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# Study On the Parasites of Falcons in the United Arab Emirates

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# STUDY ON THE PARASITES OF FALCONS IN

# THE UNITED ARAB EMIRATES

A thesis submitted to the Faculty of Science in partial fulfillment of the
requirements for the Degree of M. Sc. in Environmental Science

By

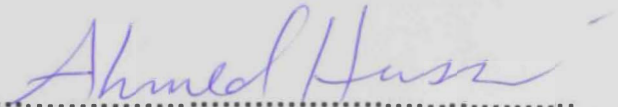Mohammed Ismail M. A. Sultan Al-Ulamaa
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(May, 1997)

The thesis of MOHAMMED ISMAIL SULTAN AL-ULAMAA for the degree of Master of Science in Environmental Sciences is approved .
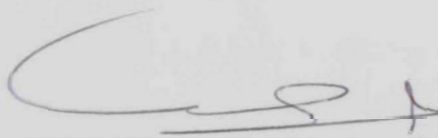
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1997

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# Abstract

Sakers *Falco cherrug*, Gyrfalcons *Falco rusticolus*, Peregrines *Falco peregrinus*, in addition to Hybrids (saker X gyrfalcon, or gyrfalcon X peregrine), were found to be the most popular species of falcons in United Arab Emirates (UAE).

The importance of falcons and falconry in Arabia was highlighted with a brief history of falconry in Arabia.

The study focused on the prevalence of intestinal parasites (coccidia, helminthes and nematodes) and bloodparasites (*Haemoproteus* sp. and *Leucocytozoon* sp.) as well as ecto-parasites (Ticks and Mites) of these falcons, with discussion on the possible sources of infection in view of the epizootiology of these parasites.

100 falcons, 89 females and 11 males, were studied at random. Of these 100 falcons, 50 falcons were considered as "resident falcons" having spent a period of 1-4 years in the UAE, the rest (50 falcons) with less than 1 year residence were considered "imported falcons".

The falcons were identified, thin blood smears were taken stained with Giemsa, examined for blood parasites and positive smears were identified. Fresh feces were collected for macroscopic examination to recognize adult worms, segments of tapeworms or fly larvae, then fecal materials were prepared (direct and floatation methods) for microscopic examination to detect protozoan cyst and helminthes eggs. Three techniques: feathers inspection, insecticide spray, and shaking the body in full sun light, were used for collecting ecto-parasites.

The results were presented in term of numbers and percentages of non-infected and infected imported and resident falcons in relation to species and sex. 52% (26/50) of imported falcons showed parasitic infections, while 38% (19/50) of resident falcons

were found to be infected. The results were compared with those of other researchers. Emphasis was also laid on the pathological aspects of parasitic infection in falcons.

Recommendations that would lead to significant decrease in the infection rates in falcons in the UAE were made.

# Acknowledgment

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# CHAPTER I

# INTRODUCTION

# Objectives

This study is the first step towards more elaborate work on the biology and pathology of parasitic infections in falcons. The principal objectives were:

1    To identify the species of resident and imported falcons brought by owners to 3 falcon hospitals in the UAE.

2    To use routine laboratory methods to isolate and identify intestinal, blood and ectoparasites that infect and infest a representative sample of this population.

3.   To determine the rate of parasite infection in terms of the species, sex and the resident status of the birds.

4    To determine the possible sources of infection in view of the epizootiology of these parasites and implications for the future of falconry in this country.

5    To underline the high level of care necessory to breed falcons and for falconry in the UAE.

6.   To make recommendations that would lead to significant decrease in the infection rates in falcons in the UAE.

# 1. Arab Tradition Of Falconry

Falconry is considered a noble sport around the world, specially in the Arabian Peninsula where the tradition goes back many centuries (Al- Nahayan, 1976). In the UAE, the Saker falcon is in fact a national emblem. Despite this symbolic significance and the great intrest and expense of this sport, scanty studies have been conducted on the breeding and health of falcons, specially from the parasitological point of view.

## 1.1.1. Falconry at the dawn of Islam

Al-Harith Bin Mu'awiyah Bin Thawr Bin Kindah was reported as the first man who trained and hunted with falcons in the pre-Islamic era. The most famous falconer during the dawn of Islam was Hamzah (God bless his soul) (565-633 AD), the uncle of Prophet Mohammed (on whom be blessings and peace). During the period of the first four caliphs (631-661 AD) there is no account of Falconry as sport. This may be due to the fact that Muslims were more engaged in establishing the spiritual, the civil and the militery stractures of State.

## 1.1.2. Falconry during the Ommayad era (661-750 AD)

Having consolidated their State, Muslims had the luxury of time and wealth during this time, and falconry became the most enjoyable sport. This sport was now engoyed by people from all sections of Society; from great wealthy leaders such as Yazid Bin Mu'awiyah (675 A/D, 56 H) who hunted for fun and pleasure, to a humble poor ascetic such as Al-Khalil Bin Ahmed Al-Frahidy who hunted to prevent himself from seeking people's charities.

The Caliph Hisham Bin Abdul-Malik (743 AC) was enough interested in falconry to appoint a state official to take care of birds of prey, and commissioned some prominent artists to draw him and his aides with birds of prey.

The main requirements of keeping of birds of prey such as taking care of their health, using of scientific methods in training them under supervision of experienced trainers or falconers led the later Caliphs of this dynasty to give a place in the affairs of state to hunting and birds of prey.

## 1.1.3. Falconry during the Abbassid era (750-1258 AC)

Due to great amount of State revenue which was gathered from different parts of this empire, and because of the Persian influence on the Abbassids, hunting in general and falconry in particular became the most favourite sport. Except Al-Mansoor(754 AD, 136 H) all Caliphs of this era were fond of hunting.

The kings of the neighboring countries therefore, used to send birds of prey to these Caliphs as gifts. For example, Taqnour, king of the Byzantium, on one occasion presented Al-Rasheed (786 AD, 170 H) with twelve falcons and three of his hunting dogs as a gesture of goodwill.

To illustrate the status of hunting in this era, it is enough to know that the amount of budget which was allocated for hunting during the first years of Al-Mu'tassim's reign (833 AD, 218 H) ran to what equals 2,500,000 dirhams in the current era per annum!

From that era till now falconry is considered in the Arab world as a noble sport, to be enjoyed by the Rulers and the ruled.

## 1.1.4. Falconry in the UAE

Falconry in the UAE is a traditional sport which attracts the leaders as well as ordinary people. New generations inherit falconry as a valuable heritage from their ancestors.

The government of His Highness Sheikh Zayed Bin Sultan Al-Nahayan supports all kinds of traditions and cultural values of the society to revive and appreciate the glorious past. Falconry is one of the foremost traditions in the UAE.

The high season of falconry around the country is between October and mid of December, and there are modern falcon hospitals and clinics and research centers, which shows how much the government supports and encourages falconry in the country.

Falcons are imported every year from many different countries such as Pakistan, China, Iran, Egypt, Syria, Russia, Germany, North America, North Africa. Also, some times Peregrines are caught during their overflight over UAE skies.

People of UAE prefer Sakers and Peregrines rather than other birds of prey because of their quietness, strength, suitable size and price. Also, Sakers and Peregrines have great ability to learn and adapt themselves to changeable climate circumstances of the deserts more than other birds of prey.

## 1.2. ORDER: FALCONIFORMES

### Genus: *Falco*

Falcons are distributed in a wide variety of habitat, with wide overlap in hunting, migration, and breeding habitat

The genus *Falco* contains a number of adaptive types following Brown and Amadon (1968) who divided the genus informally as follows:

1) Typical kestrels (10 species, including kestrel *F. tinnunculus*, lesser kestrel *F. naumanni* and American kestrel *F. sparverius*) and somewhat similar falcons of 4 species, including red-footed *F. vespertinus;*

(2) Merlins 2 species, including Merlin *F. columbarius.*

3) Typical hobbies (10 species, including Hobby *F. subbuteo*, Eleonora's Falcon *F. eleonorae*, and Sooty Falcon *F. concolor*).

(4) Large falcons (10 species) divided in 2 groups:

   (a)    Gyrfalcon and desert falcons (including Lanner *F. biarmicus* and Saker *F. cherrug* as well as Gyrfalcon *F. rusticolus* and 2 other species),

   (b)    Peregrines (including Peregrine *F. peregrinus* and Barbary falcon *F. pelegrinoides*, plus 2 other species). These resemble to Accipitriformes with sharp curved talons and hooked bills, and remarkable power of sight and flight.

## 1.2.1. General characters

Bodies strong and rigid due to ankylosed thoracic vertebrae (free in Accipitriformes). Neck is short in Falconidae (to which rest of account is largely confined), and females are usually larger and heavier than males.

Wings long and pointed in *Falco* especially, as in some other genera (e.g. *Microhierax*). Wing-beats strong in *Falco* which have great powers of diving flight 'stooping'; some *Falco* actively hover, soaring frequently. Tails narrow of medium length in *Falco* but proportionately longer in smaller species, especially those that specialize in hovering.

Plumage variable; color morphs found in some *Falco* (also in *Micrastur*). In *Falco*, plumage is often gray above and rufous to greater or lesser extent below, often with small black markings of various types both above and below; black moustachial streak in many. Some of kestrel group are mainly chestnut above, and some other species have rufous on head; some other species (e.g. *F. biarmicus, F. pelegrinoides*) have rufous on head; some large *Falco* are white below, usually with dark bars. *F. rusticolus* (white morph) and typical desert falcons *(F. cherrug* and North American prairie falcon *F. mexicanus*) are among palest of genus. *Falco* reach adult plumage usually in 2nd calendar year.

Outside the breeding season, many *Falco* are solitary: Much as in Accipitridae, they may have frequent limited home-range or exclusive feeding territory when migratory or dispersive or remain more or less in the same area as in breeding season when resident, and may sometimes be found in pairs.

Falconidae are highly predatory; in contrast to Accipitridae; carrion eating is rare. They show clear adaptations that almost eliminate direct interspecific competition for food with symmetric congeners, through ecological differentiation, much less than in Accipitridae.

Insectivorous species (e.g. *F. naumanni*) will congregate in air to exploit localized prey, but most species usually hunt singly; in some members, pairs may do so together, even so cooperatively, e.g. in Red-headed Merlin *F. chicquera* (Ali and Ripley, 1968) food-piracy occurs but is probably essentialy casual in most species. Catching of surplus food has been recorded and is perhaps more widespread than in Accipitridae.

Large *Falco* take wide variety of avian prey, and are capable of killing much larger birds of greater size than themselves. Typically, they take bird prey by swooping on victim at great speed, striking it with hind claw to knock it out of sky, or gripping it and forcing it down, or taking it direct to perch, some species will also swoop on ground prey from air. Various Falco of hobby group chase birds and insects at some height from ground. *F. eleonorae* and *F. concolor* specialize in catching migrant passerines.

Those of Merlin group hunt small birds at low level, various kestrel-type *Falco* are largely adapted to take non-avian prey, hunting insects and other arthropods, reptiles and small mammals. Large *Falco* catch much prey on ground (e.g. *F. cherrug*) but will also hover at times.

Aerial hunters will eat prey on wing at times, especially insects but also small birds. If not killed with feet when caught, vertebrate prey may be

dispatched with bill, usually at perch. Birds and mammals are carefully plucked and skinned before being eaten, and larger bony structures are broken up or often rejected.

## 1.2.2. General distribution of the Genus

Nearly word-wide distribution of genus *Falco* closely similar to that of Accipitridae, as also range of habitats of Falconidae as a whole. Relying on far-ranging aerial search and aerial pursuit of prey, *Falco* are adaptable to nearly every latitude and climatic zone on or near land wherever suitable prey is available.

Amongst 12 major habitat types recognized by Brown (1976), west Palearctic breeding species are represented as follows:

(1)   Northern tundra.

      *F. rusticolus, F. peregrinus.*

(2)   Taiga:

      Same species plus *F. columbarius.*

(3)   Temperate deciduous woodland:

      *F. vespertinus, F. subbuteo.*

(4)   Temperate moorlands and mountains:

      *F. tinnunculus, F. columbarius, F. peregrinus.*

(5)   Temperate to subtropical steppe, etc.:

      *F. naumanni, F. tinnunculus, F. vespertinus, F. columbarius,*

      *F. biarmicus, F. cherrug, F. peregrinus, F. pelegrinoides.*

(6)    Subtropical semi-arid woodlands and mountains:

   *F. naumanni, F. tinnunculus, F. subbuteo, F. biarmicus, F. cherrug,*

   *F. peregrinus, F. pelegrinoides.*

(7)    Tropical savannas:

   *F. tinnunculus, F. biarmicus, F. peregrinus.*

(8)    Tropical forests:

   *F. peregrinus* (marginally)

(9)    Tropical Montana moorlands and mountains:

   *F. biarmicus, F. peregrinus.*

(10)   Deserts and semi-deserts:

   *F. tinnunculus, F. concolor, F. biarmicus, F. cherrug,*
   *F. peregrinus, F. pelegrinoides.*

(11)   Aquatic habitats:

   *F. eleonorae and F. concolor* (coastal).

(12)   Towns:

*F. naumanni, F. tinnunculus, F. biarmicus, F. peregrinus.*

*Falco* of habitat-types 1-3 are fully migrant except for *F. rusticolus*, those

of type 4 are non-migrant or partially migrant except *F. columbarius* (wholly

migrant); those of type 5 are non-migrant (*F. columbarius, F. biarmicus, F.*

*pelegrinoides*), partially migrant or nomadic (*F. peregrinus*), or wholly migrant

*(F. naumanni, F. vespertinus, F. cherrug*); those of type 6 are mostly non-

migrant or only partially migrant, but *F. naumanni,* and *F. subbuteo* wholly

migrant; those of type 7-9 are non-migrant; those of type 10 are mostly non-

migrant, partially-migrant, or nomadic, but *F. concolor* is wholly migrant; those

of type 11 are wholly migrant; those of type 12 sometimes can not be found in the Towns, when they are not breeding due to lack of suitable habitat and food.

In most cases, species classed as non-migrant (resident) above are really dispersive to lesser or greater extent. Within west Palearctic itself, all breading species of *Falco* are migratory or partially migratory but to markedly different extents. Partial migrants move further under influence of continental than maritime climates. *F. rusticolus*, *F. biarmicus*, and *F. pelegrinoides* move the least, *F. rusticolus* moves regularly only in high latitudes; the other two making only short movements within their Mediterranean type and desert habitats. In contrast, 7 species wholly or partially transequatorial migrants of these, *F. concolor* notable for restricted winter quarters.

Though they will soar at times, migrants travel mainly in flapping flight, feeding on the way, readily cross wide areas of water, and thus have a broad-front passage across Mediterranean. Most typical concentrations are at straits of Gibraltar and, to lesser extent, the Sicilian channel though there are not representative of the true scale of passage, as no concentration is apparently found at the Bosphorus.

Movements are usually diurnal and smaller species often travel in loose (sometimes mixed) flock; larger ones generally singly. Spring passages are often more conspicuous than those in the autumn, the latter being perhaps more direct and at higher altitudes, and therefore not observed.

Little is known of changes in range or numbers of *F. concolor, F. eleonorae*, and *F. pelegrinoides*; all others have suffered declines and range

concentration to varying extents. Most of west Palearctic species have suffered persecution and other pressures from humans, though several even more are affected by activities of some falconers. Also, climatic change may also have affected southern populations. *F. biarmicus* has declined and is nearing extinction in Europe, while *F. cherrug*, though declining in central and south east Europe has apparently spread north in former USSR; in both species, human persecution and exploitation are likely to have been major factors in the general distribution of the family.

## 1.2.3. Different falcon species

## 1.2.3.1. Saker: *Falco cherrug:*

**Field Characters:** 45-55 cm (tail 16-17 cm), wing-span 102-126 cm. Averages smaller than Gyrfalcon *F. rusticolus* but larger than Peregrine. Plumage essentially dark brown above, normally lacking blue or gray tones. Tail shows pale spots rather than bars. Adult noticeably pale-headed, with indistinct facial pattern. Juvenile (and some adults) have dark bar across under wing, contrasting with-pale undersurface of flight-feathers. ( Figure 1)



Figure 1: Adult female saker falcon *F. cherrug*

Flight action is looser and lazier than *Falco peregrinus* Sexes similar; no seasonal variation. Juvenile distinct. 2 races in west Palearctic, distinguishable at close range.

**Habitat:-** In west Palearctic, across continental middle latitudes, mainly in wooded steppe and foothills, often bordering or overlapping into forests Hunts over open grassland, wetlands, and even cultivated land where more or less dense population of diurnal active small and medium-sized rodents provide ample prey biomass for rearing young, nests largely in well-grown trees Hunts up to 20 km or more from nest. In east of range inhabits high plateau country, mountains, and cliffs, at 2600-4700 m, breeding here almost always on rocks, beneath overhangs or in crevices, but occasionally in other sites such as abandoned wells.

**Distribution:-** Former USSR: appears to be spreading northwards. Turkey: recorded breeding in19th Century (Glutz et al. 1971). Syria: no proof of breeding. Also recorded in Germany, Sweden, Poland, Albania, Greece, Syria, Palastine (regular in winter), Egypt, Libya, Malta, Morocco.

**Movements:-** Migratory in Russia, partially migratory further west. Probably only minority present within European breeding range in midwinter, only sporadic then in Czechoslovakia, Austria, and Hungary and generally absent from Russia north of Crimea and Caucasus

**Food:-** Predominantly small mammals although birds also important. Most hunting carried out in open steppe areas but wide variety of techniques used for prey capture

Most important mammalian prey are rodents in particular susliks *Citellus* but also jerboas *Allactaga*, and very wide range of bird prey consumed, from small

passerines (e.g. larks *Alauda*, wagtails *Motacilla*) up to species as large as herons *Ardea* and bustards (Otididae).

**Social pattern and behavior**:- Non-gregarious, solitary for much of year, hunting singly. Many populations migratory or nomadic outside breeding season.

### 1.2.3.2. Gyrfalcon:- *Falco rusticolus*

**Field characters**:- 50-60 cm (tail 17-19 cm), wing span 130-160 cm. Birds from Greenland and Iceland population largest, all exceed Peregrine in measurements and bulk. Heavy, powerful *Falco*, lacking striking facial pattern in adult. Age and other variations produce range of plumages, from almost pure white through gray and brown to rare uniformly dark. Traditionally 3 races or phases have been recognized but only extreme morphs are discussed. Sexes are similar, no seasonal variation. Juvenile separable at close range (figure 2).

**Habitat**:- Cold northerly latitudes, arctic and subarctic or elsewhere in arctic-alpine zone, mainly above tree limit. Frequently based on sea cliffs and islands, including Arctic Ocean, where suitable secure alternative nest-sites usually available under overhanging cliffs, commonly near seabird colonies

**Distribution**:- Decline in southern parts of range in last 100 years may be due partly to climate change as well as persecution (Glutz et al., 1971). Sweden: Become extinct in south and center in 19th Century, due especially to persecution (Bijleveld, 1974) Norway: Reported breeding further south in past (Haftorn, 1971).
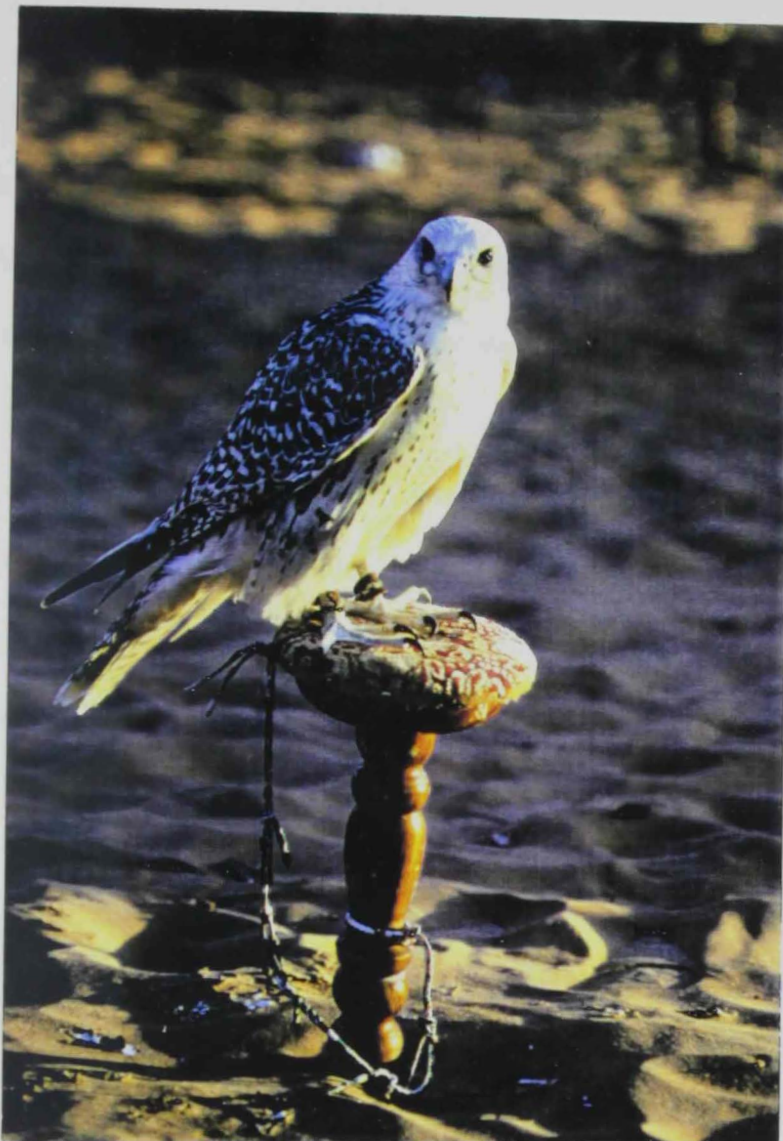
Figure 2: Adult male gyrfalcon *F. rusticolus.*

**Movements:** Migratory in high latitudes only as in Greenland population (based on Salmonsen, 1950). Resident and dispersive in low arctic and subarctic, where gray plumage predominates, local movement from interior to coast for winter.

High arctic population, mostly to white type, migratory, winter several hundred km south on coasts of southern Greenland

Food:- Mainly medium-sized birds, occasionally mammals. Choice of prey governed to great extent by habitat. At coastal nestling sites, principally seabirds, lie auks (Alcidae), Kittiwake *Rissa tridactyla* and marine diving ducks (Mergini) At inland tundra sites, principally Ptarmigan *lagopus mutus*, willow Grouse *L. lagopus*, and surface-feeding ducks. Ducks may be taken more commonly in winter. Other common species include waders (Charadriidae, etc.), passerines and Black Grouse. Range in size from *P. nivalis* to Capercaillie *T. urogallus* and Barnacle goose *Branta leucopsis*. Less usual prey item include Rough-legged Buzzard *Buteo lagopus*, skuas *Stercorarius sp.*, hawk owl *Surnia ulula*, pygmy owl *Glaucidium passerinum*, short-eared owl *Asio flammeus*, Tengmalm's Owl *Aegolius funereus* and Raven *Corvus corax*.

### 1.2.3.3. Peregrine:- *Falco peregrinus*

Field characters:- 36-48 cm (tail 10-13 cm), wing-span 95-110 cm.
Averages much smaller than Gyrfalcon *F. rusticolus* and most also smaller than Saker *F. cherrug* but noticeably stockier than all medium-sized or large falcons (figure 3)

Nominate *peregrinus* adult male upperparts are dark slate-blue, faintly barred black on back and wing-coverts and strongly so on paler gray tail. Slate-blue cap, upper cheeks, and broad mustache contrast with white lower cheeks and throat. Underparts suffused pink-buff (darkest on belly) finely spotted black on chest and barred black on rest. Underwing conspicuously barred, with coverts

appearing darker than flight-feathers, undertail also barred with subterminal band broadest



Figure 3 Juvenile female peregrine falcon *F. pergrinus*

Adult female are more coarsely marked below than male with heavier spots on chest and thicker barring on flanks and thighs, rump darker Juvenile plumage pattern of head and upperparts as adult but colour dark brown with paler fringes

to feathers obvious at close quarters, underparts cream with obvious brown streaks from chest to vent and thus quite distinct from barred adult.

**Habitat:-** In west Palearctic, from tropics to high Arctic, including arid continental and moist oceanic climatic zones. For hunting, requires extensive open terrain often including various wetland or coastal habitats. For breeding, mainly, cliffs, crags or other precipitous undisturbed situations, including sometimes tall inaccessible structures such as towers and ruins in parts of range also tree-tops or ground.

**Distribution:-** Marked recent declines have resulted in local extinction but west Palearctic populations have suffered less than those of eastern, North America where it became wholly extinct. Breeding distribution not mapped precisely in some areas for security reasons.

**Foods:-** The bird's wide range of hunting areas and prey species has produced many variations in hunting methods. Majority of prey are taken on wing, usually over open country and over water, rarely on edges of woods. May hunt almost exclusively over the sea during breeding season. Occasionally take prey from ground or from water surface, either from circling flight or elevated vantage-point, cliff, tree, hill. Pursuit flight follows, finally rising above prey preparatory to rapid swoop (wings folded and held slightly away from body). Adaptable, it can often persist even when habitat has changed drastically, but remains vulnerable to persistent and intense persecution, and to the effects of agricultural chemicals.

Among smaller west Palearctic *Falco*, only kestrel spans broader band of latitude, but presence limited to little more than one-third of the year though it is highly dependent on aerial insect prey, abundant only during the warmer months. Although ranging on occasion almost to tree-limit northward though taiga even beyond Arctic Circle, and Asia up to 30-50 m in mountain forests (Dimentiev and Gladkov, 1951) it is mainly a lowland species, tending to avoid coastlines and islands, extensive wetlands, steppes, deserts and all kinds of open treeless country.

## 1.2.3.4. Hybrids

Hybrids are captive breed falcons, as a result of hybridization between gyrfalcons across either sakers or peregrines as an attempt to produce strains which are quiet as sakers, fast as peregrines, strong as gyrfalcons, and can adapt to the changeable climate circumstances of the desert. Imported hybrids are usually free of parasitic infections, because the German exports at least, are screened and treated before export.

## 1.3. Parasites of the Genus: *Falco*

The huge amounts of reports regarding parasitic infection and infestion of falcons, showes how popular and important are falcons. Some of these reports are quoted in this chapter. The nomenclature is based on Levine et al. (1980), and Yamaguti (1961).

### 1.3.1. Phylum: Sarcomastigophora

### Order: Kinetoplastida

### I. Family: Trypanosomatidae

#### a. *Trypanosoma* sp.

A heteroxenous polymorphic haemoparasite, which spends one stage of its life in the blood and/or fixed tissues of all classes of vertebrates (figure 4), and spends the other stages of its life in the intestines of bloodsucking invertebrates.



Figure 4: *Trypanosoma pycnonti* from a white-eared bulbul. This is a non-pathogenic species occuring in African bulbuls. From: Hawkey and Dennett (1989).

Although Wenyon (1926) listed trypanosomes in 13 different species of hawks, falcon, kites and vultures, trypanosomes appear to be among the least common blood protozoa in diurnal birds of prey (Keymer, 1972).

Ward (1986) reported *Trypanosoma* sp. at necropsy of a Peregrine falcon. Samour et al. (1996) [Personal communication] found *Trypanosoma* sp. in immature female Saker falcon (*F. cherrug*) in Al-Ain, UAE.

## Order: Trichomonadida

## II. Family: Trichomonadidae

### *a. Trichomonas* sp.

The many members of this family are rather similar in structure. They are easily recognized because they have an anterior tuft of flagella, a stout median rod (the axostyle), and an undulating membrane along the flagellum. They are found in intestinal or reproductive tracts of vertebrates and invertebrates, with one group occurring exclusively in the gut of termites. Most members of this family do not form cysts (Schmidt and Roberts, 1989).

*Trichomonas gallinae* (figure 5) is probably the most pathogenic, being one of the causes of so-called "frounce", a disease of the crop especially in falconer's birds (Keymer, 1972). Perhaps the oldest recorded disease of wildlife is a trichomonad infection of the upper gastrointestinal tract of pigeons, doves, and birds of prey (Ward, 1986). Keymer (1972) reported *T. gallinae* from lesions in the buccal cavity of a red-headed Merlin *F. chicquera*.

Figure 5: *Trichomonas gallinae*, from

mouth, pharynx, and crop of many birds.

From: Mehlhorn (1988).
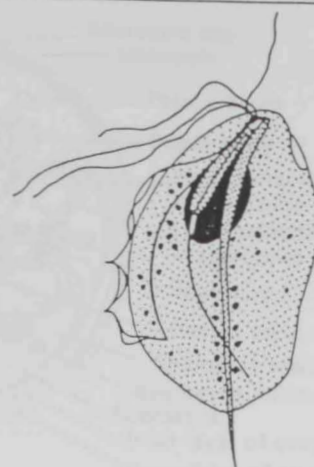
Samour et al. (1995) reported trichomoniosis (frounce) in 31% (1675/5360) of

falcons examined at the Salman Falcon Hospital in Bahrain between 1987 and 1993.

These included 1345 infected(80.2%) Saker falcons *F. cherrug*, 310 infected(18.5%)

Lanner falcons *F. biarmicus*, 8 (0.47%) Gyr X Saker crossbred falcons (*F. rusticolus*

X *F. cherrug*), 7 (0.41%) European kestrels and 5 (0.29%) lesser kestrels.

## 1.3.2. Phylum : Apicomplexa

## Order : Eucoccidiida

### a-Suborder : Eimeriina

Characteristically, members of this suborder show macrogamete and

microgamete developing independently; no syzygy; microgamont typically producing

many microgametes; zygote not motile; sporozoites typically enclosed in sporocyst

within oocyst; homoxenous or heteroxenous (Schmidt and Roberts, 1989).

## I. Genus: *Eimeria*

Oocyst contains four sporocysts (figure 6), each with two sporozoites. Host

specificity is more rigid in the genus *Eimeria* than in most other invasive organisms.

Figure 6: Structure of sporulated

*Eimeria* oocyst. From: Schmidt

and Roberts (1989).



- Micropyle cap
- Micropyle
- Polar granule
- Stieda body
- Small refractile globule in sporozoite
- Large refractile globule in sporozoite
- Sporocyst
- Oocyst residuum
- Sporocyst residuum
- Sporozoite nucleus
- Sporozoite
- Inner layer of oocyst wall
- Outer layer of oocyst wall
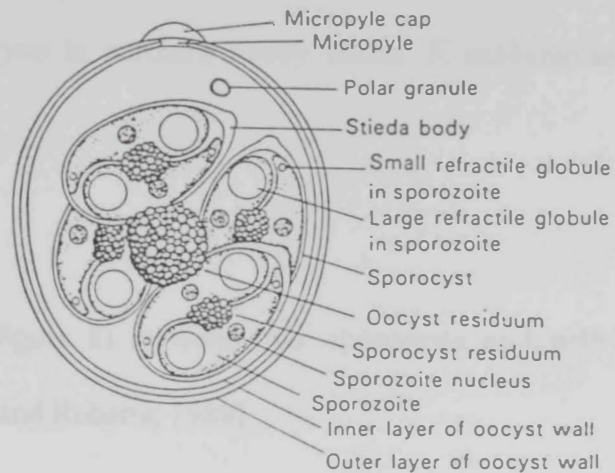
Pellerdy (1965) listed two species of *Eimeria* in the Falconiformes in Budapest.

Cooper (1969) found a few coccidian oocysts in a Saker falcon *F. cherrug*.

Levine (1988) reported *Eimeria accipitris* in lesser kestrel *F. naumanni*.

## II. Genus: *Caryospora*

Oocyst (figure 7) develops into a single spore with eight sporozoites and a residual mass; membrane thick and yellow (Kudo, 1966).
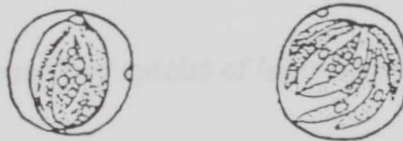


Figure 7: *Caryospora simplex* oocysts. From: Kudo (1966).

Species of *Caryospora* have uniquely facultatively heteroxenous life cycles in which merogony and gametogony are completed in (1) the intestinal epithelium of primary hosts (predatory reptiles and birds) and (2) dermal connective tissues, liver and other tissues of secondary host (rodents). (Upton et al., 1986). Also sporogony is completed in rodents (Cawthorn, 1993).

Pellerdy (1965) reported three species of *Caryospora* in the Falconiformes.

Cawthorn and Stockdale (1982) reported *Caryospora falconis* in *F. peregrinus*, and *Caryospora henryae* in northern hobby falcon *F. subbuteo* and in European kestrel *F. tinnunculus*.

## III. Genus: *Isospora*

The oocyst of *Isospora* (figure 8) contains two sporocysts, each with four sporozoites (Kudo, 1966; Schmidt and Roberts, 1989).

Figure 8: *Isospora belli* oocyst. It averages 35 by 9 μm. From: Schmidt and Roberts (1989).
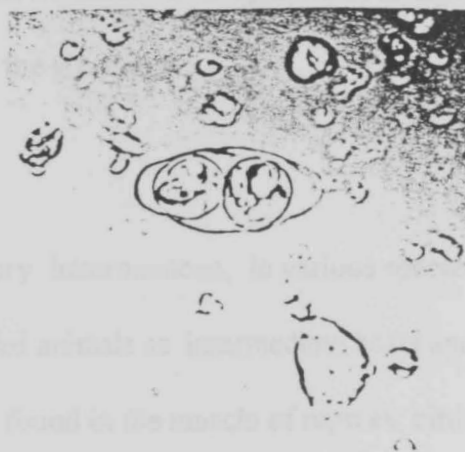
Pellerdy (1965) found two species of *Isospora* sp. in the Falconiformes.

## IV. Genus: *Toxoplasma*

*Toxoplasma* (figure 9) is an intracellular parasite of many kinds of tissues, including muscle and intestinal epithelium. In heavy acute infection the organism can be found free in the blood and peritoneal exudate. It may inhabit the nucleus of the host cell but usually live in the cytoplasm. The life cycle includes intestinal-epithelial (enteroepithelial) and extraintestinal stages in domestic cats and other felines, but extraintestinal stages only in other hosts. Sexual reproduction of *Toxoplasma* sp.

occurs while in the cat, and only asexual reproduction is known while in other hosts (Schmidt and Roberts, 1989).

Figure 9. Oocyst of *Toxoplasma gondii* from

cat feces. It is 10 to 13 by 9 to 11 μm.

From Schmidt and Roberts (1989).

Iygiste and Gusev (1962) found serological evidence of toxoplasmosis in eight different species of wild diurnal birds of prey from the Caucasus.

## V. Genus: *Sarcocystis*

*Sarcocystis* spp. (figure 10) are obligatory heteroxenous, in various species includeing reptiles, birds, small rodents, and hoofed animals as intermediate hosts and carnivora as definitive hosts. *Sarcocystis* may be found in the muscle of reptiles, birds and mammals.

Figure 10: Cross section of zoitocyst of

*Sarcocystis tennella* in muscle of

experimentally infected sheep. From:

Schmidt and Roberts (1989).

Ward (1986) reported *Sarcocystis* sp. in male Kestrel. In addition to *Sarcocystis cernae* which was found in *F. tinnunculus* (Cawthorn et al., 1984). Munday et al. (1979) reported cyst of Sarcocyst-like organisms in the musculature of various raptors including brown falcon *F. berigora* in Australia.

## b. Suborder: Haemosporina

Characteristically, macrogamete and microgamete develop independently; no syzygy; conoid ordinarily absent; microgamont producing eight flagellated microgametes; zygote motile (ookinete); sporozoites naked, with three-membraned wall; heteroxenous with merogony in vertebrates and sporogony in invertebrates; transmitted by blood-sucking insects. (Schmidt and Roberts, 1989).

## I. Genus: *Haemoproteus*

Heteroxenous haemoparasites, with merogony in vertebrates and sporogony in invertebrates. Primarily parasites of birds and reptiles Exoerythrocytic merogony occurs in endothelial cells; the merozoites produced enter erythrocytes to become pigmented gamonts (figure 11) in the circulating blood, can be transmitted by several ectoparasitic flies (Schmidt and Roberts, 1989).

Figure 11: *Haemoproteus* gametocytes in blood of a morning dove. They are about 14 µm. From: Schmidt and Roberts (1989).
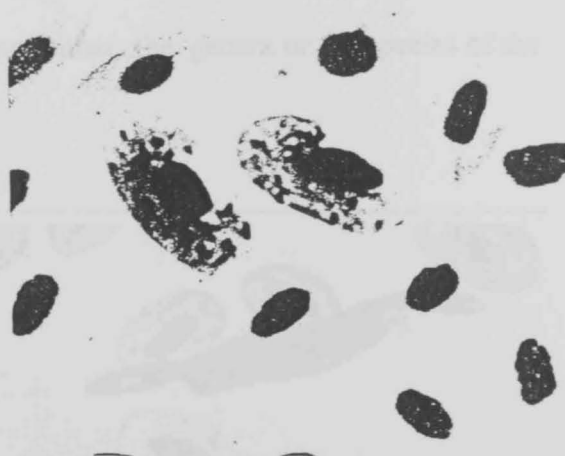
Wenyon (1926), Coatney (1937) and Stabler and Holt (1965) provided host lists of *Haemoproteus* and *Leucocytozoon*, and *Haemoproteus sp*. in particular. These were frequently recorded in the older reports of the pathologists to the Zoological Society of London, mainly by Hamerton during the years 1928-1941.

Cooper et al. (1993) reported that 31% (21/66) blood smears which were prepared from different raptors were infected with *Haemoproteus sp.* without determining either the genus or the species of the infected raptors.

Peirce et al.(1983) reported *Haemoproteus tinnunculi* in 4/12 (33%) of *F. cherrug* in Al- Ain Zoo, UAE.

## II. Genus: *Leucocytozoon*

Heteroxenous haemoparasites (figure 12) of birds, merogony is in fixed tissues, gametogony is in both leukocytes and immature erythrocytes of the vertebrate, and sporogony occurs in insects other than mosquitoes. Pigment is absent from all phases of the life cycle. (Schmidt and Roberts, 1989).

Only one species occurs in Falconiformes, which is *L. toddi* (Greiner and Kocan, 1977; Peirce and Cooper, 1977). Cooper et al. (1993) reported that (41%) 27 of a total 66 blood smears which were prepared from different raptors, were infected with *Leucocytozoon* sp. without determining either the genera or the species of the infected raptors.



Figure 12: Avian blood cells infected with elongate and round gametocytes of *Leucocytozoon simondi*. The elongate form is up to 22 μm long. From: Schmidt and Roberts (1989).

## III. Genus: *Plasmodium*

Heteroxenous haemoparasites(figure 13), with merogony in vertebrates and sporogony in invertebrates, most of them are parasites of wild animals and appear to cause little harm in most cases. Can be transmitted by blood-sucking insects.

Figure 13: *Plasmodium* sp. trophozoites in an EDTA blood sample from a snowy owl. From: Hawkey and Dennett (1989).
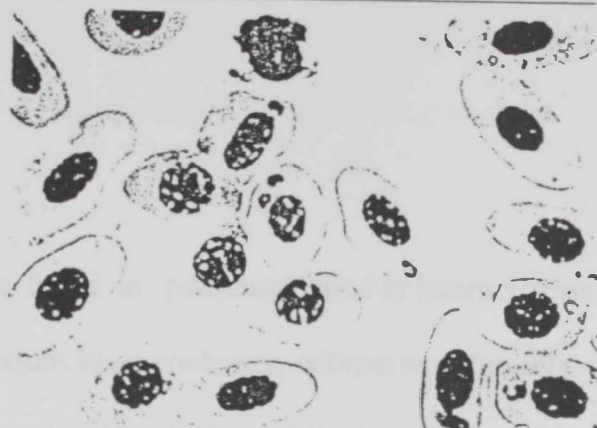
The initial identification of *Plasmodium* sp. in the Peregrine falcon by Kingston et al. (1976) constituted the first report of *Plasmodium* in this species.

Corradetti and Scanga (1963) found *Plasmodium polare* in kestrel *F. tinnunculus* from Sicily. Stabler and Holt (1965) also recorded three infections of a new species in American kestrels *F. sparverius* while Mackerras and Mackerras (1960) recorded a *Plasmodium sp.* in a gray falcon *F. hypoleucos.*

Remple (1981) demonstrated a *P. relictum* in three Gyrfalcons *F. rusticolus*, two Peregrine falcons *F. peregrinus anatum*, *F. peregrinus* and one Gyr x Peregrine hybrid.

## d. Subclass: Piroplasmia

Characteristically, these are piriform, round, rod-shaped, or ameboid; conoid absent; no oocysts, spores and pseudocysts; flagella absent; usually without

subpellicular microtubules, with polar ring and rhoptries; asexual and probably sexual reproduction; parasitic in erythrocytes and sometimes also in other circulating and fixed cells; heteroxenous, with merogony in vertebrates and sporogony in invertebrates; sporozoites with single-membraned wall; known vectors are ticks (Schmidt and Roberts, 1989).

## I. *Nuttalia shortti*

Heteroxenous parasites can be found in peripheral blood or internal organs, with merogony in vertebrates and sporogony in invertebrates, without any pigments.

Mohammed (1958) reported *Nuttalia shortti*. (figure 14)in the peripheral blood of a male Egyptian Kestrel *F. tinnunculus rupicolae formis* in the Abou-Rowash area (Cairo, Egypt).
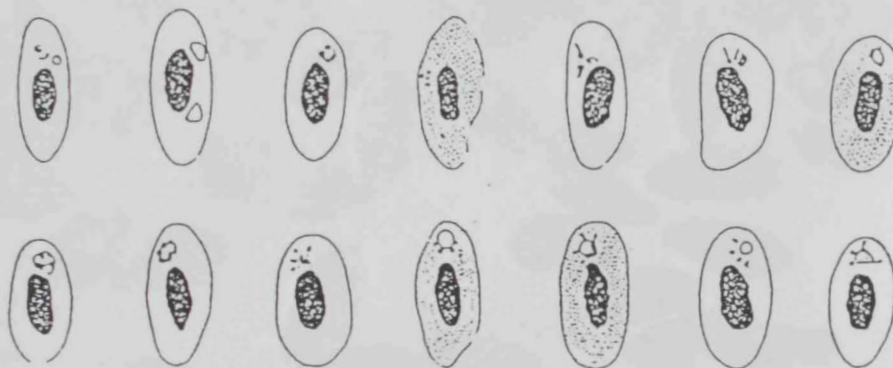


Figure 14: A series of camera-lucida drawings showing the various forms of *Nuttalia shortti* in the blood. Bar = 5 μm. From: Mohammed (1958).

## II. *Babesia* sp.

Heteroxenous parasites of erythrocytes, lymphocytes, histiocytes, erythroblasts, or other blood cells of mammals and birds and of various tissues of ticks. No stages produce intracellular pigment (Schmidt and Roberts, 1989).

Croft and Kingston (1975) reported *Babesia moshkovskii* in 20% (2/10) of males and 20% (4/20) of female Prairie falcons in Wyoming, USA.

*Babesia shortti* was also experimentally transmitted to *F. n. naumanni* by Mohammed (1958) in Cairo, Egypt.

Corradetti and Scanga, (1963) reported *Babesia shortti* from an European kestrel *F. t. tinnunculus* in Sicily.

Samour and Pierce (1996) reported heavy infection of *Babesia shortti* (figure 15) in a male Saker *F. cherrug* in Al-Ain, UAE.
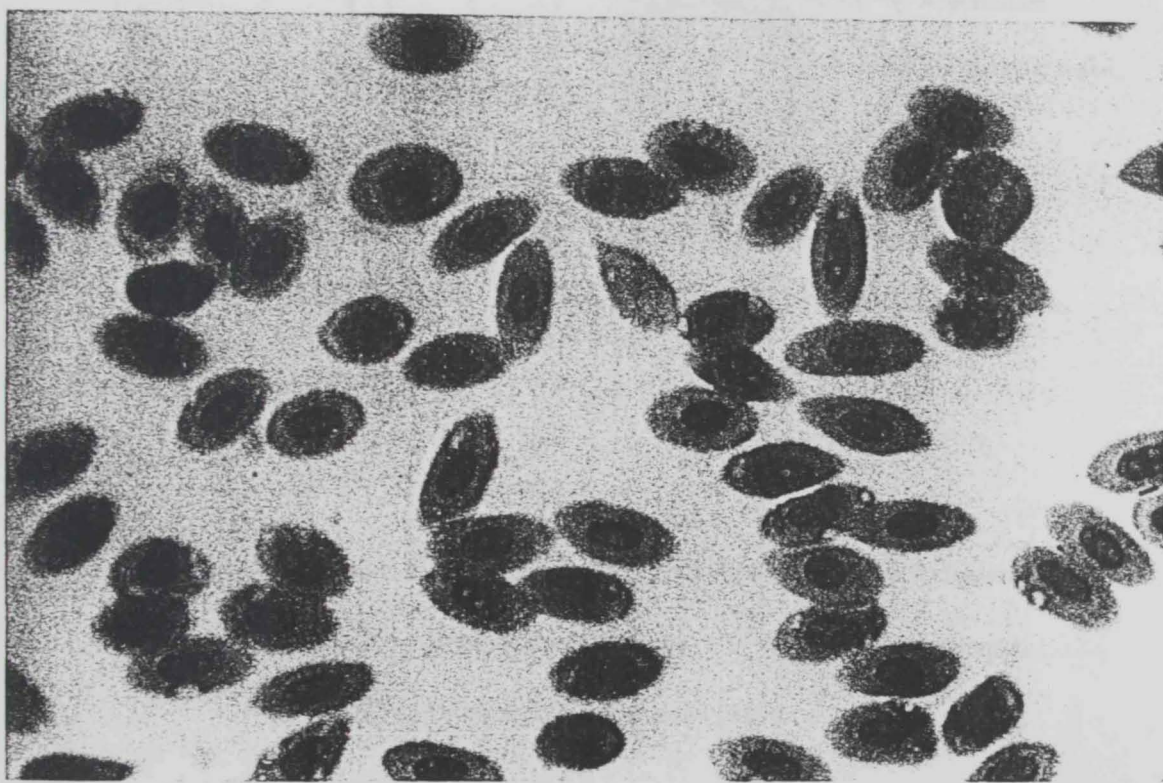


Figure 15: *Babesia shortti* in saker falcon (*Falco cherrug alticus*)

From: Samour and Peirce (1996).

## 1.3.3. Phylum: Platyhelminthes

## I. Class: Trematoda

Various dorso-ventrally flattent animals, typically bilaterally symmetrical (figure 16), all are parasitic, inhabit nearly every organ of their hosts (all classes of vertebrates) (Mehlhorn, 1988. Schmidt and Roberts, 1989).
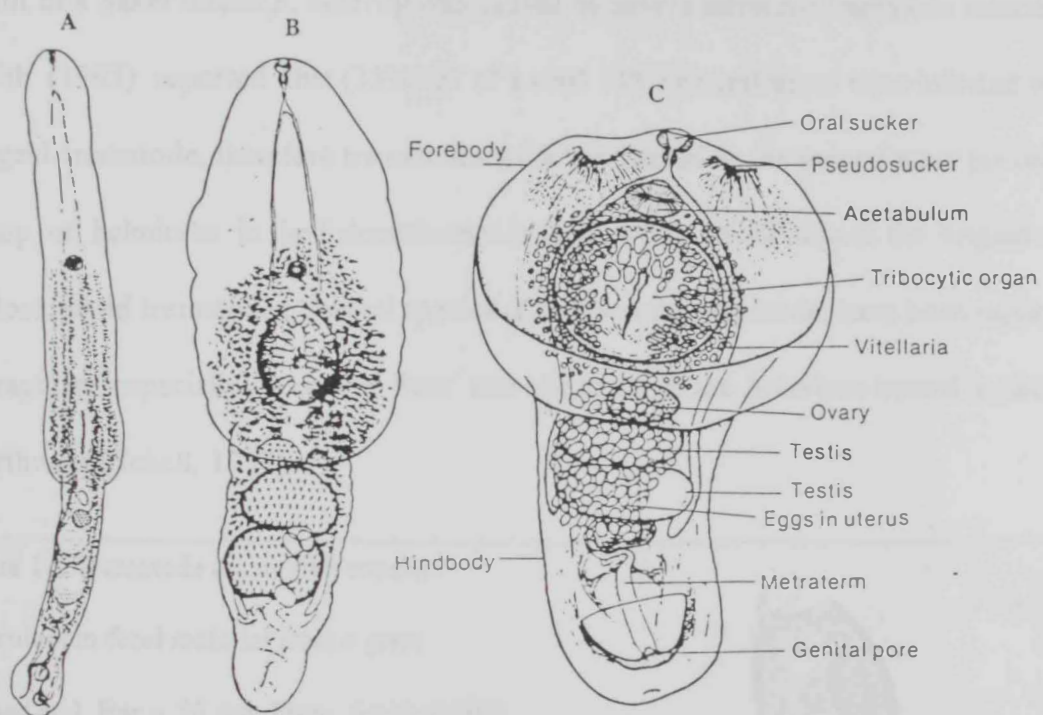


Figure 16: Typical strigeoid trematodes, illustrating body forms: A, *Mesodiplostomum gladiolum*. B, *Pseudoneodiplostomum thomasi*. C, *Proalarioides serpentis*.

From: Schmidt and Roberts (1989).

Flukes are one of the most common and usually innocuous types of internal parasites of raptors (Ward, 1986). Cooper (1969) found fluke eggs in a Saker falcon *F. cherrug*. Ward and Fairchild (1972) reported trematode ova (figure 17) in 67%

(2/3) of adult wild Peregrine *F. peregrinus*, 16% (3/19) of immature Peregrine, 25% (1/4) of adult captive Lanner falcon *F. biarmicus*, 100% (2/2) of immature captive Indian Merlin *F. chicquera*, and 100% (1/1) of immature captive kestrel *F. sparverius* which were studied in Maryland.

Croft and Kingston (1975) recognized *Neodiplostomum* (C.) *Spathula* in 60% ( 3/5) *F. mexicanus* in Wyoming, in USA. Greenwood et al. (1984) concluded that the death of a Saker falcon *F. cherrug* was caused by severe intestinal trematode infection. Smith (1993) reported that (32%) 37 of a total 115 Falconiformes were infected with strigeid trematode, therefore trematodes were considered as the second most prevalent group of helminths in the Falconiformes in Ohio, USA. In addition to the strigeid and diplostomatid trematodes, several species of dicrocoelid trematode, have been reported in raptors, especially from the liver and bile ducts of the American kestrel in pacific Northwest (Schell, 1957).



Figure 17. Trematode ovum with attached operculum in fecal material from a great horned owl. Bar = 50 µm. From: Smith (1993).

## II. Class: Cestoda

Tapeworms (figure 18) are innocuous parasites of virtually all species of raptors especially the Genus *Cladotaenia*, (Ward, 1986). Keymer (1972) reported an unidentified fragments of tapeworm from a Luggar falcon *F. jugger*. Ward and Fairchild (1972) reported cestode fragments from 33% (1/3) of adult wild Peregrine *F.*

*peregrinus*, 12.5% (1/8) of adult captive Peregrine, 42% (8/19) of immature captive Peregrine and 50% (1/2) of adult captive Gyrfalcons *F. rusticolus* which were studied in Maryland.
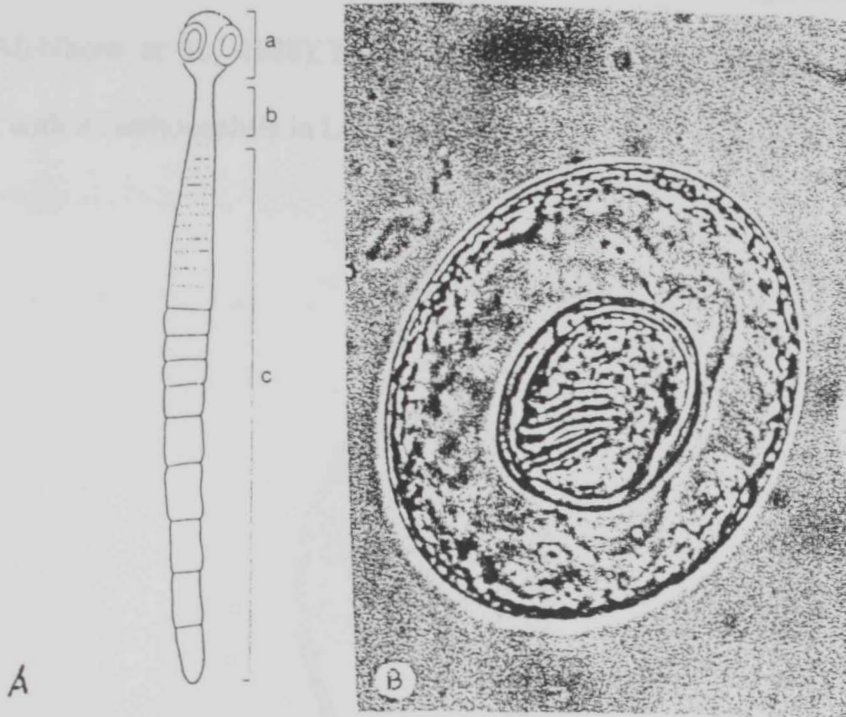


Figure 18: Tapeworm; A: Generalized diagram showing scolex (a), neck (b), and strobila (c). B: Raillient spp. egg: 25 - 50 μm. From: Thienpont et al. (1986).

*Cladotaenia globifera* in 20% (1/5) Prairie falcon *F. mexicanus* in Wyoming was reported by Croft and Kingston (1975). Smith (1993) reported that he found cestoda in 4% (3/71) of free-living Falconiformes in Ohio, USA. Schroder (1981) reported that 4% (2/45) of falcons examined were infected with helminths without mentioning the genera or species of these two falcons and without determining types of these helminths.

## 1.3.4. Phylum: Acanthocephala

Adult members of the Acanthocephala (figure 19)are highly specialized heterosexual, intestinal parasites that take up nutrition parenterally since they have no intestine. Vertebrates are used as final (definitive) hosts, arthropods as intermediate hosts (Mehlhorn et al , 1988). Nickol (1966) found 57% of wild Falconiformes to be infested with Acanthocephala in Louisiana.
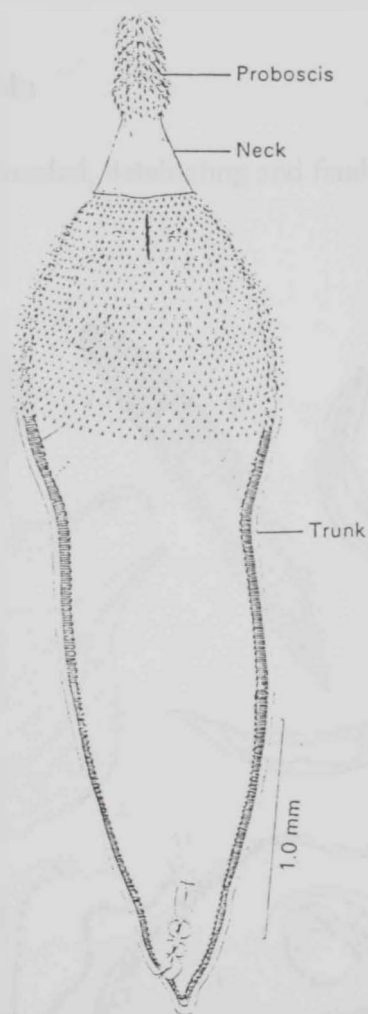


Figure 19: Acanthocephalan: *Polymorphus swartzi*, a parasite of ducks showing the main body divisions. From: Schmidt and Roberts (1989).

Jennings (see Keymer, 1972) attributed the death of a Lanner falcon *F. biarmicus* to a heavy infestation of the acanthocephalan *Polymorphus boschadis*.

Smith (1993) reported Acanthocephalan in one(1%) of free-living Falconiformes in Ohio. Although, infections with acanthocephalan in raptors is rare. Study in Louisiana showed that 57% of the free-living falcons were infected with Acanthocephala (Nickol, 1966).

## 1.3.5. Phylum: Nematoda

Some of the most dreaded, debilitating and fatal diseases of falcons are caused by nematodes (figure 20).
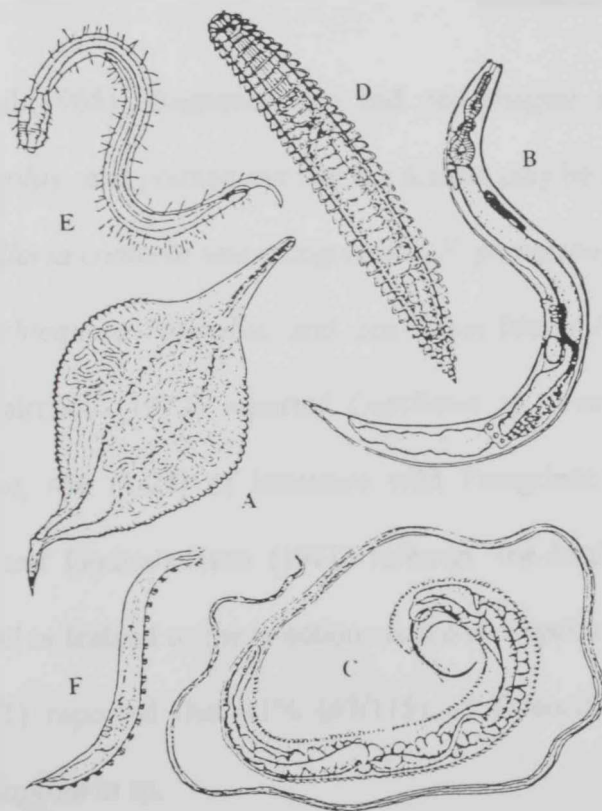


Figure 20: Variety of form in the nematodes. A, *Tetrameres*. B, *Rhabditis*. C, *Trichuris*. D, *Circonema*. E, *Chaetosoma*. F, *Bunonema*. From: Schmidt and Roberts (1989).

I. Capillariasis caused by several species of *Capillaria* (figure 21), can be a major mortality factor in wild and captive birds of prey (Ward, 1986). Keymer (1972) quoted that the most pathogenic nematodes, judging from the experience of Woodford (1960), and Cooper (1969) appear to be *Capillaria* sp.

Figure 21: *Capillaria* sp. ovum in fecal material from a red- tailed hawk. Bar = 50 µm. From: Smith (1993).

Trainer et al.(1968) diagnosed oral and oesophageal capillariasis in wild Gyrfalcons *F. rusticolus* and pointed out that the disease may be readily mistaken for trichomonosis. *Capillaria contorta* was recognized in *F. peregrinus peregrinus*, 2 red-headed Merlins *F. chicquera ruficollis*, and one Saker falcon *F. cherrug* (Cooper, 1969). Ward and Fairchild (1972) reported *Capillaria* sp. ova from 66% (2/3) of adult wild Peregrines, 4% (1/24) of immature wild Peregrines that were studied in Maryland. Clausen and Gudmundsson (1981) referred the death of 36% (13/36) of Gyrfalcons which died in Iceland to the infection caused by *Capillaria contorta*.

Smith (1993) reported that 41% (47/115) of Falconiformes in Ohio, USA were infected with *Capillaria* sp.

II. Ascarid: Ward and Fairchild (1972) found an ascarid ova (figure 22) in 11% (1/9) of immature captive Peregrines that were studied during five years in Maryland and included 73 falcons of 5 different species of Falconiformes.

Ascarid ova were reported in 13% (15/115) of Falconiformes by Smith (1993).

Figure 22: Ascaridia-type ovum in feces from an immature peregrine falcon. From: Ward (1986).
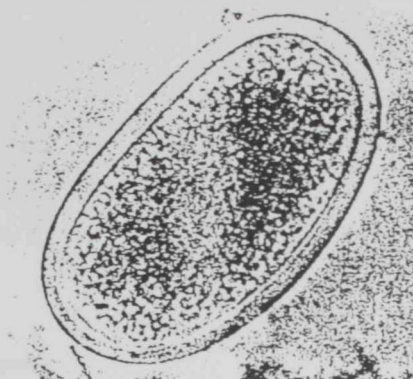


III. *Amplicaecum anisatericae*: Keymer (1972) found *Amplicaecum anisatericae* in a kestrel *F. tinnunculus*, and two unidentified nematodes, one in the respiratory tract of Peregrine falcon *F. peregrinus*, and the other one in the intestinal tract of kestrel *F. tinnunculus* and gray kestrel *F. ardosiaceus*.

IV. *Physaloptera* sp.: in 20% (1/5) of adult *F. mexicanus* was reported by Croft and Kingston (1975).

V. *Spiruroid* sp. (figure 23): was found in 14% (16/115) of Falconiformes (Smith, 1993). Johnston and Mawson (1941) found *Habronema* sp. in kestrels in Australia. Ward and Fairchild (1972) reported that *Hatertia* sp. was found in immature prairie falcon.



Figure 23: Larvated ovum of a Spirurid "stomach worms" in fecal materiall from a red-tailed hawk. Bar = 50 μm. From: Smith (1993).

VI. *Syngamus* sp. (figure 24): was reported from one free living American kestrel (Smith, 1993).



Figure 24: *Syngamus* sp. ovum in fecal material from an American kestrel. Bar = 50 μm.

From: Smith (1993).

VII. *Serratospiculum* sp.: The parasite had previously been not reported from raptors other than genus *Falco* (Ward, 1986). However, Sterner and Espinosa (1988) for first time reported *S. amaculata* from Cooper's hawk *Accipiter cooperii*, i.e. from raptor other than falcons. *Serratospiculum* sp. was reported from a single free-living prairie falcon *F. mexicanus* (Smith, 1993), and also found in 80% (4/5) adults *F. mexicanus* (Croft and Kingston, 1975).

Bigland et al. (1964) reported five cases of *Serratospiculum amaculata* in prairie falcon. Ward and Fairchild (1972) found *Serratospiculum* sp. ova (figure 25) in 33.3% (1//3) of adult wild Peregrines, 1/19 of immature female captive Peregrines, 100% (1/1) of adult female captive prairie falcons *F. biarmicus*, (2/7) of immature (male and female) captive prairie falcons, 25% (1/4) of adult captive Lanner falcon *F. biarmicus*, 100% (1/1) of captive Luggar falcons *F. jugger* and 50% (1/2) of immature captive Indian Merlin *F. chicquera* that were studied during five years in Maryland.

Figure 25: Embryonated ovum of
*Serratospiculum amaculata* in a
saliva smear from an immature
female peregrine. From: Ward (1986).
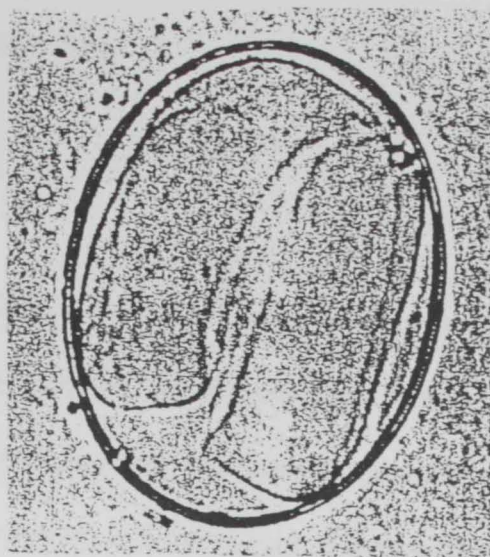


According to Ward (1986), *Serratospiculum* sp. was seen very frequently in prairie falcons but only occasionally in Peregrine falcons and Gyrfalcons.

VIII. *Microfilaria* sp.: Crisp (1854) found filarial nematodes in the heart of a Peregrine falcon. Peirce et al. (1983) reported Microfilaria in 1/3 (33%) of *F. peregrinus* in Al-Ain, UAE. Samour et al. (1996) [unpublished data] recorded *Microfilaria* sp. (figure 26) in blood smears of one immature female Peregrine falcon, one adult male Lanner falcon *F. biarmicus*, one immature female Saker falcon *F. cherrug*.

Figure 26: *Chandlerella sinensis*,
microfilarian from a red-billed blue
magpie.From: Hawkey and Dennett
(1989).
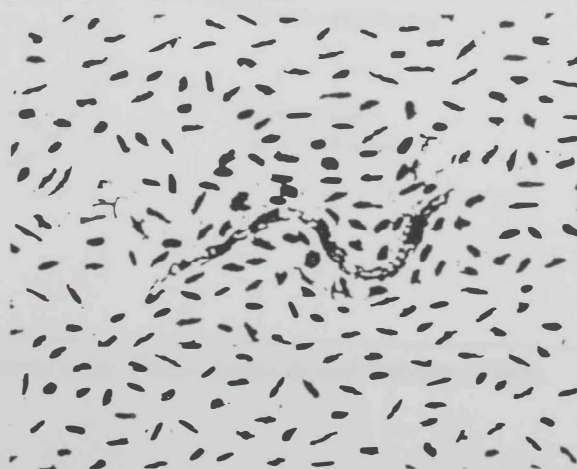
## 1.3.6. Ectoparasites (Phylum: Arthropoda)

### Class: Arachinda

### I. Order: Acarina

Ticks (figure 27) and mites (figure 28)are immensely important in human and veterinary medicine. Some of them causing diseases directly and other by acting as vectors of serious pathogens. All ticks are epidermal parasites, many mites are parasites on or in the skin or in the respiratory system or other organs of their hosts.
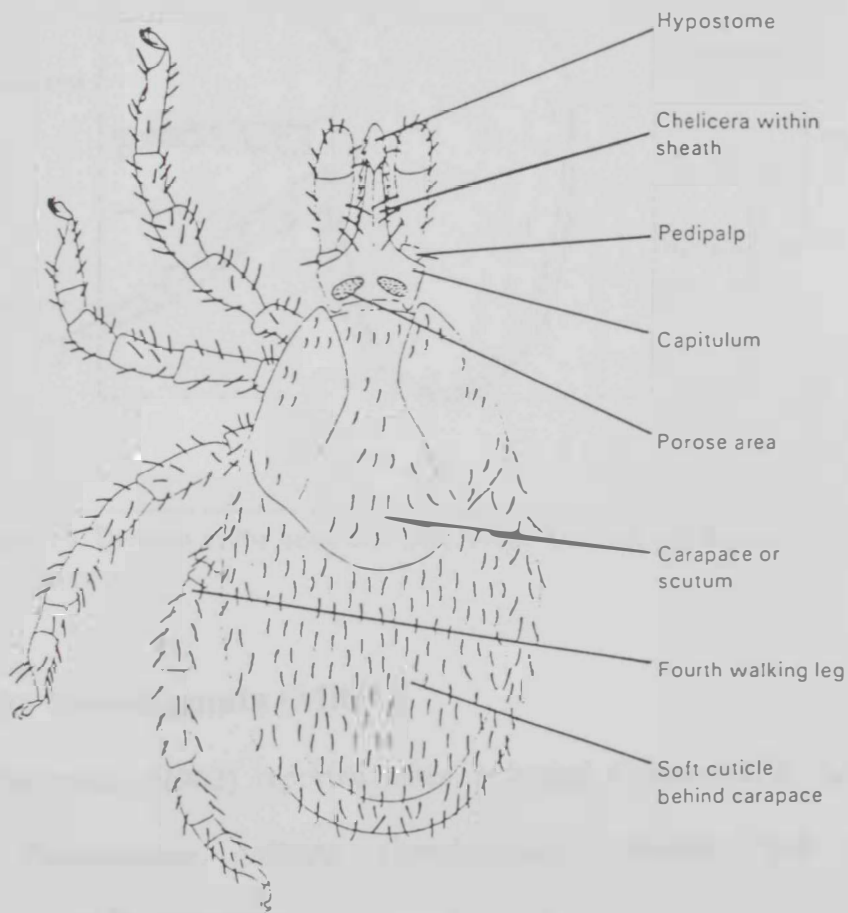


Figure 27: Female ixodid (hard) tick. Dorsal view. From: Schmidt and Roberts (1989).

## Suborder: Metastigmata (Ticks)

*Ornithodorus aquila* larvae were seen in a prairie falcon (Williams, 1947).

Croft and Kingston (1975) reported *Ornithodorus concanesis* in 3/30 of young *F. mexicanus* in Wyoming. Schulze (1929) reported *Ixodes caledonicus* in *F. peregrinus*.
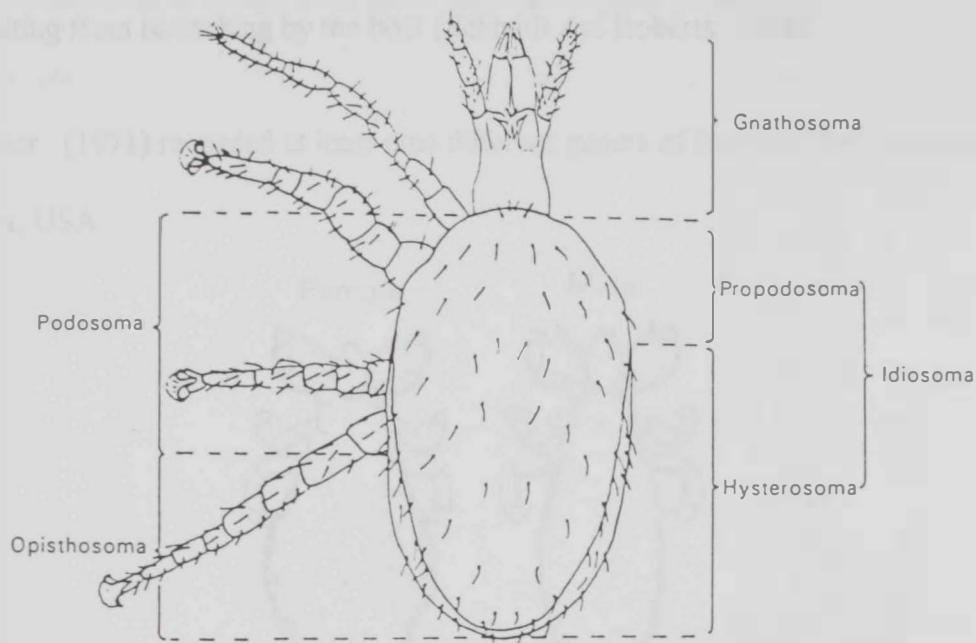


Figure 28: Division of the body of a mite. From: Schmidt and Roberts (1989)

## Suborder: Mesostigmata (Mites )

Strandtmann (1962) reported mites in kestrel. Cooper (1972) reported mites including *Dermanyssus gallinae*, *Ornithonyssus sylviarum*, and species of *Knemidokoptes* in *F. peregrinus* in Newent, England.

## Class: Insecta

## Class: Insecta

## I. Lice

Insects, about 3000 species parasitize various birds and mammals (figure 29). They feed primarily on feathers and hair, but some feed on sebaceous secretions, mucus and sloughed epidermis. Most will feed on blood, if available, such as that resulting from scratching by the host (Schmidt and Roberts, 1989).

Turner (1971) recorded at least nine different genera of lice from the Falconiformes in Iowa, USA.
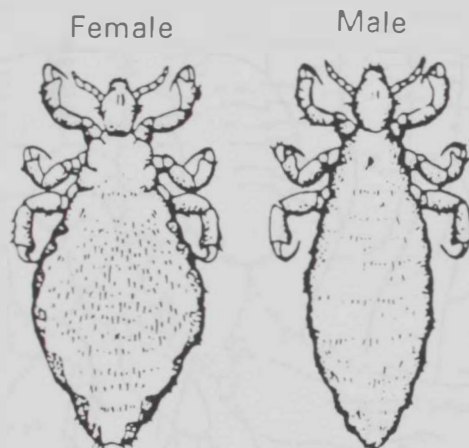
Female      Male



Figure 29: Adult male and female of head louse *Pediculus humanus*. From: Schmidt and

Roberts (1989).

Keymer (1972) reported *Degeerilla rufa* from two kestrel *F. tinnunculus* and *Laemobothrion tinnunculi* from one immature Luggar falcon *F. jugger*, and unidentified lice from duck hawk *F. peregrinus anatum*.

Croft and Kingston (1975) reported *Degeerilla rufa* in 2/30 of young *F. mexicanus* in Wyoming.

## II. Fleas

Small insects (figure 30), less than a millimeter to few millimeter, approximately a hundred of 2000 species regularly are found on birds. Some are tan or yellow, but they are commonly reddish brown to black. The adults feed exclusively on blood (Schmidt and Roberts, 1989).

Croft and Kingston (1975) reported *Thrasis francisi* in 1/30 of young *F. mexicanus* and *Opiocrostis* sp. in 1/30 of young *F. mexicanus* in Wyoming.
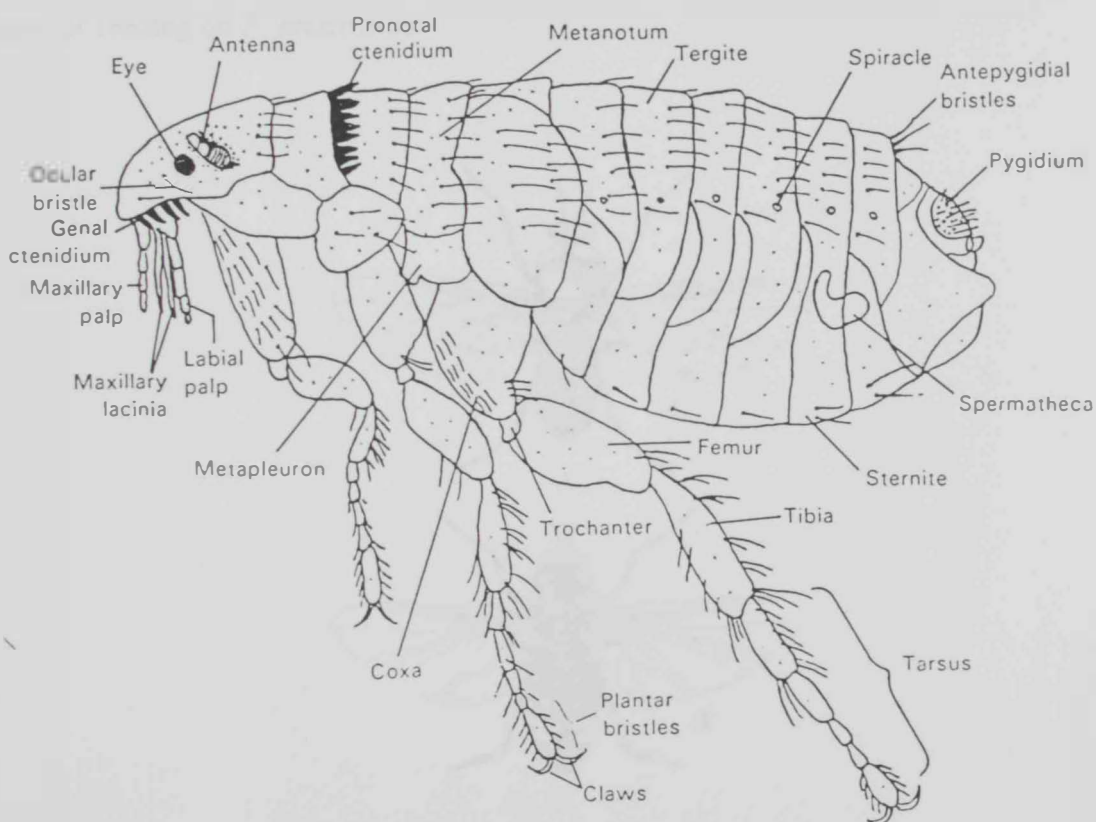
Figure 30: Diagram of a flea. From: Schmidt and Roberts (1989).

## III. Flies

Small insects (figure 31), from 1 to 5 mm long. Females of most species feed on blood as well as on nectar, but males feed only on plant juices, the Order: Diptera, is vast, with more than 80,000 species in 140 families (Schmidt and Roberts, 1989).

Croft and Kingston (1975) reported *Simulium (E.) canonicola* on 2/30 of young *F. mexicanus* and they also reported unidentified Hippoboseid fly on 2/30 young *F. mexicanus* in Wyoming, and considered them as normal ectoparasites living and/or feeding on *F. mexicanus*.
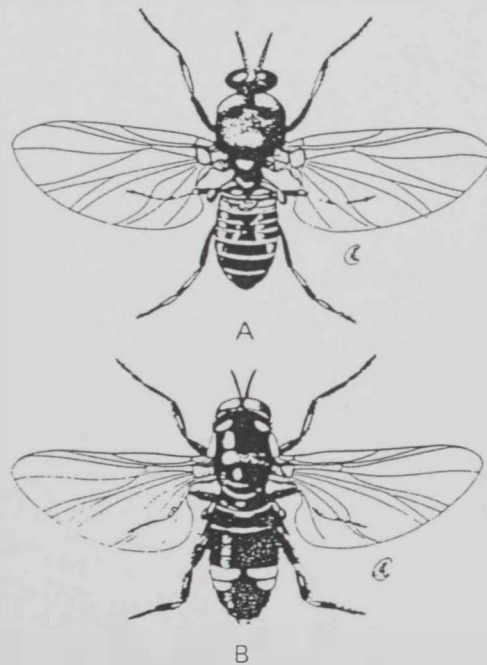


Figure 31: A black fly, Simulium nigricoxum stonue. A: female. B: male. From: Borror et al. (1989)

# CHAPTER II

# Materials and methods

## 2.1. Materials:

A total of 100 falcons presenting for various reasons, at 3 hospitals were studied at random.

Using a check-list described earlier, these falcons were identified as:

•*Falco cherrug* (Saker) (61 falcons).

•*Falco rusticolus* (Gyrfalcons) (4 falcons).

•*Falco peregrinus* (Peregrine) (28 falcons).

•Hybrid (Saker × Gyrfalcon) (Peregrine × Gyrfalcon) (7 falcons).

The differentiation between the species was carried out using characteristics given by Cramp (1987), and Al Tamimi (1992), and confirmed with the help of the falconers and veterinarians of the falcon hospitals.

Of the 100 falcons which were studied, 89 falcons were female and 11 falcons were males.

*F. cherrug* were mainly imported from Pakistan, and 2 each from Syria and China. *F. rusticolus*, one, was imported from USA. *F. peregrinus* was mainly imported from Pakistan, and 1 each from Syria, Iran, and Germany. Hybrids were all imported from Germany. (Table I)

While (34) *F. cherrug*, (12) *F. peregrinus*, (3) *F. rusticolus* and (1) hybrid were considered as "resident falcons" (Table II) having spent a period of 1- 4 years in the UAE, the rest with less than 1 year residing were considered "imported falcons".

TABLE I: NUMBERS AND PERCENTAGE OF IMPORTED FALCONS IN RELATION TO SPECIES AND SEX.

| sex species | MALE | | FEMALE | | TOTAL | |
|---|---|---|---|---|---|---|
| | No. | % | No. | % | No. | % |
| F.cherrug | 3 | 11 | 24 | 89 | 27 | 54 |
| F.rusticolus | 0 | 0 | 1 | 100 | 1 | 2 |
| F.peregrinus | 3 | 19 | 13 | 81 | 16 | 32 |
| Hybrid | 1 | 17 | 5 | 83 | 6 | 12 |
| TOTAL | 7 | 12 | 43 | 88 | 50 | 100 |

F. cherrug constituted 54%( 27/50 ) of the imported falcons studied , of those 11% ( 3/27 ) were males ,and the remaining were females . One female F. rusticolus constituted 2% ( 1/50 ) of the imported falcons. F. peregrinus constituted 32% ( 16/50 ) of the imported falcons, of those 18% ( 3/16 ) were males and the rest were females .With respect to hybrid which constituted 12% (6/50 )of the imported falcons 17% ( 1/6 ) were male and remaining 83% ( 5/6 ) were females .

TABLE II: NUMBER AND PERCENTAGE OF RESIDENT FALCONS IN RELATION TO SPECIES AND SEX.

| SEX SPECIES | MALE | | FEMALE | | TOTAL | |
|---|---|---|---|---|---|---|
| | No. | % | No. | % | No. | % |
| *F.cherrug* | 2 | 6 | 32 | 94 | 34 | 68 |
| *F.rusticolus* | 0 | 0 | 3 | 100 | 3 | 6 |
| *F.peregrinus* | 2 | 17 | 10 | 83 | 12 | 24 |
| Hybrid | 0 | 0 | 1 | 100 | 1 | 2 |
| TOTAL | 4 | 8 | 46 | 92 | 50 | 100 |

*F. cherrug* constituted 68%(34/50)of the resident falcons studied, of those 6% (2/34)were males and the rest were females. *F. rusticolus* constituted 6% (3/50) of the resident falcons studied and were all females.
*F.peregrinus* constituted 24% (12/50) of the resident falcons studied, of those 8% (2/12) were males and the remaining were females. One female hybrid falcon constituted 2% (1/50)of the resident falcons.

Blood, fecal and feather samples for the present study were collected from falcon stations at:

1. Abu- Dhabi Falcon Research Hospital (48 falcons).

2. The Veterinary Hospital, Dubai (29 falcons).

3. Dubai Falcon Hospital (23 falcons).

The imported falcons were usually taken to these hospitals for routine check up before payment of the purchase price, while the resident falcons were brought to these hospitals either for routine check up or because of ill health or injury.

Investigative and analytical laboratory work was carried out at the Faculty of Science, Dept. of Biology, and at the National Avian Research Center (NARC), Sweihan

## 2.2. Methods

### 2.2.1. Blood

#### 2.2.1.1. Blood collection:

Blood (70 μl - 200 μl) was collected from either the brachial vein or tibiotarsal vein of falcons into plastic containers which contained Dipotassium EDTA as an anticoagulant. Blood was used for preparation of two blood films: a wet film for examining motile living organisms and a thin stained film was prepared for later examination.

### 2.2.1.2. Preparation of blood smears:

A. A drop of fresh blood placed on a clean slide and covered with a cover glass.

The pereparation was examined for living motile parasites of blood.

B. Thin blood smears were prepared through the following steps(Hole, 1989):

1) A drop of blood was placed at about two cm, onto the end of a clean slide.

2) A second slide was held at an angle of about 45- degree to the first one, allowing the blood to spread along it's edge;

3) The second slide was pushed over the surface of the first so that it pulls the blood along.

The prepared thin blood smear was then dried at room temperature and fixed by immersion into absolute methanol for 10 minutes, and stained for 5 minutes with a

mixture of May-Grünwald stain diluted 1:1 with buffer pH 6.8 and for 20 minutes with a mixture of Giemsa stain diluted 1:1 with buffer pH 6.8 and washed with distilled water. The blood film were then air dried and examined under the microscope.

## 2.2.1.3. Microscopy examination

A.    The stained blood smears were examined with low power magnification(X100-X400), to locate an area where the blood cells were well distributed, then, any blood parasites found were studied under oil-immersion (X1000). In case of the presence of any haemoparasites a check list was used to identify the parasite and the infection density was estimated, then the parasites were photographed using a NIKON photomicroscope.

B.    Parasite density:

To estimate the parasite density 2000 reference blood cells should be counted. In accordance to the Godfrey technique (Godfrey, 1987), numbers of blood cells in five different fields were counted, and the mean $(x)$ was calculated. In order to ensure that 2000 blood cells were covered, this figure was divided by the mean $(x)$ to obtain the number of fields $(y)$ which should be examined, the number of parasitized blood cells were detected $(\alpha)$and was then multiplied by the mean and the number of fields. The result was divided by 2000 to obtain the parasite density {i.e. parasite density = $(\alpha / 2000) \times 100$ }in percentage (%).

C.    Morphometric measurements were made as follows:

# Micrometry

## MATERIAL

stage micrometer: a microscope slide on which 1 mm has been engraved. divided into 100 equal spaces One space is therefore equal to 1 mm/100 = 10 $\mu$m
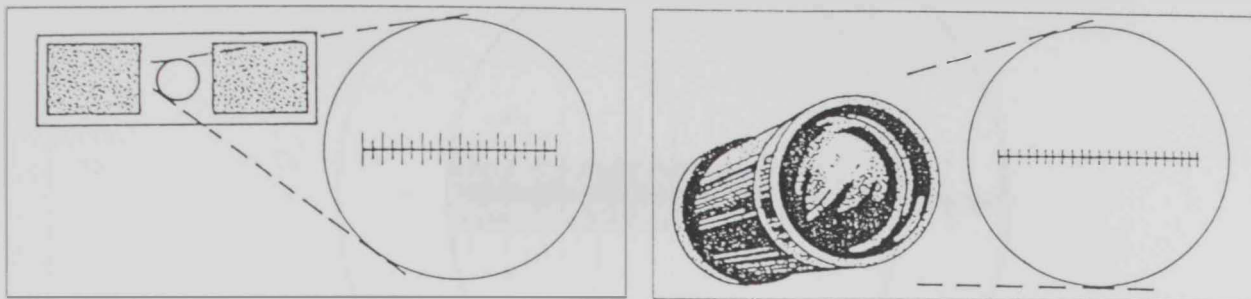


ocular micrometer scale : a special ocular on which a scale has been engraved. Not all oculars have the same subdivisions (this depends on the manufacturer)

## OCULAR MICROMETER CALIBRATION

The stage micrometer is placed on the object table and the scale is brought into focus The ocular micrometer is rotated until both scales overlap The mechanical stage is moved until both scales are aligned with the zero line The number of stage micrometer divisions in one or more ocular micrometer divisions is counted (see page 27) The higher the magnification, the thicker the lines The line of the ocular micrometer which is exactly aligned with the middle of a thick object scale line of the stage micrometer must be chosen. The weakest of the dry objectives (3x. 10x, 20x, 40x, and 50x) is first used and then the immersion objectives (50x, 100x) are calibrated

The calibration must be worked out separately for each microscope because the real magnification always differs from one microscope to another. A plate is fixed beside each microscope: this gives the table with the magnification index for each objective.

Example:

microscope x .... N° ....

10 x objective magnification 15 $\mu$m

40 x objective magnification 3.75 $\mu$m

100 x objective magnification 1.5 $\mu$m

index = unit of the ocular micrometer

## EXAMPLES: CALIBRATION OF THE OCULAR SCALE OF THE MICROSCOPE

with 10 x objective

10 divisions of the ocular micrometer are exactly superimposed over 15 divisions of the stage micrometer. For this objective (10x) each space of the ocular micrometer corresponds to

$$\frac{15 \times 10 \ \mu m}{10} = 15 \ \mu m$$
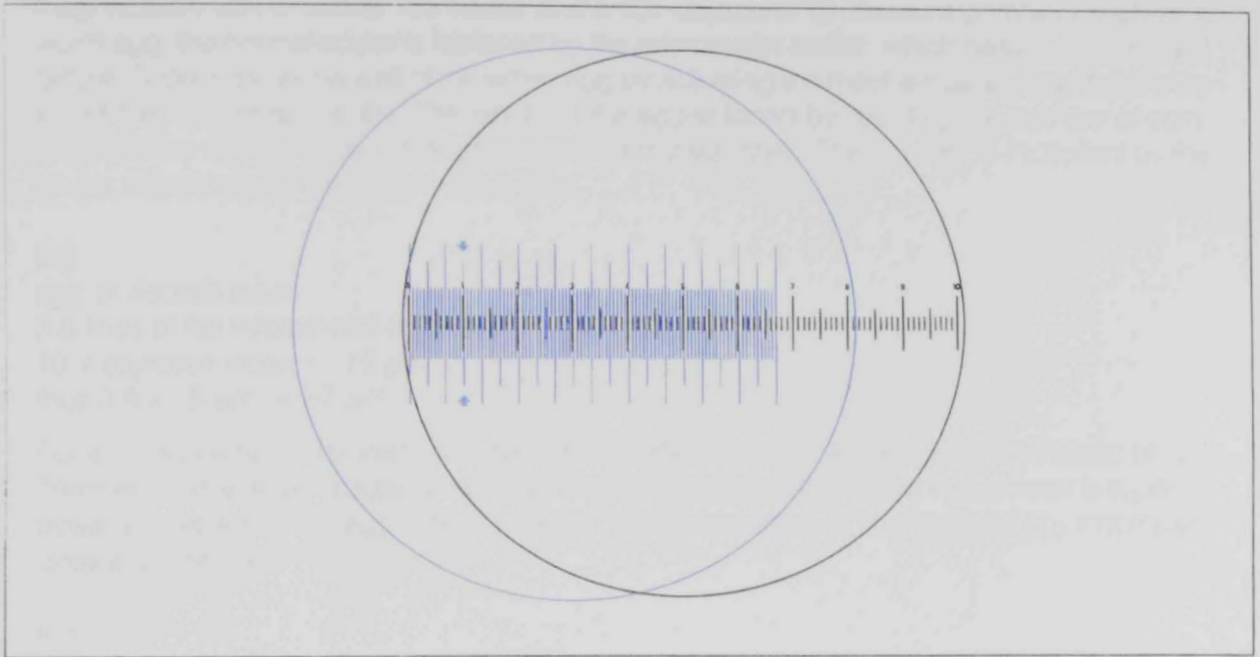


### with 40 x objective

56 divisions of the ocular micrometer are precisely superimposed over 21 divisions of the stage micrometer. For this objective, each space of the ocular micrometer corresponds to

$$\frac{21 \times 10 \ \mu m}{56} = 3.75 \ \mu m$$
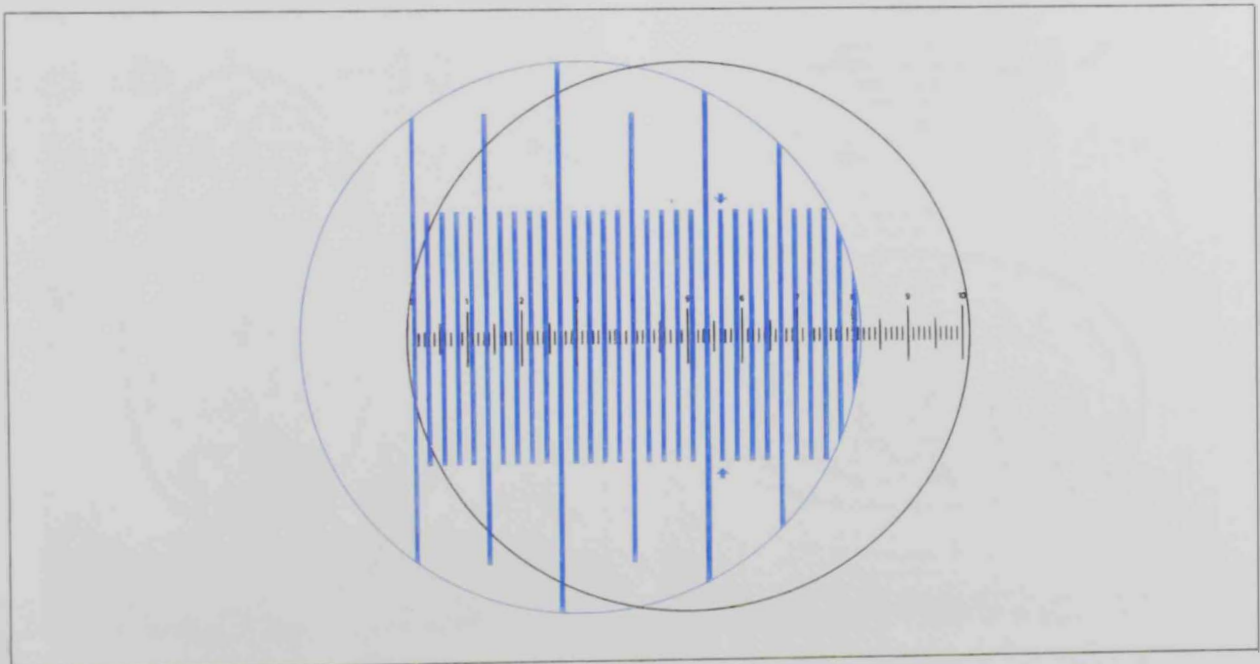
## MEASUREMENT OF AN OBJECT

Examine a fresh preparation in which worm eggs are present. The eggs can be observed by magnification with a normal 10x ocular and a 10x objective. To measure an object such as a worm egg, the normal ocular is replaced by the micrometer ocular, which has been calibrated before. Superimpose the wall of the worm egg by adjusting the mechanical stage with the zero line of the micrometer ocular. The length of the egg is found by counting the number of complete spaces and estimating the amount of incomplete ones. The number is multiplied by the ocular micrometer index which was found.

e.g.:
egg of *Ascaris suum*
3.8 lines of the micrometer eyepiece
10 x objective index — 15 $\mu$m
thus 3.8 x 15 $\mu$m = 57 $\mu$m

For a more precise measurement, a higher magnification can be used, e.g. 40x instead of 10x. The mechanical stage is again placed so that the zero line of the ocular micrometer is superimposed on the wall of the egg. The number of complete spaces is counted and any incomplete ones are estimated.

e.g.:
egg of *Ostertagia circumcincta*

24 lines of the micrometer eyepiece          13.5 lines
24 x 3.75 $\mu$m = 90 $\mu$m in length.          13.5 x 3.75 $\mu$m = 50.6 $\mu$m in width.
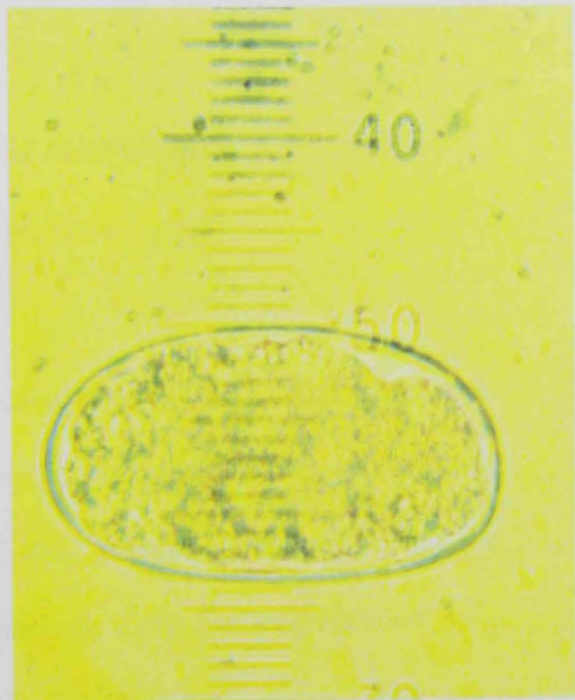
## 2.2.2. Feces

### 2.2.2.1. Collection of fecal samples

The fresh fecal samples were collected with a clean plastic syringe (without the needle) and transferred into a plastic container with a screw cap. This container then was labeled and stored in the refrigerator.

### 2.2.2.2. Macroscopic examination

Adult worms, segments of tapeworms or fly larvae could be recognized macroscopically, since:

•Nematodes in the feces are usually immobile because they are normally expelled only when they are dead They can be recognized by either their size, shape and color.

•Proglottids of tapeworms are easily recognized in the feces if they are still contracting or if they have the typical form.

•Small worms or proglottids can be isolated after sieving (sieve with mesh size: 0.3 mm or smaller).(Thienpont et al., 1986).

### 2.2.2.3. Preparation of fecal materials for microscopy

Two methods of preparation of fecal materials were used

## A) Direct method:

A drop of water was placed on a microscopic slide, in which a pinhead of feces was mixed and spread out, so that a relatively homogeneous and sufficiently transparent film was obtained. A cover glass was placed on the mixture and the preparation was examined thoroughly and systematically under low magnification.

## B) Floatation method: using:

- Saturated salt solution, with density 1.20 at 20° C.

- Saturated sugar solution, with density 1.20 at 20° C.

For detection of coccidian oocysts, and eggs of platyhelminthes, and nematodes. Because they float in a liquid with a specific gravity more than 1.15 .

1) Small amount of the fecal sample was mixed in a centrifuge tube (1/4th length of tube), with saturated salt solution (or saturated sugar solution).

2) The tube was then filled to 3/4th of its size with the chosen saturated solution.

3) Centrifuged at 5000 r.p.m. for 10 minutes.

4) The tube was then transferred to a stand, filled completely with the same saturated solution.

5) A cover glass was placed on the top of the tube which was left to stand for 10 minutes.

6) The cover glass was then placed onto a clean slide and examined under the microscope using low magnification.

7) If any eggs were detected, the infection density was measured, then the eggs were photographed by Axiophot ZEISS photomicroscope.

## 2.2.2.4. Estimating the intensity of the infection

The following scores were used to determine the intensity of the infection (10 X objective)

0. no worm eggs (normal).

+: light infection: 1 to 3 eggs per field.

+ +: moderate infection: 3 to 10 eggs per field.

+ + +: heavy infection: >10 eggs per field.

### 2.2.3. Ectoparasites

Ectoparasites were collected by:

1)  Feathers inspection.

2)  Using insecticide spray.

3)  Shaking the body in full sun light, over a collecting sheet.

When ectoparasites were encountered, they were fixed with 70% ethanol and stored in plastic containers for further identification.

### 2.2.4. Statistical Methods and Analysis

The data were coded and entered into a computer and processed on an IBM-PC compatible computer using the Statistical Packages for Social Sciences [SPSS] (Norusis, 1992). Data are expressed as mean and standard deviation (SD) unless otherwise stated. Student-t test was used to ascertain the significance of differences between mean values of two continuous variables and Mann-Whitney test was used for non-parametric distribution. Chi-square analysis was performed to test for differences in proportions of categorical variables between two or more groups. In 2X2 tables, the Fisher's exact test (two-tailed) replaced the chi-square test if the assumptions underlying chi-square were violated, namely in case of small sample size and where the expected frequency was less than 5 in any of the cells. Odds ratio (OR) and their 95% confidence intervals (CI) was calculated by using Mantel-Haenszel test (EPI6 INFO Version 6, 1994). One-way analysis of variance (ANOVA) was employed for comparison of several group means and to determine the presence of significant differences between group means of continuous variables. The level $p<0.05$ was considered as the cut-off value for significance.

# CHAPTER III

# Results and discussion

**TABLE III: INFECTION RATES WITH DIFFERENT BLOODPARASITES, INTESTINAL PARASITES, AND ECTO-PARASITES OF IMPORTED AND RESIDENT FALCONS.**

| Hosts | | Infection | IMPORTED | | | | | | Hosts | Infection | RESIDENT | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Bloodparasites | | Intestinal parasite | | Ecto-parasites | | | | Bloodparasites | | Intestinal parasite | | Ecto-parasites | |
| Species | Sex | No.exa. | No.+ve | % | No.+ve | % | No.+ve | % | Sex | No.exa. | No.+ve | % | No.+ve | % | No.+ve | % |
| *F. cherrug* | M | 3 | 1 | 33 | 1 | 33 | 0 | 0 | M | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| | F | 24 | 1 | 4 | 13 | 54 | 0 | 0 | F | 32 | 4 | 12 | 15 | 47 | 1 | 3 |
| | T | 27 | 2 | 7 | 14 | 51 | 0 | 0 | T | 34 | 4 | 12 | 15 | 44 | 1 | 3 |
| *F. rusticolus* | M | 0 | 0 | 0 | 0 | 0 | 0 | 0 | M | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | F | 1 | 1 | 100 | 1 | 100 | 0 | 0 | F | 3 | 1 | 33 | 0 | 0 | 0 | 0 |
| | T | 1 | 1 | 100 | 1 | 100 | 0 | 0 | T | 3 | 1 | 33 | 0 | 0 | 0 | 0 |
| *F. peregrinus* | M | 3 | 0 | 0 | 2 | 66 | 0 | 0 | M | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| | F | 13 | 2 | 15 | 7 | 54 | 0 | 0 | F | 10 | 0 | 0 | 2 | 20 | 0 | 0 |
| | T | 16 | 2 | 12 | 9 | 56 | 0 | 0 | T | 12 | 0 | 0 | 2 | 17 | 0 | 0 |
| Hybrid | M | 1 | 0 | 0 | 1 | 100 | 0 | 0 | M | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | F | 5 | 0 | 0 | 0 | 0 | 0 | 0 | F | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| | T | 6 | 0 | 0 | 1 | 16 | 0 | 0 | T | 1 | 0 | 0 | 0 | 0 | 0 | 0 |

Results of the parasitological investigation of imported falcons showed that with respect to saker falcon *F.cherrug* 33% (1/3) of male falcons were infected with *Haemoproteus tinnunculi* and *Leucocytozoon toddi* , whereas 4% (1/24) of female *F. cherrug* was infected with *Haemoproteus tinnunculi*.

Male *F. cherrug* 33%(1/3) and female 54% (13/24) were infected with intestinal parasites.

Females of *F. rusticolus* studied 100% (1/1) were found to be infected with *Leucocytozone toddi* and intestinal parasites, whereas 15% (2/13) of females *F. peregrinus* were infected with *Haemoproteus*

*tinnunculi,* on the other hand, 66% (2/3)of males *F. peregrinus* harbourd intestinal parasites and showed eggs in their feces.

A male 100% (1/1) of the hybrid falcons was found to be infected with stregeid trematode and *Serratospiculum seurati* .

No ectoparasites were detected in imported falcons.

While the results of parasitological investigation of resident falcons showed that 12% (4/32) of female *F. cherrug* were infected with *Haemoproteus tinnunculi* , while 47% (15/32) of female *F. cherrug* harbourd intestinal parasites and showed eggs in their feces. A female *F. cherrug* 3% (1/32) was infected with an ecto-parasite (mite). With regards to *F. rusticolus* 33% (1/3) of females was infected with *Haemoproteus tinnunculi* . Neither intestinal parasites nor ectoparasites were recognised from resident *F. rusticolus.* Female *F. peregrinus* 20% (2/10) were founed to be infected with only intestinal parasites. Resident hybrid falcons showed no parasitic infection.

TABLE IV: NUMBER AND PERCENTAGE OF IMPORTED AND RESIDENT FALCONS WITH SINGLE OR MULTIPLE PARASITIC INFECTION.

| Hosts Species | Sex | No.exa. | IMPORTED SINGLE No.+ve | % | DOUBLE No.+ve | % | TRIPLE No.+ve | % | Hosts Sex | No.exa | RESIDENT SINGLE No.+ve | % | DOUBLE No.+ve | % | TRIPLE No.+ve | % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| F. cherrug | M | 3 | 0 | 0 | 0 | 0 | 1 | 33 | M | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| F. cherrug | F | 24 | 8 | 33 | 3 | 13 | 2 | 8 | F | 32 | 11 | 34 | 4 | 12 | 1 | 3 |
| F. cherrug | T | 27 | 8 | 23 | 3 | 9 | 3 | 9 | T | 34 | 11 | 32 | 4 | 12 | 1 | 3 |
| F. rusticolus | M | 0 | 0 | 0 | 0 | 0 | 0 | 0 | M | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| F. rusticolus | F | 1 | 0 | 0 | 1 | 100 | 0 | 0 | F | 3 | 1 | 33 | 0 | 0 | 0 | 0 |
| F. rusticolus | T | 1 | 0 | 0 | 1 | 100 | 0 | 0 | T | 3 | 1 | 33 | 0 | 0 | 0 | 0 |
| F. peregrinus | M | 3 | 1 | 33 | 1 | 33 | 0 | 0 | M | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| F. peregrinus | F | 13 | 5 | 38 | 2 | 15 | 1 | 8 | F | 10 | 1 | 10 | 1 | 10 | 0 | 0 |
| F. peregrinus | T | 16 | 6 | 37 | 3 | 19 | 1 | 6 | T | 12 | 1 | 8 | 1 | 8 | 0 | 0 |
| Hybrid | M | 1 | 0 | 0 | 1 | 100 | 0 | 0 | M | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Hybrid | F | 5 | 0 | 0 | 0 | 0 | 0 | 0 | F | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Hybrid | T | 6 | 0 | 0 | 1 | 20 | 0 | 0 | T | 1 | 0 | 0 | 0 | 0 | 0 | 0 |

Prevalence of parasitic infection in imported falcons showed that 33%(8/24) of female *F. cherrug* had a single parasitic infection (in which one falcon was infected with *Caryospora* sp., one with strigeid trematode, one with unidentified trematode, and five with *Serratospiculum seurati* ). While 13% (3/24) of female *F. cherrug* had double parasitic infection (that is to say, *Caryospora* sp. and *Serratospiculum seurati* ,strigeid trematode

and *Serratospiculum seurati, Spirurid* sp. and *Serratospiculum seurati* ).

and *Serratospiculum seurati, Spirurid* sp. and *Serratospiculum seurati*).

Triple infection was found in 33%(1/3) of male *F. cherrug* (*Haemoproteus tinnunculi*, *Leucocytozoon toddi*, and *Serratospiculum seurati),* and 8%(2/24) of female *F. cherrug* (*Haemoproteus tinnunculi*, strigeid trematode, and *Serratospiculum seurati.* Or strigeid trematode, unidentified trematode, and *Serratospiculum seurati*). One Female *F. rusticolus* was found to be infected with *Caryospora* sp. and *Serratospiculum seurati.* Whereas 33%(1/3) of male and 38%(5/13) of female *F. peregrinus* showed a single parasitic infection (one falcon was infected with *Haemoproteus tinnunculi*, three with strigeid trematode, and two with *Serratospiculum seurati*), 33%(1/3) male *F. peregrinus* showed double infection (*Caryospora* sp. and *Serratospiculum seurati*), and 15%(2/13) of female *F. peregrinus* had double parasitic infection (*Caryospora* sp. and *Serratospiculum seurati,* stregeid trematode and *Capillaria* sp.). However 8%(1/13) of female *F. peregrinus* was infected with *Caryospora* sp., *Haemoproteus tinnunculi*, and strigeid trematode).

On the other hand, prevalence of parasitic infection in resident falcons showed that 34% (11/32) of *F. cherrug* had a single parasitic infection (in which one falcon was infected with *Haemoproteus tinnunculi* ,one falcon with stregeid trematode, and nine falcons with *Serratospiculum seurati).* While 12% (4/32) of females *F. cherrug* had double parasitic infection (that is to say, *Caryospora* sp. and *Haemoproteus tinnunculi, Haemoproteus tinnunculi* and *Serratospiculum seurati,* strigeid trematode and *Serratospiculum seurati, Serratospiculum seurati,* and mite).

3% (1/32)of female *F. cherrug* showed triple infection (*H. tinnunculi,* stregeid trematode, *Serratospiculum seurati*). Females of *F. rusticolus* 33% (1/3) was found to be infected with *H. tinnunculi,* whereas 10% (1/10) of resident female *F. peregrinus* was found to be infected with *Caryospora* sp., on the other hand 10% (1/10) of female *F. peregrinus* harboured two parasites; *Spiruroid* sp. and *Serratospiculum seurati,* in contrast, non of the resident hybrid falcons studied was found to be infected.

TABLE V: PERCENTAGE OF IMPORTED AND RESIDENT FALCONS INFECTED WITH ONE OR MORE INTESTINAL PARASITES IN RELATION TO SPECIES AND SEX .

| Hosts Species | Sex | No.exa. | IMPORTED SINGLE No.+ve | % | DOUBLE No.+ve | % | TRIPLE No.+ve | % | Sex | No.exa. | RESIDENT SINGLE No.+ve | % | DOUBLE No.+ve | % | TRIPLE No.+ve | % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| F. cherrug | M | 3 | 1 | 33 | 0 | 0 | 0 | 0 | M | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| F. cherrug | F | 24 | 8 | 33 | 4 | 17 | 1 | 4 | F | 32 | 12 | 37 | 3 | 9 | 0 | 0 |
| F. cherrug | T | 27 | 9 | 33 | 4 | 15 | 1 | 4 | T | 34 | 12 | 35 | 3 | 9 | 0 | 0 |
| F. rusticolus | M | 0 | 0 | 0 | 0 | 0 | 0 | 0 | M | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| F. rusticolus | F | 1 | 1 | 100 | 0 | 0 | 0 | 0 | F | 3 | 0 | 0 | 0 | 0 | 0 | 0 |
| F. rusticolus | T | 1 | 1 | 100 | 0 | 0 | 0 | 0 | T | 3 | 0 | 0 | 0 | 0 | 0 | 0 |
| F. peregrinus | M | 3 | 1 | 33 | 1 | 33 | 0 | 0 | M | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| F. peregrinus | F | 13 | 4 | 31 | 3 | 23 | 0 | 0 | F | 10 | 1 | 10 | 1 | 10 | 0 | 0 |
| F. peregrinus | T | 16 | 5 | 31 | 4 | 25 | 0 | 0 | T | 12 | 1 | 8 | 1 | 8 | 0 | 0 |
| Hybrid | M | 1 | 0 | 0 | 1 | 100 | 0 | 0 | M | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Hybrid | F | 5 | 0 | 0 | 0 | 0 | 0 | 0 | F | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Hybrid | T | 6 | 0 | 0 | 1 | 17 | 0 | 0 | T | 1 | 0 | 0 | 0 | 0 | 0 | 0 |

Prevalence of intestinal parasitic infection in imported falcons showed that 33% (1/3) of male and 33% (8/24) of female *F. cherrug* had a single intestinal parasitic infection, in which 1 falcon was infected with *Caryospora* sp., 1 falcon with unidentified trematode, 1 falcon with stregeid trematode, and 6 falcons with *Serratospiculum seurati*, while 17% (4/24)of females *F . cherrug* had double intestinal parasitic infection (*Caryospora* sp. and *Serratospiculum seurati*, or stregeid trematode and *Serratospiculum seurati* , or *Spiruroid* sp. and *Serratospiculum seurati* ).

*Serratospiculum seurati* ).

Whereas 4% (1/24) of female *F. cherrug* showed a triple intestinal parasitic infection (unidentified trematode, stregeid trematode, and *Serratospiculum seurati* ).
With respect to *F. rusticolus* 100% (1/1) had a single parasitic infection (*Caryospora* sp.). 33%(1/3) of male and 31% (4/13) of female *F. peregrinus* showed a single parasitic infection (either stregeid trematode or *Serratospiculum seurati* ). Whereas 33% (1/3) of male and 23% (3/13) of female *F. peregrinus* had double intestinal parasitic infection (*Caryospora* sp. and stregeid trematode, or *Caryospora* sp. and *Serratospiculum seurati,* or *Capillaria* sp. and *Serratospiculum seurati* ).
100% (1/1) 0f male hybrid was found to be infected with stregeid trematode and *Serratospiculum seurati* .

While prevalence of intestinal parasitic infection in resident falcons showed that 37%(12/32) of female *F. cherrug* showed a single intestinal parasitic infection, in which 1 falcon was infected with *Caryospora* sp., 1 falcon was infected with strigeid trematode, and the remaining 11 falcons were infected with *Serratospiculum seurati,* while 9% (3/32) of female *F. cherrug* revealed double intstinal parasitic infection (strigeid trematode and *Serratospiculum seurati* ).
Among *F. peregrinus* 10% (1/10) of females revealed oocysts of *Caryospora* sp., whereas 10% (1/10) of females showed double intestinal parasitic infection (*Spirurid* sp. and *Serratospiculum seurati* ).
Non of resident *F. rusticolus* and hybrid were found to be infected with intestinal parasites. Non of the resident male falcons showed intestinal infections.

**TABLE VI: INFECTION RATES OF IMPORTED AND RESIDENT FALCONS WITH BLOODPARASITES IN RELATION TO SPECIES AND SEX.**

| Parasites Hosts Species | Sex | No.exa | IMPORTED Haemoproteus tinnunculi No.+ve | % | Leucocytozoon toddi No.+ve | % | Parasites Hosts SEX | No.exa. | RESIDENT Haemoproteus tinnunculi No.+ve | % | Leucocytozoon toddi No.+ve | % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| F. cherrug | M | 3 | 1 | 33 | 1 | 33 | M | 2 | 0 | 0 | 0 | 0 |
| F. cherrug | F | 24 | 1 | 4 | 0 | 0 | F | 32 | 4 | 12 | 0 | 0 |
| F. cherrug | T | 27 | 2 | 7 | 1 | 4 | T | 34 | 4 | 11 | 0 | 0 |
| F. rusticolus | M | 0 | 0 | 0 | 0 | 0 | M | 0 | 0 | 0 | 0 | 0 |
| F. rusticolus | F | 1 | 0 | 0 | 1 | 100 | F | 3 | 1 | 33 | 0 | 0 |
| F. rusticolus | T | 1 | 0 | 0 | 1 | 100 | T | 3 | 1 | 33 | 0 | 0 |
| F. peregrinus | M | 3 | 0 | 0 | 0 | 0 | M | 2 | 0 | 0 | 0 | 0 |
| F. peregrinus | F | 13 | 2 | 15 | 0 | 0 | F | 10 | 0 | 0 | 0 | 0 |
| F. peregrinus | T | 16 | 2 | 12 | 0 | 0 | T | 12 | 0 | 0 | 0 | 0 |
| Hybrid | M | 1 | 0 | 0 | 0 | 0 | M | 0 | 0 | 0 | 0 | 0 |
| Hybrid | F | 5 | 0 | 0 | 0 | 0 | F | 1 | 0 | 0 | 0 | 0 |
| Hybrid | T | 6 | 0 | 0 | 0 | 0 | T | 1 | 0 | 0 | 0 | 0 |

After examining the stained blood smears of the imprted falcons, males 33% (1/3) and females 4% (1/24) of *F. cherrug* were found to be infected with *Haemoproteus tinnuncoli* , while a male *F. cherrug* w as infected with leu*cocytozoon toddi*. Female *F. rusticolus* was infected with *leucocytozoon toddi*. 15% (2/13) of female *F. peregrinus* were found to be infected with *Haemoproteus tinnuncoli*. With respect to resident falcons, 12% (4/32) of female *F. cherrug* were infected with *Haemoproteus tinnuncoli*. Whereas 3% (1/3) female *F. rusticolus* was infected with *Haemoproteus tinnuncoli*.

## TABLE VII: INFECTION RATES (%) OF IMPORTED FALCONS INFECTED WITH DIFFERENT INTESTINAL PARASITES IN RELATION TO SPECIES AND SEX.

| Hosts Species | Sex | No.exa | Caryospora sp. No.+ve | % | Unidentified trematode No.+ve | % | Stregeid trematode No.+ve | % | Capillaria sp. No.+ve | % | Spiruroid sp. No.+ve | % | Serratospiculum seurati No.+ve | % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *F. cherrug* | M | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 33 |
| | F | 24 | 1 | 4 | 2 | 8 | 4 | 17 | 0 | 0 | 1 | 4 | 10 | 42 |
| | T | 27 | 1 | 4 | 2 | 7 | 4 | 15 | 0 | 0 | 1 | 4 | 11 | 41 |
| *F. rusticolus* | M | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | F | 1 | 1 | 100 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | T | 1 | 1 | 100 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *F. peregrinus* | M | 3 | 0 | 0 | 0 | 0 | 1 | 33 | 0 | 0 | 0 | 0 | 1 | 33 |
| | F | 13 | 2 | 15 | 0 | 0 | 4 | 31 | 1 | 8 | 0 | 0 | 3 | 23 |
| | T | 16 | 2 | 12 | 0 | 0 | 5 | 31 | 1 | 6 | 0 | 0 | 4 | 25 |
| Hybrid | M | 1 | 0 | 0 | 0 | 0 | 1 | 100 | 0 | 0 | 0 | 0 | 1 | 100 |
| | F | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | T | 6 | 0 | 0 | 0 | 0 | 1 | 16 | 0 | 0 | 0 | 0 | 0 | 0 |

After examining the fecal materials of imported falcons, females of *F. cherrug* 8% (2/24) showed infection with unidentified trematode eggs, also females of *F. cherrug* 17% (4/24) were infected with stregeid trematode. *Spiruriod* sp. were recognized in feces of 4% (1/24) of female F. cherrug The prevalence of *Serratospiculum seurati*. among males of *F. cherrug* was 33% (1/3), whereas among females of *F. cherrug* was 42% (10/24). *Caryospora* sp. oocysts were observed in 4% (1/24) of female *F.cherrug* . Females of *F.rusticolus* 100% (1/1) was found to be infected with *Caryospora* sp. .

With respect of *F. peregrinus* 33% (1/3) of males and 15% (2/13) of females F. peregrinus showed Caryospora sp. oocysts in feces. 31% (4/13) of females were infected with stregeid trematode, while 8% (1/13) of females was found to be infected with *Capillaria* sp., whereas *Serratospiculum seurati.* eggs were found in fecal materials of 33% (1/3) of males, and 23% (3/13) of female peregrines. Regard hybrid falcons 100% (1/1) of male hybrid studied was found to be infected with stregeid trematode and *Serratospiculum seurati.*

**TABLE VIII: INFECTION RATES (%) OF RESIDENT FEMALE FALCONS INFECTED WITH DIFFERENT INTESTINAL PARASITES**

| Parasites / Hosts Species | Sex | No.exa. | Caryospora sp. No.+ve | % | Stregeid trematode No.+ve | % | Capillaria sp. No.+ve | % | Spiruroid sp. No.+ve | % | Serratospiculum seurati No.+ve | % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| F. cherrug | M | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| F. cherrug | F | 32 | 2 | 6 | 3 | 9 | 0 | 0 | 0 | 0 | 13 | 41 |
| F. cherrug | T | 34 | 2 | 6 | 3 | 9 | 0 | 0 | 0 | 0 | 13 | 38 |
| F. rusticolus | M | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| F. rusticolus | F | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| F. rusticolus | T | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| F. peregrinus | M | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| F. peregrinus | F | 10 | 1 | 10 | 0 | 0 | 0 | 0 | 1 | 10 | 2 | 20 |
| F. peregrinus | T | 12 | 1 | 8 | 0 | 0 | 0 | 0 | 1 | 8 | 2 | 16 |
| Hybrid | M | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Hybrid | F | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Hybrid | T | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Results of parasitic investigation of resident falcons revealed that 6% ( 2/32 ) of female *F. chrrug* passed *Caryospora* sp. oocysts in thir feaces and 9% (3/32) of female F. *cherrug* were found to be infected with strigeid trematode, while 41% (13/32) of female *F. cherrug* were infected with *Serratospiculum seurati* . With respect to *F. peregrinus* 20% (2/10) of females were found to be infected with *Serratospiclum seurati* , whereas *Spirurid* sp. eggs were identified in fecal materials of 10% (1/10) of females and *Caryospora* sp oocysts were found in fecal materials of 10% (1/10) of females *F. peregrinus*. Non of the resident *F. rusticolus* or hybrid showed any intestinal parasitic infection. Although, both males and females live

under same conditions, non of the resident male falcons showed any intestinal parasitic infection. Therefore we can say that male falcons appear to be  more resistent to parasites than females, but statistically there  was no significant relationship between coccidiosis and sex.

TABLE IX: SIZE ESTIMATES (IN um) OF PROTOZOAN CYSTS AND HELMINTHIC OVA USING MICROMETRY.

| parasite | Mean $ | Median | Stand. dev.* | Minimum | Maximum |
|---|---|---|---|---|---|
| | Length X Width | Length X Width | Length X Width | Length X Width | Length X Width |
| *Caryospora* sp. type: A | 47.20 X 41.95 | 46.0 X 42.0 | 7.09 X 6.45 | 35.0 X 30.0 | 57.0 X 50.0 |
| *Caryospora* sp. type: B | 22.40 X 19.65 | 25.0 X 25.0 | 5.34 X 7.25 | 17.0 X 12.0 | 30.0 X 30.0 |
| *Haemoproteus tinnunculi* | 15.53 X 10.33 | 16.0 X 11.0 | 1.76 X1.36 | 12.0 X 7.0 | 17.0 X 12.0 |
| *Leucocytozoon toddi* | 16.67 X 9.50 | 17.0 X 9.0 | 0.52 X 0.55 | 16.0 X 9.0 | 17.0 X 10 .0 |
| Strigeid trematod | 106.0 X 68.0 | 107.0 X 70.0 | 7.69 X 7.13 | 90.0 X 57.0 | 120.0 X 85.0 |
| Unidentified trematode I ! | 85.0 X 50.85 | 85.0 X 50.5 | 3.82 X 0.93 | 80.0 X 50.0 | 90.0 X 52.0 |
| Unidentified trematode II ! | 38.90 X 26.05 | 38.5 X 26.5 | 2.07 X 0.99 | 37.0 X 25.0 | 42.0 X 27.0 |
| *Capillaria* sp.          ! | 65.75 X 31.35 | 66.0 X 32.0 | 2.84 X 0.74 | 62.0 X 31.0 | 70.0 X 32.0 |
| *Spirurid* sp.   I       ! | 37.68 X 26.06 | 37.5 X 25.0 | 0.53 X 1.82 | 37.0 X 25.0 | 38.5 X 30.0 |
| *Spirurid* sp.   II      ! | 32.57 X 24.43 | 30.0 X 25.0 | 3.26 X 1.72 | 30.0 X 22.0 | 37.0 X 26.0 |
| *Serratospiculum seurati* | 52.65 X 36.48 | 5.0 X 37.0 | 3.81 X 2.68 | 41.5 X 30.0 | 55.5 X 45.0 |

\* Stand. dev: Standard deviation.

$ Numbers counted=20

! Numbers counted=8

## 3.1. *Caryospora* sp.

Two types of thick-walled oocysts, with a single sporocyst containing eight sporozoites and residual body were found on fecal examination during the present study

Based on size, these were:     Type A: 35 - 55µm X 30- 50µm;

Type B: 17 - 30µm X 12- 30µm  (Table IX)

Type (A) was obtained from 4% (1/24) of imported immature female Saker falcons *F. cherrug*, 100% (1/1) of imported immature female Gyrfalcon *F. rusticolus*, 3% (1/32) of resident adult female Saker falcon, and 10% (1/10) of resident adult female Peregrine falcon *F. peregrinus*. (Tables VII and VIII)

Type (B) was found in feces of 15% (2/13) of immature female Peregrines *F. peregrinus*. The sporulation period for type (B) was found to be 72 hrs (Figure 32, Tables VII and VIII).



Figure 32: *Caryospora* sp. oocyst, 22 µm X 19 µm.

The infection density for both types were ranging between slight to heavy infection. These coccidian oocysts were identified to belong to *Caryospora* sp. of Family: Eimeriidae, Order: Eucoccidiida.

Species of *Caryospora* have uniquely facultatively heteroxenous life cycles in which merogony and gametogony are completed in (1) the intestinal epithelium of primary hosts (predatory reptiles and birds) and (2) dermal connective tissues, liver and other tissues of secondary hosts (rodents) (Upton et al. 1986). Also sporogony is completed in rodents (Cawthorn, 1993).

Kudo (1966) described two species of *Caryospora*: *C. simplex* (from the gut-epithelium of *Vipera aspis*) the oocyst contains a single spore with eight sporozoites and a residual mass, thick-walled, 10 - 15 μm in diameter, *C. hermae* (from the gut of the sand snake *Psammophis sibilans philipsi*) the oocyst develop into a single spore with eight sporozoites and a residual body, and colorless oocyst wall, with measurement of 21 - 24 μm by 20 - 24 μm.

Oocysts with size of 9.6 - 16.8 μm X 6.6 - 15.2 μm were identified as belonging to *Caryospora bubonis* in the great horned owl *Bubo virginianus* (Cawthorn and Stockdale, 1982).

The prevalence of *Caryospora* sp. in UAE. in the present study was found to be 8% (4/50) among the imported falcons, and 6% (3/50) among the resident falcons (with an overall prevalence rate of 7% (7/100).

The parasitc investigation during the present study showed that all coccidian infections were among female falcons, in either imported or resident falcons.

Although different species of *Caryospora* sp. were reported from Budapest (Pellerdy, 1965) and Saskatchewan, in Canada (Cawthorn and Stockdale, 1982), but no prevalence was given

*Caryospora* sp. like some of the coccidia seems to be a spurious parasite (Keymer, 1972), and Pellerdy (1965) did not provide evidence of pathogenicity among the Falconiformes, which were infected with *Caryospora* sp. Cawthorn and Stockdale (1982) again, emphasized that no clinical illness was seen in the owls infected with *C. bubonis* experimentally and no gross or microscopic lesions were seen at necropsy, so that they considered *C. bubonis* as not pathogenic or at least not pathogenic in the numbers that they administered. In contrast, the death of sea turtles due to *C. chelonia* was reported by Leibovitz et al. (1978). None of our infected birds had clinical symptoms of disease.

## 3.2 *Haemoproteus tinnunculi*

Stained blood smears containing hypertrophied host cells (erythrocytes) with C-shaped intracellular parasites with light violet cytoplasm, with small, brown to dark-brown pigmented granules (14 - 30 granules), were encountered in blood films of 33% (1/3) of imported males and 4% (1/24) of imported females *F. cherrug*, 15% (2/13) of imported females *F. peregrinus*, 12% (4/32) of resident females *F. cherrug*, and 100% (1/1) of resident female *F. rusticolus* (Tables VI) Slides sent to M. A. Peirce, International Consultancy 16 Westmoreland, Woosehill, Wokingham, Berkshire RG41 3HZ, were identified as *Haemoproteus tinnunculi* (Figure 33).
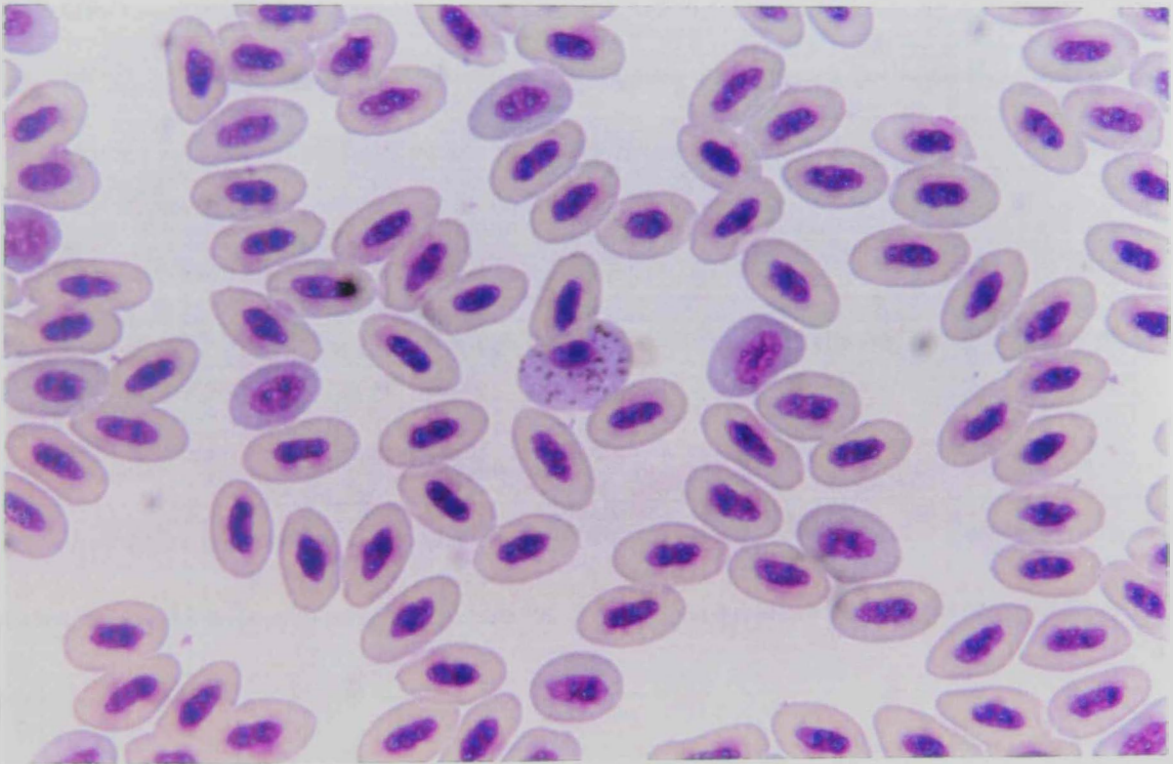


Figure 33: *Haemoproteus tinnuncoli* gametocyte, 15 μm X 10 μm.

Following the technique described by Godfrey (1987), the intensity of the infection was 0.13 % - 0.65% (percentage of blood cells infected per 2000 normal cells).

Protozoa of the Genus *Haemoproteus* are primarily parasites of birds and reptiles and have their sexual phases in insects other than mosquitoes (Schmidt and Roberts, 1989).The principal vectors are Ceratopogonids (Diptera), and only two species of *Haemoproteus* are known to be transmitted by hippoboscids. Certain host families such as Anatidae, Columbidae and Phasianidae seem more susceptible to infection than others such as Charadriidae, Scolopacidae and Laridae (Atkinson and Van Riper III, 1991) Exoerythrocytic schizogony occurs in endothelial cells, the merozoites produced enter erythrocytes to become pigmented gametocytes in the circulating blood (Schmidt and Roberts, 1989).

The prevalence of *Haemoproteus tinnunculi* among the imported falcons was found to be 8% (4/50), whereas among the resident falcons was 10% (5/50), i.e. an overall prevalence of 9% (9/100). Statistically, there was no significant relationship between the infection with *Haemoproteus tinnunculi* and sex or specie or residence status.

*Haemoproteus* sp was reported in raptors in England, with prevalence of 31% (21/66) by Cooper et al (1993) which is much higher than its prevalence in the present study in the UAE.

*Haemoproteus tinnunculi* was previously reported from UAE by Peirce (1983), with prevalence of 33% (4/12) among *F. cherrug* from Al Ain Zoo. These birds had recently been imported or were caught in the wild.

The difference between the two prevalence rates from UAE (33% in 1983, and 9% in the present study) reflects the improved health care received by these birds in UAE, like routine check up, and reduced exposure to biting insects.

Although *Haemoproteus* sp. are considered as pathogens to their natural hosts, so far their pathogenesis is not fully understood (Atkinson and Van Riper III; 1991, Herman, 1968; Remple, 1981)

The pathogenesis in pigeons is slight, and infected birds usually show no signs of disease Exceptionally, birds appear restless and lose their appetite. The air spaces of the lung may become congested, and some anaemia may result from loss of functioning erythrocytes. The spleen and liver may be enlarged and dark with pigment (Schmidt and Roberts, 1989).

## 3.3. *Leucocytozoon toddi*

Stained blood smears containing hypertrophied leukocytes with Y-shaped parasite, without pigment or granules of 33% (1/3) of imported immature male Saker falcon *F. cherrug*, and of an imported immature female Gyrfalcon *F. rusticolus* were sent to Dr M A Peirce, MP International Consultancy, 16 Westmorland, Woosehill, Wokingham. Berkshire RG41 3HZ, who identified these parasites as *Leucocytozoon toddi* (Figure 34, Table VI)
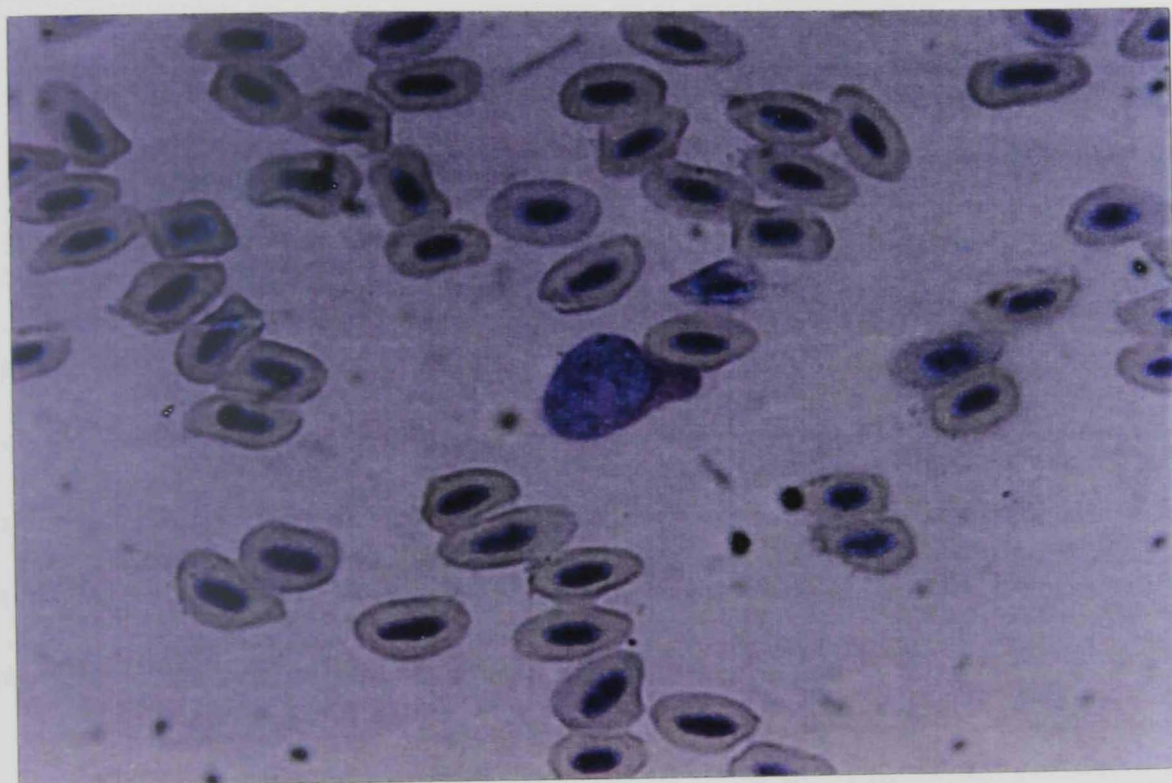


Figure 34 *Leucocytozoon toddi* gametocyte, 16 μm X 9 μm

Godfrey s (1987) technique was followed to determine the intensity of the parasitemia, which was too low 0 0005% (only one parasitized leukocyte per 2000 non-infected cells) Greiner and Kocan (1977), Peirce and Cooper (1977) reported that only one species *L. toddi* occurs in Falconiformes in fixed tissues Gametogony is in both leukocytes and immature

erythrocytes of the vertebrate, and sporogony occurs in insects other than mosquitoes. Pigment is absent from all phases of the life cycles. The Genus *Leucocytozoon* contains about 60 species in various birds

The prevalence of leukocytozoonosis among studied imported birds was 4% (2/50), but none of studied resident falcons was infected by *Leucocytozoon*. The overall prevalence of leukocytozoonosis was thus only 2% (2/100) Statistically, there was no significant relationship between the infection with *Leucocytozoon toddi* and sex or species or residence status.

This prevalence is neglegible compared with the prevalence reported by Cooper et al. (1993) of 41% (27/66) of blood smears prepared from different raptors, infected with *Leucocytozoon* sp. in Palastine.

Species of *Leucocytozoon,* are the most important blood protozoa of birds, since they are pathogenic in both domestic and wild birds (Schmidt and Roberts, 1989). In temperate regions, *Leucocytozoon* prevalence is highest in May, June and July (Borg, 1953; Bennett and Fallis, 1960). Herman (1968) and Schmidt and Roberts (1989) pointed that in case of *L. simondi* older geese and ducks are more resistant than younger ones, and the disease runs a slower course in them, but they still may succumb.

Prominent anaemia, elevated numbers of leukocytes, liver enlargement and necrosis, spleen increasing to as much as twenty times the normal size, are signs of leukocytozoonosis caused by *L. simondi* which probably kills the bird by destroying vital tissues, such as brain and heart (Schmidt and Roberts, 1989).

## 3.4. Strigeid trematode

Large, ovoid, single-operculated, brown thin-walled (with a knob), relatively homogenous ova measuring 100 - 120 μm X 57.5 - 85 μm (Table IX), were found in the feces of 17% (4/24) of female imported Saker falcon *F. cherrug*, 33% (1/3) and 31% (4/13) of female imported Peregrines *F. peregrinus*, and 100% (1/1) of male imported hybrid. While among resident falcons, 10% (3/32) of female *F. cherrug* showed these ova in their feces (Figure 35, Table VII and VIII)



Figure 35: Strigeid trematode ovum, 106 μm X 68 μm

These trematode ova were identified as belonging to Superfamily:Strigeoidea, Order: Strigeata.

Ward (1986) identified typical large, single-operculated, relatively homogenous, thin-walled ova, with dimensions of 60 X 100 μm, as strigeid trematode, and suggested that these trematodes are frequently found in the intestine of many species of falcons.

Smith (1993) showed an illustration of a similarly large, single-operculate ovum approximately 110 X 70 μm in size, and identified it as a diplostomatid strigeid trematode generally found in the duodenum.

The prevalence of the Strigeid trematode among the imported falcons was 20% (10/50) 70% (7/10) of which showed multiple infection while 6% (3/50) of the resident falcons passed trematode eggs in their feces with 67% (2/3) showing multiple infection. The overall prevalence was thus 13% (13/100). These trematodes were shown to be the second most common parasite of the falcons in UAE. The infection density was ranging between slight to moderate. Statistically, there was no significant relationship between the infection with strigeid trematode and sex or species or residence status.

Over a period of 5 years, Ward and Fairchild (1972) sampled 73 Falconiformes of 5 different species from Maryland, USA. Trematode eggs in feces were found in 7% (2/3) of adult *F. peregrinus*, 16% (3/19) of immature captive Peregrine, 25% (1/4) of adult captive Lanner *F. biarmicus*, 100% (2/2) of immature captive Indian Merlin *F. chicquera*, and 100% (1/1) immature captive Kestrel *F. sparverius*. The overall prevalence was 12% (9/73), which is very similar to the 10% prevalence rate in resident falcons in UAE. On the other hand cosiderably higher prevalence in Wyoming, USA was reported by Croft and Kingston (1975)

very similar to the 10% prevalence rate in resident falcons in UAE. On the other hand cosiderably higher prevalence in Wyoming, USA was reported by Croft and Kingston (1975) among prairie falcons (60% (3/50)), and from Ohio, USA by Smith (1993) who found 32% (37/115) of Falconiformes to be infected with strigeid trematode. The latter auther also noted that the trematodes were the second most prevalent group of helminthes of the Falconiformes in Ohio, USA.

Ward (1986) considered the infection of birds with flukes as a mild infection, and Smith (1993) also observed that trematode parasites are seldom considered pathogenic, even in large numbers On the other hand, Dedric (1965) described a fatal syndrome characterized by poor condition and diarrhea associated with trematode infection in a prairie falcon. Smith (1978) had earliar reported emaciation and death of a bald eagle due to a massive trematode infection, and Greenwood et al. (1984) attributed the death of a Saker falcon *F. cherrug* to a severe intestinal trematodiasis.

## 3.5. Unidentified trematode

Two other trematode eggs were seen during the fecal examination The first one was seen in feces of imported immature female Saker falcon *F. cherrug*, and characterized by being asymmetrical, large, brown, thick-walled, with distinct protuberance at one end, and measuring 80 - 90 X 50 - 52 μm (Figure 36, Tables VII, VIII and IX) The infection density was light, and showed multiple infection



Figure 36 Unidentified trematode ovum (type I), 85 μm X 50 μm

The second type also was detected in feces of imported immature female Saker falcon *F. cherrug*, and characterized by being small ovoid, brown, thin-shelled with distinct

protuberance at one end, dimension of 37 - 42 X 25 - 27 μm (Figure 37, Table$_S$ VII, VIII and IX), the infection den$^S$ity wa$^S$ heavy
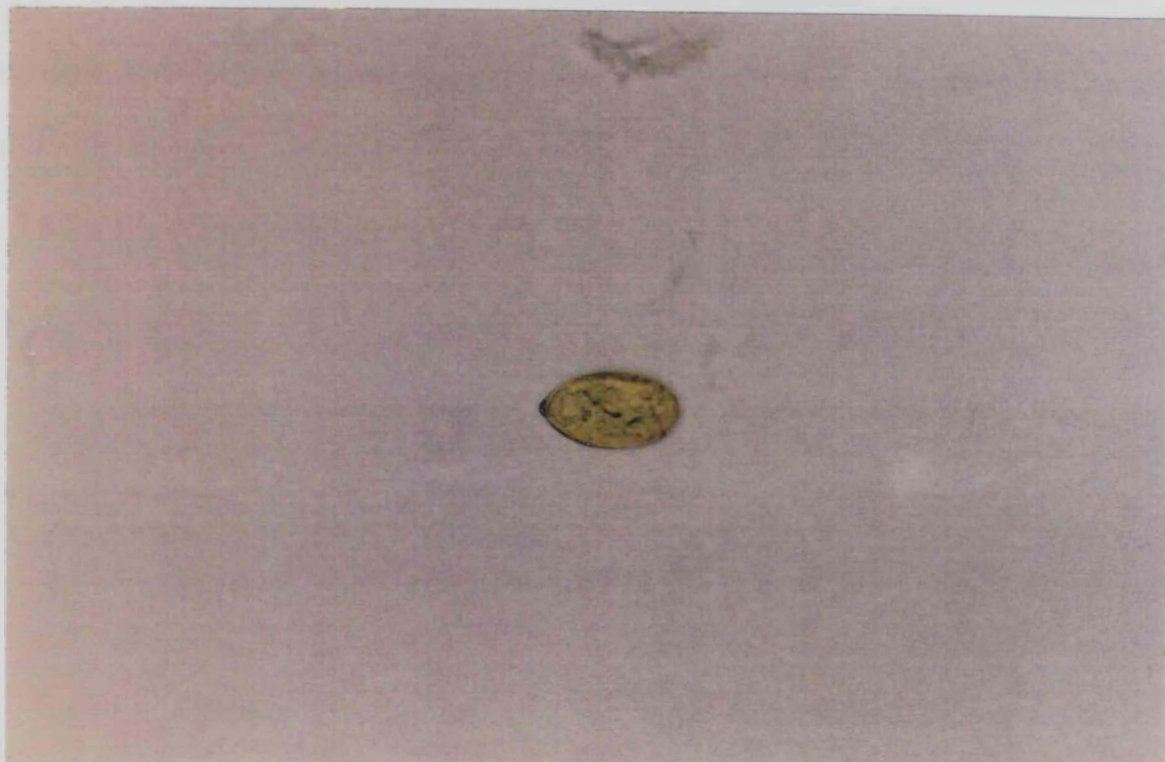


Figure 37· Unidentified trematode ovum (type II), 38 μm X 26 μm

The latter type varies slightly from the description of another unidentified fluke ovum described by Ward (1986) as a small, oval, brown, thick-shelled ovum, and usually with a distinct protuberance at one end and dimensions of 15 - 30 μm

## 3.6. *Capillaria* sp.

Lemon-shaped, thick-walled, ova with distinctive bipolar plugs, measuring 62 - 70 μm X 31 - 33 μm, were detected in the feces of 8% (1/13) of imported immature female *F. peregrinus* with light infection density. Thus, only 2% (1/50)  of imported falcons or 1% (1/100) of all falcons (imported and resident) in UAE showed these ova in feces] (see figure 38, Tables VII, VIII and IX).



Figure 38: *Capillaria* sp. ovum, 65 μm X 31 μm.

These eggs were identified according to their size and shape as belonging to *Capillaria* sp. of the Order: Trichurata, Family: Capillariidae.

In birds of prey, some species of *Capillaria* are known to infect the tongue and pharynx and the other species infect the crop, small intestine, and cecum (Cooper, 1969; Smith, 1993; Trainer et al., 1968; Ward, 1986).

Ward (1986) described the eggs of the *Capillaria* sp. as lemon-like eggs. And Schmidt and Roberts (1989) considered eggs, with distinctive bipolar plugs with measurement of 51 - 67 μm X 30 - 35 μm, and with deep pits in the shall as belonging to *Capillaria philippinensis*.

An illustration was given by Smith (1993) of a lemon-shaped, double-plugged egg measuring 70 X 30 μm identified as *Capillaria* sp.

As mentioned above, the prevalence of *Capillaria* sp. in falcons of UAE was 1% (1/100) overall or 2% (1/50) among imported falcons, and none among the resident falcons. This very low prevalence is close to the 4% (3/73) prevalence of capillariasis in Maryland, USA reported by Ward and Fairchild (1972).

However, considerably higher rate of prevalence of *Capillaria* sp., were reported among Gyrfalcons *F. rusticolus* (36% (13/36)) in Iceland (Clausen and Gudmundsson, 1981),and among Falconiformes(41% (47/115) in Ohio, USA (Smith, 1993).

Esophageal capillariasis maybe readily mistaken for trichomoniasis (Trainer et al., 1968). When *Capillaria contorta* presents in large numbers in wild birds it can cause considerable inflammation and diphtheriatic membrane production, but no records have been found of its pathogenicity in this site in captive birds of prey (Cooper 1969). In intestinal

considerable inflammation and diphtheriatic membrane production, but no records have been found of its pathogenicity in this site in captive birds of prey (Cooper 1969). In intestinal capillariasis signs of anorexia, emaciation, vomiting, weight loss, bloody diarrhea, and severe anaemia often lead to death (Trainer et al., 1968; Ward, 1986). Therefore, Keymer (1972) depending on the experience of Woodford (1960), and Cooper (1969) considered *Capillaria* sp. as the most pathogenic of nematodes.

Trainer et al. (1968) Considered capillariasis as a major mortality factor in wild and captive birds of prey.

## 3.7. *Spirurid sp.*

Two types of embryonated, small sized, thick-shelled, symmetrical ovoid ova were obtained during the present study. The first type was with measurements of 37 - 38.5 X 25 - 30 μm and was found in the feces of 4% (1/24) of the imported immature female Saker falcon *F. cherrug* (Figure 39, Tables VII, VIII and IX).



Figure 39. *Spirurid* sp. ovum (type I), 37 μm X 26 μm.

The second type measured 30 - 37 X 22 - 26 μm, and was detected from 10% (1/10) of the resident adult female Peregrine (Figure 40, Tables VII, VIII and IX).

Figure 40: *Spirurid* sp. ovum (type II), 32 μm X 24 μm.

The infection density in both cases was moderate, and both revealed multiple infection.
These two nematode ova were identified according to their size and shape to belong to
the family: Spiruridae, Order: Spirurata.

*Spirurid*s "stomach worms" occur in the lumen and submucosa of the proventriculus
and ventriculus of raptors. The adult female worm resides in the glands of the proventriculus
(Smith , 1993).

Ward and Fairchild (1972) found embryonated ova, slightly smaller than ova of
*Serratospiculum* sp. with dimension of 45 X 30 μm in one immature prairie falcon. This bird

was later necropsied and several *Spirurid*s collected from the proventriculus were identified as *Hartertia* sp.

Smith (1993) showed an illustration of a small, thin-shelled, larvated ovum, with approximate size of 55 X 25 μm, and identified it as a *Spirurid* ovum.

Prevalence of *Spirurid* in the falcons in UAE generally (imported and resident falcons) was found to be 2% (2/100).

Although this prevalence is slightly higher than the prevalence of *Spirurid* in Maryland which was found to be 1.3% (1 of a total 73 falcons were studied during 5 years by Ward and Fairchild, 1972). But still much lower than the 20% prevalence of *Spirurid*s reported by Croft and Kingston (1975) in Wyoming, USA. and 14% found by Smith (1993) in Ohio, USA.

Johnston and Mawson (1941) reported a *Spirurid* nematode *Habronema* sp. from Kestrels in Australia

So far, no pathological signs or death caused by *Spirurid* has been reported, Smith (1993) found adult females in the glands of the proventriculus, apparently causing little or no inflammatory reaction

## 3.8. *Serratospiculum seurati.*

Embryonated, medium sized ova 47 - 55 X 30 - 37 μm were found in feces of 33% (1/3) of imported male, 42% (10/24) of imported females and 31% (10/32) of resident females *F. cherrug* (**This finding is reported for the first time in the literature**) These ova were detected also in the feces of 33% (1/3) of imported male, 23% (3/13) of imported females, 10% (1/10) of resident female *F. peregrinus*, and 100% (1/1) of imported male hybrid (Figure 41, Tables VII, VII and IX) The infection density was ranging from light (+) to heavy infection (+ + +)
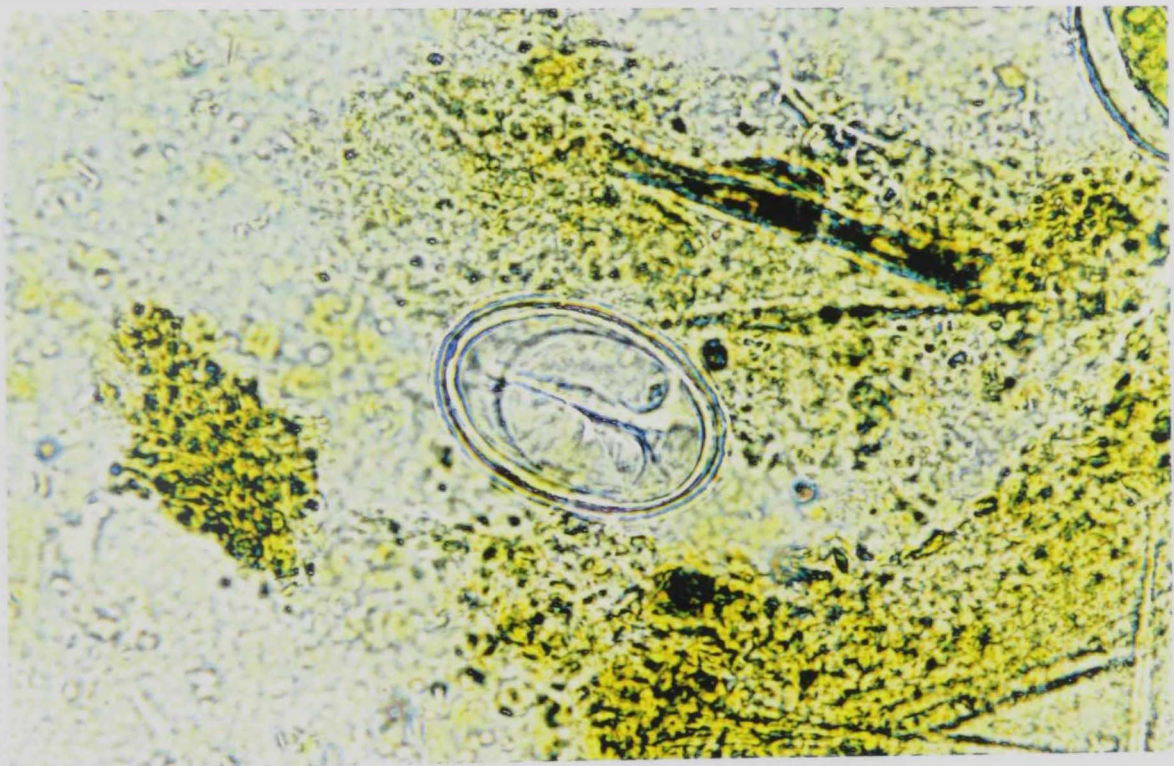


Figure 41: *Serratospiculum seuroti* ovum, 52 μm X 36 μm

These nematodes ova were identified according to their size and shape as belonging to *Serratospiculum* sp of the Superfamily Filarioidea, Subfamily Dicheilonemtinae (Wehr,

1938) Furthermore, an adult worm was sent to Dr. Lynda Gibbons, International Institute of Parasitology. 395A Hatfield Road, St Albans, Herts AL4 OXU, United Kingdom, and was identified as *Serratospiculum seuroti*

*Serratospiculum seuroti* are known to inhabit the connective tissues of the thoracic and abdominal air sacs of several falcons

The species *Serratospiculum amaculata* was described by Wehr from *F. mexicanus* and *F. peregrinus* in Montana, North Dakota and California, USA (Wehr, 1938) Wehr described the eggs of *S. amaculata* to be 54 μm. long by 29 μm wide with thick shells and containing embryos at time of deposition Typical embryonated ova are also used to diagnose serratospiculasis and measurements appear to be valuable in differentiating *Serratospiculum* ova from those of *Spirurid* parasites of the gastrointestinal tract which also have thicker egg shells than *Serratospiculum* ova. Ward and Fairchild (1972) reported the infection of the thoracic air sacs of the prairie falcon *F. mexicanus* and Peregrine *F. peregrinus tundrius* with *Serratospiculum* sp. and reported ova with measurements of 52 X 30 μm; 51 X 34 μm; 54 X 35 μm, which also falls within the range given by Bigland et al. (1964) who reported the prevalence of *S. amaculata* in *F. mexicanus* and gave the measurement of 45 - 57 μm. X 30 - 35 μm

Ward (1986) described thin-shelled embryonated ova 30 X 50 μm which were found very frequently in the feces of prairie falcons *F. mexicanus* and occasionally in Peregrines *F. peregrinus* and Gyrfalcons *F. rusticolus*, and identified them as ova of *Serratospiculum amaculata.*

*Serratospiculum seuroti* is the most common parasite among the falcons in the UAE: 32% (16/50) of the imported falcons, and 22% (11/50) of resident falcons were found to be

infected with *Serratospiculum seuroti*, with an overall prevalence of 27% (27/100). This is significantly higher prevalence rate than the 14% (1/71) rate in wild *F. mexicanus* in Ohio, USA reported by Smith (1993). Statistically, there was no significant relationship between the infection with *Serratospiculum seuroti* and sex or species or residence status

*Serratospiculum* sp. in Wyoming, USA was found to be 80% (4/5) among adult *F. mexicanus* (Croft and Kingston, 1975).

Based on the accounts given by Bigland et al. (1964); Cooper (1969) and Ward and Fairchild (1972), serratospiculosis is probably not an innocuous infection, but later Ward (1986) and Smith (1993) concluded that serratospiculosis is often an innocuous disease when the parasites are in low numbers; but heavy infections can cause illness, characterized by the presence of a yellow plaque-like lesions (about 5 mm in diameter) in the mouth and/or pharynx and/or proventriculus (Ward and Fairchild, 1972), and respiratory difficulty, vomiting and death (Ward, 1986). The respiratory difficulty due to inflammation and thickening of the air sacs, may be accompanied by clinical signs of emaciation due to inflammation of the gastrointestinal tract (Ward and Fairchild, 1972; Smith, 1993).

In accordance to table III and table IV, 52%( 26/ 50) of imported falcons were found to be infected, whereas 38%(19/50) of resident falcons were found to be infected, that may due to the fact that most of the falconers in the UAE. feed their falcons with frozen (for a period of 10 to 14 days) meats (mostly birds), instead of fresh meats which probably contain active parasites In contrast, imported (wild) falcons used to hunt and eat the prey (often infected) at the same time.

Statistically, Fisher Exact Test (two - tailed), showed no significant difference between imported and resident falcons from epizootiological point of view. On the other hand, in

accordance to table III, 10%(10/100) the falcons (imported and resident) were infected with bloodparasites, while 42%(42/100) of the same falcons (imported and resident) were found to be infected with intestinal parasites. Statistically, that means that Relative Risk (R. R.) of the intestinal parasites in the falcons is 2.06 times more than the relative risk of the bloodparasites (with 95% confidence).

# 3.9. Mite

A resident adult female saker falcon *F. cherrug* was found to be infested with small arthropods.

These arthropods were identified according to their size, shape, and peresent or absent of some taxonomic features as belonging to mites; the suborder: Mesostigmata, order: Acarina, class: Arachinda (Borror, et al. 1989; Schmidt and Roberts, 1989).

The majority of suborder: Mesostigmata, are free-living and predaceous and are usually the dominant mites in leaf litter, humus and soil. The parasitic measostigmatid mites attack insects, snakes, birds, bats, small mammals, and rarely humans (Borror, et al, 1989), and parasites on or in the skin or in the respiratory system or other organ of their hosts (Schmidt and Roberts, 1989).

The overall prevalence of mites infestation among falcons in UAE were found to be 1% (1/100), in which only one resident female saker falcon was infested by mites.

With respect to imported falcons, no mites and subsequently any other ectoparastes were recorded. This result was accepted, due to the fact that the buyers (falconers) are going to refuse any falcon infested with any noteable ectoparasites, which leads the salers (or importer) to use insecticide spray, keeping their falcons in healthy and free of ectoparasites aspect.

At the same time, the prevalence of ectoparasites among resident falcons should be as what obtained in the present study or less, because they undergo an intensive health care, and

most of the ectoparasites (except some mites) are macroscopic, therefore it is easy to be detected, and thereby treated.

Different genera of mites were reported by Strandtmann (1962) and Cooper (1972) from Newent, England, but no prevalence was given.

Mites, in addition to their parasitism nature, they were known as vectors for other infectious agents, viruses, bacteria,...etc.

Mites, due to the small size of their mouthparts, most feed on lymph or other secretions rather than on blood. Some mites, although not actually parasites of vetebrates, stimulate allergic reactions when they or their remains come into contact with susceptible individual (Schmidt and Roberts, 1989).

# CHAPTER IV

# Conclusions and recommendations

## 4.1. Conclusions

The present study suggests that falconers in the UAE prefer Saker falcons *F. cherrug* to other birds of prey for their quietness, strength, suitable size, and for their ability to learn and adapt to changeable climate and circumstances of the desert.

Falcons, like any other creature, are exposed to a large variety of parasites, which cause asymptomatic infections, or diseases which vary from mild to severe illness and death.

Two blood parasites were found, *Haemoproteus tinnunculi* with overall prevalence of 9%(9/100), and *Leucocytozoon toddi* with overall prevalence of 2%(2/100).

Also, examination of fecal materials of falcons showed that the most common intestinal parasite was found to be *Serratospiculum seuroti* with overall prevalence of 27%(27/100), then strigeid trematode with overall prevalence of 13%(13/100), followed by *Caryospora* sp. with overall prevalence of 6%(6/100), then unidentified trematode and *Spirurid* sp., each with overall prevalence of 2%(2/100), *Capillaria* sp. with overall prevalence of 1%(1/100), was found to be the most rare intestinal parasite in falcons. With respect to ecto-parasites, only one falcon was found to be infested by mites.

Results of the current study showed that the imported falcons have higher parasitic infection rates than the resident falcons which live under special health care.

Since, 52%(26/50) of imported falcons were found to be infected, while 38%(19/50) of resident falcons were found to be infected. Although, depending on these figures, the imported falcons could be then considered one of the sources of spread of parasitic infection, Fisher Exact Test, showed no significant difference between imported and resident falcons.

The relative risk of intestinal parasites among the falcons in UAE was found to be 2.06 times more than the risk of bloodparasites.

Because of the different modes of infection depending on the different sources of infection (food, water, arthropod vectors), the first step toward reducing the infection rates among falcons, is keeping them under sanitary conditions, away of any sources of the infections.

Pathology of most of parasites of birds of prey, specially falcons, is still obscure and requires more studies.

## 4.2. Recommendations

1) The emphasize on the importance of the quarantine and keeping the imported birds in these quarantine for a suitable period to carry on necessary parasitological investigations before releasing the imported birds.

2) Establish data base of falcons in the UAE with the necessary information.

3) Arranging general training courses and seminars to illustrate the different aspects of falcon health education.

4) To emphasize the importance of the role of clean liners of living quarters of birds in reducing or spreading of the parasitic infections between falcons.

5) To emphasize the importance of routine health-check of falcons.

6) Establish Quail *Coturnix sayronica* and pigeon farms and rabbit or mice colonies as source of food, instead of reliance on market birds and mammals which may be infected.

7) Although, sakers, gyrfalcons, and peregrines, prefer birds to other foods (Reptiles, mammals), it is very important to feed them on rabbits and mice, especially during the period of molting.

8) Establish a society for falconers in the UAE, which would provide a link between the falconers in the different Emirates.

9) Launch a "Journal of falconry" which would report research and advice on falcons (health, species, prices, preys...) and falconry (Arabic methods and Western methods).

10) Continuing encouragement of the younger generation of our people in practicing the falconry sport, which would be a healthy outlet, and keeping them away of anti-social behaviors.

11) Establish a club for falconry, to encourage and spread traditional values in modern societies.

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تؤدي إلى إنخفاض ملحوظ في نسبة العدوى الطفيلية في الصقور في دولة الإمارات العربية المتحدة.

# الملخص

إنحصرت هذه الدراسة على طفيليات الصقر الحر و الصقر السنقر و الصقر الشاهين وما يتفرخ من تهجين الصقر الحر X الصقر السنقر أو الصقر الشاهين X الصقر السنقر، حيث أن هذه الأنواع الثلاثة مع مهجناتها تعتبر من أكثر أنواع الصقور شعبية في دولة الإمارات العربية المتحدة.

هذا وقد ألقت الدراسة الضوء على أهمية الصقور والبيزرة في شبه الجزيرة العربية من خلال سرد مختصر لتاريخ البيزرة عند العرب، مع التركيز على نسبة إنتشار الطفيليات المعوية (الأكريات و الديدان المفلطحة و الديدان الخيطية) وطفيليات الدم (جنس هيموبروتيس وجنس ليكوسيتوزون) وكذلك الطفيليات الخارجية (القراد والعث), مع مناقشة المصادر المحتملة للعدوى من وجهة النظر الوبائية.

تمت دراسة مائة صقر – ١١ ذكر و ٨٩ أنثى – بطريقة عشوائية, وقد قسمت إلى مجموعتين: "الصقور المستوطنة" وهي التي أمضت فترة تتراوح من سنة إلى أربع سنوات, وتحوي ٥٠ صقرا. و "الصقور المستوردة" وهي التي لم تكمل بعد سنة واحدة في دولة الإمارات العربية المتحدة.

هذه الصقور, بادى ذي بدء، عرفت، أخذت منها عينة دم لتحضير مسحات مصبوغة بصبغة جيمسا لمعاينتها مجهريا بحثا عن طفيليات الدم, ومن ثم تعريفها . أيضا تم جمع عينات براز لتلك الصقور لتفحص أولا بالعين المجردة لتمييز الديدان البالغة وسلاميات الديدان الشريطية ويرقات الحشرات، وبالمجهر الضوئي ثانيا لتحديد حويصلات الحيوانات الأولية وبيضات الديدان ، وقد حضرت شرائح البراز بطريقتي الطفو والمباشر. أما للبحث عن الطفيليات الخارجية وجمعها ، فقد أستخدمت التقنيان التاليان : معاينة الريش وإستخدام المبيدات الحشرية.

عرضت النتائج كنسب مئوية للصقور المستوردة والمستوطنة، المصابة وغير المصابة بالمقارنة مع النوع و الجنس . وقد أظهرت الدراسة أن ٥٢٪ من الصقور المستوردة كانت مصابة بالطفيليات, في حين أن ٣٨٪ من الصقور المستوطنة وجدت مصابة بالطفيليات.

قورنت النتائج التي تم التوصل اليها في هذه الدراسة مع ما قد نشر من قبل باحثين آخرين ، مع التأكيد على إمراضية العدوى الطفيلية في الصقور . كما قامت الدراسة بتوصيات من شأنها أن

# دراسة طفيليات الصقور بدولة الإمارات العربية المتحدة

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