DETAIL MORPHOLOGICAL IDENTIFICATION AND PREVALENCE OF DOG FLEA (*Ctenocephalides canis*) AND CAT FLEA (*Ctenocephalides felis*) in Dhaka City

MD. YAKUB ALI

DEPARTMENT OF MICROBIOLOGY AND PARASITOLOGY

SHER-E-BANGLA AGRICULTURAL UNIVERSITY

DHAKA-1207

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BY

MD. YAKUB ALI
Reg. No. 1205074

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APPROVED BY

Dr. Uday Kumar Mohanta	**Dr. K.B.M. Saiful Islam**
Supervisor Chairman & Associate Professor Department of Microbiology and Parasitology Sher-e-Bangla Agricultural University	Co-supervisor Chairman & Associate Professor Department of Medicine and Public Health Sher-e-Bangla Agricultural University

Dr. Uday Kumar Mohanta

Chairman
Department of Microbiology and Parasitology
Sher-e-Bangla Agricultural University, Dhaka-1207

DEPARTMENT OF MICROBIOLOGY AND PARASITOLOGY
Sher-e-Bangla Agricultural University
Sher-e-Bangla Nagar, Dhaka-1207

Memo No: SAU/

CERTIFICATE

This is to certify that the thesis entitled "PREVALENCE AND MORPHOLOGICAL IDENTIFICATION OF DOG FLEA (Ctenocephalides Canis) AND CAT FLEA (Ctenocephalides Felis) IN DHAKA CITY" submitted to the Faculty of Animal Science & Veterinary Medicine, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of Master of Science in Parasitology, embodies the result of a piece of bona fide research work carried out by Md. Yakub Ali, Registration No.: 12-05074 under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that any help or source of information, received during the course of this investigation has been duly acknowledged.

Dated:
Place: Dhaka, Bangladesh

Dr. Uday Kumar Mohanta
Supervisor
Department of Microbiology and Parasitology
Sher-e-Bangla Agricultural University

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The Author

LIST OF CONTENTS

LIST OF FIGURES

LIST OF FIGURES (CONT'D)

LIST OF TABLES

ACRONYMS AND ABBREVIATIONS

ABBREVIATION		FULL MEANING
CFP	=	Care for Paws
CVH	=	Central Veterinary Hospital
et al.	=	And others/Associates
KOH	=	Potassium Hydroxide
LMA	=	Lateral Metanotal Area
Mm	=	Milimiter
M.S.	=	Master of Science
PAW	=	People for Animal Welfare
SAU	=	Sher-e-Bangla Agricultural University
+ve	=	Positive
-ve	=	Negative
%	=	Percent

MORPHOLOGICAL IDENTIFICATION AND PREVALENCE OF DOG FLEA (*Ctenocephalides canis)* AND CAT FLEA (*Ctenocephalides felis)* in Dhaka City

ABSTRACT

Ctenocephalides felis and *Ctenocephalides canis* are the most important ectoparasites of dogs and cats throughout the world; they themselves affect the host and act as vectors of diseases. The main aim of the present study was to assess the prevalence and identify the morphological properties of *Ctenocephalides* spp. in both stray and pet dogs and cats in Dhaka City. Typical morphological characteristics were observed in both species. The two species were separated according to the shape of the head, length of the first spine of the genal comb, number of bristles on the lateral metanotal area (LMA), the number of short stout bristles in the interval between the postmedian and apical long bristles of the dorsal margin of the hind tibia. Males were further identified by the shape of the manubrium of the clasper and females were identified by observing the size of the hilla of spermatheca at the posterior end. A total of 25 flea infested dogs and 25 flea infested cats were found from 57 dogs and 77 cats, respectively. In this study, a higher prevalence of flea was recorded in both dogs (43.86%) and cats (32.47%). A higher prevalence was recorded in stray dogs (61.11%) and cats (79.17%) than that in pet dogs (14.29%) and cats (11.32%). The prevalence of flea infestation was 48.28% in young dogs and 39.29% in adult dogs, respectively. In case of cat, 34.62% young and 31.37% adult were found to be infested by fleas. Among the examined fleas of dogs, 9 (60%) were *C. canis* and 6 (40%) were *C. felis.* Again, among the examined fleas of cats, 2 (13.33%) were *C. canis* and 13 (86.77%) were *C felis*. Of the 11 *C. canis* identified, were 8 (72.73%) female fleas and 3(27.27%) male fleas. Of the 19 examined *C. felis* identified as 18 (94.74%) were female fleas and 1 (5.26%) male flea. Both fleas have public health significance. Therefore, proper attention needs to be paid for the prevention of flea borne diseases through the control of dogs and cats.

Keywords: Dog flea, Cat flea, Morphological identification, Prevalence, Dhaka city

CHAPTER 1

INTRODUCTION

Fleas, particularly the species of *Ctenocephalides*, are common ectoparasites of domesticated dogs and cats throughout the world (Mircean *et al*., 2010; Gracia *et al*., 2013; Salant *et al*., 2013; Hajipour *et al.*, 2015). Fleas are clinically important parasites for human health since they may play a role as parasites by themselves causing allergic dermatitis or other conditions due to their feeding activities. Also serve as vectors and transmitting important disease causing pathogens. The cat flea, *Ctenocephalides felis*, is a known vector for *Bartonella henselae*, *Bartonella clarridgeiae* and *Rickettsia felis*, which can cause cat scratch disease, endocarditis and cat flea typhus in human, respectively (Dryden and Rust, 1994; Kenny *et al.*, 2003; Kramer and Mencke, 2001; Rolain *et al.*, 2003; Shaw *et al*., 2004). Dog and cat fleas are known to be intermediate hosts of *Dipylidium caninum*, which can be transmitted to pets and humans (Soulsby, 1982; Guzman, 1984). Domestic animals such as dog, cat, or other pets, may play an important role as bridging hosts for fleas of different wild animals, domestic animals, and humans, as they come into contact with different animals due their seeking behavior and therefore acquire the fleas of different animals (Dobler and Pfeffer, 2011). Fleas are the common etiology of dermatitis, being responsible for producing allergic dermatitis (Sousa, 2012). Fleas infestations can cause considerable irritation to animals and humans, and can lead to severe disorders, such as anaemia and dermatological problems, because repeated infestation of dogs and cats may result in hypersensitivity to components of flea saliva, which, in turn, can cause flea allergic dermatitis (Dryden and Rust, 1994; Kunkle *et al*., 2003; Newbury and Moriello, 2006). These cat and dog fleas are known as vector of the pathogens causing plague, murine typhus, and feline leukemia. Approximately 94% of all flea species are reported to feed on mammals. Most of the medically important fleas, including genus *Ctenocephalides*, are found within the family Pulicidae. The dog flea, *C. canis*, is an important ectoparasite of both wild and domestic canids around the world (Durden *et al.*, 2005). It is similar in appearance to the ubiquitous cat flea, *C. felis*, but is encountered less frequently and thus has not been studied thoroughly. The dog flea has been reported from many mammalian hosts

including dogs, cats, rabbits, rats, gray foxes, red foxes, woodchucks, and humans (Fox, 1940).

Stray cats wander outdoors and can be found on the streets, food courts, markets and can also be free roaming but return to human habitation after foraging for food (Rust and Dryden, 1997). These cats are exposed to many types of diseases and may harbour various parasites that are transmittable to human such as; toxoplasmosis, toxocariasis, opisthorchiasis, leishmaniasis (Bowman *et al*., 2010; Bush *et al*., 2011; Pennisi *et al*., 2013; Youssef and Uga, 2014).

Review of literatures revealed that at least 36 important zoonotic diseases are acquired from dogs worldwide, although the occurrence of some important zoonotic diseases acquired from dogs have reported from Bangladesh but the inland reports on this aspect are very limited (Samad, 2000).

There are approximately 2,500 species of fleas (Durden and Hinkle, 2009) and within the family Pulicidae, the genus *Ctenocephalides*, includes 13 species and subspecies (Beaucournu and Menier, 1998) according to different morphological criteria based on the shape and structure of their genitalia and the presence and distribution of setae, spines, and ctenidia on the body (Bitam *et al*., 2010). Dobler and Pfeffer (2011) reviewed the published literature from 1980 to 2010 for occurrence and frequency of fleas in the dog populations of different countries. They found that more than 15 different flea species have been described in domestic dogs, being the cat flea (*C. felis*) the most prevalent flea species found globally on dogs. *C. felis* and *C. canis* have been studied by different authors (Gil Collado, 1949; Gil Collado, 1960; Beaucournu and Launay, 1990; Lewis, 1993; Beaucournu and Menier, 1998; Menier and Beaucournu, 1998; Linardi and Guimaraes, 2000 and Durden and Traub, 2002); they based their characterization on the shape of the head, the length of the first spine of the genal comb, number of spines in the metepisternite, the distribution of spines in the hind tibia, and male and female genitalia. However, the variations of chaetotaxy, especially those on the dorsal margin of the hind tibia and metepisternite found in some individuals, have

sometimes been erroneously treated as hybrids (Holland, 1949; Fox, 1952; Amin *et al*., 1974; Amin, 1976).

In our country, there is no any detailed research on the morphology, biology, control strategies and prevalence data of *C. felis* and *C. canis*. In the present work, prevalence and comparative morphological study between *C. canis* and *C. felis* in dog and cat have been carried out of Dhaka city.

Keeping all the points mentioned above, the present piece of research work was under taken with the following objectives.

Objectives:

- ✓ To study the detail morphological properties of *C. felis* and *C. canis*.
- ✓ To study the cross infestation by *C. felis* and *C. canis* between dogs and cats, respectively.
- ✓ To study the prevalence of flea infestation in dogs and cats.
- ✓ To compare flea infestation rate between stray dogs or cats with pet dogs or cats.

CHAPTER 2

REVIEW OF LITERATURE

2.1 Flea Acts as Vectors of Diseases

C. canis and *C. felis* are known to be intermediate hosts of *Dipylidium caninum*, which can be transmitted to dogs, cats and humans (Guzman, 1984 and Soulsby, 1982).

Arthropod vectors transmit many new and reemerging diseases. Some of the notorious genera like *Ctenocephalides* are related to plague and murine typhus but some parasitise of domestic animals like dog and cat that infect humans temporarily. Such arthropods should be considered as a possible cause of erythematous and pruritic papules and nodules of unclear origin. Not only the pets but humans are also affected by the protozoan, bacteria vectored by these fleas, like *Leptomonas ctenociphali* a protozoan that is related to the development of rectal ampullae (Molyneux *et al.,* 1981).

The flea bite dermatitis was observed in workers from the power station of the Madhya Pradesh Electricity Board. Fleas were collected from affected individuals and were identified as *C. canis*, on the basis of morphological characteristics (Ghosh; Shrivastava and Das, 2001).

C. canis infestation was studied in goats in Nigeria (Opasina, 1983). He studied effects of fleas on hosts and their clinical reasons. The parasites of dogs were described as the potential sources of humans infection in Karachi (Bilqees and Khan, 1982). The prevalence was recorded of fleas in domestic animals and found that *C. felis* is most frequently found species followed by *C. canis* (Muller and Kutschmann, 1985).

The presence of *Rickettsia felis* was investigated in the cat flea from Southwestern Europe (Marquez *et al*., 2002). *Rickettsia felis*, formerly called ELB agent, was identified by using molecular biology technique in the cat flea (*C. felis felis*) from southwestern Spain. For the first time, this flea transmitted Rickettsia has been detected within its vector in Eurasia.

2.2 Morphological Studies

Adult dog fleas are small (2.0 - 3.25 mm), wingless, bilaterally compressed, and heavily chitinized (Bayer Environmental Science, 2000; Durden and Hinkle, 2009).

Fleas are wingless insects with a laterally compressed body of about 1.5-4 mm length. Body is divided into head, thorax and abdomen like other insects. Taxonomically they belong to the order Siphonaptera (Eckert *et al.,* 2000).

Members of the Genus *Ctenocephalides* have genal combs and pronotal combs, large black eyes and 5-segmented labial palps (Ewing and Fox, 1943).

Although the dog and cat fleas are very similar in appearance, the comb on the ventral margin of the head, the genal ctenidium, is used to help distinguish between *C. canis* and the cat flea, *C. felis*. The size of the first two genal spines also differentiates the two species. The first (or outer) genal spine of *C. canis* is much shorter than the second genal spine. In *C. felis*, the first genal spine is as long as, or barely shorter than, the second (Fox, 1940).

C. canis has a comparatively more rounded head and about one and a half times as long as its wide, while the head of *C. felis* is about twice as long as its wide (Fox, 1940).

C. felis has four to five "teeth" on the tibia of all six legs, whereas the dog flea, *C. canis* has seven to eight teeth on the tibia of all six legs (Kramer and Mencke, 2001).

The family Pulicidae contains several species and subspecies. These species belong to the families Pulicidae, including *Pulex spp*., *Ctenocephalides spp*., *Spilopsyllus spp*. and *Archaeopsyllus spp*., or the familia Ceratophyllidae with the genus *Ceratophyllus* or *Nosopsyllus* to mention only some of the most important veterinary and human representatives. Fleas represent one of the most important ectoparasites (Mehlhorn, 2000; Mehlhorn *et al*., 2001).

The genital apparatus (modified abdominal segments) of fleas is described in detail in a number of studies (Rothschild and Traub, 1971). Mardon (1978) and Cheetham (1988)

have made a comparative anatomical study of the aedeagus. Scanninig electron microscopy has been used for aedeagus studying (Medvedev, 1984; Cheetham, 1988). This technique and together with light microscope were used in the comparative investigations of the aedeagus of many species of fleas (Medvedev, 1993, 1994). The aedeagus of male fleas consists of modified tergites and sternites of the 8th and 9th abdominal segments and claspers. The aedeagus and claspers derive from primary phallic lobe (Snodgrass, 1946). The modified tergites and sternites of flea's belong to abdominal segments 7-9.

Chiu-ShiauYen *et al.* (2001) observed microscopic views: the comparative analysis of fleas of three different species in subtropical areas. Siphonaptera were collected from Siamese cats and Pursang (Persian) cats in Taiwan. In addition, fleas were isolated from dust containing human epithelial tissue. Three host-specific fleas were isolated, one specific to the human host (*Pulex irritans*), one to the Pursang cat (*C. felis*) and one to the cats in general.

Giangaspero A. (1999) reviewed of flea infestations (*C. felis*, *C. canis*, *Pulex irritans*) of cats and dogs covering their morphology, biology, life cycle, pathogenic role, and transmission of disease. Taxonomic study of the genus *Ctenocephalides* was done by Stiles & Collins, 1930 (Insecta: Siphonaptera: Pulicidae) by using aedeagus characters. To define more accurately the taxonomic position of the species of *Ctenocephalides*, a morphological study of the aedeagus was conducted 21 on all 14 described taxa (13 species and 1 subspecies) of this genus. Based on some phallosome structures (hamulus, lobes, tubus interior), an identification key is constructed to complement the existing taxonomic criteria. *C. orientis* (from Cambodia, China, Indonesia, Nepal and Vietnam) and *C. damarensis* (from South Africa) are confirmed to specific rank.

2.3 Morphological Variation Studies

The two species are usually separated according to the shape of the head, length of the first spine of the genal comb, number of bristles on the lateral metanotal area (LMA) and the number of short stout bristles in the interval between the postmedian and apical long bristles of the dorsal margin of the hind tibia (Hopkins *et al.*, 1953; Johnson, 1957; Amin, 1976; Menier; Beaucournu, 1998; Beaucournu; Menier, 1998; Guimaraes, 2000).

Males can be further identified by the shape of the manubrium of the clasper (Holland, 1949) and the size of the hamulus on the aedeagus (Menier; Beaucournu, 1998). However, in spite of these differences, some variations in the chaetotaxy and the number of spines in the genal comb have been found (Amin, 1976; Amin *et al.*, 1974).

In *Ctenocephalides spp*., the most frequent morphological variations are observed in the combs and chaetotaxies of LMA (erroneously referred to as the metepisternum by some authors) and in hind tibia (Amin *et al*., 1974; Amin, 1976).

Alterations in chaetotaxy on the LMA and metatibia might suggest hybridization between the two species, as previously proposed by Holland (1949), Fox (1952), Amin *et al*. (1974) and Amin (1976). According to Benton (1998), hybrids depend upon occurrence of two closely related species in close association, such as in fleas of the genus *Ceratophyllus*, 1832, which share the same bird nests in North America. However, the hypothesis of hybridization between *C. felis felis* and *C. canis* must be rejected because good species do not cross with each other, as reinforced by Beaucournu and Guiller (2006).

2.4 Prevalence Studies

In Georgia (2005), a survey of fleas on domestic dogs found *C. felis* was the most common species, with a prevalence of 61%. *C. canis* (Dryden *et al.*, 2005)

In Virginia (1985), *C. felis* was the only species of flea recovered from both dogs and cats (Dryden, 1993).

In San Francisco (1960), *C. felis* was the just about the only species of flea recovered from both dogs and cats in animal shelters. However, a single *P. irritans* flea was found on a dog (Dryden, 1993).

In Aguascalientes, Mexico (2011), fleas were recovered from dogs and identified. Out of 629 fleas, 62% were *C. canis* and 38% were *C. felis* (Hernandez *et al.*, 2011).

In Chile (2002), flea species found on dogs were 41.8% *C. felis*, 39.4% *C. canis*, and 18.8% *P. irritans* (Alcaino, 2002).

In Italy (2007), 960 fleas were recovered from dogs in veterinary clinics. 91.8% of the fleas were *C. felis* and 8.2% were *C. canis* (Rinaldi *et al.*, 2007)

In Uruguay (2006), 66 fleas were identified from dogs and cats. 94% were *C. felis* and 6% were *C. canis* (Venzal *et al.*, 2006).

In Southwest England (1995), 93.75% of fleas from infested cats were *C. felis* and 6.25% were *C. canis*. Fleas on infested dogs were 78.3% *C. felis* and 20% *C. canis* (Chesney, 1995).

In the United Kingdom (2005), flea infestations on cats were 98.83% *C. felis*, 0.21% *C. canis* and 0.43% *P. irritans*. On dogs, 93.15% of fleas were *C. felis*, 1.49% *C. canis*, and 1.49% *P. irritans* (Bond *et al.*, 2007).

In Germany (2006), flea infestations on dogs were 73.2% *C. felis* and 17.6% *C. canis*. Fleas on cats were broken down into 89.8% *C. felis* and 7.3% *C. canis*. An older

German survey (2001) had similar results, with *C. felis* being the predominant species of both dogs and cats. (Visser *et al*., 2001).

In Ethiopia (2011), 82.9% of randomly examined dogs had *C. felis*, 73.8% had *C. canis* and 2.5% had *P. irritans*. 67% of examined cats had *C. felis*, 18% had *C. canis* and 6% had *P. irritans*. (Kumsa & Mekonnen, 2011).

In Iran (2012), dogs were examined for fleas. The most prevalent species was *C. canis*, followed by *P. irritans*. No *C. felis* fleas were found (Jamshidi S. *et al*., 2012). Another survey (2010) had conflicting results, as fleas recovered from Iranian dogs were 67.5% *C. felis*, 12.1% *C. canis* and 8.4% *P. irritans* (Borji *et al.*, 2011).

In Denmark (1977), *C. felis* was the most prevalent flea on both dogs and cats (Springer, 2001).

In Indiana (1988), 93% of flea-infested dogs had *C. felis* and 18% had *C. canis*. In infested cats, *C. felis* made up 97% of the fleas (Dryden, 1993).

In Taipei, Taiwan (1993), 80% of stray cats and 60% of stray dogs were infested with *C. felis* (Hsu & Wu, 2001).

CHAPTER 3

MATERIALS AND METHODS

3.1 Site selection

Fleas were collected from several areas in Dhaka city, such as Central Veterinary Hospital (CVH) at Alauddin road, People for Animal Welfare (PAW) at Lalmatia, Care for Paws (CFP) at Bosila and Sher-e-Bangla Agricultural University (SAU). Both stray and pet dogs and cats were considered as study animal for the collection of fleas.

3.2 Restraining of animal

Pet dogs and cats were restrained with the help of the owners. On the other hand, stray dogs and cats, were restrained with the help of the assistant by covering the mouth with musk. Some dogs and cats, which were anaesthetized during neutering or spaying, were examined for the presence of fleas.

3.3 Sample collection and preservation

Dogs and cats of all age groups and sexes in Dhaka City were considered as study animals. Dogs and cats were exhaustively examined for fleas through an inspection of head, neck, body, sides, tail, and ventral regions of each animal. Fleas were collected by the use of forceps, and hand picking. Collected fleas were stored in collection vial with proper labeling, and using a record book for further information. Captured fleas were transported to laboratory of Microbiology & Parasitology, Sher-e-Bangla Agricultural University, Dhaka-1207. Collected fleas were preserved in 70% ethanol for their preservation and identification based on morphological features to the species level.

3.4 Permanent slide preparation protocol for identification

Specimens were slide mounted by clearing, staining, and dehydrating before placing them in the final mounting medium.

Clearing: Fleas were cleared by dissolving in 10% Potassium Hydroxide (KOH) solution at room temperature for overnight to allow transmitted light to pass through

them. After clearing with KOH, specimens were returned to distilled water or alcohol before being passed through the alcohol series for dehydration.

Staining: Hematoxylin dye was used to stain the specimens. Specimens were kept in Hematoxylin for overnight. Hematoxylin was added to the specimens while they were in 70% alcohol. The specimen became darker and darker as time in the stain was increased. Some of the stain leached from the specimen in later stages of the dehydration series, so over staining was done to produce proper darkness of the specimen.

Dehydration and mounting: Water was removed by dehydration because water in the specimen would cloud the slide and make it difficult to see the desired characteristics as well as to prevent specimen from spoiling by bacteria. Dehydration was accomplished by passing the specimens through a series of increasingly concentrated grades of ethanol for 30 minutes in each step.

After dehydration in 100% ethanol, the specimen was soaked in xylene before mounting on slides. The amount of time spent in each step depends on the thickness of the specimen. The dehydrated specimen was observed under microscope just before mounting by Canada Balsum medium to observe whether it is cleaned. If clouding was visible, the specimen was returned to earlier stages in the dehydration series. After mounting, slides were dried very slowly by allowing them for several days. The specimens were handled with care during the mounting process. Fine forceps, needles and insect pins were used to handle the specimens during the mounting process.

3.5 Microscopic examination for morphology study

All fleas were identified microscopically at the laboratory, according to the keys and description for identification (Gil Collado, 1949; Lewis, 1993; Beaucournu and Menier, 1998; Menier and Beaucournu,1998; Beaucournu and Launay, 1990; and Durden and Traub, 2002).

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Results

4.1.1 Morphology studies

A total of 15 fleas from 5 infested dogs, and 15 fleas from 6 infested cats were objected to morphological identification. Two species, *C. canis* and *C. felis* were identified.

Among 15 fleas of dogs examined, 9 and 6 were identified as *C. canis* and *C. felis,* respectively. Again, among 15 fleas of cats examined, 2 and 13 were identified as *C. canis* and *C. felis,* respectively (Table 6). Of the 11 examined *C. canis,* 8 (72.73%) were identified as female fleas and 3(27.27%) were male fleas. Within the 19 examined *C. felis,* 18 (94.74%) were identified as female fleas and 1 (5.26%) was male flea (Table 8).

Typical generic morphological characteristics were found in both species. They were small (2-3mm), dark or reddish brown to black in color. The females were a bit larger than males and had a slightly different color. The species were winless insects with laterally compressed body which had glossy surface. Head contained backwardly directed rows of dark spines, ctenidia or comb, at its posterior or ventral borders. Head also contained pronotal and genal ctenidium with eight or nine spines oriented horizontally. Sternum had one or two ventral spines. Abdomen contained 10 abdominal segments; tergum of 9^{th} segment modified to form clasper (male). Each species had 3 pairs of legs; 3^{rd} pair of legs was much longer than others used for jumping. Each leg beared coxa, femur, tibia and tarsus; posterior end had pygidium and antepygidial bristles (Figure 1). The female contained spermethica as a holding organ; forehead carried maxillary palpus ventrally (Figure 2).

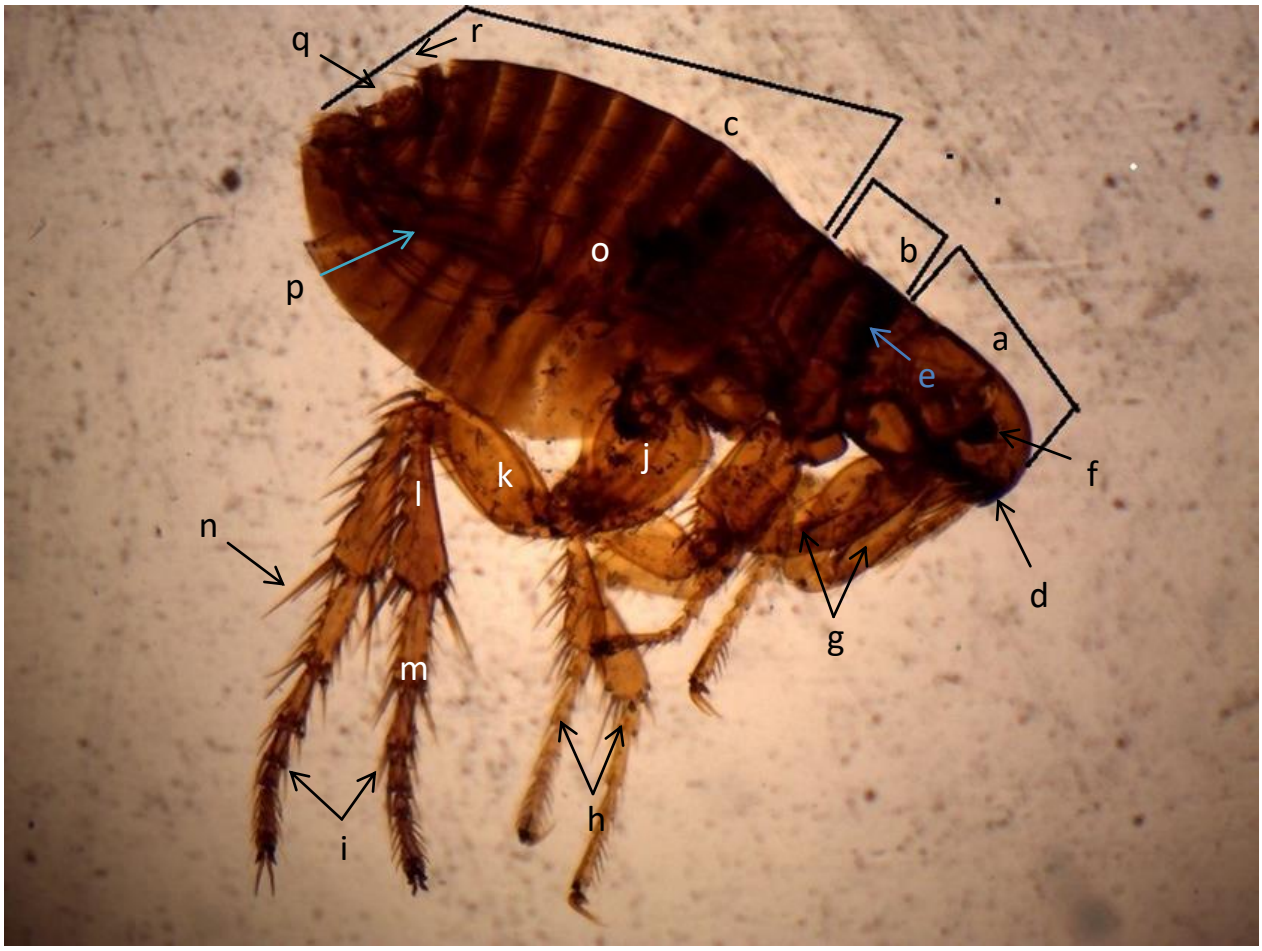

Figure 1: Morphology of the Genus *Ctenocephalides* (Male)

a) Head, b) Thorax, c) Abdomen, d) Genal comb, e) Pronatal comb, f) Eye, g) 1st pair of legs, h) 2nd pair of legs, i) 3rd pair of legs (long), j) Coxa, k)Femur, l) Tibia, m) Tarsus, n) Bristle, o) 9th abdominal segment p) Clasper, q) Pygidium, r) Antepygidial bristles.

Figure 2: Morphology of the Genus *Ctenocephalides* (Female)

a) Maxillary pulpus, b) Spermatheca, c) Genal comb, d) Pronatal comb.

C. canis and *C. felis* were separated morphologically according to the shape of the head, sloping condition of the forehead, length of the first spine of the genal comb, number of bristles on the lateral metanotal area (LMA), the number of short stout bristles in the interval between the post-median and apical long bristles of the dorsal margin of the hind tibia, metatibial formula of chaetotaxy, shape of the manubrium of the clasper in case of male, length of hilla of spermethica in case of female.

Table 1: Differential morphological properties between *C. felis* and *C. canis*

Characteristics	*C. felis*	*C. canis*
Shape of the head	Length is generally greater than twice of the height of head (Figure 3a).	Length is not twice of the height of head. (Figure 4c).
Length of the 1st and 2nd spine of genal comb	First of two spines are approximately equal in length (Figure 3b).	First spine is half as long as second spine in length (Figure 4d).
Number of bristles on the LMA or metepisternite	Two (Figure 5).	Three (Figure 6).
Number of notches on tibiae	Tibiae of all 6 legs have 5 to 6 notches (Figure 7, 9).	Tibiae of all 6 legs have 7 to 8 notches (Figure 8, 10).
Number of stout bristles on the dorsal margin of the hind tibia	One stout bristle in the interval between post-median and apical long bristles (Figure 11).	Two stout bristles in the interval between post-median and apical long bristles (Figure 12).
Metatibial formula of chaetotaxy	2-2-2-2-1-3 (Figure 13).	2-2-2-2-2-1-1-3 (Figure 14)
Male: shape of the manubrium of the clasper	The clasper of the manubrium is not expanded apically (Figure 15)	The clasper of the manubrium is expanded apically (Figure 16)
Female: length of hilla of spermethica	Spermatheca contains short hilla (Figure 17)	Spermatheca contains comparatively long hilla (Figure 18)

Figure 3: Female of *C. felis* (10X). a) Shape of the head; b) Length of the 1st and 2nd spines of genal comb (arrow).

Figure 4: Female of *C. canis* (10X). c) Shape of the head; d) Length of the 1st and 2nd spines of genal comb (arrow).

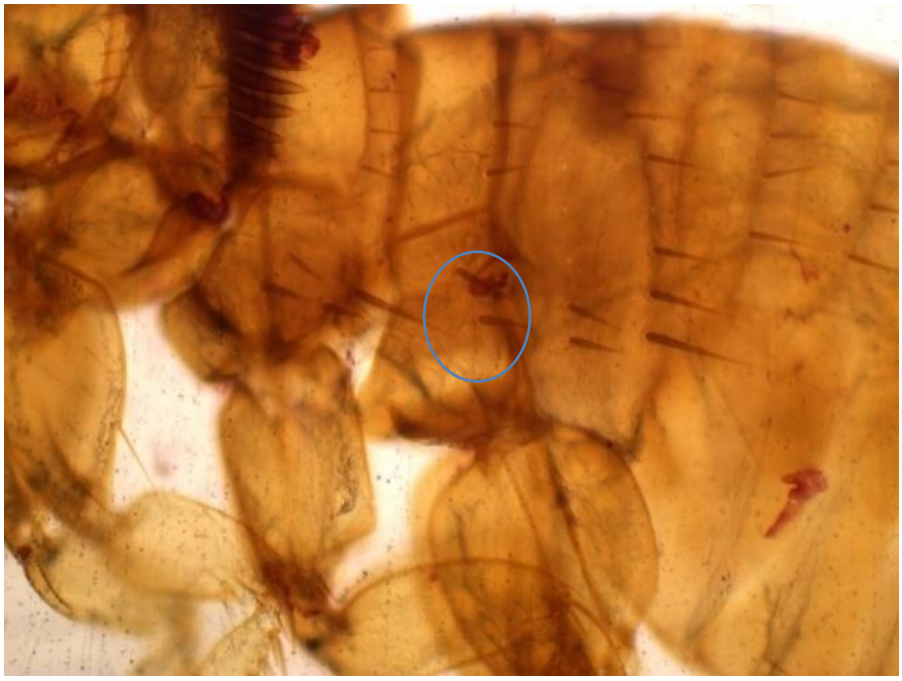

Figure 5: Female of *C. felis* (10X). Number of bristles on the lateral metanotal area (LMA) or metepisternite (circle).

Figure 6: Female of *C. canis* (10X). Number of bristles on the lateral metanotal area (LMA) or metepisternite (circle).

Figure 7: Female of *C. felis* (10X). Number of notches (5) on the hind tibia (arrow).

Figure 8: Female of *C. canis* (10X). Number of notches (7) on the hind tibia (arrow).

Figure 9: Female of *C. felis* (10X). Number of notches (6) on the hind tibia (arrow).

Figure 10: Female of *C. canis* (10X). Number of notches (8) on the hind tibia (arrow).

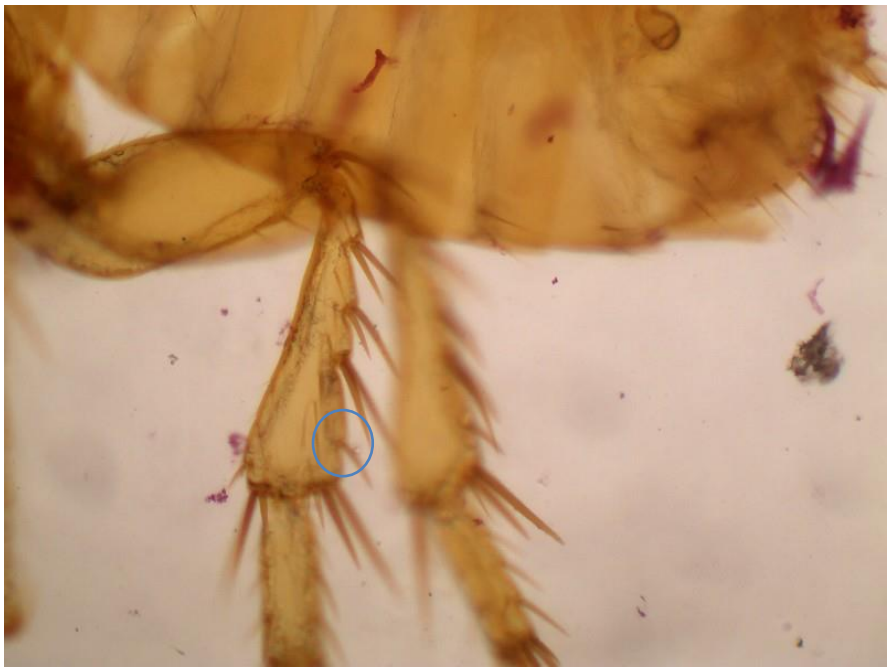

Figure 11: Female of *C. felis* (10X). Number of stout bristles between post-median and apical long bristles of the hind tibia (circle).

Figure 12: Female of *C. canis* (10X). Number of stout bristles between post-median and apical long bristles of the hind tibia (circle).

Figure 13: Female of *C. felis* (10X). Metatibial formula of chaetotaxy.

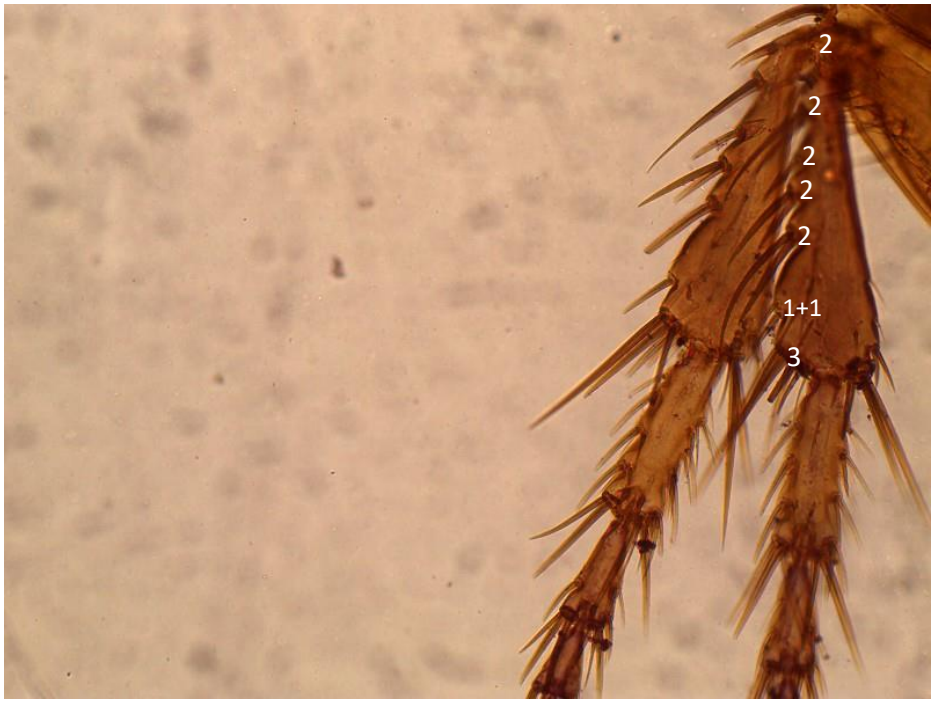

Figure 14: Female of *C. canis* (10X). Metatibial formula of chaetotaxy.

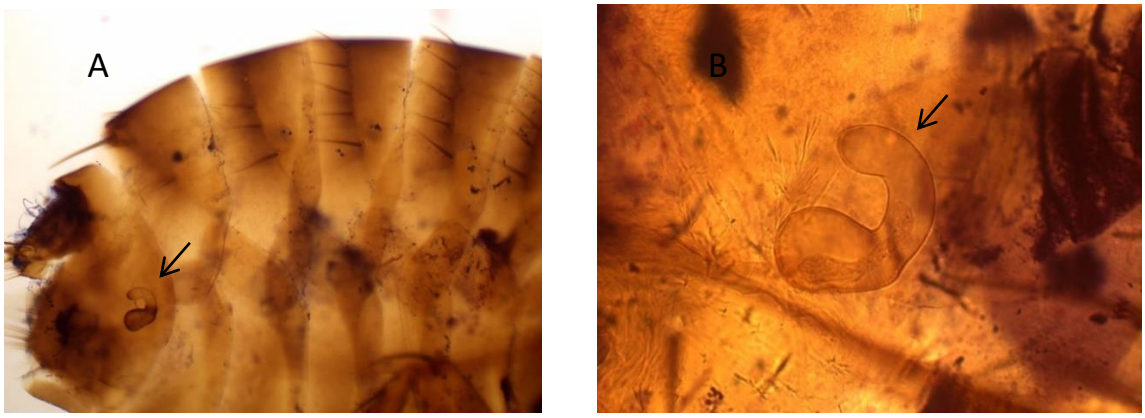

Figure 15: Female of *C. felis*. Length of hilla of spermathica (arrow); A: Showing hilla under 10X, B: Showing hilla under 40X.

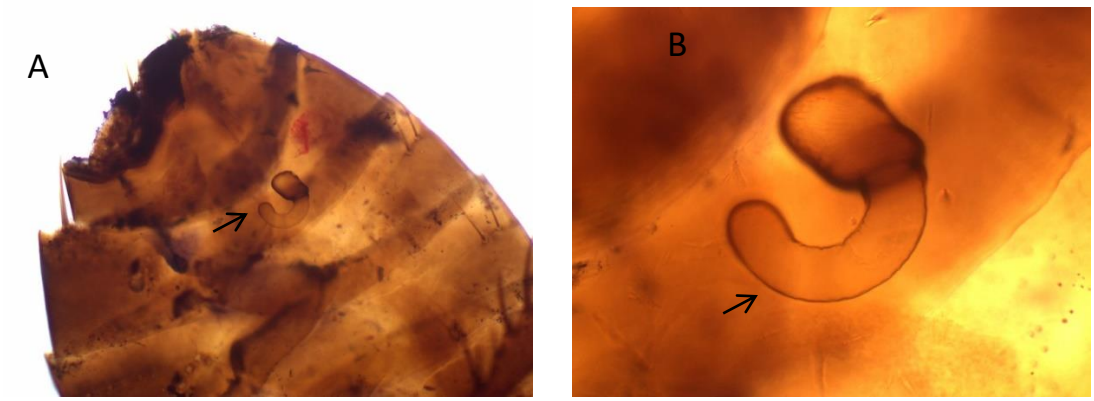

Figure 16: Female of *C. canis*. Length of hilla of spermathica (arrow); A: Showing hilla under 10X, B: Showing hilla under 40X.

Figure 17: Male of *C. felis* (10X). Shape of the manubrium of the clasper (arrow).

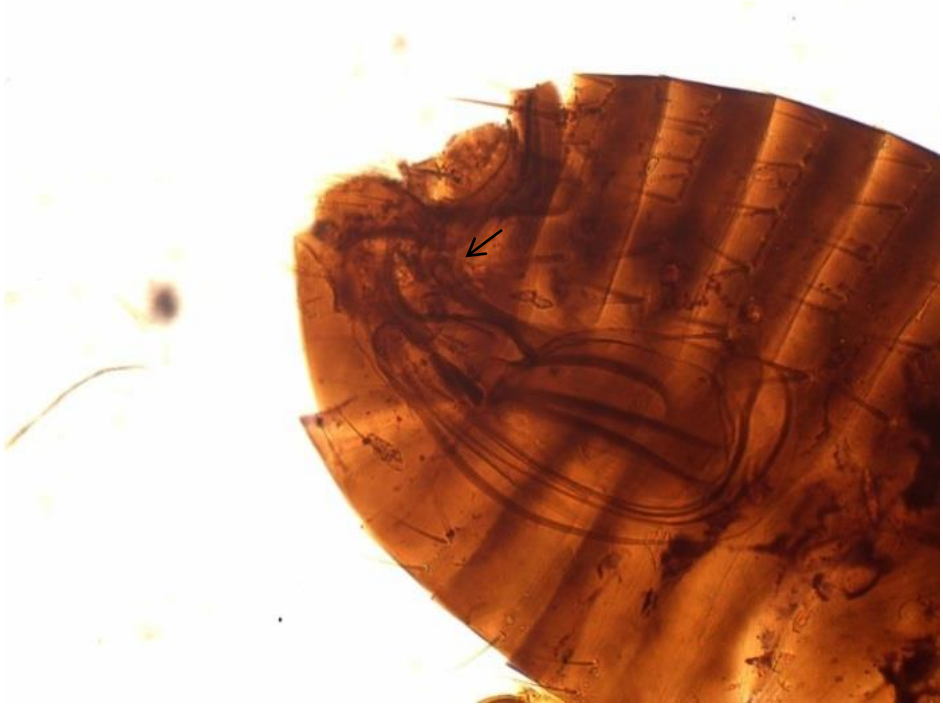

Figure 18: Male of *C. canis* (10X). Shape of the manubrium of the clasper (arrow)

4.1.2 Prevalence studies

A total of 57 dogs and 77 cats were examined for flea infestation belonging to the genus *Ctenocephalides* from different veterinary clinics and animal welfare associations of Dhaka City (Table 2). A total of 25 flea infested dogs and 25 flea infested cats were found from 57 dogs and 77 cats examined, respectively. In this study a higher infestation rate of flea was recorded in dogs (43.86%) than in cats (32.47%) (Table 2).

Higher infestation rate of flea was recorded in dogs (50%) rather than cats (24%) in the Central Veterinary Hospital (CVH). The prevalence of flea was observed in dogs (42.86%) and cats (34.09%) in the veterinary clinics of People for Animal Welfare (PAW) at Lalmatia (Table 3).

Among the 57 dogs, 42% (24/57) were female, while 58% (33/57) were male and among the 77 cats, 60% (46/77) were female, while 40% (31/77) were female (Table 4).

A significant difference was observed in the infestation rate of flea infestation between young (48.28%) and adult (39.29%) dogs. In case of cat, 34.62% young and 31.37% adult were found to be infested by fleas (Table 5).

Again, among the 57 dogs, 63% (36/57) were stray dogs, while 37% (21/57) were pet dogs. Among 77 cats, 31% (24/77) were stray cats, while 69% (53/77) were pet cats. Higher prevalence of fleas was observed in stray dogs (61.11%) and stray cats (79.17%) than pet dogs (14.29%) and pet cats (11.32%) in Dhaka City (Table 6).

A total of 15 fleas were identified from dogs which contained 9 *C. canis* (60%) and 6 *C. felis* (40%). Among identified 15 fleas collected from cat, there were 13 *C. felis* (86.67%) and 2 *C. canis* (13.33%). The prevalence rate of cross infestation was higher in dogs than that in cats (Table 7).

Table 2: Overall number of animals was examined for flea infestation

Animal	Animal infested (%)
Dog (n=57)	25 (43.86)
Cat (n=77)	25 (32.47)
Total (134)	50 (37.31)

Table 3: Comparison of the overall number of examined animals according to collection site

Location	Animal	Animal infested (%)
Central Veterinary Hospital (CVH)	Dog (n=18)	9 (50)
	Cat (n=25)	6 (24)
People for Animal Welfare (PAW)	Dog (n=35)	15 (42.86)
	Cat (n=44)	15 (34.09)
Sher-e-Bangla Agricultural University (SAU)	Dog (n=1)	-
	Cat (n=6)	3 (50)
Care for Paws (CFP)	Dog (n=4)	2 (50)
	Cat (n=1)	-
Total	(134)	50 (37.31)

Table 4: Comparison of the overall number of infested animal according to their sex

Animal	Sex	Animal infested (%)
Dog	Male (n=33)	14 (42.42)
	Female (n=24)	11 (45.83)
Total	(57)	25 (43.86)
Cat	Male (n=31)	10 (32.26)
	Female (n=47)	15 (32.61)
Total	(77)	25 (32.47)

Table 5: Comparison of the overall flea infested young and adult animals

Animal	Age	Animal infested (%)
Dog	Young	14 (48.28)
	(<1 year=29)	
	Adult	11 (39.29)
	(>1 year=28)	
Total	(57)	25 (43.86)
Cat	Young	9 (34.62)
	(<9 months=26)	
	Adult	16 (31.37)
	(>9 months=51)	
Total	(77)	25 (32.47)

Table 6: Comparison of the overall number of the flea infested stray and pet animals

Animal	**Stray animals**	**Animal infested (%)**	**Pet animals**	**Animal infested (%)**
Dog	36	22 (61.11)	21	3 (14.29)
Cat	24	19 (79.17)	53	6 (11.32)
Total	60	41 (68.33)	74	9 (12.16)

Table 7: Number of cross infestation of flea between dog and cat

Animal	**No. of Examined fleas**	***C. canis***	**Abundance (%)**	***C. felis***	**Abundance (%)**
Dog	15	9	(60)	6	(40)
Cat	15	2	(13.33)	13	(86.67)

Table 8: Comparison of the overall number of fleas examined according to their sex

Flea	**No. of fleas examined**	**Female**	**Abundance (%)**	**Male**	**Abundance (%)**
C. Canis	11	8	(72.73)	3	(27.27)
C. felis	19	18	(94.74)	1	(5.26)

4.2 DISCUSSION

Flea infested dogs and cats were found from the examined 57 dogs and 77 cats respectively, belonging to the genus *Ctenocephalides* from different localities of Dhaka City. In the present study two species of *Ctenocephalides* Including *C. felis* and *C. canis* under the family Pulicidae were found in both dogs and cats. The length of the head of *C. felis* was twice longer than wide. Genal ctenidium presenting the first spine was approximately as long as the second one. All the individuals of this species presented one single short and stout spine close to short setae and located typically between the postmedial and apical long bristles, and five to six seta-bearing notches was found along the dorsal margin. This fact was found by Linardi and Santos (2012). Presence of two bristles was observed in the metepisternite or LMA. Typical spermatheca with a short apical part of hilla was observed in the posterior end of female. The manubrium of the clasper was dilated towards its apex in case of male individuals.

The population of *C. canis* was observed on dogs and cats from all the geographical localities of Dhaka City. The individuals presented typical characteristics of this species: head strongly convex anteriorly in both sexes and not noticeably elongate; the length of the head was not twice longer than wide. Genal ctenidium presenting the first spine was approximately shorter than the second one. Three spines were observed in the metepisternite or LMA in all the individuals. Hind tibia with seven to eight seta-bearing notches along the dorsal margin and presence of two single, short and stout bristles located between the postmedial and apical long bristles were found in hind tibia. The manubrium of the clasper was dilated towards its apex in case of male individuals. Typical spermatheca with apical part of elongated hilla was observed in the posterior end of females. These aboved mentioned morphological characteristics were agreed with those cited by Gil Collado (1949), Lewis (1993), Beaucournu and Menier (1998), Menier and Beaucournu (1998), Beaucournu and Launay (1990), and Durden and Traub (2002).

However, the degree of dilation of the apex and the degree of elongation of the apical part (hilla) of the spermatheca was the most differential character between both species what was in agreement with Menier and Beaucournu (1998) and Lewis (1993),

respectively. The length observed between the first and the second genal spines was the most specific biometrical parameter observed between both species and it was in agreement to Gil Collado (1960). Furthermore, and in accordance with Durden and Traub (2002), the length and wide ratio of the head was a specific parameter to differentiate *C. felis* and *C. canis.*

In this study, an overall high prevalence of flea was recorded in both dogs (43.86%) and cats (32.47%) in Dhaka City. This high prevalence suggests that these fleas are very common, and present major problems with regard to the health, and performances of these important animals in the study area. Higher prevalence of fleas was observed in dogs than that in cats, which may be due to more efficient grooming behavior of cats (Eckstein and Hart, 2000). Higher prevalence of fleas in stray dogs and cats than pet dogs and cats in Dhaka City, which confirms to the previous study (Hsu & Wu, 2001) where it was reported that 80% of stray cats and 60% of stray dogs were infested with *C. felis* in Taipei, Taiwan. Lower prevalence of fleas was recorded in pet dogs and cats may be due to proper supportive care and management by their owners.

C. felis was identified as the most common ectoparasite in both animal groups. This finding is in line with earlier reports from Ethiopia (Melkamu 2008; Yonas 2008) as well as elsewhere in the world (Alcaino *et al.,* 2002; Aldemir, 2007; Beck *et al.,* 2006; Canon-Franco & Perez-Bedoya, 2010; Gonzalez, Castro & Gonzalez, 2004; Gracia *et al*., 2008; Rinaldi *et al*., 2007). *C. canis* was identified as the second most common ectoparasite species in both host groups, which also agrees with the earlier mentioned reports. Higher prevalence of flea infestations in young cats may be due to confinement to houses, therefore, having greater exposure to ectoparasites infestation like fleas, as well as less efficient grooming behavior than adult cats (Eckstein & Hart, 2000).

The prevalence amongst animals, more female fleas was recorded on animals in this study. The most probable reason for this is that female individuals usually have a longer lifespan than the male individuals. Male individuals also spend more time off the host and are therefore more prone to predation or starvation than female individuals (Durden *et al*. 2005).

CHAPTER 5

SUMMARY AND CONCLUSION

This study was performed in the Dhaka city aim to find out the prevalence and morphological identification of the fleas of the genus *Ctenocephalides* including *C. canis* and *C. felis* from dogs and cats. A higher prevalence rate of flea was recorded in dogs (43.86%) than in cats (32.47%). The higher prevalence of fleas in dogs than that in cats in this study may reflect more efficient grooming behavior of cats. The prevalence rate of fleas was higher in stray dogs (61.11%) and cats (79.19%) , than that in pet dogs (14.29%) and cats (11.32%). The prevalence rate of fleas was higher in young animal than adult. Among 30 fleas which were identified, the female fleas (86.67%) were higher than male fleas (13.33%) of the Genus *Ctenocephalides.* The prevalence rate of cross infestation was higher in dogs (*C. felis*, 40%) than that in cats (*C. canis*, 13.33%). Fleas are clinically important ectoparasites for animal and human health since they may play a role as parasites by themselves causing allergic dermatitis or other conditions. Sometimes they serve as vectors and transmitting important disease causing pathogens. The information presented here improves our understanding of flea infestation. In order to avoid any unpleasant situations adequate preparations of flea control should be implemented in Dhaka city and other parts of Bangladesh.

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