI (1978) Song repertories and territory defence. Nature. 271: 539-542.

Kritzeck J (1970) Modern Islamic Literature from 1800 to present. New American Library, New York. Pp. 145-178.

Kroodsma DE (1976) Learning and the ontogeny of sound signals in birds. In: Acoustic communication in birds.Vol.2. D.E. Kroodsma and E.H. Miller (Eds.). Academic Press. Pp. 25-39.

Kroodsma DE (1976) Reproductive development in a female songbird: Differential stimulation by quality of male song. Science. 192: 574-575.

Kroodsma DE (1981) Geographical variation and functions of song types in warblers (*Parulidae*). The Auk. 98: 743-751.

Kroodsma EE and Miller EH (1981) Acoustic communication in birds.2vols. New York: Academic Press. Pp. 102-115.

Kumar V (1996) Animal Behavior. Himalaya Publishing House, Ramdoot, Dr. Bhalerao Marg, Girgaon, Bombay. Pp. 54-56.

Kuyt E (1980) Distribution and breeding biology of raptors in the Thelon river area, Northwest territories. Can. Field. Nat. 94: 121-130.

Labastille A and Maclean GL (1970) The structure of the water holding feathers of the Namaqua sandgrouse. Zoological Africana. 8: 141-152.

Lack D (1954) Natural regulation of animal numbers, Clarendon Press, Oxford. The Auk. 35: 121-125.

Lack D (1963) Cuckoo hosts in England. Bird Study. 10: 185-201.

Lack D (1968) Biological adaptation for breeding in birds. Methuen, London. The Condor. 15(5): 54-56.

Lack D (1990) Ecological adaptations for breeding in birds. Methuen, London. Nature. 151:354-365.

Lack D and LackE (1951) The breeding biology of the Swift *Apus apus*. Ibis. 93: 501-546.

Lade BI and Thorpe WH (1963) Dove songs as innately coded patterns of specific behaviour. Nature.202: 366-368.

Lambrechts MM & AA Dhondt (1995) Individuals voice discrimination in birds. In: Current Ornithology (Ed. Power DM). Plenum Press, New York. The Condor.10(12): 115-139.

Lany P, Rychlik I, Barta J, Kundera J and Pavlik I (1999) Salmonellae in one Falcon Breeding Facility in the Czech Republic during the period 1989-1993. Veterinaria Medicina. The Auk. 44(11): 345-352.

Lanyon WE and Tavolga WN (1960) Animal sounds and communication. American Institute of Biological Sciences, Washington.

Lein MR (1976) Song variation in a population of Chestnut-sided Warblers *Dendroica pensylvanica*. Its nature and suggested significance. Canadian Jour. Zool. 56: 1266-1283.

Leith H and Masoom AA (Eds.) (1993) Towards the rational use of high salinity tolerant plants 1: 45-58. Kluwer Academic Publishers. The Netherlands.

Lewis SA and Gould WR (2000) Survey effort effects on power to detect trends in raptor migration counts. Wildl. Soc. Bull. 28(2): 317-329.

Lierz M, Ibrahim MM, Schmidt R, Weigand V and Runge M (2001) Isolation of Mycoplasma sp. in captive falcons in UAE. The Condor. 35(4): 67-75.

Lierz M, Schmidt R, Brunnberg L and Runge M (2000) Isolation of Mycoplasma melanogridis from free ranging birds of prey in Germany. J. Veterinary Med. 47: 63-67.

Lierz U and Lierz M (2003) Therapy of chronic superficial keratitis in birds: grid keratectomy (case report). Praktische Tierarzt. 84(4): 276-280.

Livesey TR (1933) The nesting of the Shaheen falcon Falco peregrinus on a tree. J. Bom. Nat. Hist. Soc. 36(4): 1003-04

Loke WT (1947) Swimming of Peregrine falcons. J. Bom. Nat. Hist. Soc. 46(4): 725-726.

Louis Maaloof (1986) Al-Munjid. Arabic to Arabic dictionary, published by Al-Sharqiya publication, Beirut, Lebanon. Pp.101-102.

Lucas AM and Stettenheim PR (1972) Avian Anatomy integument vol. 2. Pp.315-327.

MacQueen PM (1950) Territory and song in the Least Flycatcher. Wilson Bull. 62: 194-205.

Mactarlane R (1891) Notes on and lists of birds and eggs collected in Arctic America, 1861-1866. Proc. U.S. Nat. Mus. 14: 413-446.

Maderson PFA (1972) On how an archosaruian scale might have given rise to an avian feather Amer net. 106: 424-428.

Maguirem AJ (2000) Whimbrel attacked by a Peregrine Falcon and killed by a Common Raven in northern California, Wilson Bulletin. 112(3): 429-430.

Mandaville (1990) Birds of the Middle East and N. Africa. T&A Poyser, Staffordshire, UK. Pp. 120-160.

Manoharan TM, Biju Sd, Nayar DS and Easa PS (1998) Silent valley-Whispers of reason. Dept. of forest, Kerala Forest Research Institute, Kerala. Pp. 310-313.

Manosevitz M, Lindzey G and Theissen DD (1969) Behavioural Genetics Method and Research, Appleton Century Crofts, Educational Division, Park Avenue South, New York. Pp. 254-269.

Manvell RJ, P McKinney, U Wernery and Frost K (2000) Isolation of a highly pathogenic influenza A virus of subtype H7N3 from a Peregrine falcon *Falco peregrinus*. Avian Pathology. 29(6): 635-637.

Markus M B (1965) The number of feathers on birds. Ibis. 107: 394

Marler P (1956) Behaviour of Chaffinch *Fringilla coelebs*. Behavior sup. The Condor. 7: 25-35.

Marler P (1970a) Birdsong and speech development: Could there be parallels? Amer. Scientist. 6: 669-673.

Marler P (1970b) A Comparative approach to vocal learning Song development in White-crowned Sparrows. Jour. Comp. Physiol. Psychol. 71(2): 1-25.

Marler P and Peters S (1981) Sparrows learn adult song and more from memory. Science. 213: 780-782.

Marti CD (1987) Raptor food habit studies. In: Raptor Management Techniques Manual. B.A. Giron Pendleton BA Millsap, KW Cline and Bird DM (Eds.) Natl. Wildl. Pp. 67-80. Sci. Tech. Ser. No.1. Pp. 56-60.

Mateo R, Cadenas R, Manez M and Guitart R (2001) Lead shot ingestion in two raptor species from Donana, Spain. Ecotoxicology and Environmental Safety. 48(1): 6-10.

Matics R, Hoffmann G, Nagy T and Roulin A (2002) Random pairing with respect to plumage coloration in Hungarian Barn Owls *Tyto alba*. J. Fur. Ornithologie. 143(4): 493-495.

Mayaud N (1949) Teguments et phaneres in traite de zoologie, Ed p-p grasse Vol. 15. Paris mason et cie. Pp. 124-126.

McDonald PG (2003) Variable plumage and bare part colouration in the Brown Falcon, *Falco berigora*: the influence of age and sex. Emu. 103(1): 21-28.

Mearns R (1985) The hunting ranges of two female Peregrines towards the end of breeding season. J. Rapt. Research. 19: 20-26.

Mebs T (1989) Roofvogels van Europa. Thieme, Den Haag. Pp. 210-215.

Mewaldt L R (1958) Pterylography and natural and experimentally induced molt in Clark's Nutcracker. The Condor. 60: 165-187.

Meyer RL, Balgooyen TG (1987) A study and implications of habitat seperation by sex of wintering American kestrels *Falco sparverius*. J. Rapt. Research. 6: 107-123.

Michell CS (1990) Eastern Red footed Kestrels. Honey guide. 15(5): 37:6-7.

Miller AH (1928) The moults of the Loggerhead Shrike *Lanius ludovicianus* Linnaeus. Uni. Cali. Pub. Zool. 30: 393-417.

Miller EH (1981) Character and variance shift in acoustic signals of birds. In: Acoustic communication in birds, vol.1, Kroodsma DE and Miller EH (Eds.) Academic press. New York: Emu. 95(2): 32-38.

Miller WD (1924) Variations in the structure of the aftershaft and their taxonomic value amer mus novitaes No. 140: 1-7.

Mills GS (1975) A winter population study of the American Kestrel in central Ohio. Wilson Bull. 87: 241-247.

Mills GS (1976) American kestrel sex ratios and habitat separation. The Auk. 93: 740-748.

Mitchell TG (1958) The taxonomic position of the Gouldian Finch. Emu. 58: 395-411.

Morimando F, Pezzo Francesco and Draghi Alessandro (1997) Food habits of the Lanner falcon *Falco* biarmicus in Central Italy. J. Rapt. Research. 31(1): 40-43.

Morishita TY, Aye PP and Brooks DC (1997) A Survey of Diseases of Raptorial Birds: Journal of Avian Med. and Surgery. 11: 77-92.

Morlion M (1964) Pterylography of the wing of the Ploceidae Gerfaut. 54: 111-158

Morlion ML and Vanparijis P (1979) The pterylosis of five European corvids. Gerfaut. 69: 357-378.

Mosher JA, Fuller MR and Kopeny M (1990) Surveying woodland raptors by broadcast of conspecific vocalizations. J. Field Ornithol. 61: 453-461.

Moudoodi A (1988) Tharjumane Qur'an, Malayalam Translation, 7th Edn, published by Islamic Publishing House, Kozhikode. Pp. 442-443.

Movalli PA (2000) Heavy metal and other residues in feathers of Laggar *falcon Falco biarmicus* jugger from six districts of Pakistan. Environmental Pollution. 109(2): 267-275.

Mueller HC (1990) The evolution of reversed sexual dimorphism in size in monogamous species of birds. Biol. Rev. 65: 553-585.

Mueller HC and Meyer M (1985) The evolution of reversed sexual dimorphism in size: a comparative analysis of the Falconiformes of the Western Palearctic. Current Ornithol. 2: 65-101.

Muller MG, Wernery U and Kosters J (2000) Bumblefoot and lack of exercise among wild and captive-bred falcons tested in the UAE. Avian Diseases. 44(3): 676-680.

Mulligan JA (1966) Singing behavior and its development in the Song Sparrow. Univ. Calif.Publ.in Zool. 81: 1-76.

Murphy JR (1963) Status of a Golden Eagle Population in central Utah. Rap. Res. Rep. 3: 91-96.

Naik RM (1965) The Pterylography of the House Swift *Anus affinis* as revealed by a new staining technique. Pavo. 3: 89-95.

Nandi NC (1999) Checklist of Avian Blood Parasites Vol.97 in 1999 and Index Catalogue on Avian Haematozoa from India occasional paper. The Condor. 48: 1-63.

Naoroji R (1985) Raptors of the Rajpipla forest. J. Bom. Nat. Hist. Soc. 82(1): 345-352.

Naoroji R (1997) Breeding record of the Collared falconet *Microhierax caerulescen* for the Indian subcontinent in Corbet National park, U.P. J. Bom. Nat. Hist. Soc. 94(1): 267-268.

National Research Council (1990) Saline Agriculture; Salt tolerant plants for developing countries. Report of the Panel of the Board on Science and Technology for International Development, National Academy Press, Washington. Pp. 124-126.

Navroji R (1986a) Raptors and their habitat in danger. Hornbill 1986(3): 29-33.

Navroji R (1990) Predation by Acquila Eagles on Nestling Storks and Herons Keoladeo National Park Bharatpur. J. Bom. Nat. Hist. Soc. 87(1): 37-46.

Neelakantan KK (1960) Occurrence in Kerala in J. Bom. Nat. Hist. Soc. 57(2): 409-411.

Negro JJ, Alain M, Chastin B and David M Bird (1994) Effects of short-term food deprivation on growth of hand-reared American Kestrels. The Condor. 96 (3): 749-760.

Nelson RW & Myres TM (1970) Declines in Populations of Peregrine falcons and their sea bird prey at Lanagra island, British Columbia. The Condor. 78: 281-293.

New Scientist (2004) Bird flu death, New Scientist, 17, January 2004. Pp.5.

Newton I (1979) Population Ecology of Raptors. Buteo Books, Vermillion, SD, U.S.A.

Newton I (1990) Birds of Prey, Merehurst, London. Pp. 245-265.

Newton I, Rothery (2002) Age-related trends in different aspects of the breeding performance of individual female Eurasian Sparrowhawks *Accipiter nisus*. The Auk. 119(3): 735-748.

Nice MM (1937) Studies in the life history of the Song Sparrow, I. Trans. Linnaean Soc. New York 4:i-vi; 1-247.

Nice MM (1943) Studies in the life history of the Song Sparrow, II. Trans. Linnaean Soc. New York 6:i-viii;1-328.

Nice MM (1954) Problems of incubation periods in North American birds. The Condor. 56: 173-197.

Nitzsch CL and Burmeister CCH (1840) System der pterylographie, English translation. Pp. 124-135.

Nolan V (1978) The ecology and behavior of the Prairie Warbler *Dendroica discolor*. Amer. Ornith. Union. Ornith. Monogr. 26: 198-202.

Norberg RA, Andersson M and Wilkund CG (1983) Evolution of reversed sexual dimorphism and role partitioning among predatory birds, with a size scaling of light performance. Biol. J. Linn. Soc. 15: 105-130.

Nottebohm F (1969) The Song of the Chingolo, *Zonotrichia capensis*, in Argentina: Description and evaluation of a system of dialects. The Condor. 71: 299-315.

Nwaigbo and Adegbehin JO (1990) Mangrove resources in Nigeria: use and management perspectives. In UNESCO: Nature and resources. Managing the coast environment. Porthenon Publishing Group, Lancs and New Jersey. The Field. 14(2): 425-478.

O'Brien SJ, Roelke ME, Marker L, Newman A, Winkler CA, Meltzer D, Colly LK, Evermann JF, Bush M & Wildt DE (1985) Genetic basis for species. Vulnerability in the Cheetah. Science 227:1428-34.

Obaid HT (1992) Dubai, An Arabian Album. Motivate Publishing, Dubai. Pp. 25-58.

Obset J (1994) Gyr falcon - Tree nesting by the Gyr falcon in the Western Canadian Arctic J. Rapt. Research. 28(1): 4-7.

Ohmart RD (1967) Comparative molt and pterylography in the quail genera Callipepla and Lophortyx. The Condor. 69: 535-548.

Orton DA (1975) The speed of a Peregrine dive. The Field. 25(9): 588-590.

Osborne PE (1996) Desert Ecology of Abu Dhabi, Pisces Publication, Newbury. Pp. 21-54.

Osman SM (1979) The Peregrine. J. Bom. Nat. Hist. Soc. 75(3): 845-53

Osman SM (1983) The Peregrine. J. Bom. Nat. Hist. Soc. 80(2): 380-384.

Oystein P & Mortensen M (1999) An Anthropology study of falconry in the UAE, NARC External Report: No.7, Pp. 25. EP-0233.

Palmer AG, Nordmeyer DL and Roby DD (2001) Factors influencing nest attendance and time-activity budgets of peregrine falcons in interior Alaska, Arctic, 54(2): 105-114.

Pavlik I, Cernik J, Barta J, Kundera J and Pecka Z (1991) Occurrence of coccidia (Caryospora neofalconis and Caryospora kutzeri) in birds of prey in Falcon Breeding Facility in Milotice in the Czech Republic. Veterinarni Medicina, 43(10): 301-306.

Payne RB (1981) Population structure and social behavior: Models for testing the ecological significance of song dialects in birds. In: Natural selection and social behavior: Recent research and new theory; Alexander RD and Tinkle DW (Eds.) Chiron Press. New York. Pp. 154-165.

Peakall DB (1976) The Peregrine Falcon *Falco peregrinus* and pesticides. Canadian Field Naturalist. 90: 301-307.

Penteriane (1992) Bald Eagles and Water fowl: the leadshot connection. Trans. N.A. Wildl. Nat. Res. Conf. 48: 230-237.

Pepler D & Oettle (1992) Diet of the Hobby Falcon *Falco subbuteo* in the south western Cape. Ostrich. 62: 74-75.

Pepler D (1993) Diet and hunting behaviour of European Hobby in Africa. Pp. 163-170.

Perrins & Birkeland (1983) Egg formation in Raptors. Ibis. 125: 514-520.

Perrins & Moss CM (1975) Eggs, egg formation and the timing of breeding. Ibis. 1385: 2-15.

Perrins CM (1970) The timing of birdsbreeding season. Ibis. 112: 242-255.

Perrins CM (1994) Competition and egg weight in the Great tit *Parus major*. Ibis. 136: 454-456.

Pettingill OS (1985) Ornithology in Laboratory and Field (fifth edition). Cornell Universtiy. Academic Press, INC, New York. Pp. 162-165.

Pettingill OS Jr (1936) The American Woodcock *Philohela minor* (Gmelin). Mem. Boston Soc. Nat. Hist. 9: 167-391.

Pettingill OS Jr (1960) The effects of climate and weather on the birds of the Falkland Islands. Proc. XIIth Internatl. Ornith Congr. Pp. 604-614.

Pitelka FA (1945) Pterylography, moult and age determination of American jays of the genus Aphelocoma. The Condor. 47: 229-260.

Platt JB (1988) Gyrfalcon courtship and early breeding behavior on the Yukon North Slope. Sociobiology. 15: 43-69.

Poole KG and RG Bromley (1985) Brigham Young Uni. Science. Bull. 12: 56-85.

Porter RD and White CCM (1973) The Peregrine Falcon in Utah, emphasizing ecology and competition with Prairie falcon. Brigham Young Uni. Science. Bull. 18: 1-74.

Potter PE (1972) Territorial behavior in savannah Sparrows in south-eastern Michigan. Wilson Bull. 84: 48-59.

Prakash M, Diwan AP, Sharad Srivastava and Singhal V (1994) Recent Advances in Animal behavior. Anmol Publication, Dayangiri, New Delhi. Pp. 162-175.

Pressreenewalt CH, Brandt W and Friel DD (1960) Iridescent colours of hummingbird feathers. Journal Opticsl Soc. Amer. 50(10): 1005-1016.

Rahmani AR and Shobrak M (1987) Arabian Bustard Survey, 1987 Technical Report. No.1, National Committee for Wildlife Conservation and Development; Saudi Arabia. Pp. 13.

Ralls K, Brugger K, Ballou J (1979) Inbreeding and juvenile mortality in small populations of Ungulates. Science 206:1101-03.

Ratcliffe DA (1970) Changes attributable to pesticide in egg breakage frequency and egg shell thickness in some British birds. J. Appl. Ecol. 7: 67-107.

Ratcliffe DA (1980) The Peregrine Falcon. T & AD Poyser Ltd, Harcourt Place, 32 Jamestown Rd. London. UK. Pp. 25-58.

Ratcliffe DA (1993) The Peregrine falcon T & AD Polyser Ltd, Harcourt Place, London NW1 7BY, UK.

Ratcliffe SD (1903) Parasites on Peregrines. J. Bom. Nat. Hist. Soc. 15(2): 365-66.

Red Data Book (2003)

Redig PT, Stowe CM, Bannes DM and Arent TD (1993) Lead toxicosis in Raptors. J. Am. Vet. Med. Ass. 177: 941-943.

Reed CA (1904) North American birds eggs. New York: Doubel day, Pp. 325-340.

Remple D and Gross C (1993) Falconry and Birds of Prey in Gulf. The Condor. 102(4): 814-822.

Remple JD (1988) An overview of Arab falconry, its medical lore and the introduction of avian medicine in the Arabian Gulf. In: Peregrine Falcon Population: Their Management and Recovery. Cade, TJ, Enderson JH, Thelander CG and White CM (Eds.) The Peregrine Fund Inc. Pp. 825.

Richardson C (1990) The Birds of the United Arab Emirates. Hobby Publication, Dubai. Pp. 149-158.

Richardson C and Aspinall S (1998) The Shell Birdwatching Guide to the United Arab Emirates. Colin Richardson & Hawk Publishing, Emirates Printing Press, Dubai. Pp. 185-205.

Ricklefs RE (1965) Brood reduction in the Curve-billed Thrasher. The Condor. 67: 505-510.

Riddle KE and Remple JD (1994) Use of the Saker and large falcons in Middle east Falconry. In: Raptor Conservation Today. Meiburg, B.U., and Chancellor, R.D. (Eds). WWGBP / Pica Press. Pp. 415.

Ritchie BW, Harrison GJ and Harrison LR (1994) Avian Medicines. Principles and Applications, Buteo Books, Vermillion, SD, U.S.A. Pp. 101-115.

Rizzo MCL Migliore P and Nassa B (1993) Insects, small mammals and breeding performance of farmland populations of the Common Kestrel. In: in Nicholls MK and R Clarke (Eds.) Biology and Conservation of small falcons. Proceeding of the 1991 Hawk and Owl Trust Conference, The Hawk and Owl Trust, London, U.K. Pp.11-18.

Rosen M and Hedenstrom A (2002) Soaring flight in the Eleonora's Falcon (Falco eleonorae), The Auk.119(3): 835-840.

Roseneau DC (1972) Summer distribution number and food habits of the Gyr falcon in the Seward peninsula. Alaska College, AK, U.S.A. The Condor. 45(5): 451-456.

Russel D Dawson and Gary R Bortoloth (2000) The Reproductive Success of American Kestrels: The Role of prey abundance and weather. The Condor. 102(4): 354-358,

Salvat L and Fattorini S (2000) Responsiveness of nesting Eurasian Kestrels *Falco tinnunculus* to call playbacks. J. Rapt. Research. 34(4): 319-321.

Samour JH (1995) Veterinary Medicine, Falcons and Falconry. Motivate Publishing, Dubai. Pp. 245-256.

Samour JH and D'Aloia MA and Howlett JC (1996) Normal hematology of captive Saker falcons. Comparative Hematological International, Pp. 650-52. EP-0100.

Samour JH and Silvanose C (2000) Parasitological findings in captive falcons in United Arab Emirates. Raptor Biomedicine 3: 117-124. In:3rd International Raptor Biomedicine, South Africa, 4-11 August, 1998. Pp. 754-762, EP-0255.

Samour JH, Bailey TA and Keymer IF (1995) Use of Ammonium chloride in falconry in Middle East, Vet. Record 137: 269-270. EP-0059.

Samour JH, Bailley and Cooper JE (1995) Trichomoniasis in Falconiformes in Bahrain. Vet. Record, 136: 358-362. EP-0058.

Samour JH, D'Aloia and Marie-Ann (1996) *Babesia shortti* infection in a Saker Falcon Falco cherrug. The Veterinary Record. 139: 167-168 EP-0103.

Samour JH, D'Aloia and Marie-Ann (1998) Normal blood chemistry of captive Saker falcons. Avian Pathology. Pp. 25-178. EP-101.

Schettler E, Langgemach T, Sommer P and Streich Frolich (2001) Seroepizootiology of selected infectious disease agents in free-living birds of prey in Germany. Journal of Wildlife Diseases. 37(1): 145-152.

Schlegel H and Wulverhost JAV (1979) The world of Falconry. Lawsanne, Switzerland.

Sen DN and Rajpurohit KS (1982) Contributions to the ecology of halophytes. Task for Vegetation Sciences Geobios International, Jodhpur. Pp. 216-218.

Sferra NJ (1984) Habitat selection by American Kestrel *Falco sparverius* and red-tailed hawk *Buteo jamaicensis* wintering in Madison country, Kentucky. Raptor. Res. 18: 148-150.

Shaffer ML (1981) Minimum population sizes for species conservation. Bio Science 31: 131-134.

Siegfried WR and Skead DM (1971) Status of the Lesser kestrel in South Africa. Ostrich 42: 1-4.

Silsby J (1990) Inland Birds of Saudi Arabia. Immel Publishers London. Pp. 145-165.

Simmons KEL (1970) Breeding adaptation and social behavior Condor 102(2):159-165.

Simmons KEL (1980) Ecological determinations of breeding adaptation and social behavior in two fish-eating birds. In: Social behavior in birds and mammals Crook HJ (Ed.), The White Friars Press Ltd. London. Pp. 254-265.

Skutch A F (1957) The incubation patterns of birds. Ibis. 99: 69-93.

Skutch A F (1962) The constancy of incubation. Wilson Bull. 74: 115-152.

Skutch AF (1945) Incubation and nestling periods of Central American birds. The Auk. 62:8-37.

Slagsvold T, Johnsen A, Lampe HM and Lifjeld JT (2001) Do female pied flycatchers seek extrapair copulations with familiar males? A test of the incomplete knowledge hypothesis. Behavioral Ecology. 12(4): 412-418.

Smallwood JA (1987) Sexual segregation by habitat in American kestrels wintering in Southcentral Florida: Vegetative structure and responses to differential prey availability. The Condor. 89: 842-849.

Smallwood JA (1988) A mechanism of sexual segregation of habitat by American Kestrels *Falco sparverius* wintering in south-central Florida. The Auk. 105: 36-46.

Smallwood JA, Natale C, Steenhof K, Meetz M, Marti CD, Melvin RJ, Bortolotti GR, Robertson R, Shuford WR, Lindemann SA and Tornwal BI (1999) Clinal variation in the juvenal plumage of American Kestrels. J. Field. Ornitho. 70(3): 425-435.

Snow DW (1973) The classification of the Cotingidae, Breviora, Pp.409.

Snow DW and M Loutte (1981) Atlas of specification in African non-passerine birds-Addenda and Corrigenda, 2. Bull. Brit. Ornithol. Club. 101: 136.

Snyder NFR and JW Wiley (1976) Sexual size dimorphism in hawks and owls of North America. Ornithol. Monogr. 20: 1-96.

Southern WE (1958) Nesting of the Red-eyed Vireo in the Douglas Lake Region, Michigan. Jack-Pine Warbler. 36: 105-130, 185-207.

Staebler AE (1941) Number of contour feathers in the English Sparrow. Wilson Bull. 53: 126-127.

Stainford JK (1932) The occurrence of the Lesser Kestrel *Cerchneis naumanni* and Knot Tringa *C. canutus* in Burma. J. Bom. Nat. Hist. Soc. 36(1): 265-266.

Stainford JK (1937) Occurrence of the Chinese Lesser Kestrel *Cerchneis naumanni pekinensis* (Swinh.) in Northern Burma. J. Bom. Nat. Hist. Soc. 39(3): 633-634.

Stauber RM (1973) *Trichomonas gallinae* as a factor in the decline of the Peregrine Falcon.. In: JJ Hickey (Ed) Peregrine falcon population their biology and decline. Univ. Wisconsin Press, Madison and London. Pp. 435-438.

Stephen M Redpath, Roger Clarke, Mike Madders and Simon J Thirgood (2001) Assessing raptor diet: comparing pellets, prey remains and observational data. The The Condor. 103(1): 184-186.

Stonehouse B (1960) The King Penguin, Aptenodytes patagonica, of South Georgia. Breeding behavior and development. Falkland Islands Dependencies Surv. Sci. Repts. Pp. 145-168.

Stoner D (1942) Behavior of young Bank Swallows after first leaving the nest. Bird-Banding. 13: 107-110.

Storer RW (1966) Sexual dimorphism and food habits in three North American Accipiters. Street, Manchester, London. The Auk. 104: 635-639.

Stoutjesdijk F (2002) The ugly duckling: a thermal viewpoint. J. Therm. Bio. 27(5): 413-422.

Streseman J (1960) Ergebnisse Der Expedition Heinrich. Zur Ornithologie dir Minahassa (Nordelebs). Ornithol. Monatso. 25: 85-92.

Stressman E (1960) Vorlaufiges uber die ornithologishen Ergebnisse Der Expedition Heinrich 1930-31. Zur Ornithologie dir Minahassa (Nordelebs). Ornithol. Monatso. 39: 102-105.

Subramanya S (1963) Notes on Peregrine's nesting in Bangalore J. Bom. Nat. Hist. Soc. 79(2): 412-413.

Subramanya S (1963) The Falcon's nesting in Bangalore. J. Bom. Nat. Hist. Soc. 9 (2): 412-413.

Sutton GM and Spencer HH (1949) Observations at a nighthawk's nest. Bird-banding. 20: 141-149.

Teas HI (1983) Biology and ecology of mangroves. Dr. W. Junk publishers, The Hague, Pp. 188.

Teas HI (1984) Physiology and management of mangroves. Vol.9. Dr. W. Junk Publishers, The Hague. Pp.106.

Temeles EJ (1985) Sexual size dimorphism of bird eating hawks: the effect of prey vulnerability. Am. Nat. 125: 485-499.

Temples SA (1985) The status and conservation of endemic kestrels in the Indian ocean islands. Pp. 78-82 in: Proc. World conference of Birds of Prey, Vienna, ICBP, Cambridge.

Terres JK (1980) The Audubon encyclopaedia of North American birds. New York: Alfred A. Knopt.

The Auk. 56: 420-428. (An account of destructive forces operating in a breeding colony.)

The Hindu (2004) Human bird flu cases confirmed. The Hindu, Saturday, January 24, 2004. Pp.14.

Thorstrom R (2000) The food habits of sympatric Forest-Falcons during the breeding season in northeastern Guatemala. J. Rapt. Research. 34(3): 196-202.

Ticehurst CB (1933) The occurrence of the Lesser Kestrel *Cerchneis naumanni* (Fleisch.) in Burma. J. Bom. Nat. Hist. Soc. 36(2): 508-509.

Ticehurst NF (1909) A History of the birds of Kent. London. Pp. 142-168.

Tickell WLN (1968) The biology of the Great Albatrosses, Diomedea exulans and Diomedea epomophora. American Geophysical Union, Antarctic Res. Ser. 12: 1-55.

Tinbergen N (1939) The behavior of the Snow Bunting in spring. Trans. Linnaean Soc. New York The Condor. 14(5): 1-94.

Tinbergen N (1953) The Herring Gull's world: A study of the social behavior of birds. London: Collins. Pp. 135-146.

Toland BR (1987) The effect of vegetative cover on foraging strategies, hunting success and nesting distribution of American kestrels in central Missouri. J. Rapt. Research. 21: 14-20.

Tucker RM and Health MF (1994) Birds in Europe: their conservation status. Birdlife International Cambridge, U.K. Pp. 251-287.

Tucker VA (2000) Gliding flight: Drag and torque of a hawk and a falcon with straight and turned heads, and a lower value for the parasite drag coefficient. Journal of Experimental Biology, 203(24): 3733-3744.

Tucker VA (2000) The deep fovea, sideways vision and spiral flight paths in raptors., Journal of Experimental Biology. 203(24): 3745-3754.

Tucker VA, Cade TJ and Tucker AE (1998) Diving speeds and angles of a gyrfalcon, J. Experi. Bio. 201(13): 2061-2070.

Turcek FJ (1966) On plumage quantity in birds. Ekolog. Polska (Ser. A) 14: 617-633.

Uthaman PK (1990) Breeding of egrets in Kerala. J. Bom. Nat. Hist. Soc. 87(1): 139.

Uthaman PK (1991) A confiding falcon. In: Whispers of Silent Valley. Pp. 310-313.

Verner J (1975) Complex song repertoire of male Long-billed Marsh Wrens in eastern Washington. Living Bird. 14: 263-300.

Village A (1990) The Kestrel. T & A Poyser limited , U.K. Pp. 124-129.

Villarroe Ml, Bird DM and Kuhnlein U (1998) Copulatory behaviour and paternity in the American kestrel: the adaptive significance of frequent copulations., Animal Behavior. 56(2): 289-299.

Vyas R (1993) Food and feeding in Eagles. J. Bom. Nat. Hist. Soc. 90(2): 72-76.

Walter H (1979) Eleonoras Falcon. University of Chicago Press, Chicago, IL. Pp. 135-146.

Ward AB, Weigl PD, Conroy RM (2002) Functional morphology of raptor hindlimbs: Implications for resource partitioning. The Auk. 119(4): 1052-1063.

Ward FP (1986) Zoo and Wild Animal Medicine. Ed M. Fowler. Philadelphia, W. B. Saunders. Pp. 425.

Ward LZ (1971) Canopy density analysis at goshawk nesting territories. Final Report. Arizona Game and Fish dept. Phoenix, AZ, USA. Pp. 25-26.

Warkentin IG, Paul C, James M, Lynn R and Oliphant W (1992) Assortative mating in urban-breeding Merlins. In: the Middle East, TAMPA Annual Conference & Expo, 28-30 August 1996 Association of Avian Veterinarians. The Condor. 94(2): 233-239.

Watson BJ and Thelander CG (1988) Peregrine Falcon Management Efforts in California, Oregon, Washington and Nevada. In: Cade T J, Enderson C, Thelander and C White (Eds.), Peregrine Falcon Populations: their management and recovery. The Peregrine Fund, Boise ID, USA. Pp. 587-597.

Watson GE (1963) The mechanism of feather replacement during natural moult. The Auk. 80: 486-495.

Weary DM, RE Lemon & S Perrault (1992) Song repertoir do not hinder neighbour-strange discrimination. Behav.Ecol. Sociobiol. 31: 441-447.

Weaver JD and Cade TJ (1983) Falcon Propagation, A Manual on Captive Breeding. The Peregrine Fund, T & A Poyser Ltd. Ithaca, New York. Pp. 216-224.

Webster JD (1941) The breeding of the Black Oyster-catcher. Wilson Bull.53: 141-156.

Webster JD (1942) Notes on the growth and plumages of the Black Oyster-catcher. The Condor. 44: 205-211.

Weeds JS and Falls JB (1959) Differential responses of male oven birds to recorded songs of neighbouring and more distinct individuals The Auk. 76: 343-351.

Weidensaul S (1996) Raptors of the World. Swan Hill Press, Shrewsbury, England. Pp. 251-289.

Weir DN (1978) Wild Peregrines and grouse. J. Bom. Nat. Hist. Soc. 7: 98-102.

Weller MW (1958) Observations on the incubation behavior of a Common Nighthawk. The Auk. 75: 48-59.

Wernery U, Wernery R and Kinne J (1999) Production of a falcon herpesvirus vaccine. Berliner und Munchener Tierarztliche Wochenschrift, 112(9): 339-344.

Western (1989) Birds of the Middle East and N. Africa. T&A Poyser, Staffordshire, UK.. Pp. 135-148.

Western AR (1989) The Flora of the United Arab Emirates, An Introduction, UAE University, Al Ain. Pp. 188.

Weston HG Jr (1947) Breeding behavior of the Black-headed Grosbeak. The Condor. 49: 54-73.

Wetherbee DK (1957) Natal plumages and downy pteryloses of passerine birds of North America. Bull. Amer. Mus. Nat. Hist. 113: 341-436.

Wetmore A (1936) The number of contour feathers in passeriform and related birds. The Auk. 53: 159-169.

Wheeler BK and Clark WS (1995) A photographic guide to North American raptors. San Diego: Academic Press.

White CM and RW Nelson (1991) Hunting range and strategies in breeding Peregrine and Gyr falcons observed from a helicopter. J. Rapt. Research. 25: 49-62.

Whittow GC (1984) Energy Metabolism in Avian Physiology. 4th edition, PD, Sturkey (Ed.) Springer-Verlag, New York. . Pp. 245-265.

Wildenthal JL (1965) Structure in primary song of the Mockingbird *Mimus polyglottos* The Auk. 82: 161-189.

Wilson UW, A McMillan and Dobler FC (2000) Nesting, population trend and breeding success of Peregrine Falcons on the Washington outer coast, 1980-98. J. Rapt. Research. 34(2): 67-74.

Wink M, Biebatch H, Feldmann F, Scharlau W, Swatscheck I, Wink C & Ristow D (1999) Contribution to the Breeding biology of Eleonoras falcon *Falco eleonrae*. Pp. 59-72.

Wink M, Staudter H, Bragin Y, Pfeffer R and Kenward R (1999) The use of DNA fingerprinting to estimate annual survival rates in the Saker Falcon (Falco cherrug). J.Fur. Ornithologie. 140(4): 481-489.

Wolf BO and GE Walsberg (2000) The role of the plumage in heat transfer processes of birds. Amer. Zool. 40: 575-584

Wood CA (1943) The Art of Falconry, Stanford University Press, CA. Pp. 54-85.

www. scottishfalconry.co.uk

www.falconry_history.htm

Yahya HAS (2000) Food and feeding habits of Indian Barbets *Megalaima sp.* J. Bom. Nat. Hist. Soc. 97(1): 103.

Yehya Badr (1976) The Falconry as Sport: Our Heritage. Pp. 135-146.

Zadal AA (1277) In: Sharahul Muhaddab by Imam Nawawi. published by Abdul Hamid Hameed Hanafi, Egypt.

Zapata SJA, Carrete M, Gravilov A, Sklyarenko S, Ceballos O, Donazar JA and Iraldo F (2003) Land use changes and raptor conservation in steppe habitats of Eastern Kazakhstan. Biological Conservation.111(1): 71-77.

Zimmerman JL (1971) The territory and its density dependent effect in *Spiza americana*. The Auk. 88: 591-612.

APPENDICES

Appendix 1.1 Systematic list of the birds of the United Arab Emirates

The following annotated list covers the principal species of birds of desert areas in UAE.

The nomenclature is based on Cramp and Simmons (1977, 1980, 1983), Voous (1977) Cramp (1985, 1988, 1992) and Cramp and Perrins (1993).

1. Pallid Harrier *Circus macrourus* (Gmelin 1771)
2. Long legged buzzard *Buteo rufinus* (Cretzchmar 1827)
3. Houbara Bustard *Chlamydotis undulata* (Jacquin 1784)
4. Stone Curlew *Burhinus oedienemus* (Linnaeus 1758)
5. Cream-coloured Curser *Cursorius cursor* (Latham 1787)
6. Chest-nut bellied Sand grouse *Pterocles exustus* (Temminck 1825)
7. Rock Dove *Columba livia* (Gmelin 1789)
8. Collard Dove *Streptopelia senegalensis* (Linnaeus 1766)
9. Palm dove *Streptopelia senegalensis* (Linnaeus 1766)
10. Eagle Owl *Bubo bubo (*Linnaeus 1758)
11. Little Owl *Athene noctua* (Scopols 1769)
12. Black-crowned finch lark *Eremopteryx nigriceps* (Gould 1841)
13. Bar-tailed desert lark *Ammomanes cincturus* (Gould 1841)
14. Desert lark *Ammomanes deserti* (Lichenstein 1823)
15. Hoopoe lark *Alaemon alaudipes* (Desfontaines 1789)
16. Lesser short-toed lark *Calandrella rufescens* (Viellot 1820)
17. Crested lark *Galerida cristata* (Linnaeus 1758)
18. Skylark *Alauda arvensis* (Linnaeus 1758)
19. Tawny pipit *Anthus campestris* (Linnaeus 1758)
20. White wagtail *Motacilla alba* (Linnaeus 1758)
21. Isabelline wheatear *Oenanthe isabellina* (Temminck 1829)
22. Pied wheatear *Oenanthe pleschanka* (Lepechin 1770)
23. Desert wheatear *Oenanthe deserti* (Temminck 1825)
24. Red-tailed wheatear *Oenanthe xanthoprymna* (Hemprich & Ehrenberg 1833)
25. Mourning wheatear *Oenanthe lugens* (Lichtenstein 1823)
26. Desert warbler *Sylvia nana* (Ehrenberg 1833)
27. Desert lesser whitethroat *Sylvia curruca* (Hume 1873)
28. Arabian babbler *Turdoides squamiceps* (Cretzschmar 1827)
29. Purple sunbird *Nectarinia asiatica* (Latham 1790)
30. Great grey shrike *Lanius excubitor* (Linnaeus 1758)
31. Brown-necked raven *Corvus ruficollis* (Lesson 1831)
32. House sparrow *Passer domesticus* (Linnaeus 1758)
33. Little Grebe *Tachybaptus ruficollis* (Voous 1977)

35. Red-necked Grebe *Podiceps grisegena* (J.A.D. Chapman 1985)
36. Black-necked Grebe *Podiceps nigricollis* (Voous 1977)
37. Sooty Shearwater *Puffinus griseus* (S.J.Aspinal et al 1995)
38. Persian Shearwater *Puffinus persicus* (S.L. James & J. Vuxton 1995)
39. Wilson's Storm-petrel *Oceanites oceanicus*
40. Leach's Storm-petrel *Oceanodroma leucorhoa* (R.G.Griffiths, J.M. Lapthorne 1969)
41. Red-billed Tropicbird *Phaethon aethereus*
42. Red-footed Booby *Sula sula* (P.W.GH. Chilman 1979)
43. Masked Bvooby *Sula leucogaster* (M. Harvi 1986)
44. Great Cormorant *Phalacrocorax carbo*
45. Socotra cormorant *Phalacrocorax nigrogularis*
46. White Pelican *Pelecanus onocrotalus* (J. Stewart-Smith 1970)
47. Dalmatian Pelican Pelecanus crispus (J. Stewart-Smith 1970)
48. Bittern *Botaurus stellaris* (D.J.G. Williams 1971)
49. Little Bittern *Ixobrychus minutus*
50. Night Heron *Nycticorax nycticorax*
51. Little Green Heron *Butorides striatus*
52. Squacco Heron *Arbeola ralloides*
53. Indian Pond Heron *Ardeola grayii*
54. Cattle Egret *Bubulcus ibis*
55. Western Reef Heron *Egretta gularis*
56. Little Egret *Egretta garzetta*
57. Intermediate Egret *Egretta intermedia* (S.J. Aspinall, E.Hirschfeld et al 1995)
58. Great White Egret *Egretta alba*
59. Grey Heron *Ardea cinerea*
60. Purple Heron *Ardea purpurea*
61. Black Stork *Ciconia nigra* (J. Steward-Smith, J.D. Wellings 1973)
62. White Stork *Ciconia ciconia*
63. Glossy Ibis *Plegadis falcinellus*
64. Spoon Bill *Platalea leucorodia*
65. Greater Flamingo *Phoenicopterus ruber*
66. Mute Swan *Cygnus olor* (M. Crumbie et al 1984)
67. Bewick's Swan *Cygnus columbianus* (C.Richardson et al 1994)
68. White-fronted Goose *Anser albifrons* (Ramadan-Jaradi 1980)
69. Lesser White-fronted Goose *Anser erythropus* (M.Tunturi 1996)
70. Greylag Goose *Anser anser*
71. Egyptian Goose *Alopochen aegyptiacus*
72. Reddy Shelduck *Tadorna ferruginea*
73. Shelduck *Tadorna tadorna*
74. Cotton Teal *Nettapus coromandelianus* (J.S. Ash, N.E. Baker et al 1984)

75. Wigeon *Anas penelop*
76. Gadwall *Anas strepera*
77. Teal *Anas crecca*
78. Mallard *Anas platyrhynchos*
79. Pintail *Anas acuta*
80. Garganey *Anas querquedula*
81. Shoveler *Anas clypeata*
82. Marbled Teal *Marmaronetta algustirostris* (J.Steward-Smith 1972)
83. Red-crested Pochard *Netta rufina* (F.E. Warr 1970)
84. Pochard *Aythya ferina*
85. Ferruginous Duck *Aythya nyroca*
86. Tufted Duck *Aythya fuligula*
87. Red-breasted Merganser *Mergus serrator* (J. Steward-Smith 1972)
88. European Honey Buzzard *Pernis apiborus*
89. Crested Honey Buzzard *Pernis ptilorhyncus* (T. Tuomenoja 1992)
90. Black-shouldered Kite *Elanus caeruleus* (M. West 1984)
91. Black Kite *Milvus migrans*
92. Palla's Fish Eagle *Haliaeetus leucoryphus* (J. Steward-Smith 1972)
93. Egyptian Vulture *Neophron percnopterus*
94. Griffon Vulture *Gyps fulvus*
95. Lappet-faced Vulture *Torgus tracheliotus*
96. Short-toed Marsh Harrier Eagle *Circaetus gallicus*
97. Marsh Harrier *Circus aeruginsus*
98. Hen Harrier *Circus cyaneus*
99. Pallid Harrier *Circus macrourus*
100. Montagu'sHarrier *Circus pygargus*
101. Goshawk *Accipiter gentilis* (D.M. Simpson 1976)
102. Sparrowhawk *Accipiter nisus*
103. Lewant Sparrowhawk *Accipiter brevipes* (M.A. Hollingworth 1977)
104. Steppe Buzzard *Buteo (buteo) vulpinus*
105. Long-legged Buzzard *Buteo rufinus*
106. Lesser Spotted Eagle *Aquila pomarnia* (C. Richardson, E. List 1990)
107. Spotted Eagle *Aquila clanga*
108. Steppe Eagle *Aquila nipalensis*
109. Imperial Eagle *Aquila heliaca*
110. Golden Eagle *Aquila chrysaetos* (J.A.D. Chapman, D. Robinson 1990)
111. Booted Eagle *Hieraaetus pennatus*
112. Bonelli's Eagle *Hieraaetus fasciatus*
113. Osprey *Pandion haliaetus*
114. Lesser Kestrel *Falco naumanni*

115.Kestrel *Falco tinnunculus* (Linnaeus 1758

116.Manchurian Red-footed Falcon *Falco amurensis*

117.Merlin *Falco columbarius*

118.Hobby *Falco subbuteo*

119.Sooty Falcon *Falco concolor*

120.Lanner Falcon *Falco biarmicus*

121.Saker Falcon *Falco cherrug*

122.Peregrine Falcon *Falco peregrenus*

123.Barbary Falcon *Falco pelegrinoides*

124.Chukar *Alectoris chukar*

125.Sand Patridge *Ammopedix heyi*

126.Grey Francolin *Francolinus pondicerianus*

127.Quail *Coturnix coturnix*

128.Water Rail *Rallus aquaticus*

129.Spotted Crake *Porzana porzana*

130.Little Crake *Porzana parva*

131.Baillon's Crake *Porzana pusilla*

132.Corncrake *Crex crex*

*133.*White-breasted Waterhen *Amaurornis phoenicurus*

134.Moorhen *Gallinula Chloropus*

135. Purple Gallinule *Porphyrio porphyrio*

136.Coot *Fulica atra*

137.Common Crane *Grus grus*

138.Demoiselle Crane *Anthropoides virgo*

*139.*Macqueen's (Houbara) Bustard *Chlamydotis macqueenii*

140.Oystercatcher *Haematopus ostralegus*

141.Black-winged Stilt *Haematopus himantopus*

142. Avocet *Recurvirostra avosetta*

143.Crab Plover *Dromas rdeola*

144.Stone Curlew *Burhinus oedicnemus*

145.Cream-coloured *Courser Courser*

*146.*Collared Pratincole *Glareola pratincola*

147.Oriental Pratincole *Glareola maldivarum*

148.Black-winged Pratincole *Glareola nordmanni*

149.Little Pratincole *Glareola lactea*

*150.*Little Ringed Plover *Charadrius dubius*

*151.*Ringed Plover *Charadrius hiaticula*

*152.*Kittlitz's Plover *Charadrius pecuarius*

*153.*Kentish Plover *Charadrius alexandrinus*

*154.*Lesser Sand Plover *Charadrius mongolus*

155. Greater Sand Plover *Charadrius leschenaultii*

156. Caspian Plover *Charadrius asiaticus*

157. Dotterel *Charadrius morinellus*

158. Pacific Golden Plover *Pluvialis fulva*

159. Golden Plover *Pluvialis apricaria*

160. Grey Plover *Pluvialis squatarola*

161. Red-wattled Lapwing *Hoplopterus indicus*

162. Sociable Plover *Chettusia gregaria*

163. Lapwing *Vanellus vanellus*

164. Great knot *Calidris tenuirostris*

165. Knot *Calidris canutus*

166. Sanderling *Calidris alba*

167. Red-necked Stint *Calidris ruficollis*

168. Little Stint *Calidris minuta*

169. Long-toed Stint *Calidris subminuta*

170. Curlew Sandpiper *Calidris ferruginea*

171. Dunlin *Calidris alpina*

172. Broad-billed Sandpiper *Limicola falcinellus*

173. Ruff *Philomachus pugnax*

174. Jack Snipe *Lymnocryptes minimus*

175. Common Snipe *Gallinago gallinago*

176. Great Snipe *Gallinago media*

177. Pintail Snipe *Gallinago stenura*

178. Woodcock *scolopax rusticola*

179. Black-tailed Godwit *Limosa limosa*

180. Bar-tailed Godwit *Limosa lapponica*

181. Whimbrel *Numenius phaeopus*

182. Curlew *Numenius arquata*

183. Spotted Redshank *Tringa erythropus*

184. Redshank *Tringa totanus*

185. Marsh Sandpiper *Tringa stagnatilis*

186. Greenshank *Tringa nebularia*

187. Green Sandpiper *Tringa ochropus*

188. Wood Sandpiper *Tringa glareola*

189. Terek Sandpiper *Xenus cinereus*

190. Common Sandpiper *Actitis hypoleucos*

191. Turnstone *Arenaria interpres*

192. Red-necked Phalarope *Phalaropus lobatus*

193. Grey Phalarope *Phalaropus fulicarius*

194. Pomarine Skua *Stercorarius pomarinus*

195. Arctic Skua *Stercorarius parasiticus*

196. Long-tailed Skua *Stercorarius lonigicaudus*

197. Sooty Gull *Larus hemprichii*

198. White-eyed Gull *Larus leucopthalmus*

199. Mediterranean Gull *Larus melanocephalus*

200. Little Gull *Larus minutus*

201. Sabine's Gull *Larus sabini*

202. Black-headed Gull *Larus ridibundus*

203. Brown-headed Gull *Larus brunnicephalus*

204. Slender-billed Gull *Larus geneii*

205. Common Gull *Larus canus*

206. Baltic Gull *Larus fuscus*

207. Siberian Gull *Larus heuglini*

208. Pontic Gull *Larus cachinnans*

209. Kittiwake Rissa tridactyla

210. Gull-billed Tern Gelochelidon nilotica

211. Caspian Tern *Sterna caspia*

212. Swift Tern *Sterna bergii*

213. Lesser Crested Tern *Sterna bengalensis*

214. Sandwich Tern *Sterna sandvicensis*

215. Roseate Tern *Sterna dougallii*

216. Common Tern *Sterna hirundo*

217. White-cheeked Tern *Sterna repressa*

218. Bridled Tern *Sterna anaethetus*

219. Sooty Tern *Sterna fuscata*

220. Little Tern *Sterna albifrona*

221. Saunders Litttle Tern *Sterna saundersi*

222. Whiskered Tern *Clidonias hybrida*

223. Black Tern *Clidonias niger*

224. White-winged Black Tern *Clidonias leucopterus*

225. Lesser Noddy *Anous tenuirostris*

226. Lichtenstein's Sandgrouse *Pterocles lichtensteinii*

227. Spotted Sandgrouse *Pterocles senegallus*

228. Chestnut-bellied Sandgrouse *Pterocles exustus*

229. Black-bellied Sandgrouse *Pterocles orientalus*

230. Rock Dove *Columba livia*

231. Woodpigeon *Columba Palumbus*

232. Collared Dove *Streptopelia decaocto*

233. Turtle Dove *Streptopelia turtur*

234. Eastern Tutle Dove *Streptopelia orientalis*

235.Palm Dove *Streptopelia senegalensis*

236.Namaqua Dove *Oena capensis*

237.Rose-ringed Parakeet *Psittacula krameri*

238.Alexandrine Parakeet *Psittacula eupatria*

239.Cuckoo *cucuclus canorus*

240.Indian Koel *Eudynamys scolopacea*

241.Barn Owl *Tyto alba*

242.Striated (Bruce's) Scops Owl *Otus brucei*

243.Scops Owl *Otus scops*

244.Desert Eagle Owl *Bubo (bubo) ascalaphus*

245.Little Owl *Athene noctua*

246.Long-eared Owl *Asio otus*

247.Short-eared Owl *Asio flammeus*

248.European Nightjar *Caprimulgus europaeus*

249.Egyptian Nightjar *Caprimulgusaegyptius*

250.Common Swift *Apus apus*

251.Pallid Swift *Apus pallidus*

252.Alpine Swift *Apus melba*

253.Little Swift *Apus affinis*

*254.*White-breasted Kingfisher *Halcyon smyrnensis*

255.Grey-headed Kingfisher *Halcyon leucocephala*

256.White-collared Kingfisher *Halcyon chloris*

257.Common Kingfisher *Alcedo atthis*

258.Pied Kingfisher *Ceryle rudis*

*259.*White-throated Bee-eater *Merops albicollis*

*260.*Little Green Bee-eater *Merops orientalis*

*261.*Blue-cheeked Bee-eater *Merops persicus*

*262.*European Bee-eater *Merops apiaster*

*263.*European Roller *Coracias garrulus*

*264.*Indian Roller *Coracias benghalensis*

*265.*Hoopoe *Upupa epops*

266.Wryneck Jynx torquilla

*267.*Black-crowned Finch Lark *Eremopterix nigriceps*

*268.*Dunn's Lark *Eremopteryx dunni*

*269.*Bar-tailed Desert Lark *Ammomanes cincturus*

*270.*Desert Lark *Ammomanes deserti*

271.Hoopoe Lark *Alaemom alaudipes*

272.Calandra Lark *Melanocorypha calandra*

273.Bimaculated Lark *Melanocorypha bimaculata*

274.Short-toed Lark *Calandrella brachydactyla*

275. Lesser Short-toed Lark *Calandrella rufescena*

276. Crested Lark *Galerida cristata*

277. Small Skylark *Alauda gulgula*

278. Skylark *Alauda arvensis*

279. Temminck's Horned Lark *Eremophila bilopha*

280. Sand Martin *Riparia riparia*

281. Pale Crag Martin *Hirundo obisoleta*

282. Crag Martin *Ptyonoprogne rupestris*

283. Swallow *Hirundo rustica*

284. Wire-tailed Swallow *Hirundo smithii*

285. Red-rumped Swallow *Hirundo daurica*

286. House Martin *Delichon urbica*

287. Richard's Pipit *Anthus richardi*

288. Blyth's Pipit *Anthus gollewski*

289. Tawny Pipit *Anthus campestris*

290. Long-billed Pipit *Anthus similis*

291. Olive-backed Pipit *Anthus hodgsoni*

292. Tree Pipit *Anthus tritialis*

293. Meadow Pipit *Anthus tratensis*

294. Red-throated Pipit *Anthus cervinus*

295. Water Pipit *Anthus spinoletta*

296. Forest Wagtail *Dendronanthus indicus*

297. Yellow Wagtail *Motacilla flava*

298. Citrine Wagtail *Motacilla citreola*

299. Grey Wagtail *Motacilla cinerea*

300. White Wagtail *Motacilla alba*

301. White-cheeked Bulbul *Pycnonotus leucogenys*

302. Yellow-vented Bulbul *Pycnonotus xanthotygos*

303. Red-whiskered Bulbul *Pycnonotus jocosus*

304. Red-vented Bulbul *Pycnonotus cafer*

305. Hypocolius *Hypocolius ampelinus*

306. Rufous Bush Chat *Cercotrichas galactotes*

307. Black Bush Robin *Cercotrichas podobe*

308. Thrush Nightingale *Luscinia luscinia*

309. Nightingale *Luscinia megarhynchos*

310. Bluethroat *Luscinia svecica*

311. White-throated Robin *Irania gutturalis*

312. Eversmann's Redstart *Phoenicurus erythronotus*

313. Black Redstart *Phoenicurus ochruros*

314. Redstart *Phoenicurus phoenicurus*

315. Blackstart *Cercomela melanura*

316. Whinchat *Saxicola rubetra*

317. Siberian Stonechat *Saxicola (t.) maura*

318. Stonechat *Saxicola torquata*

319. Pied Stonechat *Saxicola caprata*

320. Isabelline Wheatear *Oenanthe isabellina*

321. Northern Wheatear *Oenanthe oenanthe*

322. Pied Wheatear *Oenanthe pleschanka*

323. Black-eared Wheatear *Oenanthe hispanica*

324. Desert Wheatear *Oenanthe deserti*

325. Finch's Wheatear *Oenanthe finschii*

326. Red-tailed Wheatear *Oenanthe (xanthoprymna) chrysopygia*

327. Eastern Pied Wheatear *Oenanthe pictada*

328. Mourning Wheatear *Oenanthe lugens*

329. Hooded Wheatear *Oenanthe monacha*

330. Hume's Wheatear *Oenanthe alboniger*

331. Scrub Wabler *Scotocerca inqueta*

332. Grasshopper *Wabler Scotocerca naeviaa*

333. River Wabler *Scotocerca fluviapilis*

334. Reed Wabler *Scotocerca sciripaceus*

335. Great Reed *Wabler Scotocerca arundinaceus*

336. Black Drongo *Dicrurus macrocercus*

337. House Crow *Corvus splendens*

338. House Sparrow *Passer domesticus*

339. Tree Sparrow *Passer montanus*

(Source: Richardson C & Aspinal S (1998) The Shell Birdwatching Guide to United Arab Emirates)

Appendix 1.2 Systematic list of the birds of the United Arab Emirates with uncertain status

1.Sacered Ibis *Threskiornis aethiopicus*

2.Brahminy Kite *Haliastur indus*

3. Black Vulture *Aegypius monacha*

4. Shikra *Accipiter badius*

5. Little Bustard *Tetras tetras*

6. American Gull *Larus armencus*

7. Arctic Tern *Sterna paradisea*

8. Red Turtle Dove *Streptopelia tranquebarica*

9. Palla's Warbler *Proregulus proregulus*

10. Wattled Starling *Creatophora cineracea*

11. Common Noddy *Anous stolidus*

(Source: Richardson C & Aspinal S (1998) Birdwatching Guide to United Arab Emirates)

Appendix 1.3 Systematic list of the mammals of the United Arab Emirates

The following annotated list covers the principal species of mammals of desert areas in UAE.

The nomenclature is based on Cramp and Simmons (1977, 1980, 1983), Voous (1977) Cramp (1985, 1988, 1992) and Cramp and Perrins (1993).

1. Arabian White-toothed Shrew *Corcidura arabica*
2. Somalian White-toothed Shrew *Corcidura somalica*
3. Straw-coloured Fruit Bat *Eidolon helvum*
4. Greater Mouse-tailed Bat *Rhinopoma microphyllum*
5. Lesser Mouse-tailed Bat *Rhinopoma hardwickii*
6. Muscut Mouse tailed Bat *Rhinopoma muscatellum* (Thomas 1903)
7. Naked-bellied tomb Bat *Taphozus nudiventris* (Cretzschmar 1830)
8. Tomb Bat *Taphozus nudiventris*
9. Egyptian slit-faced Bat *Nycteris thebaica*
10. Persian Leaf-nosed Bat *Triaenops pericus macdonaldi*
11. Arabian Pipistrelle *Pipistrellus arabicus*
12. Red Fox *Vulpes vulpes* (Linnaeus 1758)
13. White-tailed Mangoose *Icneumia albicauda*
14. African Small spotted Genet *Genetta felina*
15. Striped Hyaena *Hyaena hyaena* (Linnaeus 1758)
16. Wild Cat *Felis silvestris* (Schreber 1777)
17. Sand Cat *Felis margarita* (Loche 1758)
18. Arabian Tahr *Hemitragus jayakari* (Thomas 1894)
19. Ibex *Capra mengesi*
20. Asiatic Mouflon *Ovis ammon*
21. Mountain Gazelle *Gazella gazella*
22. Dorcas Gazelle *Gazella dorcas*
23. Goitred Gazelle *Gazella subgutturosa*
24. Roe Deer *Capreolus capreolus*
25. Cape Hare *Lepus capensis omanensis*
26. Persian Squirrel *Sciurus anomalus*
27. Lesser Jerboa *Jaculus jaculus*
28. Asian Garden Dormouse *Eliomys melanurus*
29. Lesser Mole Rat *Spalas leucodon*
30. Broad-toothed Field Mouse *Apodemus mystacenus*
31. House Rat *Rattus rattus*
32. Brown Rat *Rattus norvegicus*
33. House mouse *Mus musculus*
34. Egyptian Spiny Mouse *Acomys whitei*
35. Golden Spiny Mouse *Acomys russatus*
36. Short-tailed Bandicoot Rat *Nesokia indica*
37. Lesser Bandicoot Rat *Bandicota bengalensis*
38. Pygmy Gerbil *Gerbillus henleyi*
39. Social Vole *Microtus socialis*
40. Sundevall's Jird *Meriones crassus*
41. Libyan Jird *Meriones libycus*
42. Vinogradov's Jird *Meriones vinogradovi*
43. Tristram's Jird *Meriones tristrami*
44. Persian Jird *Meriones persicus*
45. King Jird *Meriones rex*
46. Antelope Rat Tatera pitmani
47. Ethiopian hedge dog *Hemiechinus aethiopicus* (Ehrenberg 1833)
48. Branhles hedgedog *Hemienchinus hypomelas* (Brandt 1833)
49. Wolf *Canis lupus* (Linnaeus 1758)
50. Ruppell's (sand) fox *Vulpus rueppellii* (Schine 1825)
51. Leopard *Panthera pardus* (Linnaeus 1758)

52. Arabian Oryx *Oryx leucoryx* (Pallas 1777)
53. Arabian gazelle *Gazelle gazelle*
54. Arabian Ibex *Capra ibex* (Linnaeus 1758)

Source: David L, Harrison & Paul JJ (1991) Mammals of Arabia.

Reptiles

1. *Phrenocephalus arabicus* (Anderson 1894)
2. *Phrenocephalus maculatus* (Anderson 1872),
3. *Trapelus flavimaculatus* (Ruppell 1835),
4. *Uromastyx aegyptius microlepis* (Blanford 1874)

(Source: David L, Harrison & Paul JJ (1991) Mammals of Arabia.

Appendix 2.1 Aspects of awakening and roosting in a pair of Peregrine falcons in Abu Dhabi Falcon Research Hospital for 2002

JANUARY

Date	Awakening time(Hour)(AT)	Sunrise(Hour) (SR)	Roost-exit time (Hour) (RET)	First feeding time (Hour) (FFT)	Distance between roost and first feeding location (m) (RFD)	No. of boxes perched before FFT (BBF)	Last feeding time (Hour) (LFT)	Roosting time (Hour) (RT)	Distance between roost and last feeding location (m) (RLD)	No. of boxes perched after LFT (BAL)	Sunset (Hour) (SS)	Sleeping time (Hour) (ST)
1	06.55	07.02	06.56	06.58	31	2	17.20	17.34	40	1	17.40	18.30
4	06.55	07.00	06.57	06.59	35	3	17.22	17.33	45	4	17.41	18.31
7	06.54	06.58	06.55	06.58	40	4	17.23	17.33	42	3	17.42	18.32
10	06.55	06.56	06.57	06.59	42	3	17.25	17.34	43	4	17.44	18.30
13	06.53	06.54	06.55	06.56	35	5	17.24	17.35	38	2	17.50	18.31
16	06.50	06.52	06.54	06.58	38	4	17.25	17.37	39	1	17.53	18.32
19	06.47	06.48	06.49	06.52	38	1	17.25	17.41	45	2	17.55	18.31
22	06.43	06.45	06.48	06.49	41	3	17.29	17.44	48	3	17.58	18.31
25	06.42	06.44	06.45	06.49	42	5	17.34	17.43	42	1	18.01	18.32
28	06.41	06.43	06.43	06.45	35	2	17.34	17.45	43	2	18.03	18.31
30	06.40	06.42	06.43	06.44	30	1	17.35	17.46	45	3	18.05	18.33

FEBRUARY

Date	Awakening time (Hour)(AT)	Sunrise(Hour) (SR)	Roost-exit time (Hour)(RET)	First feeding time (Hour) (FFT)	Distance between roost and first feeding location (m)(RFD)	No. of boxes perched before FFT (BBF)	Last feeding time (Hour) (LFT)	Roost time (Hour) (RT)	Distance between roost and last feeding location (m) (RLD)	No. of boxes perched after LFT (BAL)	Sunset(Hour) (SS)	Sleeping time (Hour) (ST)
1	06.40	06.40	06.43	06.45	39	2	17.39	17.44	50	1	18.06	18.35
4	06.39	06.38	06.42	06.46	42	3	17.41	17.52	46	3	18.08	18.39
7	06.34	06.35	06.39	06.42	46	1	17.45	17.52	48	5	18.10	18.40
10	06.32	06.33	06.35	06.39	45	5	17.46	17.56	49	4	18.11	18.41
13	06.30	06.31	06.36	06.39	48	2	17.47	17.58	48	1	18.12	18.39
16	06.23	06.29	06.32	06.35	47	4	17.48	17.59	42	2	18.14	18.38
19	06.20	06.28	06.30	06.32	43	3	17.49	18.01	38	4	18.15	18.37
22	06.19	06.26	06.30	06.32	42	2	17.50	18.02	37	1	18.16	18.36
25	06.17	06.24	06.30	06.31	41	4	17.51	18.03	39	2	18.18	18.34
28	06.18	06.23	06.30	06.31	45	2	17.52	18.04	38	2	18.20	18.33
30	06.18	06.22	06.31	06.32	43	1	17.53	18.05	42	3	18.22	18.32

MARCH

Date	Awakening time(Hour)(AT)	Sunrise(Hour) (SR)	Roost-exit time (Hour) (RET)	First feeding time (Hour) (FFT)	Distance between roost and first feeding location (m) (RFD)	No. of boxes perched before FFT (BBF)	Last feeding time (Hour) (LFT)	Roost time (Hour) (RT)	Distance between roost and last feeding location (m) (RLD)	No. of boxes perched after LFT (BAL)	Sunset (Hour) (SS)	Sleeping time (Hour) (ST)
1	06.16	06.21	06.31	06.34	42	2	18.02	18.25	39	1	18.23	18.30
4	06.15	06.20	06.30	06.32	45	4	18.01	18.26	38	3	18.24	18.31
7	06.15	06.19	06.19	06.31	42	3	18.01	18.26	37	2	18.25	18.32
10	06.14	06.18	06.18	06.22	43	1	18.04	18.30	45	4	18.26	18.33
13	06.14	06.17	06.17	06.19	45	3	18.04	18.31	46	2	18.26	18.34
16	06.15	06.16	06.19	06.21	48	2	18.05	18.31	42	3	18.27	18.34
19	06.15	06.15	06.16	06.19	49	1	18.05	18.31	49	4	18.27	18.35
22	06.14	06.14	06.18	06.21	41	3	18.05	18.32	42	1	18.28	18.35
25	06.15	06.14	06.16	06.20	46	1	18.06	18.32	41	2	18.29	18.36
28	06.09	06.13	06.12	06.14	37	2	18.07	18.33	39	3	18.29	18.39
30	06.08	06.12	06.11	06.15	38	1	18.07	18.37	50	1	18.29	18.42

APRIL

Date	Awakening time (Hour) (AT)	Sunrise (Hour) (SR)	Roost-exit time (Hour) (RET)	First feeding time (Hour) (FFT)	Distance between roost and first feeding location (m) (RFD)	No. of boxes perched before FFT (BBF)	Last feeding time (Hour) (LFT)	Roost time (Hour) (RT)	Distance between roost and last feeding location (m) (RLD)	No. of boxes perched after LFT (BAL)	Sunset (Hour) (SS)	Sleeping time (Hour) (ST)
1	05.59	06.10	06.01	06.03	45	2	18.07	18.31	45	2	18.32	18.38
4	05.58	06.09	06.02	06.05	49	3	18.07	18.31	46	1	18.35	18.39
7	05.59	06.07	06.03	06.06	42	1	18.07	18.32	48	3	18.38	18.40
10	05.58	06.05	06.02	06.07	39	3	18.08	18.33	37	4	18.42	18.41
13	05.57	06.03	06.01	06.05	38	2	18.09	18.32	34	2	18.43	18.45
16	05.56	06.02	06.00	06.03	45	1	18.09	18.33	43	1	18.45	18.48
19	05.58	06.01	06.01	06.04	42	3	18.10	18.30	42	3	18.46	18.50
22	05.55	05.59	05.59	06.02	43	2	18.11	18.31	48	1	18.48	18.52
25	05.52	05.55	05.55	05.57	47	3	18.10	18.31	42	4	18.49	18.53
28	05.49	05.52	05.52	05.55	42	1	18.11	18.32	38	2	18.50	18.55
30	05.41	05.48	05.43	05.46	45	4	18.11	18.35	35	3	18.51	18.57

MAY

Date	Awakening time (Hour) (AT)	Sunrise (Hour) (SR)	Roost-exit time (Hour) (RET)	First feeding time (Hour) (FFT)	Distance between roost and first feeding location (m) (RFD)	No. of boxes perched before FFT (BBF)	Last feeding time (Hour) (LFT)	Roost time (Hour) (RT)	Distance between roost and last feeding location (m) (RLD)	No. of boxes perched after LFT (BAL)	Sunset (Hour) (SS)	Sleeping time (Hour) (ST)
1	05.39	05.43	05.42	05.45	42	2	18.12	18.41	41	1	18.52	18.56
4	05.39	05.39	05.45	05.48	45	3	18.12	18.42	42	2	18.54	18.57
7	05.35	05.36	05.46	05.49	43	1	18.13	18.43	45	3	18.55	18.59
10	05.33	05.35	05.35	05.38	39	4	18.13	18.45	32	4	18.57	18.59
13	05.26	05.35	05.28	05.36	38	3	18.14	18.46	39	2	18.58	19.01
16	05.24	05.34	05.26	05.34	34	2	18.15	18.47	38	3	18.59	19.09
19	05.20	05.33	05.24	05.39	37	4	18.14	18.49	37	1	19.01	19.12
22	05.18	05.32	05.22	05.37	39	1	18.15	18.52	34	4	19.03	19.16
25	05.14	05.31	05.18	05.39	41	2	18.15	18.53	35	2	19.04	19.19
28	05.12	05.31	05.16	05.38	40	3	18.16	18.52	39	3	19.05	19.21
30	05.11	05.31	05.15	05.32	38	2	18.16	18.53	41	1	19.06	19.23

JUNE

Date	Awakening time(Hour) (AT)	Sunrise Hour) (SR)	Roost-exit time (Hour) (RET)	First feeding time (Hour) (FFT)	Distance between roost and first feeding location (m) (RFD)	No. of boxes perched before FFT (BBF)	Last feeding time (Hour) (LFT)	Roost time (Hour) (RT)	Distance between roost and last feeding location (m) (RLD)	No. of boxes perched after LFT (BAL)	Sunset (Hour) (SS)	Sleeping time (Hour) (ST)
1	05.16	05.31	05.19	05.36	30	4	18.17	18.57	40	1	19.07	19.24
4	05.14	05.31	05.17	05.38	51	2	18.17	18.58	45	3	19.07	19.25
7	05.14	05.30	05.16	05.35	50	3	18.18	18.59	41	2	19.08	19.26
10	05.14	05.30	05.18	05.36	45	4	18.19	18.58	43	4	19.09	19.27
13	05.14	05.30	05.18	05.35	49	2	18.19	19.01	39	1	19.09	19.28
16	05.13	05.31	05.16	05.31	48	1	18.20	19.02	35	2	19.10	19.27
19	05.13	05.31	05.16	05.34	45	3	18.21	19.03	31	3	19.11	19.28
22	05.12	05.31	05.15	05.33	42	2	18.21	19.05	32	1	19.12	19.29
25	05.12	05.32	05.15	05.32	49	1	18.22	19.07	23	4	19.13	19.27
28	05.11	05.32	05.14	05.33	38	3	18.23	19.08	30	2	19.14	19.28
30	05.10	05.33	05.13	05.34	37	2	18.23	19.10	35	3	19.15	19.29

JULY												
Date	Awakening time(Hour)(AT)	Sunrise(Hour) (SR)	Roost-exit time (Hour) (RET)	First feeding time (Hour) (FFT)	Distance between roost and first feeding location (m) (RFD)	No. of boxes perched before FFT (BBF)	Last feeding time (Hour) (LFT)	Roost time (Hour) (RT)	Distance between roost and last feeding location (m) (RLD)	No. of boxes perched after LFT (BAL)	Sunset (Hour)(SS)	Sleeping time (Hour) (ST)
1	05.29	05.33	05.31	05.33	52	3	18.22	19.09	51	3	19.16	19.24
4	05.30	05.34	05.32	05.34	38	2	18.23	19.03	50	2	19.14	19.20
7	05.29	05.36	05.33	05.39	48	4	18.24	19.04	36	1	19.12	19.14
10	05.31	05.38	05.33	05.39	42	1	18.25	19.05	38	2	19.09	19.13
13	05.31	05.39	05.34	05.36	52	3	18.26	19.05	39	3	19.08	19.12
16	05.32	05.40	05.35	05.37	39	2	18.27	19.06	41	4	19.03	19.08
19	05.32	05.42	05.36	05.39	38	4	18.28	19.07	43	2	19.02	19.08
22	05.33	05.43	05.36	05.39	34	1	18.31	19.09	45	3	19.03	19.10
25	05.36	05.44	05.38	05.40	39	2	18.32	19.09	46	1	19.04	19.11
30	05.36	05.45	05.39	05.42	38	3	18.29	19.10	43	2	19.05	19.12

AUGUST												
Date	Awakening time (Hour) (AT)	Sunrise(Hour) (SR)	Roost-exit time (Hour) (RET)	First feeding time (Hour) (FFT)	Distance between roost and first feeding location (m) (RFD)	No. of boxes perched before FFT (BBF)	Last feeding time (Hour) (LFT)	Roost time (Hour) (RT)	Distance between roost and last feeding location (m)(RLD)	No. of boxes perched after LFT (BAL)	Sunset (Hour) (SS)	Sleeping time (Hour) (ST)
1	05.37	05.46	05.39	05.41	39	5	18.28	18.29	36	4	19.06	19.12
4	05.36	05.48	05.39	05.41	38	3	18.27	18.29	38	2	19.03	19.13
7	05.36	05.49	05.40	05.42	41	2	18.26	18.27	39	5	18.58	18.59
10	05.37	05.50	05.41	05.43	48	4	18.25	18.26	35	3	18.50	18.52
13	05.35	05.51	05.39	05.42	49	1	18.24	18.25	34	2	18.45	18.48
16	05.37	05.52	05.41	05.44	45	2	18.22	18.24	39	1	18.39	18.42
19	05.36	05.54	05.39	05.42	47	1	18.21	18.25	41	5	18.32	18.39
22	05.35	05.56	05.39	05.43	48	2	18.21	18.25	45	4	18.29	18.34
25	05.34	05.57	05.38	05.42	46	1	18.20	18.23	46	2	18.28	18.34
30	05.39	05.59	05.41	05.44	38	2	18.19	18.22	42	3	18.27	18.32

SEPTEMBER												
Date	Awakening time (Hour) (AT)	Sunrise(Hour) (SR)	Roost-exit time (Hour) (RET)	First feeding time (Hour) (FFT)	Distance between roost and first feeding location (m) (RFD)	No. of boxes perched before FFT (BBF)	Last feeding time (Hour) (LFT)	Roost time (Hour) (RT)	Distance between roost and last feeding location (m) (RLD)	No. of boxes perched after LFT (BAL)	Sunset(Hour) (SS)	Sleeping time (Hour) (ST)
1	05.51	06.00	05.54	05.56	39	3	18.18	18.21	45	3	18.27	18.30
4	05.52	06.01	05.55	05.57	29	5	18.19	18.21	46	2	18.26	18.28
7	05.53	06.02	05.57	05.57	35	2	18.20	18.22	48	5	18.25	18.29
10	05.52	06.04	05.59	05.61	38	4	18.18	18.20	47	4	18.21	18.24
13	05.54	06.05	05.59	05.62	45	3	18.16	18.17	36	1	18.18	18.23
16	05.53	06.06	05.58	05.61	48	5	18.14	18.15	39	2	18.15	18.21
19	05.53	06.07	05.59	05.62	49	3	18.12	18.14	38	3	18.13	18.21
22	05.54	06.08	05.58	05.62	47	2	18.09	18.10	37	5	18.10	18.22
25	05.55	06.09	05.57	05.59	45	1	18.08	18.09	35	2	18.09	18.16
30	05.57	06.10	05.58	05.59	38	3	18.06	18.09	41	1	18.07	18.19

OCTOBER												
Date	Awakening time (Hour) (AT)	Sunrise(Hour) (SR)	Roost-exit time (Hour) (RET)	First feeding time (Hour) (FFT)	Distance between roost and first feeding location (m) (RFD)	No. of boxes perched before FFT (BBF)	Last feeding time (Hour) (LFT)	Roost time (Hour) (RT)	Distance between roost and last feeding location (m) (RLD)	No. of boxes perched after LFT (BAL)	Sunset (Hour) (SS)	Sleeping time (Hour) (ST)
1	05.58	06.11	06.01	06.03	52	5	18.02	18.05	40	3	18.08	18.09
4	05.59	06.13	06.02	06.03	54	4	18.01	18.06	45	2	18.04	18.05
7	06.00	06.14	06.02	06.05	35	3	18.00	18.08	48	5	18.00	18.03
10	06.01	06.16	06.03	06.05	39	1	17.48	17.51	49	4	17.58	17.59
13	06.07	06.18	06.09	06.10	38	2	17.45	17.49	47	2	17.55	17.58
16	06.06	06.19	06.09	06.12	46	3	17.41	17.45	42	3	17.51	17.55
19	06.06	06.21	06.09	06.12	45	1	17.39	17.43	43	1	17.49	17.52
22	06.06	06.22	06.08	06.12	47	2	17.38	17.42	39	3	17.48	17.51
25	06.06	06.23	06.08	06.11	49	3	17.36	17.41	38	5	17.46	17.50
30	06.07	06.24	06.09	06.11	40	5	17.34	17.42	35	4	17.44	17.49

NOVEMBER												
Date	Awakening time (Hour) (AT)	Sunrise (Hour) (SR)	Roost-exit time (Hour) (RET)	First feeding time (Hour) (FFT)	Distance between roost and first feeding location (m) (RFD)	No. of boxes perched before FFT (BBF)	Last feeding time (Hour) (LFT)	Roost time (Hour) (RT)	Distance between roost and last feeding location (m) (RLD)	No. of boxes perched after LFT (BAL)	Sunset (Hour) (SS)	Sleeping time (Hour) (ST)
1	06.08	06.25	06.18	06.32	50	4	17.28	17.35	39	3	17.42	17.51
4	06.08	06.27	06.20	06.30	49	2	17.26	17.38	41	5	17.40	17.52
7	06.09	06.28	06.22	06.33	48	3	17.25	17.37	42	2	17.38	17.54
10	06.08	06.29	06.24	06.31	42	5	17.24	17.36	45	4	17.37	17.56
13	06.10	06.33	06.25	06.35	48	1	17.25	17.29	48	2	17.35	17.58
16	06.11	06.38	06.25	06.36	49	2	17.27	17.28	45	1	17.34	17.51
19	06.15	06.41	06.26	06.34	41	3	17.22	17.27	48	6	17.33	17.49
22	06.18	06.45	06.27	06.33	42	4	17.19	17.26	49	3	17.29	17.49
25	06.21	06.47	06.28	06.35	38	2	17.18	17.25	45	5	17.28	17.48
30	06.25	06.49	06.29	06.36	39	3	17.17	17.24	45	2	17.27	17.49

DECEMBER												
Date	Awakening time(Hour) (AT)	Sunrise(Hour) (SR)	Roost-exit time (Hour) (RET)	First feeding time (Hour) (FFT)	Distance between roost and first feeding location (m) (RFD)	No. of boxes perched before FFT (BBF)	Last feeding time (Hour) (LFT)	Roost time (Hour) (RT)	Distance between roost and last feeding location (m) (RLD)	No. of boxes perched after LFT (BAL)	Sunset (Hour) (SS)	Sleeping time (Hour) (ST)
1	06.27	06.50	06.30	06.37	39	5	17.16	17.24	39	2	17.27	17.38
4	06.28	06.52	06.30	06.38	37	2	17.15	17.22	38	3	17.26	17.37
7	06.29	06.54	06.31	06.38	40	3	17.16	17.23	37	1	17.25	17.36
10	06.34	06.56	06.36	06.39	45	4	17.14	17.22	35	5	17.24	17.35
13	06.37	06.58	06.39	06.42	50	3	17.13	17.21	39	3	17.23	17.33
16	06.42	06.59	06.44	06.46	51	2	17.12	17.20	38	2	17.22	17.34
19	06.45	07.01	06.47	06.49	52	5	17.13	17.19	35	4	17.23	17.32
22	06.49	07.02	06.51	06.53	53	3	17.14	17.21	41	3	17.25	17.33
25	06.53	07.03	06.55	06.57	38	1	17.17	17.25	42	2	17.27	17.32
30	06.55	07.04	06.57	06.59	35	2	17.18	17.26	45	3	17.29	17.30

Appendix 2.2 Monthly break-up of the distance between feeding spots and the respective roosting boxes in the falcons of aviary at Study area (2001-2003)

Morning

Distance at interval of 25m	J	F	M	A	M	J	J	A	S	O	N	D	Total	%
1-25	10	11	9	8	2	3	4	7	10	11	9	4	88	69.8%
26-50	4	3	-	-	1	-	1	-	1	7	6	5	28	22.2%
51-75	1	-	-	-	2	-	1	-	2	-	1	-	7	5.6%
76-100	-	-	-	1	-	-	-	1	-	-	1	-	3	2.4%

Evening

Distance at interval of 25m	J	F	M	A	M	J	J	A	S	O	N	D	Total	%
1-25	7	6	1	1	2	1	1	1	1	9	8	9	48	38.1%
26-50	4	2	1	-	1	2	1	2	1	7	5	6	32	25.4%
51-75	3	3	-	2	1	2	1	1	2	2	1	-	18	14.3%
76-100	2	2	-	3	-	-	1	-	1	1	2	-	12	9.5%
101-125	1	2	1	-	1	-	1	-	1	1	-	1	9	7.1%
126-150	2	2	-	1	-	1	-	-	-	0	1	-	7	5.6%

Appendix 2.3 Monthly breakup of the frequency-occurrence of the numberof boxes used as perches on passage between the roost and foraging by a pair of Peregrine falcons in the aviary at Abu Dhabi Falcon Research Hospital for 126 days in 2002 in 20 Peregrine falcons

Morning

No. of boxes perched	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
0	-	1	-	1	-	-	-	1	-	1	-	-	4
1	3	4	5	4	1	2	3	4	5	1	2	1	35
2	2	2	5	3	4	5	3	6	6	4	3	4	49
3	3	2	3	4	1	3	4	1	2	2	2	-	27
4	2	-	3	-	1	-	1	-	2	-	1	-	10
5	2	-	1	-	-	2	-	-	1	-	2	-	8
6	1	-	-	-	-	1	-	-	-	-	1	-	3
7	-	-	-	-	1	-	-	1	-	-	-	-	2
8	-	-	-	-	-	1	-	-	-	1	-	-	2

Evening

No. of boxes perched	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
0	-	-	-	-	-	1	-	-	-	-	-	-	1
1	2	5	4	-	3	-	2	3	2	2	-	2	25
2	2	-	2	-	2	1	2	-	1	2	1	2	15
3	3	-	2	1	2	2	1	-	2	1	3	2	19
4	3	-	2	2	1	3	1	4	-	2	-	4	22
5	2	1	-	2	-	2	-	3	4	-	2	2	18
6	1	2	1	-	1	-	1	2	1	1	-	-	10
7	2	1	-	-	-	-	-	1	-	2	-	2	8
8	1	-	1	-	1	-	2	-	1	-	1	-	7
9	-	-	1	-	1	-	-	1	-	-	1	1	5
10	1	-	1	-	-	-	1	1	-	1	-	1	6
11	-	-	-	-	-	1	-	-	1	-	1	-	3
12	-	1	1	-	-	-	-	-	-	-	-	-	2

Appendix 2.4 Average daily distance travelled (m) by a pair of Peregrine Falcons in the study area on ull-day (05.00 – 19.00 hours)

Time (hours)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Average distance	Cumul. average distance
05.00-05.59	10	0	0	0	14	0	12	0	0	0	10	0	46	3.8	3.8
06.00-06.59	68	54	36	70	60	68	60	54	48	46	54	94	712	59.3	63.1
07.00-07.59	70	72	78	24	56	38	42	16	44	28	76	78	622	51.8	114.9
08.00-08.59	72	64	58	44	42	44	36	32	78	46	48	72	636	53	167.9
09.00-09.59	144	72	72	48	62	38	62	34	38	68	52	56	746	62.1	230
10.00-10.59	76	122	68	44	76	80	38	32	36	42	40	98	752	62.6	292.6
11.00-11.59	40	116	58	76	38	62	48	52	74	22	46	140	672	56	348.6
12.00-12.59	42	44	68	102	114	98	42	38	40	22	36	34	580	48.3	413.2
13.00-13.59	108	142	42	44	88	62	54	58	64	70	22	122	776	64.6	477.8
14.00-14.59	70	66	44	36	38	72	48	28	38	58	72	92	732	61	538.8
15.00-15.59	106	88	54	46	44	48	58	64	130	128	116	138	1020	85	623.8
16.00-16.59	180	58	68	52	96	110	52	84	32	78	52	120	982	81.8	705.6
17.00-17.59	96	84	78	82	98	112	124	176	48	138	70	80	1176	98	803.6
18.00-19.00	58	64	72	84	46	78	56	154	54	64	34	32	806	67.1	870.7
Daily Distance	1040	946	796	752	842	910	732	822	724	810	728	1156	10258	854.4	5654.4

Mean daily distance = 850m

Appendix 4.1 Time spent by the Peregrine falcons for incubation at different clutches (Data for 2001 – 2002 are pooled)

Period of incubation (days)	No. of Birds (Frequency)
30	-
31	1
32	4
33	3
34	2
35	3
36	2
37	3
38	4
39	4
40	1
41	-
42	-
Total	27

Average incubating period = 36 days

Appendix 4.2 Relationship between the sequence of eggs in clutches and their failure to hatch in the Peregrine falcons in aviary (2001-2003)

Serial No. of the egg in the clutch	Frequency of failure		Total	% failure
	2001	2002		
1	6	7	13	41%
2	7	3	10	31%
3	2	2	4	12%
4	3	2	5	16%
Total	18	14	32	100%

Appendix 4.3 Weights (gms) of Peregrine, Gyr and Saker falcons at different age levels

Spec Number	Age of the Falcon	Peregrine Male Weight in gms	Per. Female Weight in gms	Gyr Male Weight in gms	Gyr Female Weight in gms	Saker Male Weight in gms	Saker Female Weight in gms
1	1 month	350-400	500-550	500-550	550-600	500-550	550-600
2	2 month		600-700	650-700	700-750	550-600	650-700
3	3 months	430-480	720-750	700-730	800-900	600-630	800-900
4	6 months	500-550	750-800	750-800	1000-1200	650-700	950-1000
5	9 months	550-590	800-850	800-850	1300-1400	700-750	1000-1050
6	1 year	550-590	850-880	850-900	1450-1500	750-800	1050-1100
7	1.5 years	590-630	880-900	900-950	1500-1550	800-830	1100-1150
8	2 years	630-670	900-1000	950-1050	1550-1650	830-870	1150-1250
9	2.5 years	950-970	1100-1150	1050-1100	1650-1680	870-930	1250-1300
10	3 years	970-1000	1150-1200	1100-1150	1680-1700	950-1000	1300-1400

Average weight of Peregrine Female Immature (PFI) 820gm
Average weight of Peregrine Female Mature (PFM) 950gm
Average weight of Peregrine Male Immature (PMI) 500gm
Average weight of Peregrine Male Mature (PMM) 650gm
Average weight of male Gyr 1000gm
Average weight of female Gyr falcon 1600gm
Average weight of male Saker falcon 850gm
Average weight of female Saker falcon 1200gm

Appendix 4.4 The weights (gms) of Barbary, Luggar, Lanner falcons at different age levels

Sp Number	Age of the Falcon	Barbary Male Weight in gms	Barbary Female Weight in gms	Luggar Male Weight in gms	Luggar Female Weight in gms	Lanner Male Weight in gms	Lanner Female Weight in gms
1	1 month	280-300	300-350	320-350	360-400	330-350	380-400
2	2 months	240-270	350-380	350-380	400-450	350-390	400-450
3	3 months	270-300	380-420	380-400	450-500	390-420	450-500
4	6 months	300-360	420-500	400-440	500-550	420-440	500-550
5	9 months	360-380	500-550	440-480	550-580	440-460	550-600
6	1 year	380-400	550-580	480-520	580-600	460-500	600-650
7	1.5 years	400-430	580-620	520-550	600-650	500-530	650-700
8	2 years	430-470	620-680	550-650	650-750	530-630	710-850
9	2.5 years	470-490	680-720	650-680	750-800	630-660	850-880
10	3 years	490-520	720-750	680-700	800-850	660-700	880-900

Average weight of the Male Barbary Falcon 450gm
Average weight of the Female Barbary Falcon 650gm
Average weight of the Male Luggar Falcon 600gm
Average weight of the Female Luggar Falcon 700gm
Average weight of the Male Lanner Falcon 580gm
Average weight of the Female Lanner Falcon 780gm

Appendix 5.1 Monthwise distribution of the number of moulting feathers of Peregrine falcons (N=40) in aviary at Abu Dhabi Falcon Research Hospital in 2001-2002

Month	J	F	M	A	M	J	J	A	S	O	N	D	Total
Sampled numbers	-	-	0	1	1	3	2	3	4	3	2	1	20
No. of moulting body feathers	-	-	-	1	3	4	4	6	5	4	1	-	29
Capital tract	-	-	-	-	2	4	2	3	3	2	-	-	16
Spinal tract													
Cervical region	-	-	-	-	-	2	3	3	4	3	-	-	15
Interscapular region	-	-	-	-	-	1	3	3	2	3	-	-	12
Dorsal region	-	-	-	-	1	2	-	1	3	2	1	-	10
Pelvic region	-	-	-	-	-	2	1	4	4	3	-	-	14
Humeral tract	-	-	-	-	2	5	2	3	1	4	-	-	17
Femoral tract	-	-	-	-	1	3	2	3	1	1	-	-	11
Crural tract	-	-	-	-	-	1	3	2	3	3	-	-	12
Ventral tract													
Inter-ramal and submalar	-	-	-	-	-	1	-	2	1	3	-	-	7
Cervical	-	-	-	-	1	1	1	2	3	4	-	-	12
Rest of ventral	-	-	-	-	1	2	3	2	1	2	-	-	11
Alar tract													
Greater wing covert	-	-	-	-	3	3	2	3	3	1	-	-	16
Middle wing covert	-	-	-	-	-	2	1	3	2	-	-	-	8
Lesser wing covert	-	-	-	-	1	2	1	3	3	-	-	-	10
Under wing covert	-	-	-	-	2	1	1	1	1	1	-	-	7
Alula	-	-	-	-	-	1	1	-	1	-	-	-	3
Caudal tract													
Upper tail covert	-	-	-	-	1	2	2	3	2	3	-	-	13
Under tail covert	-	-	-	-	-	1	1	2	3	2	-	-	9
Anal circlet	-	-	-	-	-	1	2	1	2	2	-	-	8

Appendix 5.2 Monthwise distribution of the number of moulting feathers of Saker falcons (N=20) in aviary at Abu Dhabi Falcon Research Hospital in 2001-2003

Month	J	F	M	A	M	J	J	A	S	O	N	D	Total
Sampled numbers	-	-	0	1	1	2	3	4	3	3	2	1	20
No. of moulting body feathers	-	-	-	1	3	4	4	5	6	5	1	-	28
Capital tract	-	-	-	-	2	5	2	2	4	3	-	-	18
Spinal tract													
Cervical region	-	-	-	-	-	2	3	2	4	2	-	-	13
Interscapular region	-	-	-	-	-	1	3	3	2	4	-	-	13
Dorsal region	-	-	-	-	1	2	-	1	2	3	1	-	10
Pelvic region	-	-	-	-	-	2	-	3	3	4	-	-	12
Humeral tract	-	-	-	-	2	5	1	2	2	3	-	-	15
Femoral tract	-	-	-	-	1	3	2	1	4	2	-	-	13
Crural tract	-	-	-	-	-	1	2	1	2	3	-	-	9
Ventral tract													
Inter-ramal and submalar	-	-	-	-	-	1	-	2	1	2	-	-	6
Cervical	-	-	-	-	-	1	1	2	1	3	-	-	8
Rest of ventral	-	-	-	-	2	1	2	2	1	2	-	-	10
Alar tract													
Greater wing covert	-	-	-	-	5	3	2	3	4	1	-	-	18
Middle wing covert	-	-	-	-	-	-	3	1	2	-	-	-	6
Lesser wing covert	-	-	-	-	1	2	1	3	4	-	-	-	11
Under wing covert	-	-	-	-	2	1	-	1	-	1	-	-	5
Alula	-	-	-	-	-	1	1	-	1	-	-	-	3
Caudal tract													
Upper tail covert	-	-	-	-	1	2	2	4	2	3	-	-	14
Under tail covert	-	-	-	-	-	1	1	2	4	2	-	-	10
Anal circlet	-	-	-	-	1	1	2	1	2	2	-	-	9

Appendix 5.3 Monthwise distribution of the number of moulting feathers of Gyr falcons (N=20) in aviary at Abu Dhabi Falcon Research Hospital in 2001-2002

Month	J	F	M	A	M	J	J	A	S	O	N	D	Total
Sampled numbers	-	-	0	1	1	3	2	3	4	3	2	1	20
No. of moulting body feathers	-	-	-	1	3	4	4	6	5	4	1	-	29
Capital tract	-	-	-	-	2	4	2	3	3	2	-	-	16
Spinal tract													
Cervical region	-	-	-	-	-	2	3	3	4	3	-	-	15
Interscapular region	-	-	-	-	-	1	3	3	2	3	-	-	12
Dorsal region	-	-	-	-	1	2	-	1	3	2	1	-	10
Pelvic region	-	-	-	-	-	2	1	4	4	3	-	-	14
Humeral tract	-	-	-	-	2	5	2	3	1	4	-	-	17
Femoral tract	-	-	-	-	1	3	2	3	1	1	-	-	11
Crural tract	-	-	-	-	-	1	3	2	3	3	-	-	12
Ventral tract													
Inter-ramal and submalar	-	-	-	-	-	1	-	2	1	3	-	-	7
Cervical	-	-	-	-	1	1	1	2	3	4	-	-	12
Rest of ventral	-	-	-	-	1	2	3	2	1	2	-	-	11
Alar tract													
Greater wing covert	-	-	-	-	3	3	2	3	3	1	-	-	16
Middle wing covert	-	-	-	-	-	2	1	3	2	-	-	-	8
Lesser wing covert	-	-	-	-	1	2	1	3	3	-	-	-	10
Under wing covert	-	-	-	-	2	1	1	1	1	1	-	-	7
Alula	-	-	-	-	-	1	1	-	1	-	-	-	3
Caudal tract													
Upper tail covert	-	-	-	-	1	2	2	3	2	3	-	-	13
Under tail covert	-	-	-	-	-	1	1	2	3	2	-	-	9
Anal circlet	-	-	-	-	-	1	2	1	2	2	-	-	8

Appendix 5.4 Relative length X (mm) of Primary feathers of Peregrine falcons measured in aviary at Abu Dhabi Falcon Research Hospital in 2001-2003

	I	II	III	IV	V	VI	VII	VIII	IX	X
1	252	255	240	231	218	205	180	170	162	150
2	245	253	247	231	214	195	170	149	131	145
3	238	243	241	225	202	183	168	151	143	139
4	228	236	233	218	193	182	169	153	149	145
5	230	238	235	221	189	175	161	146	132	125
6	231	239	234	223	186	172	163	148	135	120
7	252	265	256	245	231	218	195	179	162	152
8	240	249	243	229	212	195	182	175	161	154
9	252	265	259	246	232	218	199	185	174	164
10	278	285	275	260	246	229	209	193	182	177
11	245	253	249	235	223	206	186	175	163	152
12	190	198	192	181	169	152	141	131	125	116
13	255	262	259	246	228	209	196	181	169	154
14	235	245	239	223	209	192	179	161	149	135
15	225	228	210	195	181	162	146	135	128	116
16	240	252	246	235	216	189	172	156	142	135
17	235	245	237	223	205	189	174	159	142	128
18	245	256	249	235	221	211	203	189	179	175
19	265	272	269	246	221	209	192	182	171	156
20	240	249	243	231	218	203	188	181	171	167
Total	4821	4988	4856	4579	4214	3894	3573	3299	3070	2905
Mean (M)	241.05	249.40	242.80	228.95	210.70	194.70	178.65	164.95	153.50	145.25
Σ(X-M)*(X-M)	5882.95	6128.8	6477.2	5972.95	7048.2	7406.2	6216.55	6416.95	6215	6405.75
Σ(X-M)*(X-M)/N	294.1475	306.44	323.86	298.6475	352.41	370.31	310.8275	320.8475	310.75	320.2875
√(X-M)*(X-M)/N	17.2	17.5	18.0	17.3	18.8	19.2	17.6	17.9	17.6	17.9
SD	17.2	17.5	18.0	17.3	18.8	19.2	17.6	17.9	17.6	17.9

Appendix 5.5. Relative lengths (mm) of Secondary feathers of Peregrine falcons measured in aviary at Abu Dhabi Falcon Research Hospital in 2001-2003

Sl.No	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
1	135	146	141	132	128	123	118	114	113	111	109	107
2	125	136	131	128	127	122	118	115	112	110	105	99
3	136	147	142	133	129	124	119	115	114	112	110	106
4	128	139	134	131	130	125	121	118	115	113	108	111
5	137	148	143	134	130	125	120	116	115	113	111	107
6	138	149	144	135	131	126	121	117	116	114	112	108
7	130	141	136	133	132	127	123	120	115	114	111	108
8	139	150	145	136	133	128	122	118	117	115	113	109
9	131	142	137	134	132	126	124	120	116	115	113	107
10	140	155	146	137	134	129	125	121	118	116	114	110
11	137	148	143	134	130	125	120	116	115	113	111	107
12	122	132	128	124	120	118	114	110	108	103	98	92
13	135	146	141	132	128	123	118	114	113	111	109	107
14	137	148	143	134	130	125	120	116	115	113	111	106
15	131	142	137	134	133	128	124	120	116	115	113	107
16	135	146	141	132	128	123	118	114	113	111	109	105
17	128	139	134	131	130	125	121	118	115	113	108	111
18	131	142	137	134	133	128	124	120	116	115	113	107
19	136	147	142	132	129	124	119	115	114	112	108	106
20	138	149	144	135	131	126	121	117	116	114	112	108
Total	2669	2892	2789	2655	2598	2500	2410	2334	2292	2253	2198	2128
Mean (M)	133.45	144.60	139.45	132.75	129.90	125.00	120.50	116.70	114.60	112.65	109.90	106.40
Σ (X-M)*(X-M)	464.95	556.8	464.95	155.75	175.8	122	139	144.2	86.8	148.55	247.8	336.8
Σ (X-M)*(X-M)/N	23.2475	27.84	23.2475	7.7875	8.79	6.1	6.95	7.21	4.34	7.4275	12.39	16.84
$\sqrt{}$(X-M)*(X-M)/N	4.8	5.3	4.8	2.8	3.0	2.5	2.6	2.7	2.1	2.7	3.5	4.1
SD	4.8	5.3	4.8	2.8	3.0	2.5	2.6	2.7	2.1	2.7	3.5	4.1

Appendix 5.6 Relative length (mm) of Tail feathers of Peregrine falcons measured in aviary at Abu Dhabi Falcon Research Hospital in 2001-2003

Sl. No	I	II	III	IV	V	VI
1	203	215	199	190	186	186
2	201	210	201	189	184	184
3	205	209	202	190	188	188
4	198	208	191	187	182	182
5	203	207	199	190	186	186
6	200	208	199	188	184	184
7	201	209	201	187	182	182
8	199	206	199	189	181	181
9	192	200	199	188	183	183
10	207	218	206	202	194	194
11	201	209	205	201	193	193
12	185	192	190	186	180	180
13	204	210	209	200	192	192
14	191	201	199	190	188	188
15	196	204	200	196	190	190
16	201	210	205	197	191	191
17	197	209	201	195	190	190
18	190	199	194	190	185	185
19	189	208	199	185	182	182
20	203	210	198	192	187	187
Total	3966	4142	3996	3832	3728	3728
Mean (M)	198.30	207.10	199.80	191.60	186.40	186.40
Σ (X-M)*(X-M)	684.2	623.8	401.2	496.8	338.8	338.8
Σ (X-M)*(X-M)/N	34.21	31.19	20.06	24.84	16.94	16.94
$\sqrt{}$(X-M)*(X-M)/N	5.8	5.6	4.5	5.0	4.1	4.1
SD	5.8	5.6	4.5	5.0	4.1	4.1

Appendix 5.7. Relative length (mm) of Primary feathers of Saker falcons measured in aviary at Abu Dhabi Falcon Research Hospital in 2001-2003

Sl.No	I	II	III	IV	V	VI	VII	VIII	IX	X
1	310	315	313	285	276	262	246	232	225	210
2	321	329	325	306	289	276	260	243	233	222
3	286	308	295	284	272	259	242	238	231	220
4	315	321	318	295	283	273	260	256	236	223
5	290	302	295	286	279	268	256	245	231	222
6	285	299	292	286	279	264	251	239	222	213
7	312	320	316	302	289	272	256	243	233	216
8	330	342	335	321	304	281	263	249	239	225
9	319	329	321	312	289	275	261	246	235	220
10	318	329	325	306	285	269	255	241	229	219
11	289	301	295	285	273	265	252	239	223	209
12	291	302	295	281	276	268	259	238	224	212
13	301	312	306	289	272	263	246	231	221	219
14	298	309	302	185	271	265	254	243	229	215
15	280	288	285	271	262	246	239	218	207	195
16	316	328	321	298	285	276	261	246	233	220
17	315	329	321	303	286	275	260	242	232	219
18	319	331	325	306	289	272	261	246	237	221
19	320	332	328	309	287	276	260	243	231	222
20	328	338	325	302	284	271	262	241	235	223
Total	6143	6364	6238	5812	5630	5376	5104	4819	4586	4345
Mean (M)	307.15	318.20	311.90	290.60	281.50	268.80	255.20	240.95	229.30	217.25
Σ (X-M)*(X-M)	4626.55	4225.2	4177.8	14698.8	1631	1173.2	951.2	1132.95	1026.2	907.75
Σ (X-M)*(X-M)/N	231.3275	211.26	208.89	734.94	81.55	58.66	47.56	56.6475	51.31	45.3875
√(X-M)*(X-M)/N	15.2	14.5	14.5	27.1	9.0	7.7	6.9	7.5	7.2	6.7
SD	15.2	14.5	14.5	27.1	9.0	7.7	6.9	7.5	7.2	6.7

Appendix 5.8 Relative lengths (mm) of Secondary feathers of Saker falcons measured in aviary at Abu Dhabi Falcon Research Hospital in 2001-2003

Sl.No	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
1	152	162	158	155	150	145	141	138	134	130	127	123
2	153	163	159	156	151	146	142	139	135	131	128	124
3	149	159	155	152	147	142	138	135	131	127	124	120
4	152	162	158	155	150	145	141	138	134	130	127	123
5	150	160	156	153	148	143	139	136	132	128	125	121
6	158	168	164	161	156	151	147	144	140	136	133	129
7	154	164	160	157	152	147	143	140	136	132	129	125
8	160	170	165	162	159	156	153	150	146	142	138	132
9	155	165	161	158	153	148	144	141	137	133	130	126
10	149	159	155	152	147	142	138	135	131	127	124	120
11	148	158	154	151	146	141	137	134	130	126	123	119
12	152	162	158	155	150	145	141	138	134	130	127	123
13	153	163	159	156	151	146	142	139	135	131	128	124
14	149	159	155	152	147	142	138	135	131	127	124	120
15	145	156	149	145	141	137	134	131	125	120	118	115
16	153	163	159	156	151	146	142	139	135	131	128	124
17	150	160	156	153	148	143	139	136	132	128	125	121
18	152	162	158	155	150	145	141	138	134	130	127	123
19	158	168	164	161	156	151	147	144	140	136	133	129
20	159	169	164	161	157	152	148	145	141	137	134	130
Total	3051	3252	3167	3106	3010	2913	2835	2775	2693	2612	2552	2471
Mean (M)	152.55	162.60	158.35	155.30	150.50	145.65	141.75	138.75	134.65	130.60	127.60	123.55
Σ(X-M)*(X-M)	294.95	280.8	302.55	322.2	345	364.55	369.75	369.75	404.55	424.8	382.8	326.95
Σ(X-M)*(X-M)/N	14.7475	14.04	15.1275	16.11	17.25	18.2275	18.487	18.4875	20.2275	21.24	19.14	16.3475
√(X-M)*(X-M)/N	3.8	3.8	3.7	3.9	4.0	4.3	4.3	4.3	4.5	4.6	4.4	4.0
SD	3.8	3.7	3.9	4.0	4.2	4.3	4.3	4.3	4.5	4.6	4.4	4.0

Appendix 5.9 Relative length (mm) of Tail feathers of Saker falcons measured in aviary at Abu Dhabi Falcon Research Hospital in 2001-2003

Sl. No	I	II	III	IV	V	VI
1	221	235	230	225	215	215
2	230	242	234	229	218	218
3	225	238	231	227	217	217
4	231	236	230	226	219	219
5	229	238	231	225	218	218
6	227	235	230	224	217	217
7	230	236	231	223	218	218
8	235	249	242	235	227	227
9	224	231	225	220	213	213
10	227	234	228	221	216	216
11	226	235	227	220	213	213
12	230	242	235	230	226	226
13	228	239	230	225	216	216
14	216	225	219	212	209	209
15	208	221	217	210	205	205
16	227	234	228	221	216	216
17	221	229	224	219	209	209
18	226	235	227	220	213	213
19	228	239	230	225	216	216
20	219	229	224	215	209	209
Total	4508	4702	4573	4452	4310	4310
Mean (M)	225.40	235.10	228.65	222.60	215.50	215.50
Σ (X-M)*(X-M)	694.8	731.8	564.55	672.8	535	535
Σ (X-M)*(X-M)/N	34.74	36.59	28.2275	33.64	26.75	26.75
$\sqrt{}$(X-M)*(X-M)/N	5.9	6.0	5.3	5.8	5.2	5.2
SD	5.9	6.0	5.3	5.8	5.2	5.2

Appendix 5.10 Relative length (mm) of Primary feathers of Gyr falcons measured in aviary at Abu Dhabi Falcon Research Hospital in 2001-2003

Sl.No	I	II	III	IV	V	VI	VII	VIII	IX	X
1	312	323	319	288	277	267	255	241	239	231
2	325	339	331	289	275	269	256	242	241	235
3	301	312	305	294	283	266	257	241	238	226
4	291	299	294	281	272	264	253	240	234	220
5	340	351	345	334	319	302	280	269	252	238
6	351	360	355	339	326	301	286	270	260	248
7	329	339	335	321	308	289	275	262	248	235
8	346	358	352	338	320	303	281	272	259	246
9	309	321	315	296	285	271	263	252	243	229
10	315	326	320	298	282	270	256	249	241	232
11	355	364	359	341	321	306	288	274	262	250
12	298	309	302	295	282	273	264	255	241	227
13	295	307	301	294	280	271	263	254	240	224
14	312	321	316	297	286	276	269	256	243	226
15	318	329	321	306	295	284	269	253	239	228
16	326	339	330	312	302	291	275	259	241	235
17	320	332	325	308	298	285	270	253	240	234
18	335	345	339	325	306	295	282	263	251	241
19	346	359	351	340	315	303	285	272	261	242
20	337	349	341	330	314	299	282	265	258	243
Total	6461	6682	6556	6226	5946	5685	5409	5142	4931	4690
Mean (M)	323.05	334.10	327.80	311.30	297.30	284.25	270.45	257.10	246.55	234.50
Σ (X-M)*(X-M)	6996.95	7101.8	7041.2	7810.2	5982.2	4195.75	2570.95	2341.8	1544.95	1351
Σ (X-M)*(X-M)/N	349.8475	355.09	352.06	390.51	299.11	209.7875	128.5475	117.09	77.2475	67.55
$\sqrt{}$(X-M)*(X-M)/N	18.7	18.8	18.8	19.8	17.3	14.5	11.3	10.8	8.8	8.2
SD	18.7	18.8	18.8	19.8	17.3	14.5	11.3	10.8	8.8	8.2

Appendix 5.11 Relative lengths (mm) of Secondary feathers of Gyr falcons measured in aviary at Abu Dhabi Falcon Research Hospital in 2001-2003

Sl.No	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
1	162	172	163	159	155	151	152	144	140	137	133	131
2	158	168	159	155	151	147	148	140	136	133	129	127
3	147	157	148	144	140	136	132	129	125	122	118	116
4	145	155	146	142	138	134	130	127	123	120	116	114
5	157	167	158	154	150	146	147	139	135	132	128	126
6	146	156	147	143	139	135	131	128	124	121	117	115
7	151	161	152	148	144	140	141	133	129	126	122	120
8	160	170	161	157	153	149	150	142	138	135	131	129
9	148	158	149	145	141	137	133	130	126	123	119	117
10	162	172	163	159	155	151	152	144	140	137	133	131
11	165	175	166	162	158	154	155	147	143	140	136	135
12	158	168	159	155	151	147	148	140	136	133	129	127
13	163	173	164	160	156	152	153	145	141	138	134	132
14	159	169	160	156	152	148	149	141	137	134	130	128
15	161	171	162	158	154	150	151	143	139	136	132	130
16	146	156	147	143	139	135	131	128	124	121	117	115
17	149	159	150	146	142	138	134	131	127	124	120	118
18	150	160	151	147	143	139	135	132	128	125	121	119
19	164	174	165	161	157	153	154	146	142	139	135	133
20	152	162	153	149	145	141	142	134	130	127	123	121
Total	3103	3303	3123	3043	2963	2883	2868	2743	2663	2603	2523	2484
Mean (M)	155.15	165.15	156.15	152.15	148.15	144.15	143.40	137.15	133.15	130.15	126.15	124.20
Σ (X-M)*(X-M)	902.55	902.55	902.55	902.55	902.55	902.55	1566.8	902.55	902.55	902.55	902.55	923.2
Σ (X-M)*(X-M)/N	45.1275	45.1275	45.127	45.1275	45.127	45.1275	78.34	45.1275	45.127	45.13	45.1275	46.16
$\sqrt{}$(X-M)*(X-M)/N	6.7	6.7	6.7	6.7	6.7	6.7	8.9	6.7	6.7	6.7	6.7	6.8
SD	6.7	6.7	6.7	6.7	6.7	6.7	8.9	6.7	6.7	6.7	6.7	6.8

Appendix 5.12 Relative length (mm) of Tail feathers of Gyr falcons measured in aviary at Abu Dhabi Falcon Research Hospital 2001-2003

Sl. No	I	II	III	IV	V	VI
1	233	245	238	230	228	228
2	241	252	247	241	238	238
3	235	247	240	233	228	228
4	230	236	225	215	210	210
5	241	252	247	241	238	238
6	240	251	240	235	230	230
7	238	250	238	232	229	229
8	235	247	240	233	228	228
9	233	245	238	230	227	227
10	236	248	241	234	229	229
11	242	252	245	242	240	240
12	237	249	242	235	230	230
13	238	250	238	232	229	229
14	231	243	236	230	221	221
15	241	252	247	241	238	238
16	240	251	240	235	230	230
17	235	247	240	233	228	228
18	233	245	238	230	228	228
19	241	252	247	241	238	238
20	231	231	243	236	230	230
Total	4731	4945	4810	4679	4597	4597
Mean (M)	236.55	247.25	240.50	233.95	229.85	229.85
Σ (X-M)*(X-M)	286.95	583.75	491	702.95	868.55	868.55
Σ (X-M)*(X-M)/N	14.3475	29.1875	24.55	35.1475	43.4275	43.4275
$\sqrt{}$(X-M)*(X-M)/N	3.8	5.4	5.0	5.9	6.6	6.6
SD	3.8	5.4	5.0	5.9	6.6	6.6

Appendix 7.1 Chart showing the percentage of diseased falcons brought in the Abu Dhabi Falcon Research Hospital for treatment during 1999-2003

Diseases		1999			2000			2001			2002			2003		
	Common Name	P	S	G	P	S	G	P	S	G	P	S	G	P	S	G
Viral	New Castle	13	8	11	16	13	7	7	9	11	9	12	14	16	8	6
	Raptor Pox	47	62	51	37	57	51	49	42	38	43	47	55	32	61	42
	Falcon Herpesvirus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Influenza virus	1	-	2	-	1	-	-	-	1	2	1	-	-	1	-
Bacterial	Chlamydiosis	6	7	8	7	6	9	8	9	11	10	13	9	8	7	9
	Salmonellosis	9	10	8	11	12	7	13	14	10	9	12	15	9	8	10
	Avian Tuberculosis	8	6	11	8	14	11	10	9	12	9	11	10	13	14	8
	Mycoplasma	6	4	7	3	8	2	7	4	2	12	8	5	6	4	6
Fungal	Aspergillosis	18	21	25	24	28	14	31	16	28	18	14	24	36	19	31
	Candidiasis	5	4	6	8	7	5	9	8	4	3	2	8	4	6	7
Protozoan Parasites	Trichomoniasis	28	24	31	26	28	29	31	22	17	24	19	21	24	19	20
	Coccidiosis	74	65	58	59	63	48	58	54	59	62	51	64	71	58	65
	Babesiosis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Helminths	Capillariasis	32	28	24	34	29	19	34	23	25	28	28	39	29	28	35
	Serratospeculum	25	28	32	31	34	35	29	28	27	35	38	39	34	29	25
Nematodes	Ascariasis	33	28	36	34	29	38	37	29	28	25	37	28	39	34	36
	Filarial worms	14	15	18	9	10	18	17	16	15	14	21	23	15	14	21
Trematodes	Flukes	60	58	49	62	58	47	58	56	54	59	62	60	58	58	57
Cestodes	Tape worm	56	68	59	65	67	72	52	68	63	45	58	59	60	58	53
Ectoparasite	Ticks, mites, lice	75	78	74	80	68	69	71	75	59	58	60	64	58	70	59
Bumble foot	Bumble foot	47	48	58	52	49	59	57	48	42	56	52	54	49	50	53
Injuries	Traumatic	5	4	6	3	5	7	4	6	5	6	4	7	6	4	9
Intoxication	Lead shot	4	6	5	3	4	6	5	4	6	5	4	5	6	7	5

Appendix 7.2 Chart showing the percentage of diseased falcons brought in Dubai Falcon Hospital for treatment during 1999-2003

Diseases		1999			2000			2001			2002			2003		
	Common Name	P	S	G	P	S	G	P	S	G	P	S	G	P	S	G
Viral	New Castle	10	15	21	8	12	8	21	13	9	21	8	16	12	10	9
	Raptor Pox	52	65	45	42	49	35	56	52	46	35	32	65	39	56	50
	Falcon Herpesvirus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Influenza virus	-	1	-	2	1	-	1	-	-	-	-	-	-	1	-
Bacterial	Chlamydiosis	13	12	8	15	5	12	8	9	7	10	9	12	7	5	9
	Salmonellosis	10	12	9	13	18	9	10	14	9	13	9	18	9	8	7
	Avian Tuberculosis	10	9	9	7	12	8	6	8	10	8	10	15	14	17	10
	Mycoplasma	7	3	9	5	9	1	2	3	1	9	5	2	1	3	2
Fungal	Aspergillosis	17	23	26	23	29	15	32	14	24	19	12	29	39	41	35
	Candidiasis	4	8	5	9	8	5	7	9	3	2	1	6	6	5	7
Protozoan Parasites	Trichomoniasis	25	29	31	26	31	32	32	28	34	34	30	35	36	33	39
	Coccidiosis	65	69	59	62	58	57	61	52	61	49	46	57	67	71	70
	Babesiosis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Helminths	Capillariasis	25	28	28	39	29	28	35	32	28	24	34	29	19	34	23
	Serratospeculum	27	35	38	39	34	29	25	25	28	32	31	34	35	29	28
Nematodes	Ascariasis	33	28	36	34	29	38	37	29	28	25	37	28	39	34	36
	Filarial worms	21	23	15	14	21	14	15	18	9	10	18	17	16	15	14
Trematodes	Flukes	56	68	59	65	67	72	52	68	63	45	58	59	60	58	53
Cestodes	Tape worm	60	58	49	62	58	47	58	56	54	59	62	60	58	58	57
Ectoparasite	Ticks, mites, lice	59	58	60	64	58	70	59	75	78	74	80	68	69	71	75
Bumble foot	Bumble foot	42	56	52	54	49	50	53	47	48	58	52	49	59	57	48
Injuries	Traumatic	4	7	6	4	9	5	4	6	3	5	7	4	6	5	6
Intoxication	Lead shot	4	6	5	4	5	6	7	5	4	6	5	3	4	6	3

Appendix 7.3 Chart showing the percentage of diseased falcons brought in the Sharjah Falcon Clinic for treatment during 1999-2003

Diseases		1999			2000			2001			2002			2003		
	Common Name	P	S	G	P	S	G	P	S	G	P	S	G	P	S	G
Viral	New Castle	12	8	11	16	13	7	7	9	11	9	12	14	16	8	5
	Raptor Pox	43	47	55	32	61	42	47	62	51	37	57	51	49	42	38
	Falcon Herpes virus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Influenza virus	1	2	1	-	-	1	-	1	-	2	-	1	-	-	-
Bacterial	Chlamydiosis	6	7	8	7	6	9	8	9	11	10	13	9	8	7	9
	Salmonellosis	9	12	15	9	8	10	9	10	8	11	12	7	13	14	10
	Avian Tuberculosis	10	9	12	9	11	10	13	14	8	8	6	11	8	14	11
	Mycoplasma	5	6	4	6	6	4	7	3	8	2	7	4	2	12	8
Fungal	Aspergillosis	25	24	28	14	31	16	28	18	14	24	36	19	31	29	27
	Candidiasis	5	4	6	8	7	5	9	8	4	3	2	8	4	6	7
Protozoan Parasites	Trichomoniasis	28	24	31	29	28	29	31	29	30	32	30	31	34	32	33
	Coccidiosis	63	48	58	54	59	62	51	64	71	58	65	71	70	69	52
	Babesiosis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Helminths	Capillariasis	28	24	34	29	19	34	23	25	28	28	39	29	28	35	22
	Serratospeculum	28	32	31	34	35	29	28	27	35	38	39	34	29	25	39
Nematodes	Ascariasis	36	34	29	38	37	29	28	25	37	28	39	34	36	35	29
	Filarial worms	15	18	9	10	18	17	16	15	14	21	23	15	14	21	13
Trematodes	Flukes	58	47	58	56	54	59	62	60	58	58	57	59	49	57	62
Cestodes	Tape worm	65	67	72	52	68	63	45	58	59	60	58	53	61	58	49
Ectoparasiee	Ticks, mites, lice	78	74	80	68	69	71	75	59	58	60	64	58	70	59	52
Bumble foot	Bumble foot	58	52	49	59	57	48	42	56	52	54	49	50	53	41	43
Injuries	Traumatic	3	5	7	4	6	5	6	4	7	6	4	9	4	8	7
Intoxication	Lead shot	3	4	6	5	4	6	5	4	5	6	7	5	4	2	6

Appendix 7.4 Chart showing the details of birds brought for treatment in the Charity Bird Hospital Delhi during 2000-2003

No	Cases	Year	J	F	M	A	M	J	J	A	S	O	N	D	Symptoms	Preventive Measures	Remarks
1	Sun stroke	2000	-	-	-	9	8	-	-	-	-	-	-	-	High temperature, senseless, respiratory disfunction, weakness.	Cool water administration, Dextrose solution, normal saline solution for 2-3 days	It is seen in extreme summer months
		2001	-	-	1	11	10	-	-	-	-	-	-	-			
		2002	-	-		10	9	-	-	-	-	-	-	-			
		2003	-	-	2	11	10	-	-	-	-	-	-	-			
2	Kite injury	2000	-	-	-	-	-	9	8	10	11	-	-	-	Wounds may present	Anticeptic cream or powder, Vetadine lotion	Treatment is made according to the wounds produced by kites
		2001	-	-	-	-	-	7	10	9	8	-	-	-			
		2002	-	-	-	-	-	8	10	11	12	-	-	-			
		2003	-	-	-	-	-	9	7	13	11	-	-	-			
3	Chronic Respiration Disease (CRD)	2000	6	4	-	-	-	-	-	-	-	-	6	5	Respiratory disfunction, weakness etc.	Occytetracycline liquid 1 ml 2 times/day for 10-15 days	This is present mostly in winter season
		2001	2	3	-	-	-	-	-	-	-	-	4	4			
		2002	4	2	-	-	-	-	-	-	-	-	5	2			
		2003	4	4	-	-	-	-	-	-	-	-	3	3			
4	Inseplomalites	2000	-	5	8	-	-	-	-	-	-	9	9	-	Paralysis of wing and neck	Nerobion tablet 1 daily. Evion drops 1 ml. Daily. Evion capsule 600 mgs. Daily for 1 to 1.5 month	This occurs during changing of season (October-November and February-March)
		2001	-	8	9	-	-	-	-	-	-	8	7	-			
		2002	-	7	7	-	-	-	-	-	-	9	8	-			
		2003	-	6	4	-	-	-	-	-	-	8	9	-			

Appendix 7.5 Chart showing the details of birds brought for treatment in the Shadra Charity Bird Hospital Delhi during 2000-2003

No	Cases	Year	J	F	M	A	M	J	J	A	S	O	N	D	Symptoms	Preventive Measures	Remarks
1	Sun stroke	2000	-	-	-	6	4	-	-	-	-	-	-	-	High temperature, senseless, respiratory disfunction, weakness.	Cool water administration, Dextrose solution, normal saline solution for 2-3 days.	It is seen in extreme summer months.
		2001	-	-	-	9	6	-	-	-	-	-	-	-			
		2002	-	-	-	7	10	-	-	-	-	-	-	-			
		2003	-	-	1	12	13	-	-	-	-	-	-	-			
2	Kite injury	2000	-	-	-	-	-	6	5	12	4	-	-	-	Wounds may present	Anticeptic cream or powder, Vetadine lotion	Treatment is made according to the wounds produced by kites
		2001	-	-	-	-	-	9	9	8	5	-	-	-			
		2002	-	-	-	-	-	8	13	10	15	-	-	-			
		2003	-	-	-	-	-	7	8	10	6	-	-	-			
3	Chronic Respiration Disease (CRD)	2000	10	2	-	-	-	-	-	-	-	-	5	7	Respiratory disfunction, weakness etc.	Occytetracycline liquid 1 ml 2 times/day for 10-15 days.	This is present mostly in winter season
		2001	2	3	-	-	-	-	-	-	-	-	6	2			
		2002	4	2	-	-	-	-	-	-	-	-	4	-			
		2003	4		-	-	-	-	-	-	-	-	4	2			
4	Inseplomalites	2000	-	2	5	-	-	-	-	-	-	7	8	-	Paralysis of wing and neck	Nerobion tablet 1 daily. Evion drops 1 ml. Daily. Evion capsule 600 mgs Daily for 1 to 1.5 month	This occurs during changing of season (October-November and February-March)
		2001	-	10	5	-	-	-	-	-	-	5	5	-			
		2002	-	6	8	-	-	-	-	-	-	8	5	-			
		2003	-	5	7	-	-	-	-	-	-	7	10	-			

Appendix 8.1 Crossing of Gyr X Peregrine

Hybrid Species	Size and weight	Color & Plumage	Characteristics
Gyr (3/4) X Shaheen (1/4)	Bigger than Shaheen and weigh about 1300gms	Light brown in colour and domination of the plumage of Gyr falcon	More aggressive power and hunting capacity
Gyr (1/2) X Shaheen (1/2)	As much as the size of Gyr and weight is below the Gyr falcon	Brown in colour and equal traits of plumage of both Gyr and Shaheen	Will be having equal characteristics of Gyr and Shaheen
Gyr (1/4) X Shaheen (3/4)	Little smaller than Gyr but bigger than Shaheen	Dark brown in colour and domination of the plumage of Shaheen	More characteristics of Gyr falcon than Shaheen

Appendix 8.2 Crossing of White Gyr X Peregrine

Hybrid Species	Size and Weight	Colour and Plumage	Characteristics
White Gyr (1/4) X Shaheen (3/4)	Smaller than Gyr but little bigger than Shaheen	More black in colour with white patches and plumage of Peregrine	The stooping and hunting capacity will be mo
White Gyr (1/2) X Shaheen (1/2)	Little smaller than Gyr but bigger than Shaheen	Mixed in colour i e., combination of black and white and equal traits of plumage of both	Will be having equal characteristics of Gyr and Shaheen
White Gyr (3/4) X Shaheen (1/4)	Size is big and weigh about 1500gms	Domination of the colour and plumage of White Gyr falcon	More lethal, More characteristics of White Gyr Falcon than Shaheen

Appendix 8.3 Crossing of Black Gyr X Peregrine

Hybrid Species	Size and Weight	Colour and Plumage	Characteristics
Black Gyr (3/4) X Shaheen (1/4)	Big and average weight 1500gms	Black in colour. Domination of Plumage of Black Gyr.	More power for hunting. More aggressive power
Black Gyr (1/2) X Shaheen (1/2)	Smaller than Gyr but bigger than Peregrine	Black in colour. Equal traits of plumage	More aggressive behaviour, more hunting power
Black Gyr (1/4) X Shaheen (3/4)	Black in colour Smaller than Gyr but bigger than Peregrine	Domination of the colour and plumage of Peregrine	More speed, stooping power and hunting capacity

Appendix 8.4 Crossing of Saker X Peregrine

Hybrid Species	Size and weight	Colour and Plumage	Characteristics
Saker (3/4) X Shaheen (1/4)	Bigger than Shaheen and weigh about 1300gms.	Light brown in colour and domination of the plumage of Saker falcon	More aggressive power and hunting capacity
Saker (1/2) X Shaheen (1/2)	As much as the size of Saker and weight is below the Saker falcon	Brown in colour and equal traits of plumage of both Saker and Shaheen	Will be having equal characteristics of Saker and Shaheen
Saker (1/4) X Shaheen (3/4)	Little smaller than Shaker but bigger than Shaheen	Dark brown in colour and domination of the plumage of Shaheen	More characteristics of Saker falcon than Shaheen

Appendix 8.5 Crossing of White Gyr X Saker

Hybrid Species	Size and weight	Colour & Plumage	Characteristics
White Gyr (3/4) X Saker (1/4)	As much as the size of Gyr and average weight is 1500gms	Mixed in colour, domination of plumage of White Gyr	More aggressive power and hunting capacity
White Gyr (1/2) X Saker (1/2)	Size is big and weigh about 1500gms	Mixed in colour, equal combined plumage of Black Gyr and Saker falcon	Having equal characteristics of Saker and White Gyr falcon
White Gyr (1/4) X Saker (3/4)	As much as the size of Saker falcon and weigh about 1400gms	Brown in colour and domination of plumage of Saker falcon	Having more characteristics of Saker falcon than White Gyr falcon

Appendix 8.6 Crossing of Black Gyr X Saker

Hybrid Species	Size and Weight	Colour and Plumage	Characteristics
Black Gyr (3/4) X Saker (1/4)	As much as the size of Gyr and average weight is 1500gms	Black in colour, domination of plumage of Black Gyr	More aggressive power and hunting capacity
Black Gyr (1/2) X Saker (1/2)	Size is big and weigh about 1500gms	Black in colour, equal combined plumage of Black Gyr and Saker falcon	Having equal characteristics of Saker and Black Gyr falcon
Black Gyr (1/4) X Saker (3/4)	As much as the size of Saker falcon and weigh about 1400gms	Brown in colour and domination of plumage of Saker falcon	Having more characteristics of Saker falcon than Black Gyr falcon

Courtesy

Plates 3.5, 7.1, 7.5, 8.1, 8.3 (Remple & Gross 1993)
Plates 1.3, 7.4 (ERWDA, Abu Dhabi)
Plates 6.3, 7.4 (Abu Dhabi Falcon Hospital)
Plates 7.2 (Falcon Research Hospital, Abu Dhabi)
Plates 4.4, 4.5 (www.falconry.com)
Plates 5.1 (Esnad)

Abbreviations

CITES	: Convention on International Trade of Endangered Species
NARC	: National Avian Research Centre
ERWDA	: Environmental Research and Wildlife Development Agency
FEA	: Federal Environmental Agency
PIT	: Passive Integrated Transponder
GPS	: Global Positioning System
AMSL	: Above Mean Sea Level
MSL	: Mean Sea Level
ID	: Identification
FFI	: Falcon Foundation International
FEW	: Fresh Egg Weight