ปรสิตในเลือดนกพิราบ *Columba livia* Gmelin , 1789 ในกรุงเทพมหานครและชลบุรี

นางสาวพิมพรรณ เงินเทศ

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HAEMOPARASITES OF ROCK PIGEON *Columba livia* Gmelin, 1789 IN BANGKOK AND CHONBURI

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ศึกษาความชุกและปริมาณปรสิตในเลือดนกพิราบ *Culumba livia* 450 ตัว ในกรุงเทพฯ 3 แห่ง (สวนลุมพินี สนามหลวงและสวนสัตว์ดุสิต) และจังหวัดชลบุรี 2 แห่ง (อำเภอศรีราชา (ศรีราชา) และอำเภอเมือง (ชลบุรี)) แห่งละ 30 ตัว โดยเก็บตัวอย่าง 3 ช่วงฤดู คือ ฤดูฝน (มิถุนายน-กรกฎาคม 2543) ต้นฤดูแล้ง (พฤศจิกายน-ธันวาคม 2543) และปลายฤดูแล้ง (กุมภาพันธ์-มีนาคม 2544) พบว่า *Haemoproteus columbae* เป็นปรสิตชนิดที่มีความชุกมากที่สุด ในช่วงเดือนกุมภาพันธ์-มีนาคม พบ *Trypanosoma* sp. 1 ตัว ในเลือดนกพิราบจากสวนสัตว์ดุสิต และ Microfilaria 1 ตัวในเลือดนกพิราบจากศรีราชา แต่ไม่พบ *H. columbae* ในนกทั้งสองตัวนี้เลย ความชุกของ *H. columbae* ในเลือดนกพิราบจากสวนสัตว์ดุสิตมากที่สุด (100%) ในช่วงเดือนมิถุนายน-กรกฎาคม และ พฤศจิกายน-ธันวาคม ส่วนจากสนามหลวงและสวนสัตว์ดุสิตมีมากที่สุด (96.67%) ในช่วงเดือนกุมภาพันธ์-มีนาคม และเมื่อทดสอบค่าความชุกของปรสิตโดย Chi-square test พบว่าความชุกของ *H. columbae* ไม่แตกต่างกันทั้งตามสถานที่และตามฤดูกาล ($P>0.05$) จากศึกษาจำนวน *H. columbae* ต่อ 10,000 เม็ดเลือดแดง (intensity) ของนกพิราบ พบว่าในสถานที่ต่างกัน ไม่มีความแตกต่างกันในช่วงเดือนพฤศจิกายน-ธันวาคม และเดือนกุมภาพันธ์-มีนาคม แต่มีความแตกต่างกันเฉพาะในช่วงเดือนมิถุนายน-กรกฎาคม ($df=4$, $P=0.003$) เท่านั้น ส่วน intensity ของปรสิตในนกพิราบจากสถานที่เดียวกันไม่แตกต่างกันตามฤดูกาล ดังนั้นจึงนำค่า intensity ของปรสิตในช่วงเดือนมิถุนายน-กรกฎาคม มาทดสอบด้วยวิธี Two-sample Kolmogorov-Smirnov test พบว่า ที่สนามหลวงและสวนลุมพินี มีนกติดเชื้อ *H. columbae* ในปริมาณมากๆ จำนวนมากกว่า ที่สวนสัตว์ดุสิตและชลบุรี ส่วนที่ศรีราชามีจำนวนมากกว่าที่ชลบุรี ในการศึกษาครั้งนี้พบว่า ปริมาณปรสิตในเลือดไม่มีความสัมพันธ์กับลักษณะทางสัณฐานวิทยา แต่สัมพันธ์กับสภาพภูมิอากาศ โดยแนวโน้มของปริมาณปรสิตในเลือดนั้นน่าจะพบมากในบริเวณที่มีความชื้นที่สูง ($r_s=0.296$, $P=0.005$) และมีปริมาณน้ำฝนมาก ($r_s=0.292$, $P=0.005$) และพบน้อยในบริเวณที่มีอุณภูมิสูง ($r_s=-0.296$, $P=0.005$) โดยสรุปสภาพภูมิอากาศในแต่ละสถานที่น่าจะเป็นเหตุผลหลักของการติดเชื้อ *H. columbae* ในนกพิราบ

ภาควิชา ชีววิทยา ลายมือชื่อนิสิต.....พิมพรรณ เงินเทศ.....
สาขาวิชา สัตววิทยา ลายมือชื่ออาจารย์ที่ปรึกษา.....
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KEY WORD: BLOOD PARASITE / PIGEON / *Columba livia* / *Haemoproteus columbae*
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The purpose of this study was to investigate prevalence and intensity of blood parasites in pigeon with local and seasonal variation. 450 pigeons in 5 sites, consisted of 3 sites in Bangkok (Lumpinee Park, Sanam Luang, and Dusit Zoo) and 2 sites in Chonburi Province (Sriracha District (Sriracha), and Muang District (Chonburi)) were studied in 3 periods: in rainy season (June-July 2000), in early dry season (November-December 2000), and in late dry season (February-March 2001).

Haemoproteus columbae was the most common parasite in blood samples. There were only one Trypanosome and one microfilaria in pigeons during February-March from Dusit Zoo and Sriracha, respectively. Both pigeons were virtually free from *H. columbae*. During June-July and November-December, prevalence of *H. columbae* in pigeons sampling from Dusit Zoo was the highest (100%, n=30 in both season). During February-March, parasite prevalence in birds from Sanam Laung and Dusit Zoo were the highest (96.67%, n=30 in each groups). From the results of Chi-square test, there was no significant difference of parasite prevalence in any site and any season. Results from Median test showed that *H. columbae* intensity during November-December and February-March were no significant differences in each site, however there was an statistically significant difference in each site during June-July (df=4, P=0.003). Besides, parasite intensity in the same site was no significant difference in any season. Consequently, parasite intensity during June-July was examined by Kolmogorov-Smirnov test. It was found that number of pigeons with heavy infection from Sanam Luang and Lumpinee Park were more than Dusit Zoo and Chonburi; and number of pigeons with heavy infection from Sriracha was more than Chonburi. In this study, morphological data are not directionally correlated with parasite intensity. The trend of immature parasite intensity increases with high humidity (r_s=0.296, P=0.005),and high precipitation (r_s=0.292, P=0.005) and decreases with high temperature (r_s=-0.296, P=0.005). It can be concluded that the climatic condition in different sites is likely to be the main reason for heavy infection of parasites.

Department	Biology	Student's signature.....
Field of study	Zoology	Advisor's signature.....
Academic year	2000	Co-advisor's signature.....

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Chapter 1

Introduction

Pigeons are the most ancient domestic animals in the world. They were originally used as utility birds (meat, fertilizer, and feather products), and were later used for sport and as carriers of information and, more recently, as laboratory animals (Robert et al., 1997). They are grouped under Class Aves, Order Columbi, Family Columbidae, Genus *Columba*, Species *livia* (Lekagul and Round, 1991). They usually spread out in the whole world. They are cultural and religious symbols, a source of food, and used as pets (Cooper, 1984 cited in Dranzoa, Ocaido and Katete, 1999). At present, they are fancy animals sold in many ways including on the INTERNET. In addition, they are used in several fields. For instance, there is a study about the extraction of *Haemoproteus columbae* antigen from pigeons and its use in an antibody ELISA (Graczyk, Michael and Shiff, 1994). Moreover, they can be used as a monitor of manganese contamination in environments (Loranger et al., 1994). Therefore, the importance of pigeons is obvious.However, these birds can be carriers of many diseases. For example, they can be the cause of pneumonitis (Severien, Artlich and Jonas, 1998). Moreover they can be hosts of many parasites, such as endoparasites, ectoparasites, blood parasites, bacteria and virus (Altman et al., 1997).

1.1 Pigeon basic information

Robert et al. (1997) contended that pigeons are the most ancient domestic animals in the world. They were originally used as utility birds (meat, fertilizer, and feather products), and were later used for sport and as carriers of information and, more recently, as laboratory animals.

The Order Columbiformes consists of three families, Columbidae (pigeons), Pteroclididae [two genera, 16 species]) (sandgrouses), and Raphidae (the extinct dodos). The family, pigeon (Columbidae) is divided into Columbinae [21 genera, 46 species]) (green pigeon), Didunculinae ([one genus, one species] (pigeons). The pigeons commonly kept by private owners are

classified in the genera true pigeons (*Columba* sp. [13 species, including the rock pigeon (*Columba livia*)]), turtle doves (*Streptopelia* sp. [eight species]), and ground doves (*Geopelia* sp. [two species] and *Gallicolumba* sp. [three species]).

There are at least 800 varieties of homing and racing pigeons, fancy or ornamental pigeons, and tumbler pigeons. The domesticated pigeon that have returned to the wild are also descended from the rock dove and are called city or street pigeons or, incorrectly, feral pigeons. The number of these city pigeons worldwide is estimated at approximately 500 million.

Anatomy and physiology

Weight of pigeons ranges from 50 g (diamond dove, *Geopelia cuneata*) to 1300 g (crowed pigeon, Gourinae). The average weight of the homing pigeon is 400 g. They may live 20 to 30 years.

From the cranium to the crop,both genders possess a vascular plexus in the cutis that is dorsally divided into left and right portions that are separated by a 1-mm-while gap in the median plane. It is called the plexus venosus intracutaneus collaris and is used for sexual and territorial display and regulation of circulation and body temperature. Injection of or damage of this plexus, especially during display and hot weather, can cause a fatal hemorrhage. By administering injections only in the distal third part of the neck, dorsally, this problem can be prevented (Altman et al., 1995). In addition, pigeons use small home ranges, and there is very little exchange between adjacent populations despite their proximity (Sol and Senar et al., 1995).

The normal cloacal body temperature rages from 39.8 ^{o}C to 43.3 ^{o}C and is dependent on the state of excitement, vigor of flight, and ambient temperature. The heart rate of homing pigeons ranges from 180 to 250 beats per minute.

Nutrition

The natural feed of the Columbidae consists mainly of cereals, peas, beans, lentils,and oil-containing seeds. Many free-ranging doves and pigeons feed on other cultivated plants, berries, and other fruits and on animals (insects, snails, earth-worms) (Altman, et al., 1995). Furthermore, young free-ranging rock doves (*Columba livia*) were poorer competitors in foraging than adults (Sol et al., 1998).

Reproduction

In the wild, pigeons breed in caves; half-dark nests; or in open, poorly tended nests consisting of twigs or similar material. They normally lay two eggs. In captivity, reproductive timing is almost completely related to the showing and racing season and the playing system.

All pigeons are considered monogamous, and the sexes cannot always be distinguished with certainly. Both partners share sitting on eggs; the male prefers the daytime. The eggs hatch after 13 days for the turtle doves and diamond doves and after 17 to 19 days for homing pigeons.The nestlings fledge after 3 to 4 weeks and are able to fly well after 35 days. The molt starts normally during the second nest and is completed after 3 to 4 months. The chicks are sexually mature between 4 and 6 months of age, and reproduction continues until 10 years of age. Poor winters with little sunshine, relatively high temperatures, and high humidity are associated with more reproductive problems than freezing, dry periods with bright sunshine (Altman et al., 1995).

Ewins and Bazely (1995) revealed that at colony site of feral rock doves (*Columba livia*) in Toronto, Ontario, breeding in 1991-1994 occurred in every month of the year. Numbers of active nests and reproductive success peaked in winter (November-April), and were much lower in summer (May-October).

Earle and Little (1993) explored haematozoa from the large numbers of feral rock doves (feral pigeons) *Columba livia* and rock pigeons *C. guinea* fly daily in mixed flocks between roosting and nesting sites in Cape Town, South Africa, and feeding sites in farmlands north of the city during the austral summer. An

explanation for significantly higher infection by *Haemoproteus columbae* in feral pigeons than in rock pigeons in the south-western Cape might be related to nest site locations and availability (Altman et al., 1995).

Table 1-1 The most common infectious problems in racing pigeons (*Columba livia*) (Atman et al., 1995)

Endoparasites	
Nematoda	*Ascaridia columbae* *Capillaria obsignata* *Tetrameres* spp. *Acuaria* spp.
Cestoda	*Aporina delafondi* *Hymenolepsi* spp. *Raillietina* spp.
Trematoda	*Echinoparyphium paraulum* *E. recurvatum*
Protozoa	*Elmeria labbeana* *E. columbarum* *Trichomonas columbae* *Hexamita (Spiranucleus) columbae*
Ectoparasites	*Columbicola columbae* (slender pigeon louse) *Campanulotes bidentatus (Goniocotis) compar* (small pigeon louse) *Falculifer rostratus* (feather damaging mite) *Megninia columbae* (quill mite) *Knemidokoptes laevis* (depluming and scaly mite, seldom seen in pigeons) *Dermanyssus gallinae* (blood sucking mite)
Blood Parasistes	*Haemoproteus* spp. *Leucocytozoon* spp. *Plasmodium* spp.
Bacteria	*Chlamydia psittaci* *Salmonella typhimurium* *Escherichia coli* *Streptococcus bovis*
Viruses	Pigeon paramyxovirus Pigeon pox Herpesvirus Adenovirus Circovirus

1.2 Common avian blood parasites

Parasites are often found in peripheral blood films of birds. The genus identification of the common avain blood parasites can usually be made from the microscopic characteristics of the organism on a peripheral blood film stained with Wright's or Giemsa stain. The common blood parasites of birds are *Haemoproteus*,

Plasmodium, *Leukocytozoon*, and microfilaria. Blood parasites seen less commonly include *Atoxoplasma sp.*, *Aegyptianella sp.*, and *Trypanosoma sp*.

Haemoproteus

Parasites of the genus *Haemoproteus* occur only in birds and are commonly found in the peripheral blood of many species of wild birds. *Haemoproteus* has worldwide distribution. The organism is transmitted by bloodsucking insects (primarily the hippoboscid, or louse fly), which serve as the intermediate hosts. The mature gametocyte occupies over one-half the erythrocyte cytoplasm. Mature gametocytes have refractile, yellow to brown pigment granules. Macrogamonts stain blue with Romanowsky stains and have pigment granules dispersed throughout the cytoplasm. Microgamonts stain pale blue to pink and have pigment granules gathered into a spherical mass. When this occurs, the macrogametes appear as small spindle-shaped structures. The number of gametocytes seen in the peripheral blood varies with the age of the bird, degree of stress, and season.

Schizogony of *Haemoproteus* occurs in endothelial cell of blood vessels in various tissues of the body, especially the lung, liver, and spleen. Mature schizonts in endothelial cells may be found in imprints from the lung, liver, spleen, or bone marrow. The endothelial cell is enlarged and contains numerous multinucleated bodies (cytomeres) surrounded by a delicate cyst wall.

Plasmodium

Parasites of the genus *Plasmodium*, which cause avian malaria, have a worldwide distribution. A number of avian species serve as the definitive host for *Plasmodium*; however, the organism is most commonly found in passerine birds. Mosquitoes (*CulexI* and *Aedes*) serve as the intermediate host. *Plasmodium* can be pathogenic to canaries, penguins, domestic poultry, ducks, pigeons, and falcons. Many birds, especially in endemic areas and primarily in the fall in other areas where there is an increase in the mosquito population. Clinical signs of avain malaria include hemolytic anemia, leukocytosis, lymphocytosis, hemoglobinuria, and acute death.

Detection of *Plasmodium* is based on the presence of intraerythrocytic gametocytes (pigmented), trophozoites, and schizonts in the Romanowsky-stained peripheral blood films. The organism can also be found in thrombocytes, leukocytes, and endothelial cells. Certain species of *Plasmodium* have round to irregular gamonts that displace the nucleus of the host cell; other species have elongate gamonts that usually do not displace the host cell nucleus. Macrogametocytes of *Plasmodium* stain a deeper blue than do microgametocytes, and their nuclei appear less diffuse than those of microgametocytes. The gametocytes contain refractile, yellow to brown pigment granules.

The trophozoite, which develops after the merozoite enters the erythrocyte, is a small, round to oval form with a large vacuole that forces that parasite nucleus to one pale, resulting in a “signet-ring” appearance. Early trophozoites undergo schizogony to produce merozoites. The number of merozoites produced depends on the species of *Plamodium*.

Schizonts are round to oval inclusions within the erythrocytes. These inclusions contain the deeply staining merozoites. *Plasmodium* can be differentiated from *Haemoproteus* by the presence of schizonts in peripheral blood, the occurrence of forms within thrombocytes and leukocytes, and the marked displacement of the erythrocyte nucleus by the parasite.

Leukocytozoon

Parasites of the genus *Leukocytozoon* occur in a number of species of wild birds. They are transmitted by black flies (*Simuliidae*). The pathogenicity is usually low, but *Leukocytozoon* can be pathogenic to waterfowl, turkeys, and occasionally young raptors. The clinical signs include anorexia, hemolytic anemia, hemoglobinuria, depression, and dehydration.

Leukocytozoon is identified by the presence of round to elongated gametocytes in the peripheral blood. The gametocytes grossly distort the infected host cell, causing the cell to become distended and elongated. The host cell nucleus appears as a long, thin, flat structure lying along one side of the cell. The

identification of the host cell for the gamonts is usually difficult because of the distorted appearance; however, many parasitologists believe that immature erythrocytes rather than leukocytes serve as the host cell. Parasitized cell have tapering ends and appear to have tapering ends and appear to have two nuclei (one host cell nucleus and one parasite nucleus). Macrogametes stain dark blue with a diffuse, pale blue with a diffuse, pale pink nucleus. Gametocytes of *Leukocytozoon* do not contain the refractile pigment granules found in the gametocytes of *Haemoproteus* and *Plasmodium*.

Schizogony occurs in endothelial and parenchymal cells of the liver, heart, kidney, and tissues. Schizonts are not found in the peripheral blood. Schizonts are large and may be found on impression cytology. Hepatic schizonts may be found in hepatocytes. Megaloschizonts develop within lymphoid cells and macrophages of various tissues.

Microfilaria

Microfilaria occur in a wide variety of birds. The number of microfilaria observed in the peripheral blood of birds may show diurnal variation. Microfilaria are immature forms of filarial nematodes. The adult filarial nematodes are usually undetected and may occur in the air sacs, thoracic and abdominal cavities, or joints. The vectors for microfilaria are biting insects, such as mosquitoes or blackflies (*Simuliidae*). Most cases are considered nonpathogentic.

***Atoxoplasma* (formely *Lankesterella*)**

Atoxoplasma is a parastie of mononuclear leukocytes (lymphocytes, monocytes, and macrophages). Most infections occur in passerine birds, and the disease can cause a high mortality in young canaries. The parasite is transmitted by mites, such as the red mite (*Dermanyssus gallinae*).

Atoxoplasmosis is diagnosed by the demonstration of the characteristic sporozoites within mononuclear leukocytes in the peripheral blood films or in cytology imprints of the liver, spleen, or lung. The sporozoites are pale-staining, round to oval intracytoplasmic inclusions that indent the host cell nucleus to form the

characteristic crescent-shaped nucleus. The sporozoites do not contain pigment granules.

Aegyptianella

Aegyptianella is a red blood cell parasite of birds found in the tropics and subtropics. Because of its limited distribution, this parasite is found primarily in recently imported birds in USA. *Aegyptianella pullorum* occurs in chickens, geese, ducks, and turkeys. Other *Aegyptianella* species parasitize other avian species. Three forms occur within erythrocytes: (1) initial bodies, which are anaplasmalike organisms that appear as small (less than 1 μm in diameter), round, basophilic intracytoplasmic inclusions; (2) developing forms that resemble *Babesia* (*Aegyptianella* differs from *Babesia* in that the erythrocytic forms divide several times); and (3) large oval, elliptical, or round forms measuring 2-4 μm in length (Campbell, 1995).

Trypanosoma

Most birds harbour trypasomes. The parasites may be slender or large and striated. The transmission cycle is not well known; various vectors are suspected: Culicidae, Pupipara flies, tsetse flies, *Simulium*, mites. At least 78 species of avian trypanosomes have been identified, among which are *T. avium, T. bouffardi, T. gallinarum* and *T. numidae* (C.A.B International, 1989).

Trypanosomes are common in wild birds, especially in passerines, galliforms, waterfowl, and pigeons. Trypanosomes are transmitted by biting insects (e.g., mosquitoes, hippoboscids, and blackflies) or mites (*Dermanyssus gallinae*). These parasite is diagnosed by its characteristic features in Romanowsky-stained films from peripheral blood or bone marrow. Avain trypanosomes resemble those found in mammals. They have a short, anteriorly directed flagellum, an undulating membrane, and a slender, tapering posterior end (Campbell, 1995).

1.3 ***Haemoproteus columbae*** **(Kruse, 1890)**

The pigeon is infected when bitten by Hippoboscid or Culicoides. Sporozoites enter the blood and invade the endothelial cells of the blood vessels (http://www.allpets.co.za/varenmed/malaria.htm). The type specimen of *Haemopreteus columbae* (Kruse, 1890) was obtained by Kruse from domestic pigeons in Naples. *Haemoproteus columbae* is a cosmopolitan parasite and is common in domestic pigeons in most parts of the world.

Sporogony

The common ectoparasitic fly, *Pseudolynchia canariensis* (= *Lynchia maura*), transmitted *H. columbae* by biting clean pigeons, but it was not until nearly 20 years later that the full details of sporogony were elucidated in the Sergents' laboratory in Algiers (Edmond & Etienne Sergent, 1906 cited in Garnham, 1966). The role of these flies in transmission was confirmed by various observers was carried out in the laboratory. The vectors in Brazil are *Microlynchia pusilla* and *Pseudolynchia brunea*. The cycle in hippoboscid fly (*Ornithomyia avicularia*) resembles that in *Lynchia*.

Natural and experimental infections in all these species of flies have been found. Exflagelation occurs within a few minutes at room temperature, and can be observed under a coverslip (MacCallum, 1898 and Opie, 1898 cite in Garnham, 1966). Baker (1966) watched exflagellation of the species in wood-pigeon, and found that process occurred readily at 28 ^{o}C, but not 20 ^{o}C; this difference was due to the fact that in nature exflagellation takes place in the ectoparasitic fly, which live at the higher temperature on the surface of the bird's body (Baker, 1966 cited in Garnham, 1966). Four to eight whip-like microgametes are produced, which quickly break away from the microgametocyte; they are slender bodies, about 21-24 μ in length and with a thick central nucleus (Garnham, 1966). While, Sloss and Kemp

(1978) reported that adult female and male gametocyte size is 8 μm long x 1-2 μm wide.

The zygote soon assumes an elongated form, and the ookinete reaches up to 23 in length. Sergents (1906) noticed that the yellowish-brown pigment collected in the posterior third of the body, but lies nearer the narrower end (Sergent, 1906 cited in Garnham, 1966). The anterior end is swollen and is occupied by a red-staining zone. The cytoplasm tends to retract slightly from the covering membrane of the ookinete, and it contains several large clear vacuoles. The posterior massing of the pigment, or even its extrusion, seems to be a special feature of *Haemoproteus*. The ookenete makes its way through the epithelium of the mid-gut, and encysts between the muscular layers.

The earliest oocysts are identifiable when they are 4 days old, when they become visible in fresh preparations as little glistening bodies, protruding usually from the posterior third of the gut wall, and successive examples can be seen if the intestine is rolled on the slide. At this stage, the pigment is in form of round dark particles, and the oocyst is about 8 μ in diameter. On the sixth day it has grown to 13 μ; on the seventh day, 21 μ; on the eight day, 35 μ, and on the ninth day, at maturity, the oocyst measures about 40 μ, at least in flattened specimens under coverslip. Fixed specimens of oocysts tend to be smaller. “Sporoblasts” or “cytomeres” form during the later stages of sporogony, and on the ninth day, coarse striations representing bundles of sporozoites can be detected. The cyst wall is thin and the body is easily ruptured, when multitudes of sporozoites escape.

Sporozoites appear in the salivary glands on the tenth day, and are curved or spindle-shaped bodies, with one tapered and one blunt end. The nucleus is usually subcentral and may bulge out from the surface; it is sometimes in the form of a single compact mass or may be split into several portions. A reddish staining is occasionally visible near one extremity.

Various measurements of the sporozoites of *H. columbae* have been recorded that they are 7-11 μ in length. They are thus rather shorter than those of most species

of *Plasmodium*, while the width is greater, usually just under 1 μ (Adies, 1924; Mohamed, 1958; and Baker, 1966 cited in Garnham, 1966).

The flies remained infected throughout the winter in Algiers, and transmitted the organism to young squabs in the spring (Adie, 1924 cited in Garnham, 1966).

Exoerythrocytic schizogony

Aragao (1908) noticed that the blood of pigeon nestlings was invaded by small rings within 20 days of hatching, and that species of *LynchiaI* were the vectors of the parasites. By inoculation infective flies, or allowing them to bite, he obtained heavy infections in the pigeons, and although he failed to trace the direct development of the sporzoite, he discovered profuse schizogony in the lungs after 13 days (Garnham, 1966). Schizonts are formed in the endothelial cells. Schizonts undergo multiple fission and for 15 or more cytomeres (http://www.allpets.co.za/varenmed/malaria.htm). Aragao noted that the appearance, first, of a small uninucleated body, 3-4 μ in size, within a "leucocyte" (= endothelial cell) of a capillary in the lung; this divides into twelve to fifteen corpuscles or cytomeres after a further 2 days' development (Aragao, 1908 cited in Garnham, 1966). The nucleus in each cytomere divides repetedly and the body grows inside a delicate membrane, the whole parasite measuring about 60 μ at this time. Further growth occurs, and the cytomeres or "cysts" break free and continue to grow up and down the capillaries, sending out branches along the bifurcations of the blood vessels, so that the whole schizogony, the nuclei become concentrated on the periphery of each cytomere; finally, about 25–30 days.(Garrham, 1966 and http://www.allpets.co.za/varenmed/malaria.htm). Days after the insect bite, the last segmentation occurs, and each granule of chromatin becomes clothed with an envelope of cytoplasm to form a merozoite. Thousands of merozoites are the end product of each schizont; the parasite burst and the merozoites are set free into the blood stream where they grow into gametocyes.

Certain merozoites return to endothelial cells to continue the tissue cycle, but these secondary gerneration are transitory and exoerythrocytic development soon declines to negligible proportions. Two kinds of schizonts, corresponding to the alleged

macro- and micro-schizonts, can be seen in lung sections or smears. The nuclei of the former are twice as large as those of the latter, and the cytoplasm stains a brighter blue colour with Giemsa's stain. In the later stages, cytomeric differentiation may be lost, and the schizonts bear a remarkable resemblance to the tissue forms of *Plasmodium gallinaceum*.

Table 1-2 Incidence of *haemoproteus columbae* in wild birds (Livine & Kantor, 1959 cited in Garnham, 1966)

Columba fasciata	*Columba rufina*
Columba guinea	*Streptopelia senegalensis*
Columba livia	*Streptopelia humilis*
Columba oenas	*Zenaida asiatica*
Columba palumbus	*Zenaidura macroura*

The asexual cycle of *H. columbaeI* is largely confined to endothelial cells in the small capillaries of the lung; schizonts are less frequently found in the liver and spleen. Rendtorff et al. (1949) were able to produce infections in clean pigoens by inoculating intramuscularly, suspensions of macerated lung (Rendtorff et al., 1949 cited in Garnham, 1966). The results, however, were erratic, the prepatent period was delayed up to 7 weeks, and parasitaemia was low; it was thought, therefore, that few viable parasites were present in the inoculum.

The minimum duration of the preerythrocytic phase is not precisely known (14-28 days) (Aragao, 1924; Sergents, 1906; Mohamed, 1958; and Rendtorff et al., 1949 cited in Garnham, 1966)

Gametocytes

The merozoites invaded erythrocytes are only about 1 μ in size and multiple infections are so common, that a dozen little rings may be found in a single cell. Only one or two, however, manage to survive, but eventually an infection develops in which more than a third of the corpuscles are parasitized. Growth continues for 5 or 6 days when the parasites apparently reach maturity. Rendtorff et al. (1949) determined the actual time when gametocytes become mature by feeding *Pseudolynchia carnariensis* on pigeons on various days in the initial phase of

gametocytaemia; the flies did not become infected until between the eighth and tenth day.

As the parasite increases in size, it elongates, first lying alongside and then growing around the nucleus, which may be slightly displaced laterally. Granules of dark brown pigment appear in the cytoplasm, small in the female and much bigger in the male. The nucleus of the young macrogametocyte is wider and may have an irregular border.

The mature macrogametocyte (14 μ in length) grows around the nucleus to give rise to the typical "Halteridium" form; the granular cytoplasm stains a deep blue colour and contains about fourteen small dark brown pigment granules. The nucleus is small, and often the centriole lies quite apart.

The mature male (13 μ in length) is less Halteridium-shaped and apart from the usual difference in colouration, is distinguished from the female by the huge pigment granules, numbering about six to eight and grouped at the two extremities of the parasite. The nucleus is light and diffuse, and in it are embedded several more deeply staining dots.

Ralapse of gametocytaemia occur at irregular intervals in the course of the infection, which Coatney (1933) ascribes to a sudden fail in immunity mechanism of the pigeon. If this is the true explanation, the inhibitory process is presumably directed against the exoerythrocytic stages, because gametocytes, as such, are thought to be unaffected by immunity.

Vertebrate host

Columbiform birds are the hosts of *H. columbae*, and Table gives a list of species in which this parasite or closely related species have been found, the incidence rising from young nestlings to juveniles and varying from a very low figure in certain regions, to 100% in others. Several closely related species may be concerned in this *H. columbae* complex, of which *H. sakharoffi* and *H. maccallumi* have been particularly studied. Considerable host specificity is evident amongst some of these parasites, and Baker (1963) failed to transmit the *Haemoproteus* of the

wood-pigeon to the domestic pigeon, though succeeding readily enough from wood-pigeon to wood-pigeon. Huff (1932) on the other hand transmitted the parasites of the mourning dove to the domestic pigeon. *H. columbae* fails to infect canaries via the bite of infected hippoboscids.

Pathology

H. columbae must be pathogenic to some extent, because the crisis of parasitaemia, nearly half of the erythrocytes contain gametocytes. The liver becomes enlarged and congested, and the spleen is black and hypertrophied. Levine (1961) states that in heavy infections, the pigeons appear restless and go off food, and anaemia may result from the destruction of erythrocytes.

In the early stages of the infection, the lung forms the chief site of the exoerythrocytic development of the parasite. Considerable cellular infiltration occurs in the alveolar septae, and the air spaces become occluded an almost pneumonic degree. Thus the condition at this stage may be termed an interstitial pneumonia, though leucocytes and eosinophiles are absent (Garnham, 1966).

Coatney (1933) has documented that the number of parasites of *Haemoproteus columbae* in the blood of birds at the peak of a beginning infection and the rate of their destruction during the crisis show wide variations among individual birds. Heavy infections may be pathogenic. No periodicity of gametocyte production was discovered. Small numbers of gametocytes may persist in the blood from 17 to 68 days. The resistance mechanism operating within the body of bird is thought to conditions of food, temperature and light. Relapse is regarded as entirely sistinct rom any possible periodicity of sporulation or any other cyclical phenomenon. The frequency of relapse is held to linked up with the activity of the resistance mechanism. When this mechanism is operating at a low level, relapse may occur; at any other time they are inhibited. A quantitative study of an extended infection in two birds showed wide differences in the degree of susceptibility to *Haemoproteus* infection. Re-infection is possible after recovery from an initial infection. Relapse in *Haemoproteus columbae* infections can not be induced by artificial provocatives such as adrenalin, normal horse serum, ultra violet light or

starvation. The infection may be transferred from one bird to another by injecting parasitized lung tissue, but was found to be impractical as a routine procedure. Mourning doves (*Zenaidura macroura carolinensis*) are not susceptible to *Haemoproteus columbae* of the pigeon.

Ectoparasites in pigeons

The Pigeon Fly

The pigeon fly (*Pseudolynchia canariensis*) is of sufficient importance as a parasite to warrant the attention of those who raise pigeons as messengers in the military service, for food, for the study of diseases or of genetics, or simply as a hobby

This peculiar, bloodsucking flies feed only upon pigeons or closely related birds and breed in association with them. The flies attack squabs soon after the latter hatch and live and move about with ease among the closely set feathers of the adult pigeons. The loss of blood and the irritation caused by the flies are distinctly injurious to both squabs and adult birds. The flies also transmit the organism *Haemoproteus columbae*, which causes pigeon malaria, serving as its intermediate host.

A little smaller than a housefly and very active, the pigeon fly is a parasite only of pigeons and their close relatives. Bishopp describes how the insect craws rapidly about among the feathers and sucks blood from both adult birds and squabs. In addition to causing irritation and loss of blood, it carries the pigeon malaria organism. It also bites human beings.

The fly lays neither eggs nor larvae, but pupae already formed, from which adult flies emerge, usually in about a month or less. These egg shaped pupae tend to drop to the bottom of the nest boxes. The simplest way to control the pest, then, is to clean the nests and floors thoroughly every 25 days. The trash should be burned, or stored in a screened manure pit or bin equipped with a fly trap, or promptly spread and plowed under. Thorough soaking with a high-grade pyrethrum-kerosene spray will also kill the pupae.

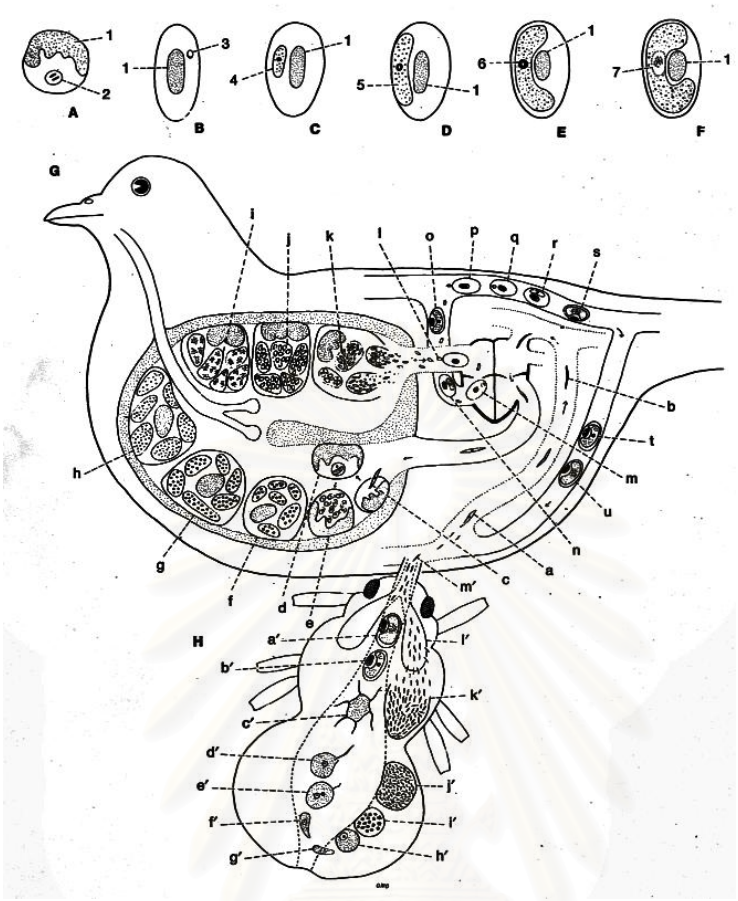

Fig. 2.2. Life history of *Haemoproteus columbae*. **A**, Mononuclear leucocyte with the parasite. **B**, Erythrocyte with a ring stage of a gametocyte. **C** and **D**, Growing gametocytes. **E**, Macrogametocyte. **F**, Microgametocyte. **G**, Pigeon host.. **H**, Pigeon louse fly *(Pseudolynchia canariensis)* invertebrate host. *1*, Nucleus of a blood cell; *2*, young schizont; *3*, ring stage of a gametocyte in an erythrocyte; *4* and *5*, growing gametocytes; *6*, nucleus of a mature macrogametocyte; *7*, nucleus of a mature microgametocyte. *a* to *u*, In pigeon; *a*, sporozoite injected into the bloodstream; *b*, sporozites in blood go through the heart to the lungs; *c*, sporozoite entering an endothelial cell in the lungs; *d*, growth of the sporozite in the endothelial cell; *e* to *k*, schizogony in endothelial cells; *e*, formation of uninucleate cytomeres (the host cell enlarges at the parasite grows); *f* and *g*, cytomeres become multinucleate; *h*, cytomeres with a large number of nuclei; *i*, great increase in the number of small nuclei; *j*, formation of numerous minute merozoites in schizonts; *k*, escape of merozoites from schizonts into the bloodstream (this process of schizogony may be repeated); *l*, merozoite entering a red blood cell; *m* to *u*, gametogony in erythrocytes; *m*, ring stage in an erythrocyte; *n* and *o*, forrmation of a macrogametocyte; *p*, merozoite entering a red blood cell; *q*, ring stage; *r* and *s*, formation of a microgametocyte; *t*, mature macrogametocyte; *u*, mature microgameocyte in the general circulation. *a'* to *l'*, In pigeon louse fly; *a'*, microgametocyte and, *b'*, macrogametocyte sucked up by the pigeon louse fly; *c'*, exflagellation fo the microgametocyte with formation of microgametes; *d'*, macrogamete being fertilized by a microgamete; *e'*, zygote; *f'*, ookinete in stomach; *g'*, ookinete migration through the epithelium of the stomach; *h'*, young oocyst betwiin the epithelium and basement membrane; *i'*, oocyst with sporoblasts; *j'*, ripe oocyst filled with sporozoites; *k'*, rupture of ripe oocyst and liberation of sporozoites; *l'*, migration of sporozoite into salivary glands; *m'*, injection of sporozites into the blood by the feeding pigeon louse fly. (From Olsen, O. W. Animal parasites: their life cycles and ecology. 3d ed. Baltimore: University Park Press; 1974 cited in Farmer, 1980)

Adult flies on squabs can be killed by applying two or three pinches of pyrethrum, debris, or cube powder. Kerosene extract of pyrethrum kills the flies on adult birds or squabs, and also in handling and killing rooms. When used on the birds, it should be applied with great care. Once a loft has been freed of pigeon flies, Bishopp emphasizes, it should be kept free.

The pigeon fly is slightly smaller than the common housefly, flat, and brownish. It has a rounded abdomen, rather long wings, and a stout beak (fig.). Its flight is quick and erratic and it does not usually leave the birds and take wing unless it is considerably disturbed. When driven off the host, it usually alights on some nearby object, especially a moving object, and in buildings it often goes toward the light at windows or open doors.

On grown pigeons the flies may be found on any part of the body. They crawl rapidly from place to place on or among the feathers, often moving backwards or sideways. Squabs often become heavily infested especially when they are partly feathered, the flies usually congregating at the base of the feathers of the tail and wings.

Both male and female flies suck blood. They leave no marked evidence of their bites on pigeons but evidently annoy them a great deal. They frequently bite human beings, especially where squabs are dressed for market, and often very annoying to the workers. The points of attack may continue to show signs of irritation for 4 or 5 days

The flies are active on the pigeons throughout the winter in the warmer parts of the country, though their numbers diminish markedly toward spring. The insect has the peculiar habit of retaining its larvae until they have pupated. The fly gives birth to the ovoid pupae one at a time. The pupae are about one-eighth of an inch long, at first pale yellowish in color but soon turning brownish, and within about 3 hours becoming shiny black. They are usually deposited while the flies are on the pigeons and may hang temporarily in the feathers, though they soon drop off among the nest material, where they usually fall through to the bottom of the nest

boxes. At an average temperature of 73^{o} F the pupal stage lasts 25 days during hot weather to 31 days or longer in cold weather.

The fly emerges by pushing open the front end of the hard pupa case, which splits along a definite line running around the case about one-third of its length from the head end. The fly is pale and soft at first, but it soon hardens, turns brown, and is ready to take a meal of blood (Bishopp cited in United States Department of Agriculture, 1942).

Columbicola columbae (Linnaeus)
Comon name: Slender pigeon louse
Classification: OrderMallophaga; Family Philopteridae
Known distribution: worldwide:
Host: pigeons
Biology: These lice feed on the barbules of the feather, nearly always near the proximal enc. Adults are commonly found on flight feathers of the wing, and nymphs are found on the feathers on the back of the head. Eggs are laid at the rate of 0.3 to 0.5 per day and require 3 to 5 days to hatch. The first-instar nymph requires 7 days to develop, and the second and third-instars require 6 to 8 days each. Adults have been recorded to live for as long as 51 days and to lay as many as 60 eggs (William et al., 1985).

Pigeons are subject to the attacks of six species of lice. Some of these are to be found on the birds in practically every pigeon loft, but they seldom become sufficiently abundant to cause marked ill effects. Carrier pigeons and show birds frequently have damaged feathers, and some owners attribute this to lice, particularly the large body louse. The damage in such case adversely affects the appearance of the birds are probably also their speed and endurance in flight (United States Department of Agriculture, 1942).

Argus reflexus

This species is known as the pigeon tick because of its close association with this host. It is abundant in Middle- and Near- East, whence it has spread it Europe and most of Asia.

Morphology: the adult *Argus reflexus* is between 6 and 11 mm in length. Its body margin composes of irregular grooves and the hypostome does not notch apically (Fig.). It is reddish brown in color with pale legs.

Life cycle: It is nocturnal and during the day lives in crevices in the pigeon house or nest material. It can withstand prolonged periods of starvation.

Pathology: heavy infestations may cause death from anaemia. It may also transmit fowl spirochaetosis (Wall and Shorer, 1997).

As for other kinds of avain, there are many studies on blood parasites with several variables. For instance, in Missouri (USA), hematozoa of wood ducks (*Aix sponsa*) were examined for hematozoa from two localities in 1989-1990. There was no difference in prevalence between sex, location, or year. Based on seasonal prevalence, transmission probably did not occur at either location in the summer. Increased prevalence in the winter samples occurred after northern wood ducks migrated into the sample (O'Dell and Robbins, 1994). As for another example, Boonkong and Meckvichai (1987), studied ectoparasites in tree sparrow (*Passer montanus*) in Bangkok throughout the year. The researchers mentioned that seasonal change has effects on the biology of some ectoparasites.

Accordingly, prevalence of ectoparasites, which can be the vectors of pigeon haemoparasites, may have locational and seasonal variations. To our knowledge, there are no studies which compare prevalence and abundance of pigeon blood parasites in different habitats which vary in seasons. Therefore, this study was conducted.

Objective

The main purpose of this present study is to explore pigeon haemoparasites with different habitats and seasons in a year.

Expected contribution:

This study may be used as a basis for haemoparasite control in free-living pigeons or pigeons in the aviary.

Chapter 2

Literature Review

2.1 Avain blood parasite studies

Up to the present, there have been many pigeon-parasite surveys. For instance, in Kampala, Uganda, thirty-four pigeons in different locations were studied for parasites from October 1966 to March, 1977. This study about ectoparasites revealed that pigeon fly *Pseudolynchia canariensis* had mostly prevalent (100%). The louse *Columbicola columbae* was next in prevalence, accounting for (94.1%). It is suspected that the pigeon fly transports this parasite (Dranzoa, Ocaido and Katete, 1999), although in Hawaii mosquito (*Culex pipiens*) was suspected (http://webdata.fsl.orst.edu/fresc/administrative/detail.php?projectID=253&cat=Wildlife). In addition, the lice of economic importance were found: *Menopon gallinae, Menacanthus stramineus* and *Chelopsis meleagridis*. Cestodes were the only helminths found, occurring in 23.5% of the birds. Haemoparasites were *Haemoproteus* sp. (76.5%) and *Plasmodium* sp. (29.4%) (Dranzoa, Ocaido and Katete, 1999).

Furthermore, in Sebele, Gaborone, and Bostwana, the following parasites were found in apparently healthy pigeons: a haemoprotozoan, *Haemoproteus columbae* cause of pigeon malaria (http://planeta.clix.pt/cf_hompage/diseases.htm) (80%); endoparasite metazoan nematodes, *Ascaridia columbae* (30%) and *Dispharynx spiralis* (10%); a cestode, *Raillietina* sp. (80%) and coccidian oocysts (40%); 2 ectopasite, namely the pigeon fly, *Pseudolynchia carnariensis* (50%) and the louse, *Columbicola columbae* (30%). The later infection in these domestic pigeons has a number public health implications (Mushi et al., 2000).

Moreover, in Thailand, there are several studies on pigeon parasites. First, Moungyai (1967) studied hemoparasite in pigeons and found that 60%

(24/45) of *Haemoproteus columbae* were found in pigeons from the lifestock breeding station in Surin Province in summer (April). Furthermore, 96% (23/24) of the same species and malaria parasites like *Plasmodium circumflexum* infected pigeons caught from Surin in the rainy season (June). Second, Komweerawong et al. (1981) investigated parasitic infection in 50 domestic pigeons caught in rainy season (September) from Surin and found ectoparasites: sucking louse (88% of 50 samples), biting louse (74%), mite (78%) and pigeon fly (8%); endoparasites: *Raillietina* sp. (82%), nematode *Ascaridia columbae* (10%), echinostome (6%) and *Eimeria* sp. (26%); and blood parasite *Haemoproteus columbae* (96%). Third, Un-art-ngarm (1994) found that endoparasite of 5 pigeons from Chulalongkorn University in Bangkok were infected with *Raillietina* sp. and *Cotugnia* sp.

Allander and Bennett (1994) have indicated that there were year and age class differences in both prevalence and mean intensity of haematozoan infections of a nest box breeding population of Great Tits on the island of Gotland in the Baltic Sea during 1990 and 1992. *Haemoproteus majoris* dominated with an overall prevalence of around 76%. The results of this study showed that older birds (≥ 2 years old) had a lower mean intensity of infection than young (1 year old) birds.

Deviche, Greiner and Manteca (2001) confirmed that prevalence of various hematozoa in adult passerine birds during the breeding season (May and June 1997-1998) in interior Alaska (USA) was bird species-dependent. No relationship was observed between prevalence and either foraging (aerial versus tree/shrubs) or nesting habits (ground versus arboreal) or general location of the wintering area of the different species examined. The researchers proposed that differences in blood parasite prevalence among species breeding in a same region and in the same type of habitat may result from differences in host specificity such as immunological resistance to infection or blood meal preference by potential vectors and/or in behavioral adjustments/physiological traits that alter exposure to vectors.

Merila, Bjorklund and Bennett (1995) reported that there were no consistent differences in prevalence of haematozoan infections between sexes or between older age-classes among greenfinch *Carduelis chloris* within nine geographically widely separated populations, but prevalence was significantly lower among yearling birds (<5 months old) in one population. However, this study has shown that significant differences in prevalence between Fennoscandian (high), central European (low) and Iberian (high) populations is consistent with hypothesis that destruction of natural habitats has led to a significant decline of vector populations in central Europe.

Bennett et al. (1995) investigated 3 Fenno-Scandian populations of pied flycatchres *Ficedula hypoleucaI* of haemotozoan parasites over the period 1989-1992. This study clearly shows the role of ecologically diverse conditions in determining the composition, transmission and prevalence of a blood parasite fauna presumably through their effect on vector composition and population density.

Greiner et al. (1975) collated and analyzed the literature pertaining to the prevalence of avian hematozoa in North America, north of Mexico, together with unpublished records. They maintained that a total of 21,048 (36.9%) birds harbored one or more species of *Haemoproteus* (19.5%), *Leucocytozoon* (17.7%), *Trypanosoma* (3.9%), *Plasmodium* (3.8%). They also proposed that sea- and shore- birds were nearly hematozoan-free. Furthermore, they have concluded that prevalence of blood parasites is considered on a localized geographic basis but no correlation exist when the results are pooled from the continent.

McClure et al. (1978) examined blood smears from over 55,000 birds of 1,132 species representing 77 families. The researchers concluded that prevalence of *Haemoproteus* was 11.3%, *Leukocytozoon* 2.7%, microfilariae 1.8%, *Plasmodium* 0.8%, and *Trypanosoma* 0.2%. They also maintained that other parasites (e.g. *Atoxoplasma, Akiba* and *Babesia*) were less commonly observed.

Work and Rameyer (1996) named a new parasite species *Haemoproteus iwa* found in great frigatebirds *Fregata minor* captured on Tern Island-French Frigate Shoals and Laysan Island in Hawaii.

In Thailand, Wina Wilasdachanont and Suthasanee Boonkong (1983) showed that tree sparrow (*Passer montanus*) were infected with three kinds of helminth. Plus, they reported that parasite prevalence differed in 5 sites examined in Bangkok.

2.2 Pigeon parasite studies

Dranzoa, Ocaido and Katete (1999) investigated prevalence of pigeon (*Columba livia*) parasites in three different locations in Kampala, Uganda during October (1996) and March (1997). They found endoparasites: cestodes (23.5%); ectoparasites: pigeon fly *Pseudolynchia canariensis* (100%), louse *Columbicola columbae* (94.1%), and three economic importance lice *Menopon gallinae, Menacathus stramineus* and *Chelopistes meleagridis*; haemoparasites: *Haemoproteus* sp. (76.5%) and *Plasmodium* sp. (29.4%).

Mushi et al. (1999) also reported that there was *Haemoproteus columbae* in 75% of blood smears prepared form 30 healthy domestic pigeons in Sebele location, Gaborone, Botswana. The researchers also reported that both the dexamethasone-treated and the central pigeons remained clinically normal.

Earle et al. (1993) pointed out that two doves from the same aviary died following heavy infections with *Haemoproteus columbae*. Histopathological examination of various organs revealed numerous schizonts and megaloschizonts. There seemed to be two cycles of schizogony, one within the muscles and another in a wide range of tissues. The shape and size of the schizonts appeared to be a function of the site of formation. The rupture of megaloschizonts, especially in the striated muscles caused extensive fiber necrosis and the resultant muscle damage, is believed to be the major cause of mortality.

Mushi et al. (2000) have reported that there are following parasites in apparently healthy domestic pigeons (*Columba livia domestica*) kept in Sebele, Gaborne, Boswana: endoparasite metazoan nematodes, *Ascaridia columbae* (30%) and *Dispharynx spiralis* (10%); a cestode, *Raillietina* sp. (80%) and coccidian oocysts (40%); 2 ectoparasites, pigeon fly *Pseudolynchia canariensis* (50%) and louse, *Columbicola columbae* (30%); and Haemoprotozoan, *Haemoprotues columbae* (80%).

Sol, Jovani and Torres (2000) investigated geographical varition in blood parasites in feral pigeon (*Columba livia*). This study has revealed that vector abundance is the major factor influencing that spatial variation in prevalence of *H. columbae* in pigeon.

Bennett, Earle, and Peirce (1992) found 4 species of *Leucocytozoon* in South African birds; *Leucocytozoon marchouxi* of the Columbidae (pigeons and doves), *L. caprimulgi* of the Caprimulgidae (nightjars), *L. grusi* of the Gruidae (cranes) and *L. tawaki* of the Spheniscidae (penguins). The researchers revealed that *L. turtur* is declared a synonym of *L. marchouxi*.

Bennett, Earle and Squiresparsons (1994) compared the linear measurements and derived indices from striated trypanosomes in nine species of sub-Saharan birds representing seven families of the Passeriformes. The dimensions of the straited trypomastigotes from the the Carduelinae, Estrildidae, Nectarinindae, Passeridae, Pycnonotidae, Turdinae and Zosteropidae were similar to each other as well as to those of the striated trypanosomes from the boreal owl (Strigidae). All these trypanosomes were considered to be *Trypanosoma avium* Danilewsky, 1885.

Crocco and Catala (1997) found that *Triatoma sordida*, widespread vector of *Trypanosoma cruzi*, does not have more host preference in guinea-pig than pigeon. In addition, the researchers stated that it is probably a generalist species that can invade a variety of habitats to exploit the range of available vertebrate hosts.

Bessot et al. (1997) stated that *Argas reflexus* is a soft tick belonging to the order of house dust mites. It is a specific blood-sucking parasite of pigeons, mainly city pigeons. These ticks live inside houses, especially in old urban housing and on higher floors due to the presence of pigeon colonies, and can bite humans, inducing anaphylactic reactions (urticaria, angioedema, anaphylactic shock, often recurrent). The allergens are presumed to be anticoagulant substances present in saliva.

Dautel, Scheurer and Kahl (1999) have contended that the European pigeon tick *Argus reflexus* is in central Europe predominantly an urban pest parasitizing wild and domesticated pigeons *Columba livia*. Under certain circumstances, however, it also bites humans, occasionally causing an IgE-mediated type-I allergy. Infestations were found in 17 out of the 21 districts, clustering in the inner city.

Godfrey and Pence and Fedynich (1990) observed two species of hematozoa, *Haemoproteus columbae* and *H. sacharovi*, on thin blood smears from populations of mourning doves (*Zenaida macroura*) in the Rolling Plains (dryland farming and grazing area) and Southern High Plains (an intensively cultivated and irrigated agricultural region with playa lakes) of western Texas (USA).

According to Martin (1993) eggs of pigeon louse, *Columbicola columbae* hatch in 4 days and nymphs pass through their three molts and reach maturity in about 3 weeks (Chandler and Read, 1961).

Toro et al. (1999) found *Trichomonas gallinae* in free-living urban pigeons *Columba livia* from the city of Santiago, Chile. They also found chewing lice (*Columbicola columbae* and *Campanulotes bidentatus compar*, and mite *Laminosioptes cysticola*), nematode (*Tetrameres* sp., *Capillaria annulata*, *Capillaria columbae*, *Capillaria obsignata*, *Ascarida columbae*, *Dispharyns spiralis*, and *Gongylonema ingluvicola*) and cestode (*Aporina delafondi*).

2.3 Studies of fluctuation asymetry and parasite infection relationship

Dawson and Bortolotti (1999) studied the pattern of blood parasitism in American kestrels (*Falco sparverius*). The researcher concluded that There were no sex differences in either prevalence or intensity prevalence, but prevalences were higher in young birds than older birds. Food supply had no effect on parasite load. Change in intensity between sampled in 1994 and 1995 was depended on year. Even so intensity remained relatively stable throughout the breeding season.

Rintamaki et al. (1997) indicated that prevalence of blood parasites in blood samples from three passerine bird species, collected during spring migration in the southwestern archipelgo of Finland did not differ between the sexes in Redstarts and between age classes in Robins and Lesser Whitethroats.

Rintamaki et al. (1999) found that prevalence of *Leucocytozoon* spp. and *Trypanosoma* spp. blood parasites in the redstart (*Phoenicurus phoenicurus*) was higher during the breeding season (48%) than during migration period (13%), with no age or sex differences in the breeding site birds.

Moller (1992) suggested that the degree of fluctuating asymmetry in tail ornaments, but not in other feather traits, of swallows *Hirundo rustica* reliably reveals the level of parasite infestation. He also implied that the ability of conspecifics to use the size and the expression of ornaments in assessment of phenotypic quality and thus in sexual selection.

2.6 The impact of haemoparasite on host

Coatney (1937) stated that during the summer an immature Mouring dove was found harboring a light infection of *Plasmodium relictum*. The infection was transferred to other doves and to the canary. In all these birds the infection was a light one. When inoculations were made to the pigeon very heavy infection of the same species was found in a common pigeon. This strain when passed to doves and canaries also produced light transitory infections. In the pigeon the infections were heavy and decidedly pathogenic. Two birds,

given plasmochin during the acute, recovered and now carry chronic infections. Infections have been maintained in the chick for 17 days, at this writing, by the “rapid passage” method.

Symptoms of pigeon infected with *Haemoproteus columbae* are very similar to plasmodiosis. This disease seen only in summer and has a definitive host, a fly haemografe (fed on blood), *pseudolynchia canariensis*. The intermediate host is pigeon. The flies that suck infected blood are able to transmit the haemoproteosis 15 days late and between 25 to 30 days later begin the symptoms such as recurrent fever (it raises and low) 43 ^{o}C , diarrea (white lees or yellowish, liquid and persistent), disnea (increase of the respiratory frequency) and gradual anemia, caquexia (weakness when the disease becomes chronicle). (http://planeta.clix.pt/cf_hompage/diseases.htm)

Nevertheless, Leng (1999) pointed out that there was no significant difference between the sexes of 33 rock pigeons in Singapore in terms of *Haemoproteus columbae* infection and the various health-immune variables ($p \geq 0.14$) such as haematocrit, haemoglobin concentration, total white blood cell count, lymphocyte count and non-lymphocyte count. It was also shown that parasitaemia did not correlate significantly with any of the health-immune variables ($p \geq 0.09$), except for the white blood cell count (QBC method) in September ($\tau = -0.39$, $p = -0.007$); parasitaemia also did not differ significantly between groups of pigeons with high- and low-albumin / IgG levels ($p \geq 0.59$).

Dale, Kruszewicz and Slagsvold (1996) have maintained that there are no effects of blood parasites *Haemoproteus* and *Trypanosoma* on sexual and natural selection in the pied flycatcher, *Ficedulla hypoleuca.*

Siikamaki et al. (1997) discovered that the most frequent blood parasites of the Pied flycatcher in central Finland were *Haemoproteus pallidus*, *H. balmorali* and *Trypanosoma avium complex.* However, they did not find evidence that these haematozoan parasites have any debilitation effects on either reproduction or survival.

Bennett, Peirce and Ashford (1993) have concluded a review of 5640 articles on avian blood parasites that 236 reported mortality or gross pathogenicity in birds, and 89% of them were concerned with mortality in domesticated birds and how to control the blood parasites involved. Only 6% of records concerned birds in zoological gardens; the remainder referred to mortality in wild birds.

Nordling et al. (1998) showed that in collared flycatcher *Ficedula albicollis* reproductive effort increasing increased the intensity of *Haemoproteus* infections. This study also showed that such infections are associated with higher mortality. In addition these finding provide support for the hypothesis that immune suppression caused by reproductive effort may be an important mechanism mediating the life-history cost of reproduction.

Rattio, Dufva and Alatalo (1993) have examined whether blood parasites in pied flycatcher, a small migratory passerine bird, have any effect on male arrival time. The researchers have discovered that male infected with *trypanosoma* arrived on average 2 days later than males without *Trypanosoma* infection. Infected males also had shorter tails and tended to have shorter wings. By contrast, there was no difference in male arrival time between males infected with *Haemoproteus* and healthy males.

Seutin (1994) found that 97 breeding redpoll finches (Aves; Carduelinae; *Carduelis f. flammea*) caught at Churchill, Manitonba was most commonly infected with *Leucocytozoon fringillinarum*, followed by three species of *Haemoproteus* ,and three *Trypanosoma avium*. Overall, almost two thirds of the individuals sampled had blood parassites, whose prevalence or incidence did not vary significantly over the sampling period (i.e. 24 d in June). In male (n=76), parasitic burden and size of red patches varied with host age, with one-year-old birds being significantly less frequently parasitized and less showy than older individuals. He concluded that when age was taken into account, there was no relationship between parasite prevalence or incidence and plumage redness in male birds. This study provides no support for the Halmilton-Zuk hypothesis, the evolution of secondary sexual characters is that variation in the expression of

these traits among conspecific individuals is reliable indicator of their parasitic burden.

Norrisk, Anwar and Read (1994) reported that blood parasite prevalence of great tits *Parus major* was higher in females than males. The prevalence of parasites in males increased with both increasing clutch size and increasing age. There was no evidence of similar effects in females. Plus, experimental manipulation of clutch sizes showed that males were more likely to be infected if they had naturally large clutches or when their clutch size was artificially increased. There was not evidence of such effects on female infection probability. Reproductive effort thus increases susceptibility of males to parasites throughout the breeding period.

Raidal and Jaensch (2000) have suggested that central nervous disease and blindness in Nankeen kestrels *Falco cencroides* due to a novel *Leucocytozoon*-like infection.

Dawson and Bortolotti (1997) found that hematocrits of both sexes American kestrels *Falco sparverius* declined with the time of day that sample was taken, and increased with the level of infection of the blood parasite *Haemoproteus*.

Dawson and Bortolotti (1997) discovered that plasma protein level of both sexes of American kestrl *Falco sparverius* did not vary significantly *Haemoproteus* sp. infection.

Mary and Remsen (1997) have stated that certain ornithophilic vectors are most common in the canopy, the relationship between nest height and parasite prevalence may follow from the natural history of parasitism. They have suggested that ecological conditions may influence blood parasite loads in the species studied, suggesting that genetically based resistance is less important. Also, they have proposed that if parasite vectors are more common in the canopy, then more colorful bird species will be more heavily parasitized, on average, than less colorful species, because bird species that live high in the trees tend to be more colorful than those that live closer to the ground.

Greiner (1970) examined mourning doves (*Zenaidura macroura*) for *Haemoproteus maccallumi* and *H. Sacharovi* infection in Lancaster County, Nebraska. He revealed that all developmental stages of *Haemoproteus* would exhibit long-term fluctuations in parasitemia levels but the nature of the fluctuations differed at the species level.

Hamilton-Zuk hypothesis of sosigonic selection argues that intensity of mate choice and corresponding ornamentation is positively related to pressure from parasites that are competent to engender positive heritability of fitness. Research into this idea has been controversial from study of John (1995) that total brightness and the number of birds parasitized by haematozoa related to the number of individuals examined (haematozoa relative presence) was not consistently significant.

Merila, Sheldon and Lindstrom (1999) provided a clear example of the negative association between plumage brightness and blood parasite loads in birds, and suggested that male plumage yellowness in the greenfinch *Carduelis chloris* can function of male quality.

Ots and Horak (1996) have concluded that experimental reduction of Great tits *Parus major* clutch size results in decreased intensity of *Haemoproteus* parasitemia, providing further evidence that individual great tits accept immunosuppression to increase their reproductive investment.

Ots and Horak (1998) maintained that infected individual Great tits were heavier than uninfected ones in the urban but not in the rural study area.

Ots, Murumagi and Horak (1998) contended that body mass and intensity of *Haemoproteus* infection in Great tits were the least variable state indices during the nestling period. Females had higher intensities of *Haemoproteus* infection, higher heterophile counts and higher heterophile/lymphocyte ratios than male.

Underhill and KaleitaSummers (1995) pointed out that the group of 464 passerine species with the highest brightness score had infection rates similar to the dullest group.

2.5 Fluctuating asymmetry and parasitic infection

Quek, Sodhi and Kara (1999) stated that intensity of Rock Pigeon parasites, the chewing lice *Columbicola columbae* and *Campanulotes bidentatus* and the haematozoon *Haemoproteus columbae*, in Singapore between June and September 1996 was not related to the magnitude of fluctuating asymmetry (FA) of the hosts.

Lee (1999) investigated in correlation between genetic similarity based on Random Amplified Polymorphic DNA (RAPD) analysis and fluctuating asymetry (FA) in the 45 Singapore rock pigeons. This study has revealed that genetic similarity (an indicator of inbreeding level) can enhance FA (wing, tail, tarsus and third digits) in some non-renewable traits of rock pigeons.

Chye (1997) examined 56 male and 38 female feral pigeon (*Columba livai*) caught from Tiong Bahru and Palmer road in Singapore between June and September (1996) to study the role of parasitisim on the developmental instability. Four species of parasites were found. There were the chewing lice *Columbicola columbae* and *Campanulotes bidentatus* (100%); the louse fly *Pseudolynchia canariensis* (13%) and the blood parasite *Haemoproteus columbae* (94.5%). Correlation tests between the intensity of parasites and fluctuating asymmetry, the length of wing, tail, tarsus and third digit, was not significant ($p>0.150$) (http://www.dbs.nus.edu.sg/lab/cons-lab/prev1.html).

Horak, Ots and Murumagi (1998) performed a brood size manipulation in Great Tit (*Parus major* L.) populations in order to evaluate the effect of raising different numbers of nestlings on parental health state. They have concluded that no effect of brood size manipulation on total leukocyte count, heterophil count, intensity of *Haemoproteus* blood parasite infection or plasma proteins can be detected in Great Tits. Furthermore, they stated that health state

indices were more sensitive to brood size manipulation in the Great Tits breeding in a rural habitat than urban birds.

Shutler et al. (1999) concluded that the Gadwalls *Anas streper* and Mallards blood parasites detected were relatively benign with respect to reproductive investment, at least at the intensities observed.

Psittacosis in Pigeons and Chickens

The investigation of a fatal case of human psittacosis in California disclosed the important fact that the patient had frequently watched the return of the some racing pigeons owned by his son. A blood-serum reactions indicative of a present or past infection with the psittacosis virus. The organs of the entire pigeon flock were tested on mice, and a virus similar to that of psittacosis was ultimately isolated from one of the pigeons.

While these studies were in progress, the father of another boy who owned a flock of racing pigeons outside Los Angeles contracted psittacosis. In this case, also, a psittacosis virus was demonstrated as being present in the kidneys of an old, emaciated, and definitely sick female pigeon in the loft.

In New York, a mother and daughter picked up a sick pigeon; both contracted a disease that was diagnosed as psittacosis at the Rockefeller Hospital. Of 30 pigeons obtained through the courtesy of the New York City Health Department, at least 20 gave positive serum reactions.

A group of pigeons obtained from a dealer in the San Francisco Bay area were held in crowded cages in a damp room. Over a period of a month, 8 birds died. On postmortem examination they showed lesion of emaciation, fibrinous pericarditis (inflammation of the membrane lining the abdominal cavity), spleen tumor, and enlarged and engorged livers occasionally studded with small necroses. Since the culture yielded *Salmonella typhimurium* Castellani and (United States Department of Agriculture, 1942).

2.6 The factors favored the infestation of the host by the parasite

First, those which predispose an animal to infestation with any parasite. Among such factors are, on the one hand, those features of the structure and function of the animal which permit the parasite to gain entry into the host; on the other hand, they include also those details of the new host's biochemistry which make it possible for the parasite to survive and to continue and to continue its life cycle.

Second, concurrently with above factors must operate others which make possible the establishment of biocoenotic links between the potential host and the potential parasite (via the intermediate host or other means of invasion).

Factors of the first category can be referred to as endogenous, depending only on the host animal itself; the second are exogenous factors, depending on the environmental conditions.

Finally, the third aspect of the processes resulting in the animal becoming a host is the appearance of conditions under which the factors of the external environment, acting both on the susceptible host and the infective parasite, make it possible, in the final result, for the parasite to survive within the host (Pavlovski and Gnezdilov, 1939 cited in Dogiel, 1964).

Young, Garvin and McDonald (1993) reported that birds sampled in Costa Rica were infected by at least on species of hematozoan. Among resident species, infections were more commonly detected during the wet season when most birds breed than during the dry season when few birds breed. Infections caused by *Haemoproteus* sp. were most common, while *Plasmodium* sp., *Leucocytozoon* sp., *Trypanosoma* sp., and microfilaria were rare. The intensity of the 40 *Haemoproteus* infections in adult birds was low and did not undergo seasonal changes in intensity.

Foster et al. (1998) found that *Hamoproteus tinnunculi* infection prevalence of Crested Caracaras (*Caracara plancus audubonii*) from eight countries in south central Florida in 1994-1996 was higher in adults than

nestlings but not differed between year. This study was concluded that there are only significant interaction between age and sampling month.

Forbes, Weatherhead and Bennett (1994) sampled blood parasites of blue grouse (*Dendragapus obscurus*) and investigated the factors responsible for variation in prevalence of blood parasites, and patterns of association among parasite species. This study have revealed that prevalence of blood parasites vary significantly between years; sexes differ in number of parasite species in one of two years.

Rozsa (1993) has proposed that there seems to be some correspondence in the site specificity of the louse species *Columbicola columbae* and that of the efficiency of preening by the host, which is the feral pigeon (*Columba livia*)

Tripet and Richner (1997) suggested that the absence of ectoparasites on the blue tit *Parus caeruleus* offspring may be due to the fact that parents bear the cost parasitism.

There are several studies shown the relationship between bird age and parasitism. For example, Allander and Sundberg (1997) stated that young Yellowhammer males Emberiza had more parasites and a consistently higher body mass than older birds. In addition they concluded that blood parasites are probably most severe during, but occur in the hosts long after, the breeding season.

McCurdy et al. (1998) compared prevalence of blood parasites between male and female birds from 33 studies. This comparison showed that there were no difference in prevalence between males and females, in either breeding or non-breeding birds.

Chapter 3

Materials and Methods

3.1 Materials

- Spoon net
- Bird bag
- Spring scale
- Virnier
- Distance scale
- 25 gauge or 26 gauge needle
- Syringe (1ml) 0.05 ml
- Cotton wool
- Methanol
- 70% Ethanol
- Glass slides
- Jar
- Giemsa's stain
- Phosphate Buffer (pH 7.2)

3.2 Study areas

The subjects of this study included 450 pigeons from 3 areas in Bangkok and 2 areas in Chonburi Province.

3.2.1 In Bangkok, birds were captured by spoon-net from 3 sites as follows:

3.2.1.1 Lumpinee Park

3.2.1.2 Pra Meru Ground or Sanam Luang

3.2.1.3 Dusit Zoo

3.2.2 In Chonburi, samples were taken from following areas:

3.2.1.4 Sriracha School in Sriracha district

3.2.1.5 Chonburi seaside (area with large flocks of birds in the inner-city)

3.3 Data Collection Periods

At each period and site, blood samples were obtained f om 30 free-living birds. The data collection period consisted of three seasons si ce 2000 to 2001 as show in Table 3-1.

Table 3 –1 Date of sampling in each period since June 2000 to March 2001

Location / Season	June-July 2000	November-December 2000	February-March 2001
Lumpinee Park	29-Jun	9-Nov	27-Feb
Dusit Zoo	23-Jun	10-Nov	26-Feb
Sanam Luang	21-Jun	17-Nov	28-Feb
Chonburi	8-Jul	1-Dec	3-Mar
Sriracha	29-Jul	2-Dec	2-Mar

3.4 Climatic data

Climatic data from Klontoey, Chonburi, and Lamchab ıg station during June 2000 to April 2001 (Bangkok Meteorological Department, 2001) were calculated the correlation with parasite intensity of pigeons from 3 sampling areas near these station, Lumpinee Park, Chonburi, and Sriracha. In addition to classification sampling period into 3 period of the years, correlation of climatic data between daily average, monthly average and average of two month during sampling period was examined to define sampling period into 3 season, rainy season, winter and summer.

3.5 Morphological measurement

Each bird was measured morphological characteristic to investigate correlation with parasite intensity as follows:

3.5.1 Body weight : weighted pigeon in cotton b ıg by spring balance.

3.5.2 Wing : measured from middle of pigeon back (spine) to tip of spread wing.

3.5.3 Beak : measured from the tip of beak to the loral point

3.5.4 Tarsus : measured length of tarsometatasus

3.5.5 Third digit : measured length of middle-toe

3.5.6 Head : measured for nape to forehead

3.5.7 Tail : measured from anus to end of horizontal tail

3.6 Blood Smear Preparation

These following method were modified from Dranzoa, Ocaido and Katete (1999), Fedynich and Rhodes (1995), Godfrey, Pence and Fedynich (1990), and O'Dell and Robbins (1994).

3.6.1 The wing was fully stretched to expose the wing (basilic) vein.

3.6.2 Cotton wool with 70% ethanol was used to cleaned blood sucking area on the wing of bird.

3.6.3 Blood was obtained with a 25 gauge or 26 gauge needle and syringe (1ml) 0.05 ml.

3.6.4 Cotton wool was placed over the area and pressure was applied for haemostasis (Appendix IV).

3.6.5 The blood obtained was made into thin smears immediately. Then blood smears were air-dried.

3.6.6 Fixed with absolute methanol for 1-2 minutes and air-dried before being kept in the laboratory (Fig. 3.2).

3.6.7 Blood smears were stained by Giemsa's stain (Galigher and Kozloff, 1964) in phosphate-buffered (pH 7.2) with ratio1 : 0 (Appendix 4) for 40-50 minutes.

3.6.8 After staining, the excess stain was washed off with phosphate-buffered and distilled water, then left to dry in the air.

3.6.9 Blood parasites were examined under microscope using an oil emersion len (x100).

3.7 Parasite Identification

Blood smears were identified following the descriptions of Schmidt and Roberts (2000), Campbell (1995), and Garnham (1966). Each group sample was examined for the following data

3.7.1 Parasite prevalence is the ratio of number of individuals of a host species infected with a particular parasite species per number of hosts examined. In this step, blood smears were scan for present or absent of parasite.

3.7.2 Parasite intensity is a number per 10,000 red blood cells of individuals (determined directly or indirectly) of a particular parasite species in each infected host in a sample.

For investigation in parasite intensity was count for gametocyte classified into two stages as follows: mature stage (microgametocyte and macrogametocyte) and unidifferentiated stage. Each stage was classified following Garnham (1966) based on these criteria.

- Mature macrogametocyte has a "Halteridium" form; the granular cytoplasm stains a deep blue color and contains small dark brown pigment granules. The nucleus is small, and often the centriole lies quite apart.
- Mature male is less Halteridium-shaped and apart from the usual difference in coloration, is distinguished from the female by the huge pigment granules, numbering about six to eight and grouped at the two extremities of the parasite. The nucleus is light and diffuse, and in it are embedded several more deeply staining dots.
- The others forms were count to be into unidentified group.

3.8 Statistical Analysis

3.8.1 Nonparametric Chi-square test was calculated to test the difference of parasite prevalence between sample groups. From SPSS program, if asymptotic significance (P) more than α (in this study was 0.05), it showed that prevalence of tested groups were no significant differences (Kanlaya Wanichbancha, 2000).

3.8.1 Median test was processed to test the difference among groups of parasite intensity of 5 locations and 3 seasons. (Daniel, 1990 and Daniel, 1995).

3.8.2 The set of data of parasite intensity distribution in the groups, which were difference within the group, were paired together and calculated by the Kolmogorov-Smirnov goodness-of-fit test for comparison the difference of parasite intensity between a couple. (Daniel, 1990).

3.8.3 The correlation of parasite intensity and climatic data was investigated in each location by Spearman's rank coefficient (Daniel, 1995).

3.8.4 Climatic and morphological data was calculated different of each sampling group by one way ANOVA.

3.8.5 The correlation between morphological data (body weight, head length, mandible, tail length, wing cord length, tarsus length, and third digit) and parasite intensity was also examined by Spearman's rank coefficient (Daniel, 1995).

Chapter 4

Results

4.1 Climatic Data

From the data obtained it was found that daily mean temperature, maximum temperature, and mean relative humidity correlate with monthly. (P=0.015, 0.032 and 0.026 respectively); yet, minimum temperature and precipitation (rainfall) was no correlation. Otherwise, daily and monthly climatic data were correlated in maximum temperature (P = 0.002) and minimum temperature (P = 0.011). However, monthly maximum temperature, minimum temperature, mean relative humidity and precipitation were correlated with average of two month (between June-July 2000, November – December 2000, and February – March 2001) (P = 0.004, 0.000, 0.000 and 0.000 respectively), but mean temperature was no correlated (Table 4-1 to 4-4amd Fig. 4.2).

In short, there was relationship between sampling period and sampling season which mean that June-July, November-December, February-March correlated with rainy, November-December and February-March; hence, sampling period can be classified into 3 season as follows June-July, November-December and February-March.

4.2 Morphological Measurement

weight (gram) of pigeon caught during June-July, Sriracha is the highest weight group (297.0±7.0), and Sanam Luang is the lowest (256.3± 7.1); during November-December, Sriracha is the highest (323.0±5.4) and the lowest is Lumpinee (264.7±7.0); during February-March, Sriracha is the highest (306.3±7.3and Dusit Zoo is the lowest .

Wing length (cm), during June-July, Sanam Luang is the highest weight group (32.6±0.2), and Sanam Luang is the lowest (31.5±0.2); during November-December, Sanam Luang (33.1±0.2) and the lowest is Lumpinee

(32.5±0.2); during February-March, Sanam Luang is the highest (33.4±0.2), and Chonburi is the lowest (32.1±0.2).

Tail length (cm), during June-July, Lumpinee is the highest weight group (13.4±0.2) and Sriracha is the lowest (12.7±0.1); during November-December, Chonbburi (12.9±0.1) and the lowest is Dusit Zoo (13.7±0.2); during February-March, Dusit Zoo is the highest (12.8±0.1), and Sriracha is the lowest (12.4±0.1).

Length of tarsus (cm), during June-July, Chonburi is the highest weight group (3.3±0.2) and Lumpinee is the lowest (3.6±0.0); during November-December, Sriracha (3.8±0.0) and the lowest is Lumpinee (3.3±0.0); during February-March, Dusit Zoo, Sanam Luang, Chonburi Sriracha are equal (13.0±0.0), and Lumpinee is the lowest (3.6±0.0).

Mandible (cm) in every group, both local and periodical variation, had only little different , 2.3-2.4 cm. Third digit was 3.7 cm, head was 5.3 and 1.8-1.9, in group of Chonburi and Sriracha during November-December and every local variable group during February-March.

Morphological data of 8 parts of birds are showed in Table 4-5 were calculated the correlation with parasite intensity. Also, these data would be calculated by Spearman's rank correlation test to investigate the correlation with parasite intensity, as will be showed in Table .

4.3 Parasite Identification

In this study, *Haemoproteus columbae* was commonly found, while, during Feb-March, there was only one *Trypanosoma* sp.in a pigeon caught from Dusit Zoo and one microfilaria in a pigeon caught from Sriracha, both pigeons were virtually free from *H. columbae.*

This results consistent with several previous studies such as Dranzoa, Ocaido and Katete (1999), Mushi et al. (1999), and Earle et al. (1993).

Parasites found in this study were divided in these three main groups as follows:

Phylum Apicomplexa
Class Telospora
Subclass Coccidia
Order Eucoccidia
Suborder Haemosporida
Family Haemoproteidae
Genus *Haemoproteus*
Haemoproteus columbae
(Fig. 4-1 A, B, C)

Order Kinetoplastida
Suborder Trypanosomatina
Family Trypanosomatidae
Genus *Trypanosoma*
Trypanosoma sp. (Fig. 4-1 E)

Phylum Nematode
Microfilaria (Fig. 4-1 D) was also found in this study.

4.4 Prevalence of *H. columbae*

The average of prevalence in three periods shows that Dusit Zoo is highest. As shown in Table 4-6, during June-July and November-December prevalence of *H. columbae* in pigeons sampling from Dusit Zoo was the highest (100%, n=30 in both season), also, in November-December, parasite prevalence in birds from both Sanam Laung and Dusit Zoo were the highest (96.67%, n=30 in each groups), in June-July, November-December and February-March respectively. From a statistical point view by Chi-Square test, there was no significant difference of parasite prevalence among 15 groups, varied with 5 location 3 periods ($P>0.05$) (Table 4-7, 4-8 , 4-9 and Fig. 4-3, 4-4); consequently, intensity of parasite was used to examine in the next step.

4.5 Intensity of *H. columbae*

It was found that the distribution of parasite intensity all of 5 locations in 3 periods were not normality distribution ($P<0.05$). Since most of pigeons were infected with low number of parasite (per 10,000 red blood cells) or low intensity (Table 4-9 and Fig. 4-5, 4-6 and 4-7). For this reason, nonparametric statistics were used in several steps.

From Median test in local variation, *H. columbae* intensity of pigeons caught during November-December and February-March were no significant differences in every location (df = 4, $P= 0.270$ and $P= 0.113$ respectively), yet there was a statistically significant difference group of June-July sample (df = 4, $P= 0.003$) (Table 4-10 and 4-12). Besides that, periodical variation were no significant difference in every sampling site (df = 2, $P > 0.05$) (Table 4-12). Furthermore, median intensity of *H. columbae* was concluded by local and periodical variation in Table 4-12 and 4-13.

From Kolmogorov-Smirnov test distribution of parasite intensity in group of Lumpinee Park was less than Dusit Zoo and Chonburi ($P= 0.016$ and 0.003 respectively) (Table 4-14). There was more number of pigeons with heavy intensity in Dusit Zoo than Chonburi because most of pigeon were infected with low intensity (Table 4-16). In addition, **distribution of parasite intensity** of pigeons captured from Dusit zoo was more than Sanam Luang; while, Sanam Luang was more than Chonburi; however, Chonburi group was more than Sriracha

Lumpinee Park, Sanamluang, Dusit Zoo, Chonburi and Sriracha only during June-July. From a statistically point of view, distribution of parasite intensity in group of Lumpinee Park was less than Dusit Zoo and Chonburi ($P= 0.016$ and 0.003 respectively) (Table 4-17 to 4-21). In short, at Dusit Zoo there was more number of pigeons with heavy intensity than at Chonburi because most of pigeon were infected with low intensity . What's more, parasite intensity of pigeons captured from Dusit zoo was more distribution than Sanam Luang. Nevertheless, Sanam Luang was less distribution of

intensity than Chonburi (P= 0.003). In spite of Chonburi group was more distribution of intensity than Sriracha (P= 0.016).

4.3 Climatic Effects

The results from Spearman's correlation rank test between average parasite and climatic data showed that daily minimum temperature was negatively correlated with parasite intensity of undifferentiated stage (P= 0.001), macrogametocyte (P= 0.044) and intensity of every stage (P= 0.005). On contrary, daily mean relative humidity was positively correlated with parasite intensity of undifferentiated stage (P= 0.001), macrogametocyte (P= 0.044) and intensity of every stage (P= 0.005). Also, daily precipitation in milimetres was positively correlated with undifferentiated stage (P= 0.007), microgametocyte (P = 0.005), macrogametocyte (P= 0.007) and intensity of every stage (P= 0.005).

In this study, it was found that during June-July 2000 parasite intensity were significant difference based on local variation. Hence, ANOVA was calculated the difference climatic data of Klong Toey, Chonburi and Lamchabang station, which near sampling sites (Lumpinee Park, Chonburi, Sriracha)3. There was significant correlation between daily and average of two month climatic data at the 0.01 level in every characteristic climate.

4.4 Morphological Effect

The one factor interesting to determine the cause of parasite intensity differences was morphological effect. The measure of association between morphological data and parasite intensity of all free living pigeon samples (n=450) obtained from Spearman rank correlation coefficient as shows in Table 4-22, 4-23 and 4-24 pointed out that pigeons which were heavily infected with *H. columbae* tend to have low body weight ($P < 0.05$) in group of June-July and February-March, excluded during November-December which correlated only with microgametocyte intensity. Therefore, ANOVA

was examined the pigeon weight difference based on local ariation. However, there was no more directional difference of weig.it between location. Infact, during June-July, group of pigeon from Sriracha (297.0± 7.0) had mean weight more than Dusit Zoo (269.7±4.4), Sanam Luang (256.3±7.1), Chonburi (272.3±6.3) (P= 0.012, P= 0.000, P= 0.032), in these three location had no different mean weight. While directional parasite intensity difference was not related with mean weight direactional difference.

Table 4-1 Climatic data at three station near sampling sites since June 2000 to March 2001

Period	Station	Date	Temperature (oC)			Relative humidity (%)	Daily rainfall (mm)
			Mean	Max.	Min.		
Jun-Jul	Klongtoey	29-Jun-00	30.6	34.2	26.5	70.0	0.3
	Chonburi	8-Jul-00	29.7	32.7	27.5	69.(	0.0
	Lamchabang	29-Jul-00	28.5	30.3	24.0	75.	0.0
Nov-Dec	Klongtoey	9-Nov-00	29.8	34.5	23.5	54.0	0.0
	Chonburi	1-Dec-00	29.6	35.8	26.3	70.0	0.0
	Lamchabang	2-Dec-00	29.0	34.5	25.0	73.0	0.0
Feb-Mar	Klongtoey	27-Feb-01	32.3	37.0	27.6	66.0	0.0
	Chonburi	3-Mar-01	29.0	33.1	26.5	73.0	0.0
	Lamchabang	2-Mar-01	28.3	31.6	23.3	71.0	0.0

Fig. 4-1 Climatic graph at Klongtoey, Chonburi and Lamchabang station sine June 2000 to March 2001 in each month

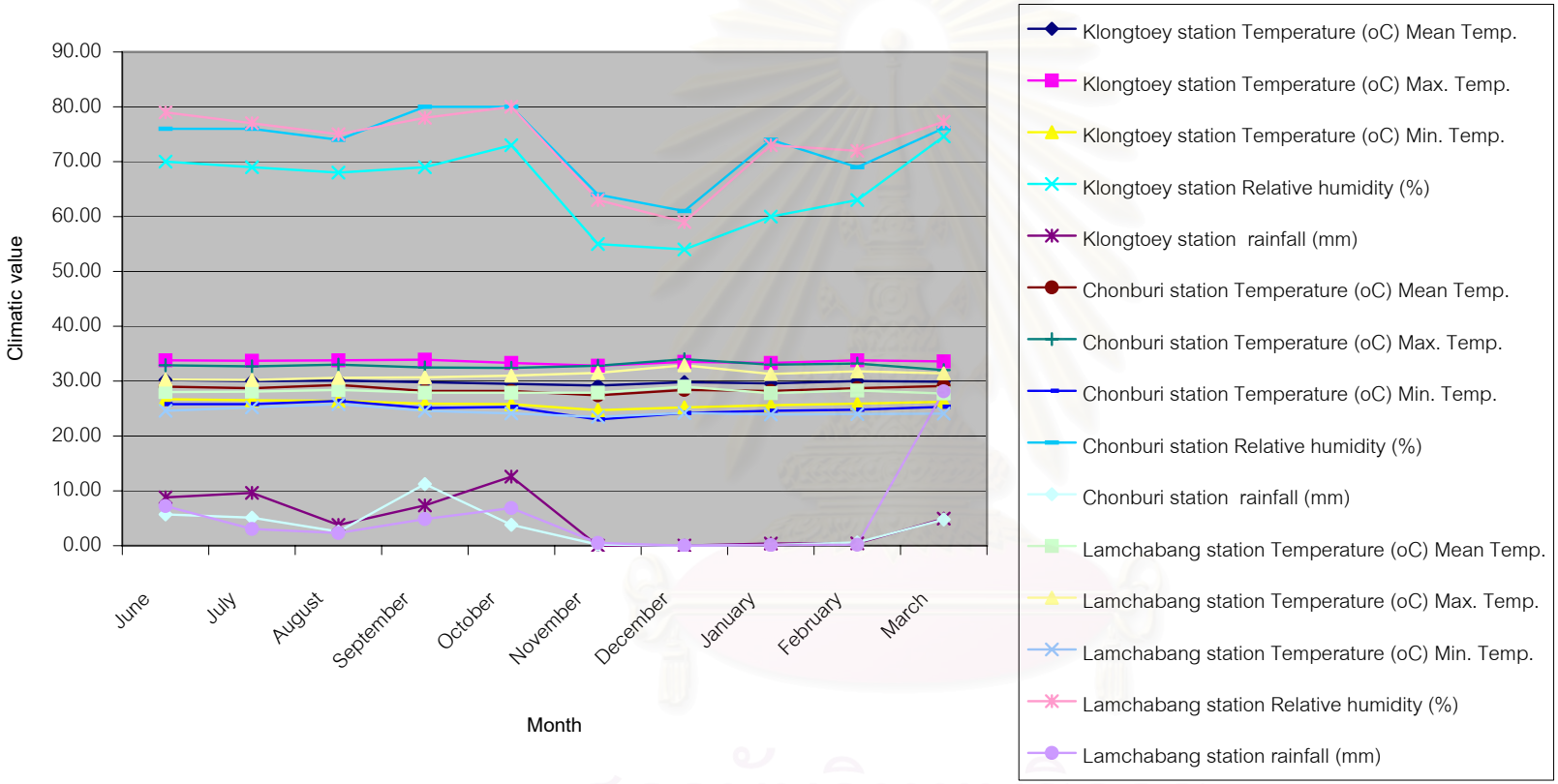

Table 4-4 Spearman's rank correlation coefficient of climatic databetween daily, monthly and average of two month during sampling period

	DMET	DMAT	DMIT	DMH	DR	MMET	MMAT	MMIT	MMH	MR	AMET	AMAT	AMIT	AMH	AR
DMET		.676*	.651	-.793*	.413	.485	.706*	.710*	-0.577	-.204	.770*	.912**	.669*	-.555	-.259
DMAT			.378	-.561	.000	.393	.882**	.105	-.812**	-.664	.293	.711*	.008	-.622	-.653
DMIT				-.295	.206	.678*	.450	.790*	-.084	.068	.510	.594	.644	-.168	.100
DMH					-.069	-.345	-.511	-.295	.529	.171	-.471	-.714*	-.403	.730*	.277
DR						.137	.344	.550	.000	.418	.548	.548	.548	.138	.411
MMET							.561	.402	-.267	-.136	.133	.617	.217	-.510	-.150
MMAT								.218	-.711*	.443	.259	.845**	.075	-.588	-.418
MMIT									.025	.272	.812**	.586	.929**	.029	.243
MMH										.814**	-.267	-.517	.117	.828**	.817**
MR											.119	-.119	.458	.587	.983**
AMET												.617	.883**	-.134	.067
AMAT													.533	-.502	-.167
AMIT														067	.400
AMH															.628
AR															

* Correlation is significant at the .05 level (2-tailed) ** Correlation is significant at the .01 level (2-tailed)

D = daily, M = monthly, A = Average of two n MET = mean temperature, MAT = maximum temperature, MIT = minimum temperature, MMH= mean relative humidity, R = rainfall

Table 4-5 Mean of mophological data of pigeons sampling in 5 location during June 2000 to March 2001

Period	Location	Weight (g)	Wing (cm)	Tail (cm)	Tarsus (cm)	Third digit (cm)	Head (cm)	Beak (cm)
June-July	Lumpinee Park	279.7±5.0	31.8±0.2	13.4±0.2	3.6±0.0	-	-	-
	Dusit Zoo	269.7±4.4	32.5±0.2	13.2±0.1	3.5±0.0	-	-	-
	Sanam Luang	256.3±7.1	32.6±0.2	12.8±0.2	3.4±0.0	-	-	-
	Chonburi	272.3±6.3	32.1±0.2	13.3±0.2	3.3±0.0	-	-	-
	Sriracha	297.0±7.0	31.5±0.2	12.7±0.1	3.5±0.0	-	-	-
November-December	Lumpinee Park	264.7±7.0	32.5±0.2	13.6±0.1	3.3±0.0	-	-	-
	Dusit Zoo	273.5±5.3	32.9±0.2	13.7±0.2	3.5±0.0	-	-	-
	Sanam Luang	284.7±4.9	33.1±0.2	13.3±0.2	3.5±0.0	-	-	-
	Chonburi	276.3±6.2	32.7±0.3	12.9±0.1	3.5±0.0	3.7±0.0	5.3±0.0	1.8±0.0
	Sriracha	323.0±5.4	32.7±0.2	13.0±0.0	3.8±0.0	3.7±0.0	5.3±0.0	1.9±0.0
February-March	Lumpinee Park	274.3±8.0	33.0±0.2	12.7±0.1	3.6±0.0	3.7±0.0	5.3±0.0	1.9±0.0
	Dusit Zoo	268.0±4.7	33.0±0.2	12.8±0.1	3.7±0.0	3.7±0.0	5.2±0.0	1.8±0.0
	Sanam Luang	[illegible]±6.7	33.4±0.2	12.7±0.1	3.7±0.0	3.7±0.0	5.3±0.0	1.8±0.0
	Chonburi	282.7±5.5	32.1±0.2	12.7±0.1	3.7±0.0	3.7±0.0	5.3±0.0	1.9±0.0
	Sriracha	306.3±7.3	32.5±0.2	12.4±0.1	3.7±0.0	3.7±0.0	5.3±0.0	1.8±0.0

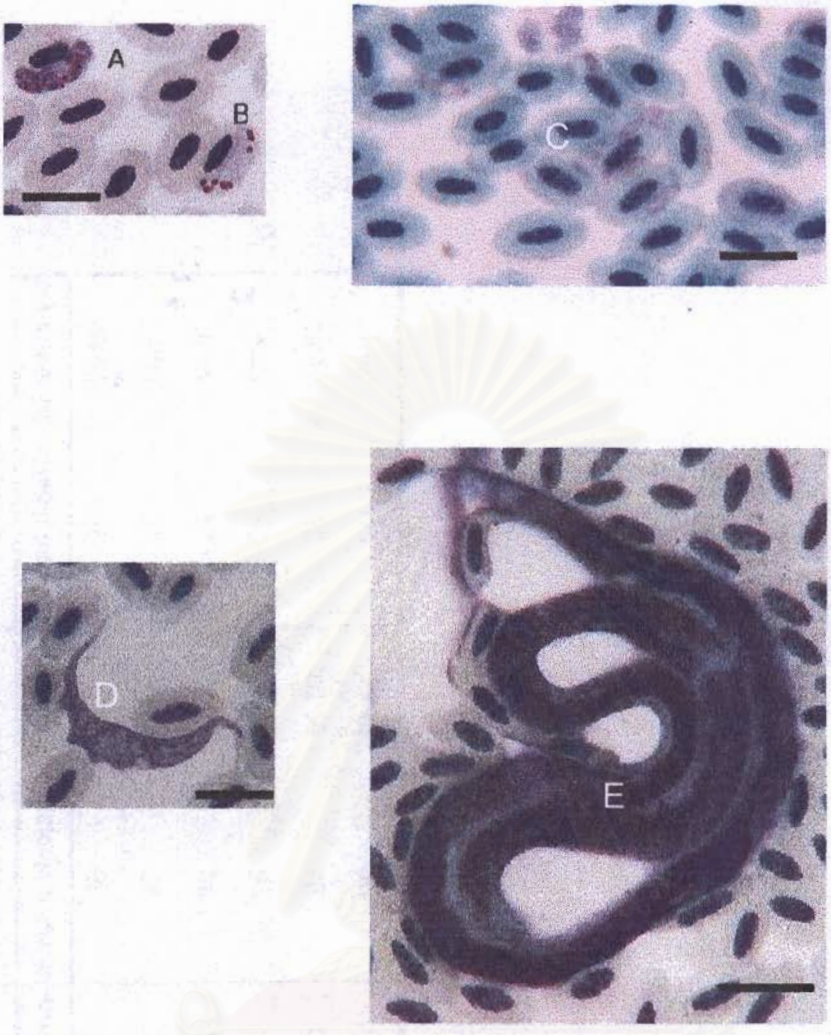

Fig. 4- Blood parasites found in pigeons. (▬▬ = 1.127 μm)

A-C *Haemoproteus columbae* : A. Macrogametocyte

B. Microgametocyte C. Immature stage

D. *Trypanosoma* sp.

E. Microfilaria

Table 4-6 Percentage of parasite prevalence of pigeons from 5 sampling sites in 5 sampling periods

Location	June - July 2000		November-December 2000		February-March 2001	
	Infected pigeons	%Prevalence	Infected pigeons	%Prevalence	Infected pigeons	%Prevalence
Lumpinee Park	29	96.67	28	93.33	27	90.00
Sanam Luang	28	93.33	27	90.00	29	96.67
Dusit Zoo	30	100.00	30	100.00	29	96.67
Chonburi	22	73.33	26	86.67	26	86.67
Sriracha	27	90.00	27	90.00	26	86.67
Total	138	86.25	139	86.88	141	88.13

Fig. 4-3 Prevalence percentage of *Haemoproteus columbae* varied with 5 locations in 3 sampling periods

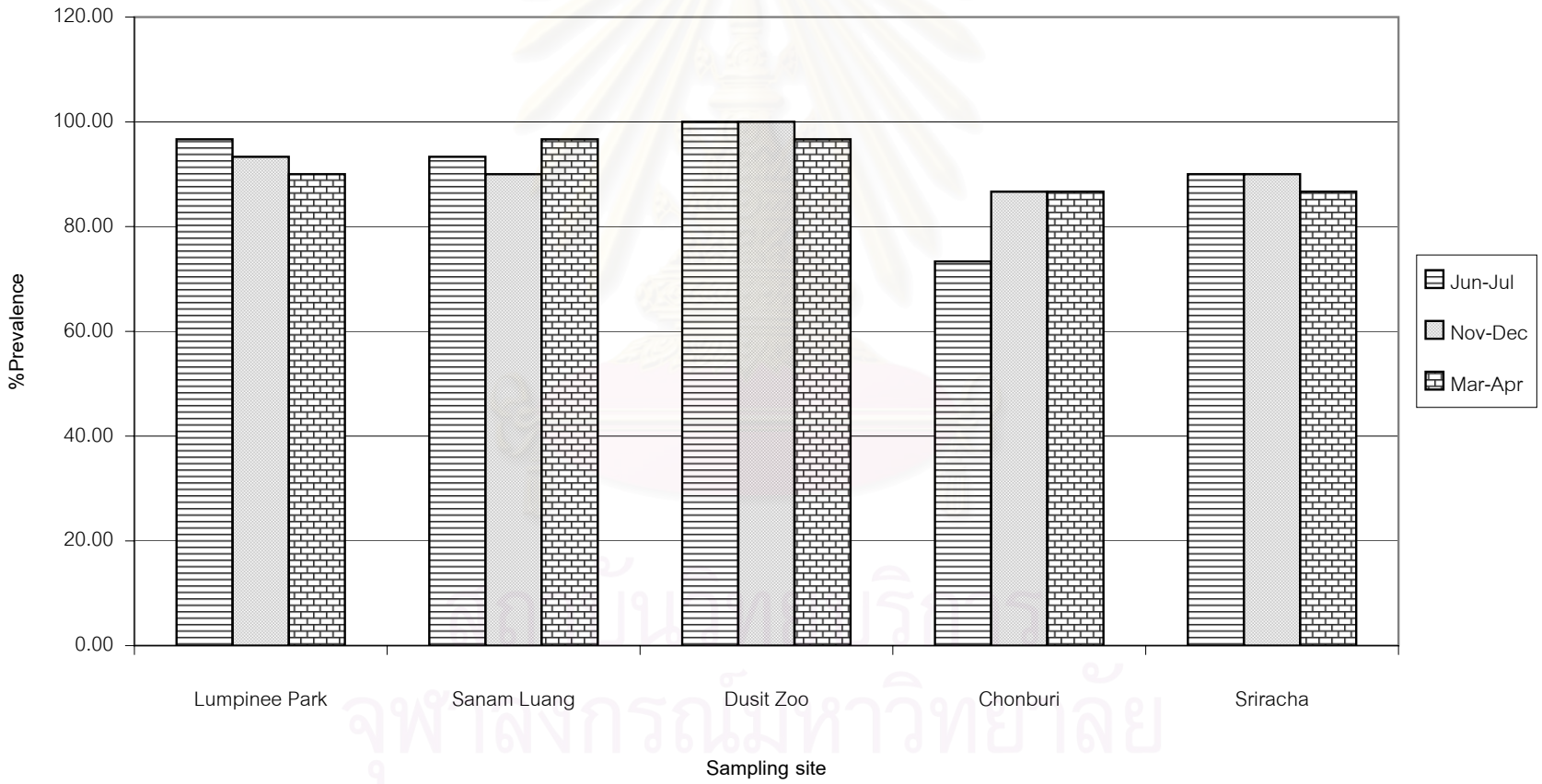

Fig. 4-4 Prevalence percentage of *Haemoproteus columbae* varied with 3 sampling period in 5 sampling sites.

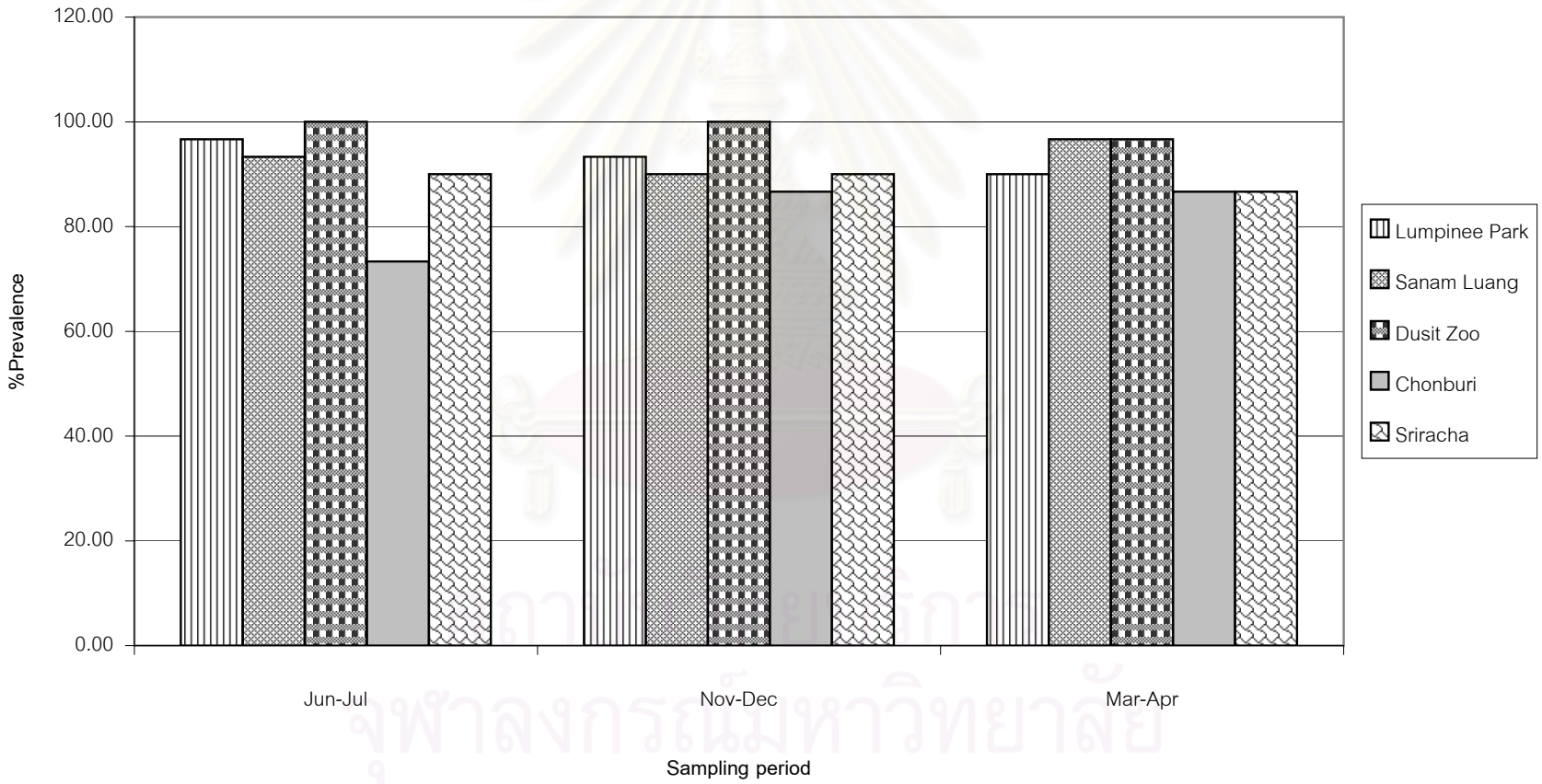

Table 4-7 Chi-Square test for prevalence of *Haemoproteus columbae* in pigeons caught from the same location in each sampling period

Period	df	Expected value	Chi-Square	P
Jun-Jul 2000	4	27.2	1.426	0.840
Nov-Dec 2001	4	27.6	0.333	0.988
Feb-Mar 2001	4	27.4	0.366	0.987

Table 4-8 Chi-Square test for prevalence of *Haemoproteus columbae* in pigeons during the same period in each sampling site

Location	df	Expected value	Chi-Square	P
Lumpinee Park	2	29.0	0.207	0.902
Dusit Zoo	2	29.7	0.022	0.989
Sanam Luang	2	29.7	0.022	0.989
Chonburi	2	28.7	0.372	0.830
Sriracha	2	28.7	0.372	0.830

Table 4-9 Intensity, rank intensity of *Haemoproteus columbae* and number of pigeons in 5 locations (Lumpinee Park, Dusit Zoo, Sanam Luang, Chonburi and Sriracha) during 3 periods (June-July,November-December and February-March)

Parasite intensity	Rank of intensity	June - July					November-December					February-March				
		Lumpinee Park	Dusit Zoo	Sanam Luang	Chonburi	Sriracha	Lumpinee Park	Dusit Zoo	Sanam Luang	Chonburi	Sriracha	Lumpinee Park	Dusit Zoo	Sanam Luang	Chonburi	Sriracha
0-9	1-10	9	14	10	22	13	11	10	11	19	13	11	7	11	15	9
10-19	11-20	2	5	1	2	3	2	8	6	5	6	3	7	8	7	6
21-29	21-30	5	6	1	2	4	9	3	5	2	4	6	2	2	5	7
30-39	31-40		3	3	1			3	2	1	3	1	4	1	1	2
40-54	41-50	3	1	2	1	1	1	2	2		2		3	1	1	1
55-70	51-60	4	1	1		2	1		1	2		1	3	1		
72-91	61-70	1		1		3	1	1					2			1
92-128	71-80	4		1		2		1			1	2		1		
135-235	81-90	2						1	1		1	1	1	2		2
247-411	91-100			3	1	2	1					1	1			
433-734	101-110			3	1		1		1	1		2				1
744-1680	111-120			3			2	1	1			2				1
1865-3986	> 121			1			1							3	1	
Total		30	30	30	30	30	30	30	30	30	30	30	30	30	30	30

Fig. 4-5 Number of pigeons caught from Lumpinee park,Dusit Zoo,Sanam Luang,Chonburi and Sriracha which were infected with Haemoproteus columbae with different range of intensity during June-July 2000

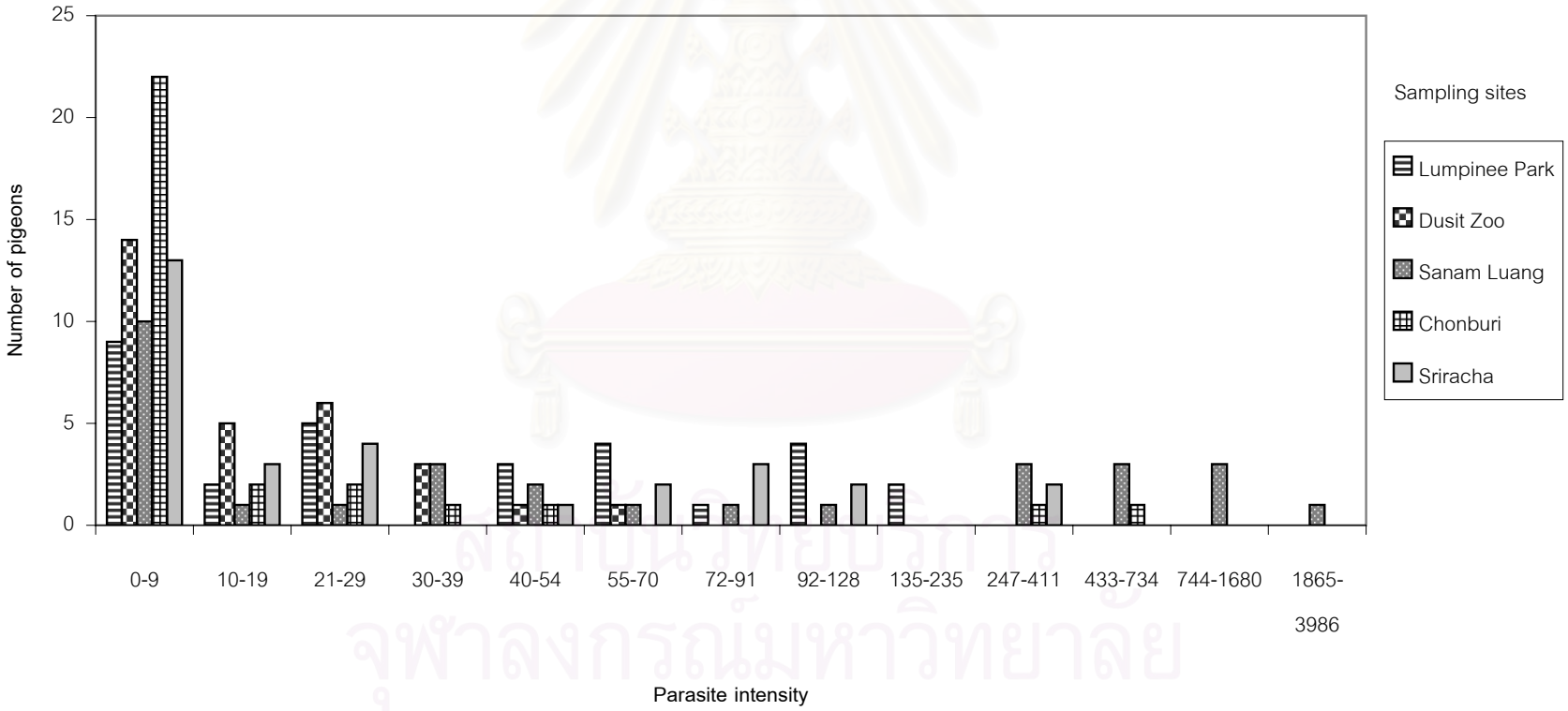

Fig. 4-6 Number of pigeons caught from Lumpinee Park,Dusit Zoo,Sanam Luang,Chonburi and Sriracha which were infected with *Haemoproteus columbae* with different range of intensity during Novermber-December 2000

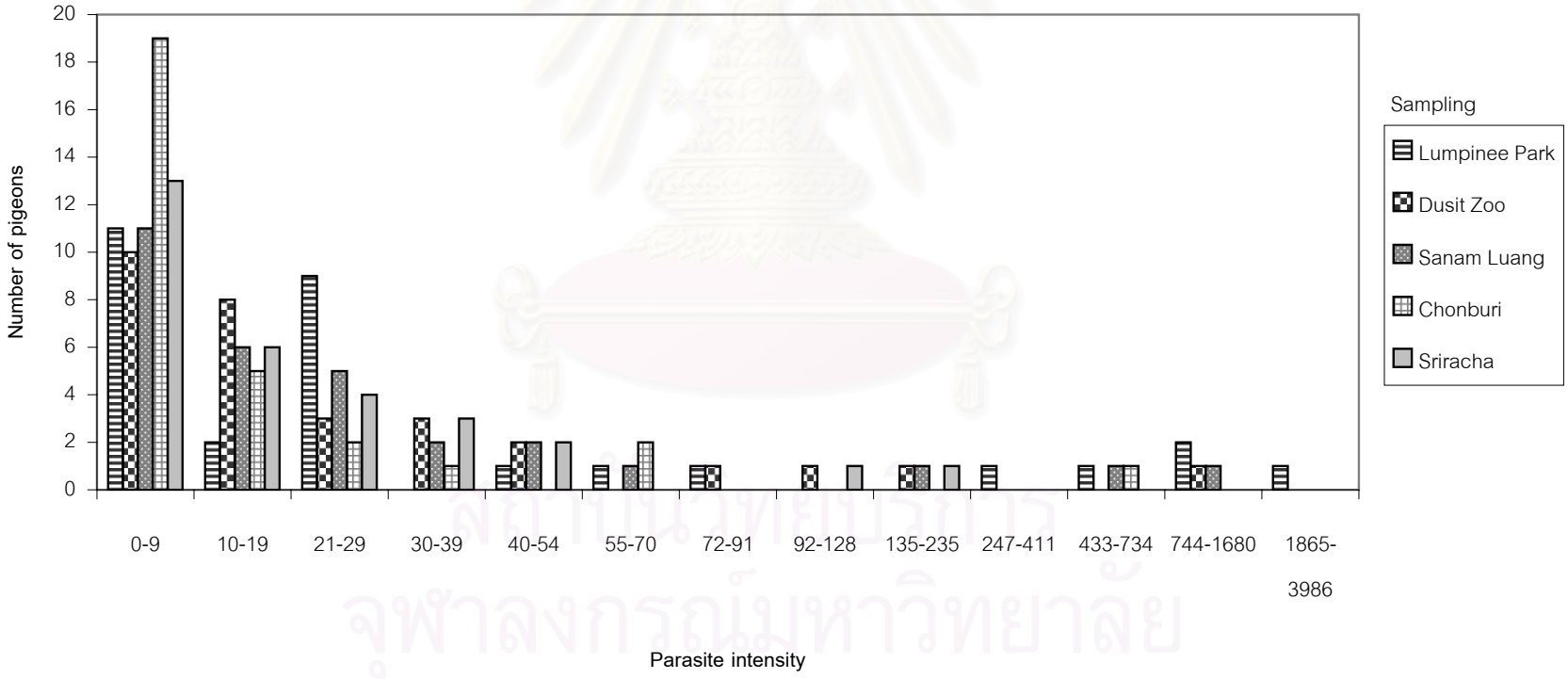

Fig. 4-7 Number of pigeons caught from Lumpinee Park,Dusit Zoo,Sanam Luang,Chonburi and Sriracha which were infected with Haemoproteus columbae with different range of intensity during February-March 2001

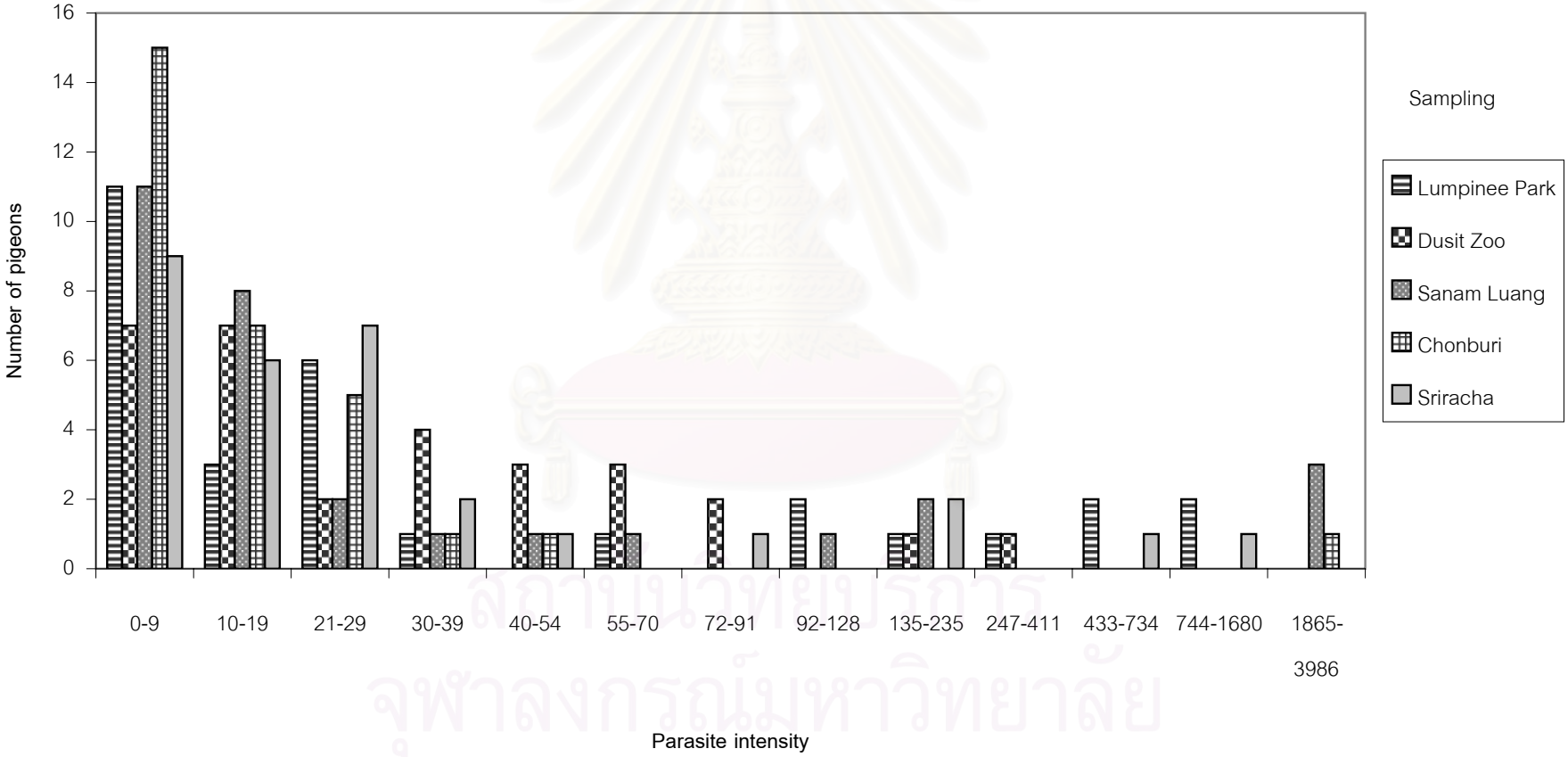

Table 4-10 Median test of *Haemoproteus columbae* intensity of pigeons caught from the same location in each sampling period (N = 150 in each group)

Period	df	Median	Chi-Square	P
Jun-Jul 2000	4	14.5	16.267	0.003**
Nov-Dec 2001	4	12	5.174	0.270
Feb-Mar 2001	4	16.5	7.467	0.113

* Significant difference of median at least one group at the .01 level (2-tailed)

Table 4-11 Median test of *Haemoproteus columbae intensity of* pigeons during the same period in each sampling site (N = 90 in each group)

Location	df	Expected value	Chi-Square	P
Lumpinee Park	2	23.0	1.071	0.585
Dusit Zoo	2	16.0	2.490	0.228
Sanam Luang	2	16.5	3.467	0.177
Chonburi	2	5.0	3.295	0.192
Sriracha	2	14.5	2.400	0.301

Table 4-12 Median test of *Haemoproteus columbae* intensity of difference sampling site in the same period (N = 150, df =4)

Sampling period	Parasite intensity	Number of pigeons in group of				
		Lumpinee	Dusit zoo	Sanam Laung	Chonburi	Sriracha
June – July 2000	> Median	20	15	19	6	15
	<= Median	10	15	11	24	15
November-December 2000	> Median	18	17	15	10	14
	<= Median	12	13	15	20	16
February-March 2001	> Median	17	18	12	10	18
	<= Median	13	12	18	20	12

Statistic value	June- July	November- December	February-March
Median	14.50	12.00	16.50
Chi-square	16.267	5.174	7.467
P	.003	.270	.113

Table 4-13 Median test of *Haemoprotues columbae* intensity in different sampling period at the same location (N=90 df = 2 in each locaiton)

Location	Parasite intensity	Number of pigeons		
		June-July 2000	November-December	Febuary-March 2001
Lunpinee Park	> Median	16	14	12
	<= Median	14	16	18
Dusit Zoo	> Median	12	14	18
	<= Median	18	16	12
Sanam Luang	> Median	19	14	12
	<= Median	11	16	18
Chonburi	> Median	11	14	18
	<= Median	19	16	12
Sriracha	> Median	15	12	18
	<= Median	15	18	12

Statistic value / location	Lumpinee Park	Dusit Zoo	Sanam Luang	Chonburi
Median	16.5	5.00	14.50	0.00
Chi – Square	3.467	3.295	2.400	2.609
P	0.177	0.192	0.301	0.271

Table 4-14 Two – sample Kolmogorov-smirnov test of *Heamoproteus columabae* intensity of different sampling site during June-July 2000 (N = 30 in each location)

Lacation	Difference			Kolmogorov-Smirnov Z	P
	absolute	Positive	Negative		
Lumpinee Park and Dusit Zoo	.400	.000	-.400	1.549	.016
Lumpinee Park and Sanam Laung	.333	.333	-.167	1.291	.071
Lumpinee Park and Sriracha	.467	.067	-.467	1.807	.003
Lumpinee Park and Chonburi	.167	.067	-.167	0.645	.799
Dusit Zoo and Sanam laung	.433	.433	.000	1.678	.007
Dusit Zoo and Sriracha	.333	.067	-.333	1.291	.071
Disit Zoo and Chonburi	.267	.267	-.100	1.033	.236
Sanam laung and Sriracha	.467	.000	-467	1.807	.003
Sanam laung and Chonburi	.300	.067	-.300	1.162	.134
Sriracha and Chonburi	.400	.400	-.033	1.549	.016

Table 4-15 Spearman's rank correlation coefficient of climatic databetween *Haemoproteus columbae* intensity of pigeon caught from Lumpinee Park, Chonburi and Sriracha and daily-monthly climatic data during June-July 2000

	UNDIF	MIC	MAC	INT	DMET	DMAT	DMIT	DMH	DR	AMET	AMAT	AMIT	AMH	AR
UNDIF		.701**	.742**	.920**	.070	.070	-.350**	.350**	.283**	.070	.070	.070	-.070	.070
MIC			.809**	.851**	.199	.152	-.199	.199	.291**	.152	.152	.152	-.152	.152
MAC				.892**	.138	.138	-.213*	.213*	.282**	.138	.138	.138	-.138	.138
INT					.105	.105	-.296**	.296**	.292**	.105	.105	.105	-.105	.105
DMET						.1000**	-.500**	-.500**	.866**	1.000**	1.000**	1.000**	-1.000**	1.000**
DMAT							.500**	-.500**	.866**	1.000**	1.000**	1.000**	-1.000**	1.000**
DMIT								-1.000**	.000	.500**	.500**	.500**	-.500**	.500**
DMH									.000	-.500**	-.500**	-.500**	.500**	-.500**
DR										.866**	.866**	.866**	-.866**	.866**
AMET											1.000**	1.000**	-1.000**	1.000**
AMAT												1.000**	-1.000**	1.000**
AMIT													-1.000**	1.000**
AMH														-1.000**
AR														

* Correlation is significant at the .05 level ** Correlation is significant at the .01 level UDIF=undifferentiated , MAC=macrogametocyte, MAC=macrogametocyte, INT=Every stage

D = daily, M = monthly, A = Average of two month MET = mean temperature, MAT = maximum temperature, MIT = minimum temperature, MMH= mean relative humidity, R = rainfall

Table 4-16 ANOVA mutiple comparisons (P=0.000) between climatic data at Klongtoey (1) , Chonburi (4)and Lamchabang station (5) during June - July 2000, November - December 2000, and February - March 2001

Climatic data	Daily	Average of two months
Mean temperature	1>5>4	1>5>4
Maximum temperature	1>4>5	1>4>5
Minimum temperature	4>1>5	1>4>5
Mean relative humidity	5>1>4	1<4<5
Precipitaiton	1>5>4	1>4>5

Table 4-17 Spearman's rank correlation coefficient of *Haemoproteus columbae* intensity and morphological data of pigoens sampling from Lumpinee, Sanam Luang, Dusit Zoo, Chonburi and Sriracha during June-July 2000

	UNDIF	MIC	MAC	INT	WE	WI	TL	TA
UDIF		.741**	.760**	.932**	-.180*	.013	-.056	-.075
MIC			.818**	.882**	-.229**	.094	-.038	.002
MAC				.902**	-.218**	.018	-.080	-.029
INT					-.213*	.025	-.059	-.031
WE						.227**	.218**	.231**
WI							.274**	.067
TL								.099
TA								

* Correlation is significant at the .05 level (2-tailed) ** Correlation is significant at the .01 level (2-tailed)

UDIF = undifferentiated stage, MAC = macrogametocyte, MAC = MACrogametocyte, INT = Every stage

WE = weight, WI = wing, TL = tail, TA = tarsus

Table 4-18 Spearman's rank correlation coefficient of *Haemoproteus columbae* intensity and morphological data of pigoens sampling from Lumpinee, Sanam Luang, Dusit Zoo, Chonburi and Sriracha during November-December 2000

	UNDIF	MIC	MAC	INT	WE	WI	TL	TA
UDIF		.538**	.540**	.873**	.124	.146	-.012	-.048
MIC			.724**	.763**	-.169*	-.036	.090	-.060
MAC				.787**	-.001	-.134	-.092	-.024
INT					-.088	-.127	.012	-.027
WE						.215**	.009	.230**
WI							.429**	.326**
TL								.101
TA								

* Correlation is significant at the .05 level (2-tailed) ** Correlation is significant at the .01 level (2-tailed)

UDIF = undifferentiated stage, MAC = macrogametocyte, MAC = MACrogametocyte, INT = Every stage

WE = weight, WI = wing, TL = tail, TA = tarsus

Table 4-19 Spearman's rank correlation coefficient of *Haemoproteus columbae* intensity and morphological data of pigoens sampling from Lumpinee, Sanam Luang, Dusit Zoo, Chonburi and Sriracha during February-March 2001

	UNDIF	MIC	MAC	INT	WE	WI	TL	TA
UDIF		.597**	.556**	.863**	-.218**	.028	.066	-.056
MIC			.785**	.826**	-.242**	-.024	-.059	-.123
MAC				.834**	-.235**	-.102	-.131	-.122
INT					-.221**	-.008	-.023	-.067
WE						.205**	.334**	.363**
WI							.539**	.461**
TL								.307**
TA								

* Correlation is significant at the .05 level (2-tailed) ** Correlation is significant at the .01 level (2-tailed)

UDIF = undifferentiated stage, MAC = macrogametocyte, MAC = MACrogametocyte, INT = Every stage

WE = weight, WI = wing, TL = tail, TA = tarsus

Table 4-20 Spearman's rank correlation coefficient of *Haemoproteus columbae* intensity and morphological data of pigoens sampling from Chonburi and Sriracha during November-December 2000

	UNDIF	MIC	MAC	INT	DI	HE	BE
UDIF		.430**	.589**	.844**	-.164	-.126	-.124
MIC			.690**	.725**	-.141	.241	-.028
MAC				.835**	-.028	.119	.001
INT					-.133	.095	-.071
DI						.255*	.295*
HE							.446*
BE							

* Correlation is significant at the .05 level (2-tailed) ** Correlation is significant at the .01 level (2-tailed)

UDIF = undifferentiated stage, MAC = macrogametocyte, MAC = MACrogametocyte, INT = Every stage

DI = third digit, HE = head, BE = beak

Table 4-21 Spearman's rank correlation coefficient of *Haemoproteus columbae* intensity and morphological data of pigoens sampling from Lumpinee, Sanam Luang, Dusit Zoo, Chonburi and Sriracha during February-March 2001

	UNDIF	MIC	MAC	INT	DI	HE	BE
UDIF		.430**	.589**	.844**	-.164	-.126	-.124
MIC			.690**	.725**	-.141	.241	-.028
MAC				.835**	-.028	.119	.001
INT					-.133	.095	-.071
DI						.255*	.295*
HE							.446*
BE							

* Correlation is significant at the .05 level (2-tailed) ** Correlation is significant at the .01 level (2-tailed)

UDIF = undifferentiated stage, MAC = macrogametocyte, MAC = MACrogametocyte, INT = Every stage

DI = third digit, HE = head, BE = beak

Table 4-22 One way ANOVA test weight of pigeons caught from Lumpinee, Dusit Zoo, Sanam Luang, Chonburi, and Sriracha during June-July 2000

	Sum square	df	Mean Square	F	Sig.
Between Groups	26693.333	4	6673.333	6.099	.000
Within Groups	158656.667	145	1094.184		
Total	185350.000	149			

Table 4-23 Post Hoc Tests by Oneway ANOVA test of weight of pigeons caught from Lumpinee Park, Dusit Zoo, Sanam Luang, Chonburi and Sriracha during June-July 2000

group	group	Mean Difference ± Std.Error	Sig.
Lumpinee Park	Dusit zoo	10.00±8.54	.768
	Sanam Luang	23.33±8.54*	.049
	Chonburi	7.33±8.54	.912
	Sriracha	-17.33±8.54	.252
Dusit zoo	Lumpinee Park	-10.00±8.54	.768
	Sanam Luang	13.33±8.54	.523
	Chonburi	-2.67±8.54	.998
	Sriracha	-27.33±8.54*	.012
Sanam Luang	Lumpinee	-23.33±8.54*	.049
	Dusit zoo	-13.33±8.54	.523
	Chonburi	-16.00±8.54	.332
	Sriracha	-40.67±8.54*	.000
Chonburi	Lumpinee	-7.33±8.54	.912
	Dusit zoo	2.67±8.54	.998
	Sanam Luang	16.00±8.54	.332
	Sriracha	-24.67±8.54*	.032
Sriracha	Lumpinee	17.33±8.54	.252
	Dusit zoo	27.33±8.54*	.012
	Sanam Luang	40.67±8.54	.000
	Chonburi	24.67±8.54	.032

* The mean difference is significant at the .05 level

Table 4-24 Homogeneous Subsets by Oneway ANOVA test of weight of pigeons caught from Lumpinee Park ,Dusit Zoo,Sanam Luang , Chonburi and Sriracha during June-July 2000

group	N	Subset for alpha = .05		
		Lumpinee	Dusit Zoo	Sanam Luang
Sanam Luang	30	256.33		
Dusit Zoo	30	269.67	269.67	
Chonburi	30	272.33	272.33	
Lumpinee	30		279.67	279.67
Sriracha	30			297.00
Sig.		.332	.768	.252

Means for groups in Homogeneous subsets are displays

a. Uses Harmonic Mean Sample Size = 30.000

Chapter 5

Discussion

To compare *Haemoproteus columbae* with results of climatic effect, noticeable that trend of intensity of Chonburi sample group was lower than every group in every season. High precipitation, high humidity and low temperature are likely to be the cause of these results because these flocks of Chonburi pigeons live near seashore. Furthermore, this finding is consistent with a previous study has been concluded that most species of seashore birds are less infected with parasite (Greiner et al., 1975). On contrary with morphological effect, which was no correlation with parasite intensity. Other factors may be attentive in considering the cause of parasite infection.

Another one reason was interested, pigeon behavior from field notice. Noticeable that both pigeons at Sanam Luang, Lumpinee Park and Chonburi were pigeons in public area, which clutching by people feeding. So, it i possible that clutching is likely to be cause of heavy parasite intensity in pigeons, but may be the important reason than climatic data of each location.

There are another two interesting factors for these results, breeding behavior. First, behavior of pigeon is likely to be considered. Altman et al. (1995) mentioned that high humidity is associated with more reproductive problems than dry periods with bright sunshine with conversely with this results climatic correlation with parasite intensity. Consistently, Ewins and Bazely (1995) revealed that numbers of active nests and reproductive success peaked in winter and lower in summer. While parasite intensity was not different in each season in the same location. Not at all, pigeons can be breed in a whole year. Therefore, breeding behavior may not be the one factor for this reason.

Second, the vector prevalence is interesting to be another o e factors. Bishopp (cited in United Sates Department of Agriculture, 1942) reported that

pigeon fly *Pseudolynchia carnariensis* are active on the pigeons throughout the winter in the warmer parts of USA though their numbers substantially diminish toward spring. On the contrary, in the field this fly mostly found in summer.

As Bishop (United States Department of Agriculture, 1942) has proposed that the pigeon fly *Pseudolynchia canariensis* transmit the organism *H. columbae*, which causes pigeon malaria, serving as its intermediate host. The flies are active on the pigeon throughout the winter in the warmer parts of the country, though their numbers diminish markedly toward spring. From this data, the spread of these flies are likely to be cause of continuous increasing of *H. columbae* intensity in winter to rainy season. In addition, the life cycle of this heamoparasite from immature to be mature gametocyte is 25 –30 days (Garnham, 1966; and http//www.allpets.co.za/varenmed/malaria.htm) so it may be increased enough for the intensity differences could be critically seen in rainy season.

There are several factors effected on parasite infection should be studied. One example of these, optimum temperature for exflagellation in wood-pigeon, as Baker (1966) mentioned, is 28 °C. Nevertheless, to our knowledge, there is no study about optimum humidity and other physical effects either *in vitro* or *in vivo*, especially in Thailand. Not only that, several studies showed that age of bird had a different intensity of blood parasite infection (Allander and Bennett, 1994; and Merila, Bjorklund ad Bennett, 1995). For this reason age of pigeons should be the one fascinating factor in extending study, since in random sampling only adult pigeons were caught in this field. On the top of that, resistant or eliminated capacity the blood parasite of pigeons in different parameters such as age, morphology, healthy condition and sex are under suspicion which should be investigated later.

Chapter 6

Conclusions and Recommendations

6.1 Conclusions

With respect to sampling period, there was relationship between sampling period and sampling season; hence, sampling period can be classified into 3 season as follows rainy season, winter and summer.

H. columbae were most commonly occurred in birds sampled. Besides that, in summer, there was only one *Trypanosoma* sp.in a pigeon caught from Dusit Zoo and one microfilaria in a pigeon caught from Sriracha, both pigeons were virtually free from *H. columbae*. In rainy season and in winter prevalence of *H. columbae* in pigeons sampling from Dusit Zoo was the highest (100%, n=30 in both season), also, in winter, parasite prevalence in birds from both Sanam Laung and Dusit Zoo were the highest (96.67%, n=30 in each groups); however, birds from Kaow-Keow had lowest prevalence (6.67%, 3.33% and 13.33% , n = 10 in each group) in rainy season, winter and summer respectively. Not only that, the average of prevalence in three season shows that Dusit Zoo is highest. From a statistical point view, there was no significant difference of parasite prevalence in every group ($P>0.05$); consequently, intensity of parasite was used to examine in the next steps.

With respect, local variation, the *H. columbae* intensity of pigeons during November-December and February-March were no significant differences ($df = 4$, $P = 0.270$ and $P = 0.113$ respectively), yet there was a statistically significant difference group of June-July sample ($df = 4$, $P = 0.003$). Besides that, periodical variation were no significant difference in every sampling site ($df = 2$, $P > 0.05$)

In part of parasite intensity examined by Kolmogorov-Smirnov test, Number of pigeons with heavy infection could be interpreted as follows: Sanam Luang and Lumpinee Park were more than Dusit Zoo and Chonburi and Sriracha was more than Chonburi sampling groups.

Later, climatic and morphological effects were two factors interested in determining the correlation with parasite intensity. In this study, trend of immature parasite intensity maybe increase with high humidity, low precipitation and low temperature. What's more, it was found that morphological data is not directional correlated with parasite intensity.

To summarize, climatic character in each different habitat is likely to be the main reason of heavy infection of parasite.

6.2 Recommendations

6.2.1 Blood sampling should be fix and stain freshly for facility to investigate the prevalence and intensity of blood parasite.

6.2.2 White blood cell count should be examined for parasitization effects.

6.2.3 Age and sex of bird should be studied effecting on parasite infection.

6.2.4 Relationship between pigeon fly and *Haemoproteus columbae* is the one of interesting items.

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Appendices

Appendices I

Haemoproteus columbae intensity

and morphological data of pigeons

Dusit Zoo during June-July 2000

Date	Label	Parasite intensity				Rank of intensity				Morphological data						
		uni	mic	mac	int	r_uni	r_mic	r_mac	r_int	Weigh	Wing	Tail	Tarsus	3rd Digit	Head	Beak
										(g)	(cm)	(cm)	(cm)	(cm)	(cm)	(cm)
23-Jun	RD01	65	23	26	114	49	24	26	78	290	32	13.2	3.33	.	.	.
23-Jun	RD02	3	7	6	16	4	8	7	17	240	32.2	13.3	[illegible]6	.	.	.
23-Jun	RD03	6	1	1	8	7	2	2	9	250	31.2	13	[illegible]44	.	.	.
23-Jun	RD04	5	13	7	25	6	14	8	26	290	34	11	3.86	.	.	.
23-Jun	RD05	3	7	6	16	4	8	7	17	240	34	13.2	3.58	.	.	.
23-Jun	RD06	4	1	1	6	5	2	2	7	310	32.5	13.7	3.11	.	.	.
23-Jun	RD07	4	2	1	7	5	3	2	8	280	32.1	13.8	3.48	.	.	.
23-Jun	RD08	19	0	2	21	19	1	3	22	220	31.2	12.5	3.71	.	.	.
23-Jun	RD09	11	2	4	17	12	3	5	18	280	34	13.9	3.56	.	.	.
23-Jun	RD10	0	0	3	3	1	1	4	4	220	31	13	3.58	.	.	.
23-Jun	RD11	4	15	2	21	5	16	3	22	280	32	13.6	3.52	.	.	.
23-Jun	RD12	11	7	6	24	12	8	7	25	280	33	12.5	3.54	.	.	.
23-Jun	RD13	0	2	0	2	1	3	1	3	280	32	13.7	[illegible]63	.	.	.
23-Jun	RD14	1	1	0	2	2	2	1	3	240	30.7	13	3.64	.	.	.
23-Jun	RD15	0	0	0	0	1	1	1	1	320	31.8	12.5	[illegible]51	.	.	.
23-Jun	RD16	0	3	2	5	1	4	3	6	270	31.5	12.3	[illegible]4	.	.	.
23-Jun	RD17	13	26	38	77	14	27	34	63	260	34.1	13	3.77	.	.	.
23-Jun	RD18	6	2	0	8	7	3	1	9	250	32.1	13.8	3.81	.	.	.
23-Jun	RD19	1	2	2	5	2	3	3	6	260	32.2	12.5	3.71	.	.	.
23-Jun	RD20	11	6	6	23	12	7	7	24	270	31.8	14.2	3.1	.	.	.
23-Jun	RD21	9	7	0	16	10	8	1	17	280	34.5	14	3.71	.	.	.
23-Jun	RD22	1	1	3	5	2	2	4	6	280	33.2	14	3.48	.	.	.
23-Jun	RD23	9	5	11	25	10	6	12	26	280	32.2	13.2	3.79	.	.	.
23-Jun	RD24	3	7	2	12	4	8	3	13	270	32.2	13.3	3.18	.	.	.
23-Jun	RD25	8	17	13	38	9	18	14	39	250	32.9	12.7	3.16	.	.	.
23-Jun	RD26	10	14	9	33	11	15	10	34	300	34.6	14.6	[illegible]71	.	.	.
23-Jun	RD27	16	9	12	37	17	10	13	38	250	33	12.5	3.62	.	.	.
23-Jun	RD28	0	0	2	2	1	1	3	3	290	33.2	13.3	[illegible]32	.	.	.
23-Jun	RD29	0	0	0	0	1	1	1	1	280	31.5	13.5	[illegible]28	.	.	.
23-Jun	RD30	1	0	2	3	2	1	3	4	280	32	12.5	3.11	.	.	.

Sanam Luang during June-July 2000

Date	Label	Parasite intensity				Rank of intensity				Morphological data						
		uni	mic	mac	int	r_uni	r_mic	r_mac	r_int	Weigh	Wing	Tail	Tarsus	3rd Digit	Head	Beak
										(g)	(cm)	(cm)	(cm)	(cm)	(cm)	(cm)
21-Jun	RS01	2	4	7	13	3	5	8	14	270	33.5	13.5	3.85	.	.	.
21-Jun	RS02	0	3	2	5	1	4	3	6	260	32	13.5	3.61	.	.	.
21-Jun	RS03	236	103	435	774	64	50	64	112	260	32.6	12	3.18	.	.	.
21-Jun	RS04	193	112	93	398	61	52	50	100	170	32	11	3.12	.	.	.
21-Jun	RS05	326	47	38	411	72	40	34	101	240	33.5	12.3	3.34	.	.	.
21-Jun	RS06	295	68	79	442	67	43	49	104	280	34	13.4	3.2	.	.	.
21-Jun	RS07	9	20	14	43	10	21	15	44	320	33.5	13.4	3.81	.	.	.
21-Jun	RS08	39	22	13	74	33	23	14	62	250	33	12.5	3.3	.	.	.
21-Jun	RS09	1	1	1	3	2	2	2	4	270	33.5	14	3.16	.	.	.
21-Jun	RS10	63	43	16	122	48	39	17	80	250	33.7	13.3	3.34	.	.	.
21-Jun	RS11	30	20	9	59	29	21	10	54	220	30	12	2.57	.	.	.
21-Jun	RS12	389	42	27	458	76	38	27	105	190	31	13	3.21	.	.	.
21-Jun	RS13	23	5	9	37	23	6	10	38	280	35	14	3.34	.	.	.
21-Jun	RS14	301	25	107	433	68	26	53	102	240	30.5	12.5	3.41	.	.	.
21-Jun	RS15	7	5	18	30	8	6	19	31	300	32	13.5	3.54	.	.	.
21-Jun	RS16	975	24	40	1039	84	25	36	116	180	31.8	12.8	3.57	.	.	.
21-Jun	RS17	4	0	1	5	5	1	2	6	300	33	13.2	3.25	.	.	.
21-Jun	RS18	19	7	4	30	19	8	5	31	260	32.3	13.2	3.63	.	.	.
21-Jun	RS19	1	0	1	2	2	1	2	3	280	31.6	12.5	3.42	.	.	.
21-Jun	RS20	3	0	2	5	4	1	3	6	280	33.6	12.5	3.53	.	.	.
21-Jun	RS21	0	0	1	1	1	1	2	2	270	31.6	12.7	3.51	.	.	.
21-Jun	RS22	25	10	7	42	25	11	8	43	260	32	10.2	3.94	.	.	.
21-Jun	RS23	0	2	2	4	1	3	3	5	280	34	13.8	3.8	.	.	.
21-Jun	RS24	1	0	1	2	2	1	2	3	260	32.4	13	4.2	.	.	.
21-Jun	RS25	271	260	362	893	66	56	62	114	170	30.5	13	3.12	.	.	.
21-Jun	RS26	3	2	0	5	4	3	1	6	300	32.4	13	4.2	.	.	.
21-Jun	RS27	2	8	11	21	3	9	12	22	260	30.5	12.4	3.97	.	.	.
21-Jun	RS28	120	92	118	330	57	48	56	96	240	33	11	3.21	.	.	.
21-Jun	RS29	2229	900	857	3986	90	59	65	126	240	32.5	12.6	3.12	.	.	.
21-Jun	RS30	3	2	0	5	4	3	1	6	310	35.6	13	3.81	.	.	.

Muang District in Chonburi Province (Chonburi) during June-July 2000

Date	Label	Parasite intensity				Rank of intensity				Morphological data						
		uni	mic	mac	int	r_uni	r_mic	r_mac	r_int	Weigh	Wing	Tail	Tarsus	3rd Digit	Head	Beak
										(g)	(cm)	(cm)	(cm)	(cm)	(cm)	(cm)
8-Jul	RC01	2	0	0	2	3	1	1	3	300	30.2	14.4	3.61	.	.	.
8-Jul	RC02	0	0	0	0	1	1	1	1	300	31.3	12.5	. 22	.	.	.
8-Jul	RC03	0	0	0	0	1	1	1	1	230	33.2	12.3	3.15	.	.	.
8-Jul	RC04	0	0	0	0	1	1	1	1	300	30.8	12.5	3.17	.	.	.
8-Jul	RC05	0	0	1	1	1	1	2	2	220	32.1	14	3.12	.	.	.
8-Jul	RC06	356	110	113	579	74	51	54	108	220	31	13	3.14	.	.	.
8-Jul	RC07	0	0	0	0	1	1	1	1	300	32.5	14.5	3.14	.	.	.
8-Jul	RC08	0	2	0	2	1	3	1	3	320	33.5	13.3	3.24	.	.	.
8-Jul	RC09	2	0	2	4	3	1	3	5	310	32.7	14	3.11	.	.	.
8-Jul	RC10	1	1	2	4	2	2	3	5	320	34	14.5	3.18	.	.	.
8-Jul	RC11	0	0	0	0	1	1	1	1	290	33.7	16	3.88	.	.	.
8-Jul	RC12	10	7	30	47	11	8	30	46	240	31	13.5	3.42	.	.	.
8-Jul	RC13	1	1	4	6	2	2	5	7	300	31	12.5	3.98	.	.	.
8-Jul	RC14	0	7	6	13	1	8	7	14	330	32.5	14	3.12	.	.	.
8-Jul	RC15	17	7	14	38	18	8	15	39	260	31.5	13	: 17	.	.	.
8-Jul	RC16	0	5	3	8	1	6	4	9	210	29.5	12.2	.14	.	.	.
8-Jul	RC17	4	9	8	21	5	10	9	22	270	33	14	3.48	.	.	.
8-Jul	RC18	7	11	8	26	8	12	9	27	260	34	14	3.22	.	.	.
8-Jul	RC19	3	2	0	5	4	3	1	6	230	31.7	11.5	3	.	.	.
8-Jul	RC20	0	0	0	0	1	1	1	1	270	32	14	3.23	.	.	.
8-Jul	RC21	2	1	2	5	3	2	3	6	280	32.3	12.7	3.14	.	.	.
8-Jul	RC22	1	2	5	8	2	3	6	9	260	32.5	12.5	3.22	.	.	.
8-Jul	RC23	3	1	0	4	4	2	1	5	320	33.2	13.5	3.55	.	.	.
8-Jul	RC24	0	0	0	0	1	1	1	1	250	31.7	13.6	3.42	.	.	.
8-Jul	RC25	1	0	0	1	2	1	1	2	290	32.4	12.8	3.03	.	.	.
8-Jul	RC26	315	2	4	321	70	3	5	95	230	32.6	12.2	. 02	.	.	.
8-Jul	RC27	0	0	1	1	1	1	2	2	250	32.3	12	3.53	.	.	.
8-Jul	RC28	0	0	1	1	1	1	2	2	300	31.2	13.2	: 62	.	.	.
8-Jul	RC29	6	3	2	11	7	4	3	12	250	31.5	12.3	33	.	.	.
8-Jul	RC30	0	0	0	0	1	1	1	1	260	31.1	13	3.43	.	.	.

Sriracha Distric in Sriracha Province during June-July 2000

Date	Label	Parasite intensity				Rank of intensity				Morphological data						
		uni	mic	mac	int	r_uni	r_mic	r_mac	r_int	Weigh	Wing	Tail	Tarsus	3rd Digit	Head	Beak
										(g)	(cm)	(cm)	(cm)	(cm)	(cm)	(cm)
29-Jul	RR01	14	15	20	49	15	16	21	47	260	30	13	3.16			
29-Jul	RR02	3	4	2	9	4	5	3	10	340	31.3	12.5	3.2			
29-Jul	RR03	0	0	0	0	1	1	1	1	200	31.4	12	3.18			
29-Jul	RR04	15	10	3	28	16	11	4	29	350	33.2	13.4	3.56			
29-Jul	RR05	0	0	0	0	1	1	1	1	260	32	13	3.52			
29-Jul	RR06	6	3	5	14	7	4	6	15	300	31	12	3.41			
29-Jul	RR07	19	15	26	60	19	16	26	55	300	32.2	12.5	3.46			
29-Jul	RR08	5	1	1	7	6	2	2	8	350	31	13	3.77			
29-Jul	RR09	20	1	4	25	20	2	5	26	340	32	12	3.5			
29-Jul	RR10	4	11	9	24	5	12	10	25	330	32.6	13.7	3.45			
29-Jul	RR11	2	0	0	2	3	1	1	3	270	29.5	12.2	3.35			
29-Jul	RR12	331	0	12	343	73	1	13	97	290	31.1	13.3	3.32			
29-Jul	RR13	5	1	2	8	6	2	3	9	300	31.7	12.6	3.31			
29-Jul	RR14	0	6	6	12	1	7	7	13	290	31.5	12.8	3.62			
29-Jul	RR15	17	27	28	72	18	28	28	61	290	32	12.3	3.33			
29-Jul	RR16	1	0	0	1	2	1	1	2	290	31.6	12.5	3.5			
29-Jul	RR17	1	0	3	4	2	1	4	5	370	32	13.2	3.71			
29-Jul	RR18	3	4	1	8	4	5	2	9	300	31	13.1	3.44			
29-Jul	RR19	1	0	0	1	2	1	1	2	280	31.5	12.2	3.61			
29-Jul	RR20	33	18	34	85	30	19	32	67	240	29.5	12	3.34			
29-Jul	RR21	0	0	0	0	1	1	1	1	340	32.3	12.5	3.64			
29-Jul	RR22	37	26	29	92	32	27	29	71	270	31	13	3.4			
29-Jul	RR23	26	3	0	29	26	4	1	30	270	31.5	12.8	3.45			
29-Jul	RR24	87	23	18	128	54	24	19	81	260	31.5	13.7	3.57			
29-Jul	RR25	46	14	7	67	40	15	8	58	320	32.4	13	3.78			
29-Jul	RR26	79	2	6	87	53	3	7	68	310	32.2	13.5	3.42			
29-Jul	RR27	10	1	8	19	11	2	9	20	320	32.1	12.5	3.47			
29-Jul	RR28	87	41	136	264	54	37	57	93	320	31	11.5	3.62			
29-Jul	RR29	2	3	2	7	3	4	3	8	240	30.5	12.2	3.2			
29-Jul	RR30	2	0	3	5	3	1	4	6	310	31.5	13.5	3.4			

Lumpinee Park during November-December 2000

Date	Label	Parasite intensity				Rank of intensity				Morphological data						
		uni	mic	mac	int	r_uni	r_mic	r_mac	r_int	Weigh	Wing	Tail	Tarsus	3rd Digit	Head	Beak
										(g)	(cm)	(cm)	(cm)	(cm)	(cm)	(cm)
9-Nov	WL01	0	0	0	0	1	1	1	1	260	31.5	13	3.2	.	.	.
9-Nov	WL02	3	6	0	9	4	7	1	10	260	31.5	14.5	.09	.	.	.
9-Nov	WL03	12	6	2	20	13	7	3	21	240	30	13.5	3.42	.	.	.
9-Nov	WL04	2	0	0	2	3	1	1	3	250	31.5	14	3.26	.	.	.
9-Nov	WL05	16	5	8	29	17	6	9	30	300	31.5	13.5	3.34	.	.	.
9-Nov	WL06	2318	596	385	3299	91	58	63	125	210	31.5	13	3.38	.	.	.
9-Nov	WL07	6	9	10	25	7	10	11	26	310	32	14	3.65	.	.	.
9-Nov	WL08	3	6	2	11	4	7	3	12	260	32.5	12.5	3.21	.	.	.
9-Nov	WL09	3	3	1	7	4	4	2	8	320	33	14	3.65	.	.	.
9-Nov	WL10	14	8	7	29	15	9	8	30	330	33	14	3.46	.	.	.
9-Nov	WL11	8	6	10	24	9	7	11	25	260	32	14	3.25	.	.	.
9-Nov	WL12	0	2	0	2	1	3	1	3	280	31.5	13	3.24	.	.	.
9-Nov	WL13	34	7	18	59	31	8	19	54	230	32	12	3.05	.	.	.
9-Nov	WL14	319	49	115	483	71	41	55	106	210	32	12.5	3.26	.	.	.
9-Nov	WL15	5	8	8	21	6	9	9	22	240	31	12.5	.07	.	.	.
9-Nov	WL16	0	0	1	1	1	1	2	2	280	34	14	.57	.	.	.
9-Nov	WL17	719	198	118	1035	81	55	56	115	270	33.5	14	3.41	.	.	.
9-Nov	WL18	2	11	11	24	3	12	12	25	250	33.5	13	3.21	.	.	.
9-Nov	WL19	305	33	14	352	69	32	15	98	260	31.5	12.7	3.6	.	.	.
9-Nov	WL20	0	1	0	1	1	2	1	2	320	33	14	3.31	.	.	.
9-Nov	WL21	3	9	13	25	4	10	14	26	240	31	13.5	3.21	.	.	.
9-Nov	WL22	0	4	9	13	1	5	10	14	290	33	14.5	3.51	.	.	.
9-Nov	WL23	59	18	14	91	46	19	15	70	190	33	14	3.38	.	.	.
9-Nov	WL24	1016	94	98	1208	85	49	51	117	210	33.5	14	3.12	.	.	.
9-Nov	WL25	0	0	0	0	1	1	1	1	240	33.3	15	3.71	.	.	.
9-Nov	WL26	4	11	8	23	5	12	9	24	310	35.5	14.5	.48	.	.	.
9-Nov	WL27	2	4	1	7	3	5	2	8	300	32.5	13.2	3.24	.	.	.
9-Nov	WL28	2	2	1	5	3	3	2	6	220	32.5	14	.23	.	.	.
9-Nov	WL29	2	1	4	7	3	2	5	8	300	34.5	14.5	.27	.	.	.
9-Nov	WL30	23	11	10	44	23	12	11	45	300	35.8	14.3	3.61	.	.	.

Dusit Zoo during November-December 2000

Date	Label	Parasite intensity				Rank of intensity				Morphological data						
		uni	mic	mac	int	r_uni	r_mic	r_mac	r_int	Weigh	Wing	Tail	Tarsus	3rd Digit	Head	Beak
										(g)	(cm)	(cm)	(cm)	(cm)	(cm)	(cm)
10-Nov	WD01	0	5	0	5	1	6	1	6	250	34.6	14.8	3.95	.	.	.
10-Nov	WD02	0	3	11	14	1	4	12	15	320	33	15	3.51	.	.	.
10-Nov	WD03	0	0	0	0	1	1	1	1	270	33	13.3	3.25	.	.	.
10-Nov	WD04	3	2	0	5	4	3	1	6	280	33.8	13.5	3.45	.	.	.
10-Nov	WD05	14	16	13	43	15	17	14	44	260	33	13.5	3.61	.	.	.
10-Nov	WD06	840	187	232	1259	83	54	60	120	220	31	12.8	3.31	.	.	.
10-Nov	WD07	1	3	1	5	2	4	2	6	320	34	13.3	3.5	.	.	.
10-Nov	WD08	2	2	8	12	3	3	9	13	260	33	14	3.24	.	.	.
10-Nov	WD09	12	28	14	54	13	29	15	50	240	32.5	13.4	13	.	.	.
10-Nov	WD10	25	3	6	34	25	4	7	35	290	32	15	3.41	.	.	.
10-Nov	WD11	0	0	0	0	1	1	1	1	280	31.5	13.2	3.63	.	.	.
10-Nov	WD12	2	5	3	10	3	6	4	11	280	33.7	14.5	3.62	.	.	.
10-Nov	WD13	3	0	0	3	4	1	1	4	250	32.2	13	3.35	.	.	.
10-Nov	WD14	6	7	3	16	7	8	4	17	280	33.5	13.5	3.5	.	.	.
10-Nov	WD15	43	29	23	95	37	30	24	73	260	32.5	13.2	3.57	.	.	.
10-Nov	WD16	2	12	5	19	3	13	6	20	260	32.5	13.5	3.46	.	.	.
10-Nov	WD17	41	75	37	153	35	45	33	86	200	31	13.5	3.43	.	.	.
10-Nov	WD18	2	8	21	31	3	9	22	32	280	31.6	14.2	3.15	.	.	.
10-Nov	WD19	10	0	1	11	11	1	2	12	280	33.5	13	3.55	.	.	.
12-Nov	WD20	1	4	11	16	2	5	12	17	280	32.7	13.6	3.56	.	.	.
12-Nov	WD21	0	1	0	1	1	2	1	2	280	32	12.3	3.56	.	.	.
12-Nov	WD22	7	10	10	27	8	11	11	28	260	33.5	12.8	3.37	.	.	.
12-Nov	WD23	5	7	5	17	6	8	6	18	300	33	13.3	3.7	.	.	.
12-Nov	WD24	16	3	6	25	17	4	7	26	285	30.6	12.4	3.8	.	.	.
12-Nov	WD25	1	2	0	3	2	3	1	4	260	33.5	14.2	3.2	.	.	.
12-Nov	WD26	13	5	2	20	14	6	3	21	280	33.3	14.5	3.61	.	.	.
12-Nov	WD27	67	8	4	79	50	9	5	65	300	35.5	15.5	3.63	.	.	.
12-Nov	WD28	0	5	3	8	1	6	4	9	240	32.4	13	3.63	.	.	.
12-Nov	WD29	0	0	0	0	1	1	1	1	340	33.5	14	3.92	.	.	.
12-Nov	WD30	21	9	5	35	21	10	6	36	300	34.1	15	3.63	.	.	.

Sanam Luang during November-December 2000

Date	Label	Parasite intensity				Rank of intensity				Morphological data						
		uni	mic	mac	Int	r_uni	r_mic	r_mac	r_int	Weigh	Wing	Tail	Ta ;us	3rd Digit	Head	Beak
										(g)	(cm)	(cm)	(cm)	(cm)	(cm)	(cm)
17-Nov	WS01	0	2	0	2	1	3	1	3	270	33.5	13.5	: 54	.	.	.
17-Nov	WS02	2	0	1	3	3	1	2	4	260	31.5	13.5	)6	.	.	.
17-Nov	WS03	12	0	0	12	13	1	1	13	280	33.6	14.5	3.02	.	.	.
17-Nov	WS04	10	3	0	13	11	4	1	14	240	30.8	13.4	3.41	.	.	.
17-Nov	WS05	2	6	4	12	3	7	5	13	230	31.5	11.5	3.53	.	.	.
17-Nov	WS06	1246	0	0	1246	86	1	1	119	280	34.7	14.6	3.58	.	.	.
17-Nov	WS07	2	5	3	10	3	6	4	11	280	34.5	14.6	3.51	.	.	.
17-Nov	WS08	8	0	0	8	9	1	1	9	270	33.2	14	3.52	.	.	.
17-Nov	WS09	3	0	1	4	4	1	2	5	270	33.3	14	3.48	.	.	.
17-Nov	WS10	7	3	14	24	8	4	15	25	300	32.7	12.8	3.55	.	.	.
17-Nov	WS11	23	8	1	32	23	9	2	33	300	33.5	13.5	3.5	.	.	.
17-Nov	WS12	1	1	1	3	2	2	2	4	290	32.6	13.8	: 47	.	.	.
17-Nov	WS13	570	33	57	660	77	32	42	110	240	34.5	14	3.67	.	.	.
17-Nov	WS14	1	2	5	8	2	3	6	9	310	32	13.8	3 63	.	.	.
17-Nov	WS15	2	8	17	27	3	9	18	28	280	34.2	13.5	- 35	.	.	.
17-Nov	WS16	0	0	4	4	1	1	5	5	330	33.5	13.4	3.77	.	.	.
17-Nov	WS17	10	12	16	38	11	13	17	39	280	32.2	12.5	3.55	.	.	.
17-Nov	WS18	4	6	2	12	5	7	3	13	290	33.5	13.5	3.47	.	.	.
17-Nov	WS19	1	4	2	7	2	5	3	8	290	33.3	13.2	3.55	.	.	.
17-Nov	WS20	3	2	4	9	4	3	5	10	340	33.5	13.5	3.95	.	.	.
17-Nov	WS21	15	8	5	28	16	9	6	29	280	33	13.5	3.38	.	.	.
17-Nov	WS22	16	5	4	25	17	6	5	26	270	31.2	11.8	3.36	.	.	.
17-Nov	WS23	0	1	0	1	1	2	1	2	260	34.4	13.5	3.68	.	.	.
17-Nov	WS24	40	4	6	50	34	5	7	48	300	34.5	14.5	3.53	.	.	.
17-Nov	WS25	157	0	0	157	59	1	1	87	320	32	12.8	3.3	.	.	.
17-Nov	WS26	8	1	10	19	9	2	11	20	340	32.8	13	3.79	.	.	.
17-Nov	WS27	2	2	0	4	3	3	1	5	270	33.3	14	3.37	.	.	.
17-Nov	WS28	25	10	17	52	25	11	18	49	270	32.3	13.8	32	.	.	.
17-Nov	WS29	24	32	14	70	24	31	15	60	290	33.2	10.5	3.88	.	.	.
17-Nov	WS30	4	6	10	20	5	7	11	21	310	33.2	11	3.26	.	.	.

Muang District in Chonburi Province (Chonburi) during November-December 2000

Date	Label	Parasite intensity				Rank of intensity				Morphological data						
		uni	mic	mac	int	r_uni	r_mic	r_mac	r_int	Weigh	Wing	Tail	Tarsus	3rd Digit	Head	Beak
17-Nov	WC01	14	4	13	31	15	5	14	32	350	34.5	13.8	3.65	3.7	5.32	1.84
17-Nov	WC02	1	1	2	4	2	2	3	5	280	34.7	13.2	3.74	3.66	5.32	1.81
17-Nov	WC03	10	3	2	15	11	4	3	16	290	33.3	13	3.72	3.68	5.19	1.89
17-Nov	WC04	8	1	5	14	9	2	6	15	260	32.7	13	3.72	3.58	5.24	1.71
17-Nov	WC05	0	2	3	5	1	3	4	6	330	31.8	12.5	[illegible]68	3.83	5.4	2.03
17-Nov	WC06	0	0	2	2	1	1	3	3	330	32.2	12.2	3.23	3.81	5.21	1.71
17-Nov	WC07	0	0	2	2	1	1	3	3	260	34	12.7	[illegible]33	3.64	5.19	1.83
17-Nov	WC08	0	0	2	2	1	1	3	3	290	34.5	14.8	[illegible]56	3.87	5.36	2.05
17-Nov	WC09	1	12	8	21	2	13	9	22	270	34	13.5	3.45	3.58	5.36	1.81
17-Nov	WC10	0	1	1	2	1	2	2	3	250	35	13	3	3.36	5.03	1.53
17-Nov	WC11	5	5	6	16	6	6	7	17	250	31.3	12	3.22	3.82	5.21	1.85
17-Nov	WC12	44	7	5	56	38	8	6	52	320	32	13.5	3.51	3.89	5.3	1.77
17-Nov	WC13	12	2	8	22	13	3	9	23	280	31.7	12	3.7	3.67	5.36	1.72
17-Nov	WC14	6	2	3	11	7	3	4	12	310	32.5	13	3.54	3.85	5.4	1.87
17-Nov	WC15	0	0	0	0	1	1	1	1	280	34.5	13.5	3.35	3.7	5.27	1.96
17-Nov	WC16	0	0	0	0	1	1	1	1	290	33.9	13.3	3.65	3.71	5.26	1.76
17-Nov	WC17	5	0	2	7	6	1	3	8	280	33.2	13.1	3.51	3.66	5.36	1.96
17-Nov	WC18	5	0	4	9	6	1	5	10	250	32.5	13	[illegible]35	3.53	5.05	1.67
17-Nov	WC19	0	0	2	2	1	1	3	3	280	31.7	12.2	3.44	3.6	5.33	1.97
17-Nov	WC20	0	0	0	0	1	1	1	1	300	31.5	12.9	[illegible]67	3.71	5.43	1.91
17-Nov	WC21	52	4	5	61	45	5	6	56	220	31	12.5	[illegible]96	3.47	5.26	1.76
17-Nov	WC22	636	0	0	636	79	1	1	109	240	31.3	12.4	3.51	3.53	5.26	1.87
17-Nov	WC23	4	0	2	6	5	1	3	7	300	32.8	12.8	3.62	3.92	5.36	1.8
17-Nov	WC24	3	1	1	5	4	2	2	6	270	32.9	12.9	3.32	3.44	5.18	1.76
17-Nov	WC25	0	0	3	3	1	1	4	4	240	32	12.5	3.65	3.83	5.51	2.02
17-Nov	WC26	0	0	0	0	1	1	1	1	240	35.1	13.6	3.66	4	5.56	1.9
17-Nov	WC27	3	5	6	14	4	6	7	15	250	31.3	13.2	3.42	3.53	5.13	1.88
17-Nov	WC28	1	0	1	2	2	1	2	3	310	32.1	12.5	3.34	3.61	5.1	1.61
17-Nov	WC29	0	1	1	2	1	2	2	3	270	32.1	12.5	2.96	3.81	5.26	1.82
17-Nov	WC30	1	0	4	5	2	1	5	6	200	29.5	12.2	3.33	3.37	5.07	1.75

Sriracha District in Chonburi Province (Sriracha) during November-December 2000

Date	Label	Parasite intensity				Rank of intensity				Morphological data						
		uni	mic	mac	int	r_uni	r_mic	r_mac	r_int	Weigh	Wing	Tail	Tarsus	3rd Digit	Head	Beak
										(g)	(cm)	(cm)	(cm)	(cm)	(cm)	(cm)
1-Dec	WR01	4	0	6	10	5	1	7	11	330	34.6	13.4	3.55	3.81	5.2	2.1
1-Dec	WR02	1	4	19	24	2	5	20	25	340	32.5	13.5	3.5	3.64	5.3	1.97
1-Dec	WR03	0	0	0	0	1	1	1	1	370	33.4	13.3	3.68	3.8	5.1	1.94
1-Dec	WR04	0	0	4	4	1	1	5	5	280	32	12.6	3.52	4	5.22	1.71
1-Dec	WR05	6	0	3	9	7	1	4	10	310	33.1	13.2	3.51	3.95	5.1	1.82
1-Dec	WR06	7	0	5	12	8	1	6	13	300	31.7	13	3.34	3.75	5.05	1.81
1-Dec	WR07	15	3	8	26	16	4	9	27	340	32.8	13	3.36	3.75	5.15	1.88
1-Dec	WR08	0	0	1	1	1	1	2	2	330	33.2	12.9	3.52	4.01	5.25	1.98
1-Dec	WR09	1	2	0	3	2	3	1	4	320	33.7	13.2	3.6	3.66	5.25	1.47
1-Dec	WR10	1	1	1	3	2	2	2	4	320	31.3	13.2	3.22	3.41	5.26	1.76
1-Dec	WR11	1	0	1	2	2	1	2	3	360	32.5	12.8	3.65	3.79	5.18	1.68
1-Dec	WR12	1	1	2	4	2	2	3	5	330	32.9	13.2	3.5	3.71	5.22	1.36
1-Dec	WR13	2	0	0	2	3	1	1	3	310	32	13.5	3.34	3.79	5.14	1.84
1-Dec	WR14	16	7	26	49	17	8	26	47	370	32.6	12	3.24	3.62	5.31	1.68
1-Dec	WR15	14	14	26	54	15	15	26	50	330	33.3	12.8	3.5	3.55	5.41	1.83
1-Dec	WR16	1	5	9	15	2	6	10	16	310	32.1	13.1	3.44	3.36	5.2	1.75
1-Dec	WR17	2	6	5	13	3	7	6	14	260	32.6	12.8	3.4	3.66	5.11	1.78
1-Dec	WR18	0	4	3	7	1	5	4	8	370	32.2	12.5	3.51	3.6	5.57	2.06
1-Dec	WR19	0	0	0	0	1	1	1	1	280	32	12.5	3.3	3.51	5.26	2.28
1-Dec	WR20	20	0	8	28	20	1	9	29	340	32	12.8	3.51	3.78	5.17	1.76
1-Dec	WR21	0	0	0	0	1	1	1	1	320	33.3	12	3.53	3.71	5.18	1.93
1-Dec	WR22	186	10	39	235	60	11	35	91	290	32.2	12.5	3.43	3.66	5.37	1.96
1-Dec	WR23	1	2	11	14	2	3	12	15	260	33	13.2	3.42	3.71	5.27	1.78
1-Dec	WR24	11	2	12	25	12	3	13	26	340	31.5	12.8	3.23	3.63	5.25	1.97
1-Dec	WR25	3	8	19	30	4	9	20	31	360	34.1	14	3.47	4.02	5.42	1.88
1-Dec	WR26	1	11	19	31	2	12	20	32	340	32.6	13.8	3.46	3.96	5.6	1.97
1-Dec	WR27	11	11	15	37	12	12	16	38	320	31	11.8	3.4	3.65	5.18	1.76
1-Dec	WR28	3	1	8	12	4	2	9	13	300	32.8	13.4	3.6	3.82	5.32	1.96
1-Dec	WR29	0	6	2	8	1	7	3	9	320	34.6	13.5	3.52	3.91	5.34	1.94
1-Dec	WR30	42	13	51	106	36	14	40	76	340	32.2	12.5	3.32	3.75	5.12	1.86

Muang District in Chonburi Province (Chonburi) during November-December 2000

Date	Label	Parasite intensity				Rank of intensity				Morphological data						
		uni	mic	mac	int	r_uni	r_mic	r_mac	r_int	Weigh	Wing	Tail	Tarsus	3rd Digit	Head	Beak
										(g)	(cm)	(cm)	(cm)	(cm)	(cm)	(cm)
17-Nov	WC01	14	4	13	31	15	5	14	32	350	34.5	13.8	3.65	3.7	5.32	1.84
17-Nov	WC02	1	1	2	4	2	2	3	5	280	34.7	13.2	3.74	3.66	5.32	1.81
17-Nov	WC03	10	3	2	15	11	4	3	16	290	33.3	13	3.72	3.68	5.19	1.89
17-Nov	WC04	8	1	5	14	9	2	6	15	260	32.7	13	3.72	3.58	5.24	1.71
17-Nov	WC05	0	2	3	5	1	3	4	6	330	31.8	12.5	3.68	3.83	5.4	2.03
17-Nov	WC06	0	0	2	2	1	1	3	3	330	32.2	12.2	3.23	3.81	5.21	1.71
17-Nov	WC07	0	0	2	2	1	1	3	3	260	34	12.7	3.33	3.64	5.19	1.83
17-Nov	WC08	0	0	2	2	1	1	3	3	290	34.5	14.8	3.56	3.87	5.36	2.05
17-Nov	WC09	1	12	8	21	2	13	9	22	270	34	13.5	3.45	3.58	5.36	1.81
17-Nov	WC10	0	1	1	2	1	2	2	3	250	35	13	3	3.36	5.03	1.53
17-Nov	WC11	5	5	6	16	6	6	7	17	250	31.3	12	3.22	3.82	5.21	1.85
17-Nov	WC12	44	7	5	56	38	8	6	52	320	32	13.5	3.51	3.89	5.3	1.77
17-Nov	WC13	12	2	8	22	13	3	9	23	280	31.7	12	3.7	3.67	5.36	1.72
17-Nov	WC14	6	2	3	11	7	3	4	12	310	32.5	13	3.4	3.85	5.4	1.87
17-Nov	WC15	0	0	0	0	1	1	1	1	280	34.5	13.5	3.35	3.7	5.27	1.96
17-Nov	WC16	0	0	0	0	1	1	1	1	290	33.9	13.3	3.65	3.71	5.26	1.76
17-Nov	WC17	5	0	2	7	6	1	3	8	280	33.2	13.1	3.51	3.66	5.36	1.96
17-Nov	WC18	5	0	4	9	6	1	5	10	250	32.5	13	3.35	3.53	5.05	1.67
17-Nov	WC19	0	0	2	2	1	1	3	3	280	31.7	12.2	3.44	3.6	5.33	1.97
17-Nov	WC20	0	0	0	0	1	1	1	1	300	31.5	12.9	3.67	3.71	5.43	1.91
17-Nov	WC21	52	4	5	61	45	5	6	56	220	31	12.5	3.96	3.47	5.26	1.76
17-Nov	WC22	636	0	0	636	79	1	1	109	240	31.3	12.4	3.51	3.53	5.26	1.87
17-Nov	WC23	4	0	2	6	5	1	3	7	300	32.8	12.8	3.62	3.92	5.36	1.8
17-Nov	WC24	3	1	1	5	4	2	2	6	270	32.9	12.9	3.32	3.44	5.18	1.76
17-Nov	WC25	0	0	3	3	1	1	4	4	240	32	12.5	3.65	3.83	5.51	2.02
17-Nov	WC26	0	0	0	0	1	1	1	1	240	35.1	13.6	3.66	4	5.56	1.9
17-Nov	WC27	3	5	6	14	4	6	7	15	250	31.3	13.2	3.42	3.53	5.13	1.88
17-Nov	WC28	1	0	1	2	2	1	2	3	310	32.1	12.5	3.34	3.61	5.1	1.61
17-Nov	WC29	0	1	1	2	1	2	2	3	270	32.1	12.5	2.96	3.81	5.26	1.82
17-Nov	WC30	1	0	4	5	2	1	5	6	200	29.5	12.2	3.33	3.37	5.07	1.75

Lumpinee Park during February-March 2001

Date	Label	Parasite intensity				Rank of intensity				Morphological data						
		uni	mic	mac	int	r_uni	r_mic	r_mac	r_int	Weigh (g)	Wing (cm)	Tail (cm)	Tarsus (cm)	3rd Digit (cm)	Head (cm)	Beak (cm)
27-Feb	SL01	102	348	100	550	56	57	52	107	240	34.2	13	3.77	3.52	5.42	1.84
27-Feb	SL02	14	36	44	94	15	35	39	72	240	32.3	12.2	3.5	3.51	5.26	1.78
27-Feb	SL03	9	0	2	11	10	1	3	12	280	32.7	12.2	3.77	3.52	5.47	1.78
27-Feb	SL04	204	13	7	224	63	14	8	89	260	33.2	12.7	3.94	3.7	5.3	1.93
27-Feb	SL05	0	1	0	1	1	2	1	2	360	34.5	13.3	3.91	4.01	5.51	1.93
27-Feb	SL06	22	1	0	23	22	2	1	24	240	33.2	12.7	3.65	3.77	5.34	1.96
27-Feb	SL07	7	1	1	9	8	2	2	10	220	31.5	13.2	3.71	3.61	5.26	1.94
27-Feb	SL08	8	1	0	9	9	2	1	10	280	34.8	13.4	3.92	3.88	5.29	1.92
27-Feb	SL09	4	12	7	23	5	13	8	24	240	31.6	12	3.88	3.25	5.02	1.85
27-Feb	SL10	244	60	136	440	65	42	57	103	240	34.4	12.5	36	4.01	5.44	1.88
27-Feb	SL11	1589	35	56	1680	87	34	41	121	220	33	11.8	3.74	3.73	5.21	1.87
27-Feb	SL12	12	1	1	14	13	2	2	15	370	34.2	13.3	3.87	3.84	5.6	1.82
27-Feb	SL13	3	2	2	7	4	3	3	8	350	34.2	13.5	4	3.76	5.48	1.86
27-Feb	SL14	10	2	12	24	11	3	13	25	340	32.1	13.1	3.95	3.7	5.24	1.86
27-Feb	SL15	295	3	3	301	67	4	4	94	270	33.6	13.2	3.64	3.51	5.22	1.7
27-Feb	SL16	11	4	3	18	12	5	4	19	320	35.3	14.6	3.94	3.86	5.53	1.93
27-Feb	SL17	0	1	3	4	1	2	4	5	260	34.1	13	4	4.12	5.27	1.66
27-Feb	SL18	11	9	8	28	12	10	9	29	280	32.1	11.8	3.82	3.7	5.03	1.61
27-Feb	SL19	2	1	3	6	3	2	4	7	270	33.3	12	3.81	3.68	5.07	1.72
27-Feb	SL20	0	0	0	0	1	1	1	1	240	30.9	12.6	3.42	3.31	5.05	1.76
27-Feb	SL21	2	0	3	5	3	1	4	6	320	33.4	13.6	3.67	3.67	5.37	1.94
27-Feb	SL22	0	0	0	0	1	1	1	1	280	31.1	12	3.82	3.78	5.38	1.83
27-Feb	SL23	0	0	0	0	1	1	1	1	240	34	12.8	3.87	3.9	5.35	1.86
27-Feb	SL24	4	10	8	22	5	11	9	23	300	31.7	12	3.63	3.67	5.16	1.77
27-Feb	SL25	1	1	0	2	2	2	1	3	270	32.5	12.1	3.57	3.72	5.23	1.84
27-Feb	SL26	73	10	17	100	52	11	18	75	300	33.9	13.1	3.78	3.67	5.53	1.93
27-Feb	SL27	15	3	16	34	16	4	17	35	290	32.5	13	3.64	3.79	5.35	1.92
27-Feb	SL28	12	0	11	23	13	1	12	24	280	30.9	12.8	3.95	3.84	5.46	1.85
27-Feb	SL29	753	157	327	1237	82	53	61	118	240	32.7	12.5	3.65	3.57	5.17	1.9
27-Feb	SL30	11	24	22	57	12	25	23	53	190	32.5	12	3.6	3.61	5.02	2.12

Dusit Zoo during February-March 2001

Date	Label	Parasite intensity				Rank of intensity				Morphological data						
		uni	mic	mac	int	r_uni	r_mic	r_mac	r_int	Weigh (g)	Wing (cm)	Tail (cm)	Tarsus (cm)	3rd Digit (cm)	Head (cm)	Beak (cm)
26-Feb	SD01	5	14	8	27	6	15	9	28	270	34.3	13.2	3.76	3.86	5.36	1.45
26-Feb	SD02	24	3	42	69	24	4	37	59	190	32.1	12.8	3.36	3.51	5.14	1.71
26-Feb	SD03	7	2	10	19	8	3	11	20	280	32.1	12.8	3.66	3.88	5.05	1.84
26-Feb	SD04	2	1	0	3	3	2	1	4	270	32.4	12.8	3.25	3.42	5.05	1.77
26-Feb	SD05	0	2	2	4	1	3	3	5	290	34.6	13.4	3.61	3.71	5.31	1.91
26-Feb	SD06	17	14	19	50	18	15	20	48	260	32.4	12.5	3.54	3.63	5.05	1.92
26-Feb	SD07	1	5	9	15	2	6	10	16	260	31.1	10.7	3.8	3.72	5.06	1.7
26-Feb	SD08	8	17	17	42	9	18	18	43	270	31.1	12.2	3.55	3.44	5.3	1.94
26-Feb	SD09	11	8	15	34	12	9	16	35	260	32.1	12	3.67	3.67	5.2	1.71
26-Feb	SD10	19	5	8	32	19	6	9	33	320	33.9	12.8	3.9	3.67	5.6	1.98
26-Feb	SD11	5	1	2	8	6	2	3	9	300	34	13.2	3.56	3.67	5.24	1.83
26-Feb	SD12	3	18	19	40	4	19	20	41	270	34.5	14	3.81	3.62	5.37	1.93
26-Feb	SD13	0	8	8	16	1	9	9	17	320	32.7	12.8	3.63	3.67	5.2	1.8
26-Feb	SD14	39	16	8	63	33	17	9	57	280	34.2	13	3.7	3.82	5.22	1.81
26-Feb	SD15	16	9	9	34	17	10	10	35	250	32.7	12.2	3.61	3.68	5.3	1.86
26-Feb	SD16	0	0	0	0	1	1	1	1	250	32.2	12.3	3.52	3.6	5.03	1.61
26-Feb	SD17	24	34	33	91	24	33	31	70	250	33.2	12.7	3.54	3.55	5.36	1.97
26-Feb	SD18	14	9	2	25	15	10	3	26	270	32.5	12.7	3.6	3.72	5.22	1.85
26-Feb	SD19	51	80	69	200	44	46	46	88	260	33.6	13.1	3.55	3.76	5.27	1.66
26-Feb	SD20	13	10	13	36	14	11	14	37	250	32.2	13.5	3.5	3.37	5.08	1.82
26-Feb	SD21	4	0	1	5	5	1	2	6	280	34	13.5	3.81	3.6	5.26	1.76
26-Feb	SD22	61	13	8	82	47	14	9	66	240	34.1	13	3.81	3.66	5.4	1.9
26-Feb	SD23	199	19	29	247	62	20	29	92	290	32.7	12.5	3.81	3.61	5.25	1.71
26-Feb	SD24	25	11	27	63	25	12	27	57	290	33.8	13.8	3.71	3.97	5.46	1.8
26-Feb	SD25	0	4	0	4	1	5	1	5	250	34.4	13.2	3.61	3.81	5.37	1.95
26-Feb	SD26	14	3	1	18	15	4	2	19	280	31.8	12.8	3.78	3.64	5.21	1.9
26-Feb	SD27	1	5	6	12	2	6	7	13	240	32.4	12.6	3.56	3.53	4.86	1.71
26-Feb	SD28	2	3	2	7	3	4	3	8	290	34.2	13.8	3.86	3.82	5.47	2.04
26-Feb	SD29	9	4	2	15	10	5	3	16	260	32.7	12.6	3.56	3.62	5.07	1.93
26-Feb	SD30	5	2	6	13	6	3	7	14	250	32.7	12.8	3.7	3.76	5.22	1.81

Sanam Luang during February-March 2001

Date	Label	Parasite intensity				Rank of intensity				Morphological data						
		uni	mic	mac	int	r_uni	r_mic	r_mac	r_int	Weigh	Wing	Tail	Tarsus	3rd Digit	Head	Beak
										(g)	(cm)	(cm)	(cm)	(cm)	(cm)	(cm)
28-Feb	SS01	14	10	10	34	15	11	11	35	300	34.8	12.7	3.92	4.01	5.46	1.88
28-Feb	SS02	0	2	5	7	1	3	6	8	260	34.5	13.2	3.78	3.59	5.45	1.95
28-Feb	SS03	0	41	59	100	1	37	44	75	320	34.5	13.1	4.02	3.92	5.55	1.84
28-Feb	SS04	2	7	4	13	3	8	5	14	340	32.6	13.1	3.63	3.56	5.21	2
28-Feb	SS05	1	5	7	13	2	6	8	14	300	33.5	13.2	3.86	3.74	5.47	1.85
28-Feb	SS06	1	2	0	3	2	3	1	4	330	33.3	13.2	4.01	3.87	5.53	1.93
28-Feb	SS07	3	2	4	9	4	3	5	10	240	31.8	12.5	3.46	3.69	5.13	1.81
28-Feb	SS08	2	5	3	10	3	6	4	11	280	32.7	12.7	3.45	3.44	5.11	1.93
28-Feb	SS09	4	10	6	20	5	11	7	21	260	34.5	12.4	3.98	3.77	5.42	2
28-Feb	SS10	0	1	3	4	1	2	4	5	260	33.1	12	3.75	3.45	5.26	1.81
28-Feb	SS11	6	5	7	18	7	6	8	19	300	32.8	12.5	3.74	3.58	5.38	1.95
28-Feb	SS12	6	1	1	8	7	2	2	9	250	33.7	12.4	3.51	3.74	5.21	1.85
28-Feb	SS13	2	3	0	5	3	4	1	6	370	33.5	13.7	3.93	3.95	5.41	2.07
28-Feb	SS14	1793	34	38	1865	88	33	34	122	280	33.2	12.5	3.62	3.67	5.14	1.94
28-Feb	SS15	0	0	0	0	1	1	1	1	240	33.8	12.2	3.62	3.62	5.21	1.86
28-Feb	SS16	133	23	73	229	58	24	47	90	210	32.1	11.7	3.66	3.74	5.22	1.86
28-Feb	SS17	45	47	43	135	39	40	38	82	260	33.1	12.9	3.68	3.72	5.25	1.82
28-Feb	SS18	1	3	3	7	2	4	4	8	240	33.4	12.7	3.76	3.63	5.15	1.77
28-Feb	SS19	2490	13	11	2514	92	14	12	124	240	33.8	13.2	3.81	3.63	5.32	1.98
28-Feb	SS20	6	3	6	15	7	4	7	16	220	33.4	12.7	3.9	3.82	5.39	1.89
28-Feb	SS21	4	26	19	49	5	27	20	47	260	33.1	12.2	3.62	3.67	5.24	1.9
28-Feb	SS22	2	3	10	15	3	4	11	16	270	32.2	12.5	3.46	3.44	5.47	1.97
28-Feb	SS23	2	6	5	13	3	7	6	14	270	33.2	13.1	3.71	3.66	5.37	1.94
28-Feb	SS24	1	0	9	10	2	1	10	11	270	34.3	14.1	3.86	3.8	5.6	1.93
28-Feb	SS25	1	0	1	2	2	1	2	3	250	34.2	13	3.57	3.46	5.24	1.82
28-Feb	SS26	1	1	0	2	2	2	1	3	240	33.2	11.7	74	3.67	5.47	1.91
28-Feb	SS27	1805	35	171	2011	89	34	59	123	280	34.4	13.5	3.58	3.81	5.31	1.92
28-Feb	SS28	33	9	14	56	30	10	15	52	300	32.4	13.2	3.88	3.85	5.51	1.86
28-Feb	SS29	1	4	16	21	2	5	17	22	230	32	11.2	3.64	3.76	5.27	1.84
28-Feb	SS30	2	0	1	3	3	1	2	4	260	34.1	12.8	3.71	3.52	5.28	1.96

Dusit Zoo during February-March 2001

Date	Label	Parasite intensity				Rank of intensity				Morphological data						
		uni	mic	mac	int	r_uni	r_mic	r_mac	r_int	Weigh	Wing	Tail	Tarsus	3rd Digit	Head	Beak
										(g)	(cm)	(cm)	(cm)	(cm)	(cm)	(cm)
2-Mar	SC01	0	0	0	0	1	1	1	1	290	33.2	14	3.87	3.76	5.46	1.82
2-Mar	SC02	0	1	1	2	1	2	2	3	320	34	13	3.91	3.91	5.43	1.91
2-Mar	SC03	0	0	5	5	1	1	6	6	290	32.4	12.4	3.37	3.76	5.35	1.8
2-Mar	SC04	596	32	157	785	78	31	58	113	260	30.7	10.8	3.65	3.52	5.16	1.88
2-Mar	SC05	1	8	6	15	2	9	7	16	280	32	14	3.7	3.5	5.42	1.94
2-Mar	SC06	0	0	1	1	1	1	2	2	270	34.1	12.9	3.71	3.78	5.34	1.78
2-Mar	SC07	0	1	3	4	1	2	4	5	280	33.3	12	3.72	3.56	5.45	1.96
2-Mar	SC08	1	1	8	10	2	2	9	11	250	30.5	11.7	3.76	3.8	5.38	1.87
2-Mar	SC09	23	6	12	41	23	7	13	42	280	30.1	13	3.69	3.73	5.16	1.55
2-Mar	SC10	1	0	4	5	2	1	5	6	240	32	12.4	3.54	3.84	5.26	1.84
2-Mar	SC11	7	12	17	36	8	13	18	37	250	31.6	11.2	3.71	3.61	5.06	1.84
2-Mar	SC12	15	0	1	16	16	1	2	17	320	30.8	13	3.71	3.62	5.32	1.74
2-Mar	SC13	19	2	2	23	19	3	3	24	240	32.3	12.6	3.67	3.65	5.31	1.66
2-Mar	SC14	4	3	10	17	5	4	11	18	310	33.2	12.6	3.88	3.95	5.46	1.9
2-Mar	SC15	6	6	9	21	7	7	10	22	330	32.5	12.8	3.84	3.83	5.48	1.84
2-Mar	SC16	3	3	4	10	4	4	5	11	260	31.6	12.9	3.57	3.67	5.23	1.84
2-Mar	SC17	0	3	2	5	1	4	3	6	280	30.7	12.2	3.57	3.47	5.11	1.62
2-Mar	SC18	0	0	0	0	1	1	1	1	290	32.3	12.5	3.74	3.72	5.2	1.79
2-Mar	SC19	0	0	1	1	1	1	2	2	290	31.6	12.5	3.5	3.52	4.95	1.59
2-Mar	SC20	0	0	0	0	1	1	1	1	280	32.2	12.5	3.59	3.47	5.18	1.7
2-Mar	SC21	6	8	8	22	7	9	9	23	250	31	12.7	3.5	3.6	5.48	2.01
2-Mar	SC22	1	5	1	7	2	6	2	8	270	30.4	12.5	3.72	3.72	5.12	1.55
2-Mar	SC23	0	1	7	8	1	2	8	9	260	33.2	13	3.67	3.71	5.03	1.85
2-Mar	SC24	0	2	5	7	1	3	6	8	260	32.5	12.9	3.71	3.72	5.36	1.61
2-Mar	SC25	9	0	1	10	10	1	2	11	260	32.1	12.4	3.57	3.62	5.41	1.85
2-Mar	SC26	10	8	10	28	11	9	11	29	260	32.7	13.3	3.63	3.6	5.11	1.84
2-Mar	SC27	6	6	6	18	7	7	7	19	360	32.8	13.6	3.63	3.82	5.37	1.77
2-Mar	SC28	0	0	0	0	1	1	1	1	310	31.2	12.7	3.54	3.62	5.16	1.65
2-Mar	SC29	14	7	2	23	15	8	3	24	340	33.6	13.2	3.38	3.97	5.65	1.96
2-Mar	SC30	3	0	0	3	4	1	1	4	300	31.7	12.8	3.54	3.83	5.45	1.91

Muang District in Chonburi Province during February-March 2001

Date	Label	Parasite intensity				Rank of intensity				Morphological data						
		uni	mic	mac	int	r_uni	r_mic	r_mac	r_int	Weigh	Wing	Tail	Tarsus	3rd Digit	Head	Beak
										(g)	(cm)	(cm)	(cm)	(cm)	(cm)	(cm)
3-Mar	SR01	6	1	2	9	7	2	3	10	290	33.5	13.3	3.7	3.84	5.27	1.91
3-Mar	SR02	49	39	64	152	42	36	45	85	240	33.8	13.2	3.76	3.86	5.42	1.9
3-Mar	SR03	0	2	16	18	1	3	17	19	340	32.6	12.4	3.83	3.72	5.61	1.94
3-Mar	SR04	0	0	2	2	1	1	3	3	380	31.6	12.5	3.78	3.76	5.35	1.73
3-Mar	SR05	1	1	2	4	2	2	3	5	360	32.3	12	3.63	3.67	5.3	1.81
3-Mar	SR06	17	3	5	25	18	4	6	26	310	31.5	13	3.57	3.58	5.2	1.7
3-Mar	SR07	0	0	0	0	1	1	1	1	300	33	12	3.57	3.7	5.34	1.89
3-Mar	SR08	1	6	13	20	2	7	14	21	350	34.3	13.2	3.9	3.89	5.55	1.89
3-Mar	SR09	0	4	10	14	1	5	11	15	330	31.7	12.2	3.66	3.42	5.4	1.87
3-Mar	SR10	3	1	7	11	4	2	8	12	300	33	12.2	3.7	3.66	5.38	1.94
3-Mar	SR11	7	8	7	22	8	9	8	23	330	32.2	13.8	3.85	3.42	5.34	1.83
3-Mar	SR12	1	15	5	21	2	16	6	22	350	32	12.5	3.73	3.61	5.09	1.74
3-Mar	SR13	0	3	15	18	1	4	16	19	350	31.6	11.7	3.64	3.61	5.22	1.71
3-Mar	SR14	12	7	6	25	13	8	7	26	300	32.1	12.5	3.77	3.86	5.44	1.86
3-Mar	SR15	6	9	20	35	7	10	21	36	360	33.5	13.2	3.77	3.82	5.7	1.82
3-Mar	SR16	7	84	58	149	8	47	43	84	290	32.4	12.6	3.82	3.86	5.34	1.77
3-Mar	SR17	50	4	24	78	43	5	25	64	300	33.7	13	3.77	3.77	5.4	1.93
3-Mar	SR18	680	16	38	734	80	17	34	111	290	33.1	12	3.68	3.81	5.26	1.95
3-Mar	SR19	9	7	23	39	10	8	24	40	320	33.4	12	3.56	3.96	5.32	1.78
3-Mar	SR20	7	15	4	26	8	16	5	27	210	32.5	12.5	3.6	3.62	5.35	1.77
3-Mar	SR21	0	0	3	3	1	1	4	4	280	33.3	12.2	3.55	3.47	5.47	1.91
3-Mar	SR22	5	1	2	8	6	2	3	9	300	33	13	3.74	3.67	5.2	1.88
3-Mar	SR23	0	0	0	0	1	1	1	1	250	29.5	10.5	4	3.81	5.46	1.9
3-Mar	SR24	4	13	12	29	5	14	13	30	270	32	12	3.54	3.37	5.32	1.76
3-Mar	SR25	3	4	12	19	4	5	13	20	310	32.5	12.7	3.57	3.86	5.07	1.76
3-Mar	SR26	34	5	2	41	31	6	3	42	250	32.8	12.5	3.62	3.9	5.14	1.92
3-Mar	SR27	372	0	8	380	75	1	9	99	270	33	12.2	3.76	3.74	5.18	1.82
3-Mar	SR28	0	0	0	0	1	1	1	1	290	33.1	12.7	3.64	3.73	5.48	1.97
3-Mar	SR29	6	7	1	14	7	8	2	15	330	30.2	10.7	3.51	4.1	5.45	1.97
3-Mar	SR30	0	0	0	0	1	1	1	1	340	33	12	3.92	3.82	5.47	1.89

Appendices II

Correlation test between *Haemoproteus columbae*

and climate during June-July 2000

Correlation of Haemoproteus columbae intensity and morphological data of pigeons during February-March 2000

			undifferentiate	microgamete	macrogamete	every stage	weight	wing	tail	tarsus	3rd digit	head
Spearman's rho	undifferentiate	Correlation Coefficient	1.000	.598**	.557**	.850**	-.191*	.060	.102	-.005	.046	-.068
		Sig. (2-tailed)	.	.000	.000	.000	.019	.466	.216	.953	.575	.410
		N	150	150	150	150	150	150	150	150	150	150
	microgamete	Correlation Coefficient	.598**	1.000	.764**	.839**	-.145	.071	.008	-.008	-.016	-.071
		Sig. (2-tailed)	.000	.	.000	.000	.076	.389	.918	.919	.850	.390
		N	150	150	150	150	150	150	150	150	150	150
	macrogamete	Correlation Coefficient	.557**	.764**	1.000	.851**	-.120	.004	-.060	.015	-.012	-.029
		Sig. (2-tailed)	.000	.000	.	.000	.144	.959	.468	.855	.880	.729
		N	150	150	150	150	150	150	150	150	150	150
	every stage	Correlation Coefficient	.850**	.839**	.851**	1.000	-.161*	.043	.020	.020	.016	-.059
		Sig. (2-tailed)	.000	.000	.000	.	.049	.600	.804	.806	.848	.476
		N	150	150	150	150	150	150	150	150	150	150
	weight	Correlation Coefficient	-.191*	-.145	-.120	-.161*	1.000	.074	.263**	.227**	.281**	.366**
		Sig. (2-tailed)	.019	.076	.144	.049	.	.366	.001	.005	.000	.000
		N	150	150	150	150	150	150	150	150	150	150
	wing	Correlation Coefficient	.060	.071	.004	.043	.074	1.000	.510**	.374**	.346**	.406**
		Sig. (2-tailed)	.466	.389	.959	.600	.366	.	.000	.000	.000	.000
		N	150	150	150	150	150	150	150	150	150	150
	tail	Correlation Coefficient	.102	.008	-.060	020	-.3**	.510**	1.000	.229**	.205*	.304**
		Sig. (2-tailed)	.216	.918	.468	.804	.001	.000	.	.005	.012	.000
		N	150	150	150	150	150	150	150	150	150	150

Correlation of Haemoproteus columbae intensity and morphological data of pigeons during February-March 2000

			undifferentiate	microgamete	macrogamete	every stage	weight	wing	tail	tarsus	3rd digit	head
Spearman's rho	tarsus	Correlation Coefficient	-.005	-.008	.015	.020	.227**	.374**	.229**	1.000	.441**	.453**
		Sig. (2-tailed)	.953	.919	.855	.806	.005	.000	.005	.	.000	.000
		N	150	150	150	150	150	150	150	150	150	150
	3rd digit	Correlation Coefficient	.046	-.016	-.012	.016	.281**	.346**	.205*	.441**	1.000	.417**
		Sig. (2-tailed)	.575	.850	.880	.848	.000	.000	.012	.000	.	.000
		N	150	150	150	150	150	150	150	150	150	150
	head	Correlation Coefficient	-.068	-.071	-.029	-.059	.366**	.406**	.304**	.453**	.417**	1.000
		Sig. (2-tailed)	.410	.390	.729	.476	.000	.000	.000	.000	.000	.
		N	150	150	150	150	150	150	150	150	150	150
	beak	Correlation Coefficient	.114	.099	.011	.064	.034	.328**	.148	.145	.115	.446**
		Sig. (2-tailed)	.165	.230	.890	.434	.684	.000	.070	.076	.162	.000
		N	150	150	150	150	150	150	150	150	150	150
	gap	Correlation Coefficient	-.040	.131	.153	.076	.265**	.143	.167*	.153	.183*	.403**
		Sig. (2-tailed)	.626	.111	.061	.353	.001	.080	.041	.062	.025	.000
		N	150	150	150	150	150	150	150	150	150	150

Correlation of Haemoproteus columbae intensity and morphological data of pigeons June-July 2000

			undifferentiate	microgamete	macrogamete	every stage	weight	wing	tail	tarsus
Spearman's rho	undifferentiate	Correlation Coefficient	1.000	.741**	.760**	.932**	-.180*	.013	-.056	-.075
		Sig. (2-tailed)	.	.000	.000	.000	.028	.874	.494	.364
		N	150	150	150	150	150	150	150	150
	microgamete	Correlation Coefficient	.741**	1.000	.818**	.882**	-.229**	.094	-.038	.002
		Sig. (2-tailed)	.000	.	.000	.000	.005	.252	.643	.978
		N	150	150	150	150	150	150	150	150
	macrogamete	Correlation Coefficient	.760**	.818**	1.000	.902**	-.218**	.018	-.080	-.029
		Sig. (2-tailed)	.000	.000	.	.000	.007	.826	.332	.723
		N	150	150	150	150	150	150	150	150
	every stage	Correlation Coefficient	.932**	.882**	.902**	1.000	-.213**	.025	-.059	-.031
		Sig. (2-tailed)	.000	.000	.000	.	.009	.761	.472	.710
		N	150	150	150	150	150	150	150	150
	weight	Correlation Coefficient	-.180*	-.229**	-.218**	-.213**	1.000	.227**	.218**	.231**
		Sig. (2-tailed)	.028	.005	.007	.009	.	.005	.007	.004
		N	150	150	150	150	150	150	150	150
	wing	Correlation Coefficient	.013	.094	.018	.025	.227**	1.000	.274**	.067
		Sig. (2-tailed)	.874	.252	.826	.761	.005	.	.001	.416
		N	150	150	150	150	150	150	150	150
	tail	Correlation Coefficient	-.056	-.038	-.080	-.059	.218**	.274**	1.000	.099
		Sig. (2-tailed)	.494	.643	.332	.472	.007	.001	.	.230
		N	150	150	150	150	150	150	150	150

Correlation of Haemoproteus columbae intensity and morphological data of pigeons June-July 2000

			undifferentiate	microgamete	macrogamete	every stage	weight	wing	tail	tarsus
Spearman's rho	tarsus	Correlation Coefficient	-.075	.002	-.029	-.031	.231**	.067	.099	1.000
		Sig. (2-tailed)	.364	.978	.723	.710	.004	.416	.230	.
		N	150	150	150	150	150	150	150	150

**. Correlation is significant at the .01 level (2-tailed).

*. Correlation is significant at the .05 level (2-tailed).

Correlation of Haemoproteus columbae intensity and morphological data of pigeons during Novem-December 2000

			undifferentiate	microgamete	macrogamete	every stage	weight	wing	tail	tarsus
Spearman's rho	undifferentiate	Correlation Coefficient	1.000	.538**	.540**	.873**	-.124	-.146	-.012	-.048
		Sig. (2-tailed)	.	.000	.000	.000	.132	.075	.882	.559
		N	150	150	150	150	150	150	150	150
	microgamete	Correlation Coefficient	.538**	1.000	.724**	.763**	-.169*	-.036	.090	-.060
		Sig. (2-tailed)	.000	.	.000	.000	.039	.660	.275	.465
		N	150	150	150	150	150	150	150	150
	macrogamete	Correlation Coefficient	.540**	.724**	1.000	.787**	-.001	-.134	-.092	-.024
		Sig. (2-tailed)	.000	.000	.	.000	.987	.101	.261	.773
		N	150	150	150	150	150	150	150	150
	every stage	Correlation Coefficient	.873**	.763**	.787**	1.000	-.088	-.127	.012	-.027
		Sig. (2-tailed)	.000	.000	.000	.	.282	.122	.888	.743
		N	150	150	150	150	150	150	150	150

Correlation of Haemoproteus columbae intensity and morphological data of pigeons during Novem-December 2000

			undifferentiate	microgamete	macrogamete	every stage	weight	wing	tail	tarsus
Spearman's rho	weight	Correlation Coefficient	-.124	-.169*	-.001	-.088	1.000	.215**	.009	.230**
		Sig. (2-tailed)	.132	.039	.987	.282	.	.008	.915	.005
		N	150	150	150	150	150	150	150	150
	wing	Correlation Coefficient	-.146	-.036	-.134	-.127	.215**	1.000	.492**	.326**
		Sig. (2-tailed)	.075	.660	.101	.122	.008	.	.000	.000
		N	150	150	150	150	150	150	150	150
	tail	Correlation Coefficient	-.012	.090	-.092	.012	.009	.492**	1.000	.101
		Sig. (2-tailed)	.882	.275	.261	.888	.915	.000	.	.217
		N	150	150	150	150	150	150	150	150
	tarsus	Correlation Coefficient	-.048	-.060	-.024	-.027	.230**	.326**	.101	1.000
		Sig. (2-tailed)	.559	.465	.773	.743	.005	.000	.217	.
		N	150	150	150	150	150	150	150	150

**. Correlation is significant at the .01 level (2-tailed).

*. Correlation is significant at the .05 level (2-tailed).

Appendices III

Correlation test between *Haemoproteus columbae*

and morphological data of pigeons

during June-July 2000

Correlation of Haemoproteus columbae intensity and morphological data of pigeons during Novem-December 2000

			undifferentiate	microgamete	macrogamete	every stage	3rd digit	head	beak
Spearman's rho	undifferentiate	Correlation Coefficient	1.000	.430**	.589**	.844**	-.164	-.126	-.214
		Sig. (2-tailed)	.	.001	.000	.000	.212	.338	.101
		N	60	60	60	60	60	60	60
	microgamete	Correlation Coefficient	.430**	1.000	.690**	.725**	-.141	.241	-.028
		Sig. (2-tailed)	.001	.	.000	.000	.281	.064	.832
		N	60	60	60	60	60	60	60
	macrogamete	Correlation Coefficient	.589**	.690**	1.000	.835**	-.028	.119	.001
		Sig. (2-tailed)	.000	.000	.	.000	.831	.365	.995
		N	60	60	60	60	60	60	60
	every stage	Correlation Coefficient	.844**	.725**	.835**	1.000	-.133	.095	-.071
		Sig. (2-tailed)	.000	.000	.000	.	.311	.469	.589
		N	60	60	60	60	60	60	60
	3rd digit	Correlation Coefficient	-.164	-.141	-.028	-.133	1.000	.255*	.295*
		Sig. (2-tailed)	.212	.281	.831	.311	.	.049	.022
		N	60	60	60	60	60	60	60
	head	Correlation Coefficient	-.126	.241	.119	.095	.255*	1.000	.446**
		Sig. (2-tailed)	.338	.064	.365	.469	.049	.	.000
		N	60	60	60	60	60	60	60
	beak	n Coefficien	-.214	-.028	.001		.295*	.446**	1.000
		Sig. (2-tailed)	.101	.832	.995	.589	.022	.000	.
		N	60	60	60	60	60	60	60

**. Correlation is significant at the .01 level (2-tailed).

*. Correlation is significant at the .05 level (2-tailed).

Correlation of Haemoproteus columbae intensity and morphological data of pigeons during February-March 2000

			undifferentiate	microgamete	macrogamete	every stage	weight	wing	tail	tarsus	3rd digit	head	beak
Spearman's rho	undifferentiate	Correlation Coefficient	1.000	.598**	.557**	.850**	-.191*	.060	.102	-.005	.046	-.068	.114
		Sig. (2-tailed)	.	.000	.000	.000	.019	.466	.216	.953	.575	.410	.165
		N	150	150	150	150	150	150	150	150	150	150	150
	microgamete	Correlation Coefficient	.598**	1.000	.764**	.839**	-.145	.071	.008	-.008	-.016	-.071	.099
		Sig. (2-tailed)	.000	.	.000	.000	.076	.389	.918	.919	.850	.390	.230
		N	150	150	150	150	150	150	150	150	150	150	150
	macrogamete	Correlation Coefficient	.557**	.764**	1.000	.851**	-.120	.004	-.060	.015	-.012	-.029	.011
		Sig. (2-tailed)	.000	.000	.	.000	.144	.959	.468	.855	.880	.729	.890
		N	150	150	150	150	150	150	150	150	150	150	150
	every stage	Correlation Coefficient	.850**	.839**	.851**	1.000	-.161*	.043	.020	.020	.016	-.059	.064
		Sig. (2-tailed)	.000	.000	.000	.	.049	.600	.804	.806	.848	.476	.434
		N	150	150	150	150	150	150	150	150	150	150	150
	weight	Correlation Coefficient	-.191*	-.145	-.120	-.161*	1.000	.074	.263**	.227**	.281**	.366**	.034
		Sig. (2-tailed)	.019	.076	.144	.049	.	.366	.001	.005	.000	.000	.684
		N	150	150	150	150	150	150	150	150	150	150	150
	wing	Correlation Coefficient	.060	.071	.004	.043	.074	1.000	.510**	.374**	.346**	.406**	.328**
		Sig. (2-tailed)	.466	.389	.959	.600	.366	.	.000	.000	.000	.000	.000
		N	150	150	150	150	150	150	150	150	150	150	150
	tail	Correlation Coefficient	.102	.008	-.060	.020	.263**	.510**	1.000	.229**	.205*	.304**	.148
		Sig. (2-tailed)	.216	.918	.468	.804	.001	.000	.	.005	.012	.000	.070
		N	150	150	150	150	150	150	150	150	150	150	150

Correlation of Haemoproteus columbae intensity and morphological data of pigeons during February-March 2000

			undifferentiate	microgamete	macrogamete	every stage	weight	wing	tail	tarsus	3rd digit	head	beak
Spearman's rho	tarsus	Correlation Coefficient	-.005	-.008	.015	.020	.227**	.374**	.229**	1.000	.441**	.453**	.145
		Sig. (2-tailed)	.953	.919	.855	.806	.005	.000	.005	.	.000	.000	.076
		N	150	150	150	150	150	150	150	150	150	150	150
	3rd digit	Correlation Coefficient	.046	-.016	-.012	.016	.281**	.346**	.205*	.441**	1.000	.417**	.115
		Sig. (2-tailed)	.575	.850	.880	.848	.000	.000	.012	.000	.	.000	.162
		N	150	150	150	150	150	150	150	150	150	150	150
	head	Correlation Coefficient	-.068	-.071	-.029	-.059	.366**	.406**	.304**	.453**	.417**	1.000	.446**
		Sig. (2-tailed)	.410	.390	.729	.476	.000	.000	.000	.000	.000	.	.000
		N	150	150	150	150	150	150	150	150	150	150	150
	beak	Correlation Coefficient	.114	.099	.011	.064	.034	.328**	.148	.145	.115	.446**	1.000
		Sig. (2-tailed)	.165	.230	.890	.434	.684	.000	.070	.076	.162	.000	.
		N	150	150	150	150	150	150	150	150	150	150	150

**. Correlation is significant at the .01 level (2-tailed).

*. Correlation is significant at the .05 level (2-tailed).

Nonparametric Correlations

Correlations test between Haemoproteus columbae intensity and climatic data at Lumpinee Park, Chonburi and Sriracha during June-July 2000

			undifferentiate	microgamete	macrogamete	every stage	daily mean temperature	daily maximum temperature	daily mininum temperature
Spearman's rho	undifferentiate	Correlation Coefficient	1.000	.741**	.760**	.932**	.070	.070	-.350**
		Sig. (2-tailed)	.	.000	.000	.000	.510	.510	.001
		N	150	150	150	150	90	90	90
	microgamete	Correlation Coefficient	.741**	1.000	.818**	.882**	.152	.152	-.199
		Sig. (2-tailed)	.000	.	.000	.000	.151	.151	.060
		N	150	150	150	150	90	90	90
	macrogamete	Correlation Coefficient	.760**	.818**	1.000	.902**	.138	.138	-.213*
		Sig. (2-tailed)	.000	.000	.	.000	.194	.194	.044
		N	150	150	150	150	90	90	90
	every stage	Correlation Coefficient	.932**	.882**	.902**	1.000	.105	.105	-.296**
		Sig. (2-tailed)	.000	.000	.000	.	.325	.325	.005
		N	150	150	150	150	90	90	90
	daily mean temperature	Correlation Coefficient	.070	.152	.138	.105	1.000	1.000**	.500**
		Sig. (2-tailed)	.510	.151	.194	.325	.	.	.000
		N	90	90	90	90	90	90	90
	daily maximum temperature	Correlation Coefficient	.070	.152	.138	.105	1.000**	1.000	.500**
		Sig. (2-tailed)	.510	.151	.194	.325	.	.	.000
		N	90	90	90	90	90	90	90

Correlations test between Haemoproteus columbae intensity and climatic data at Lumpinee Park, Chonburi and Sriracha during June-July 2000

			undifferentiate	microgamete	macrogamete	every stage	daily mean temperature	daily maximum temperature	daily minimum temperature
Spearman's rho	daily minimum temperature	Correlation Coefficient	-.350**	-.199	-.213*	-.296**	.500**	.500**	1.000
		Sig. (2-tailed)	.001	.060	.044	.005	.000	.000	.
		N	90	90	90	90	90	90	90
	daily mean relative humidity	Correlation Coefficient	.350**	.199	.213*	.296**	-.500**	-.500**	-1.000**
		Sig. (2-tailed)	.001	.060	.044	.005	.000	.000	.000
		N	90	90	90	90	90	90	90
	daily precipitation	Correlation Coefficient	.283**	.291**	.282**	.292**	.866**	.866**	.000
		Sig. (2-tailed)	.007	.005	.007	.005	.000	.000	1.000
		N	90	90	90	90	90	90	90
	average of two month of mean temperature	Correlation Coefficient	.070	.152	.138	.105	1.000**	1.000**	.500**
		Sig. (2-tailed)	.510	.151	.194	.325	.	.	.000
		N	90	90	90	90	90	90	90
	average of two month of maximum temperature	Correlation Coefficient	.070	.152	.138	.105	1.000**	1.000**	.500**
		Sig. (2-tailed)	.510	.151	.194	.325	.	.	.000
		N	90	90	90	90	90	90	90
	average of two month of minimum temperature	Correlation Coefficient	.070	.152	.138	.105	1.000**	1.000**	.500**
		Sig. (2-tailed)	.	.151	.194	.325	.	.	.000
		N	90	90	90	90	90	90	90

Correlations test between Haemoproteus columbae intensity and climatic data at Lumpinee Park, Chonburi and Sriracha during June-July 2006

			undifferentiate	microgamete	macrogamete	every stage	daily mean temperature	daily maximum temperature	daily minimum temperature
Spearman's rho	average of two month of relative humidity	Correlation Coefficient	-.070	-.152	-.138	-.105	-1.000**	-1.000**	-.500**
		Sig. (2-tailed)	.510	.151	.194	.325	.000	.000	.000
		N	90	90	90	90	90	90	90
	average of two month of precipitation	Correlation Coefficient	.070	.152	.138	.105	1.000**	1.000**	.500**
		Sig. (2-tailed)	.510	.151	.194	.325	.	.	.000
		N	90	90	90	90	90	90	90

Correlations test between Haemoproteus columbae intensity and climatic data at Lumpinee Park, Chonburi and Sriracha during June-July 2000

			daily mean relative humidity	daily precipitation	average of two month of mean temperature	average of two month of maximum temperature	average of two month of minimum temperature
Spearman's rho	undifferentiate	Correlation Coefficient	.350**	.283**	.070	.070	.070
		Sig. (2-tailed)	.001	.007	.510	.510	.510
		N	90	90	90	90	90
	microgamete	Correlation Coefficient	.199	.291**	.152	.152	.152
		Sig. (2-tailed)	.060	.005	.151	.151	.151
		N	90	90	90	90	90
	macrogamete	Correlation Coefficient	.213*	.282**	.138	.138	.138
		Sig. (2-tailed)	.044	.007	.194	.194	.194
		N	90	90	90	90	90
	every stage	Correlation Coefficient	.296**	.292**	.105	.105	.105
		Sig. (2-tailed)	.005	.005	.325	.325	.325
		N	90	90	90	90	90
	daily mean temperature	Correlation Coefficient	-.500**	.866**	1.000**	1.000**	1.000**
		Sig. (2-tailed)	.000	.000	.	.	.
		N	90	90	90	90	90
	daily maximum temperature	Correlation Coefficient	-.500**	.866**	1.000**	1.000**	1.000**
		Sig. (2-tailed)	.000	.000	.	.	.
		N	90	90	90	90	90

Correlations test between Haemoproteus columbae intensity and climatic data at Lumpinee Park, Chonburi and Sriracha during June-July 2000

			daily mean relative humidity	daily precipitation	average of two month of mean temperature	average of two month of maximum temperature	average of two month of minimum temperature
Spearman's rho	daily minimum temperature	Correlation Coefficient	-1.000**	.000	.500**	.500**	.500**
		Sig. (2-tailed)	.000	1.000	.000	.000	.000
		N	90	90	90	90	90
	daily mean relative humidity	Correlation Coefficient	1.000	.000	-.500**	-.500**	-.500**
		Sig. (2-tailed)	.	1.000	.000	.000	.000
		N	90	90	90	90	90
	daily precipitation	Correlation Coefficient	.000	1.000	.866**	.866**	.866**
		Sig. (2-tailed)	1.000	.	.000	.000	.000
		N	90	90	90	90	90
	average of two month of mean temperature	Correlation Coefficient	-.500**	.866**	1.000	1.000**	1.000**
		Sig. (2-tailed)	.000	.000	.	.	.
		N	90	90	90	90	90
	average of two month of maximum temperature	Correlation Coefficient	-.500**	.866**	1.000**	1.000	1.000**
		Sig. (2-tailed)	.000	.000	.	.	.
		N	90	90	90	90	90
	average of two month of minimum temperature	Correlation Coefficient	-.500**	.866**	1.000**	1.000**	1.000
		Sig. (2-tailed)	.000	.000	.	.	.
		N	90	90	90	90	90

Correlations test between Haemoproteus columbae intensity and climatic data at Lumpinee Park, Chonburi and Sriracha during June-July 2000

			daily mean relative humidity	daily precipitation	average of two month of mean temperature	average of two month of maximum temperature	average of two month of minimum temperature
Spearman's rho	average of two month of relative humidity	Correlation Coefficient	.500**	-.866**	-1.000**	-1.000**	-1.000**
		Sig. (2-tailed)	.000	.000	.000	.000	.000
		N	90	90	90	90	90
	average of two month of precipitation	Correlation Coefficient	-.500**	.866**	1.000**	1.000**	1.000**
		Sig. (2-tailed)	.000	.000	.	.	.
		N	90	90	90	90	90

Correlations test between Haemoproteus columbae intensity and climatic data at Lumpinee Park, Chonburi and Sriracha during June-July 2000

			average of two month of relative humidity	average of two month of precipitation
Spearman's rho	undifferentiate	Correlation Coefficient	-.070	.070
		Sig. (2-tailed)	.510	.510
		N	90	90
	microgamete	Correlation Coefficient	-.152	.152
		Sig. (2-tailed)	.151	.151
		N	90	90
	macrogamete	Correlation Coefficient	-.138	.138
		Sig. (2-tailed)	.194	.194
		N	90	90
	every stage	Correlation Coefficient	-.105	.105
		Sig. (2-tailed)	.325	.325
		N	90	90
	daily mean temperature	Correlation Coefficient	-1.000**	1.000**
		Sig. (2-tailed)	.000	.
		N	90	90
	daily maximum temperature	Correlation Coefficient	-1.000**	1.000**
		Sig. (2-tailed)	.000	.
		N	90	90

Correlations test between Haemoproteus columbae intensity and climatic data at Lumpinee Park, Chonburi and Sriracha during June-July 2000

			average of two month of relative humidity	average of two month of precipitation
Spearman's rho	daily mininum temperature	Correlation Coefficient	-.500**	.500**
		Sig. (2-tailed)	.000	.000
		N	90	90
	daily mean relative humidity	Correlation Coefficient	.500**	-.500**
		Sig. (2-tailed)	.000	.000
		N	90	90
	daily precipitation	Correlation Coefficient	-.866**	.866**
		Sig. (2-tailed)	.000	.000
		N	90	90
	average of two month of mean temperature	Correlation Coefficient	-1.000**	1.000**
		Sig. (2-tailed)	.000	.
		N	90	90
	average of two month of maximum temperature	Correlation Coefficient	-1.000**	1.000**
		Sig. (2-tailed)	.000	.
		N	90	90
	average of two month of minimum temperature	Correlation Coefficient	-1.000**	1.000**
		Sig. (2-tailed)	.000	.
		N	90	90

Correlations test between Haemoproteus columbae intensity and climatic data at Lumpinee Park, Chonburi and Sriracha during June-July 2000

			average of two month of relative humidity	average of two month of precipitation
Spearman's rho	average of two month of relative humidity	Correlation Coefficient	1.000	-1.000**
		Sig. (2-tailed)	.	.000
		N	90	90
	average of two month of precipitation	Correlation Coefficient	-1.000**	1.000
		Sig. (2-tailed)	.000	.
		N	90	90

**. Correlation is significant at the .01 level (2-tailed).

*. Correlation is significant at the .05 level (2-tailed).

Appendices IV

ANOVA test of climatic data

at Lumpinee Park (1), Chonburi (4) and Sriracha (5)

Oneway

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
daily mean temperature	Between Groups	66.600	2	33.300	9.6049364E+29	.000
	Within Groups	3.016E-27	87	3.467E-29		
	Total	66.600	89			
daily maximum temperature	Between Groups	232.200	2	116.100	2.0872973E+30	.000
	Within Groups	4.839E-27	87	5.562E-29		
	Total	232.200	89			
daily mininum temperature	Between Groups	195.000	2	97.500	.	.
	Within Groups	.000	87	.000		
	Total	195.000	89			
daily mean relative humidity	Between Groups	620.000	2	310.000	.	.
	Within Groups	.000	87	.000		
	Total	620.000	89			
daily precipitation	Between Groups	1.800	2	.900	8.7136626E+32	.000
	Within Groups	8.986E-32	87	1.033E-33		
	Total	1.800	89			
average of two month of mean temperature	Between Groups	64.050	2	32.025	6.3967368E+29	.000
	Within Groups	4.356E-27	87	5.006E-29		
	Total	64.050	89			

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
average of two month of maximum temperature	Between Groups	201.050	2	100.525	2.4407033E+30	.000
	Within Groups	3.583E-27	87	4.119E-29		
	Total	201.050	89			
average of two month of minimum temperature	Between Groups	48.600	2	24.300	8.7484497E+29	.000
	Within Groups	2.417E-27	87	2.778E-29		
	Total	48.600	89			
average of two month of relative humidity	Between Groups	1040.000	2	520.000	.	.
	Within Groups	.000	87	.000		
	Total	1040.000	89			
average of two month of precipitation	Between Groups	236.418	2	118.209	2.7678887E+31	.000
	Within Groups	3.716E-28	87	4.271E-30		
	Total	236.418	89			

Multiple Comparisons

Tukey HSD

Dependent Variable	(I) group	(J) group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
daily mean temperature	1	4	.9000*	1.520E-15	.000	.9000	.9000
		5	2.1000*	1.520E-15	.000	2.1000	2.1000
	4	1	-.9000*	1.520E-15	.000	-.9000	-.9000
		5	1.2000*	1.520E-15	.000	1.2000	1.2000
	5	1	-2.1000*	1.520E-15	.000	-2.1000	-2.1000
		4	-1.2000*	1.520E-15	.000	-1.2000	-1.2000
daily maximum temperature	1	4	1.5000*	1.926E-15	.000	1.5000	1.5000
		5	3.9000*	1.926E-15	.000	3.9000	3.9000
	4	1	-1.5000*	1.926E-15	.000	-1.5000	-1.5000
		5	2.4000*	1.926E-15	.000	2.4000	2.4000
	5	1	-3.9000*	1.926E-15	.000	-3.9000	-3.9000
		4	-2.4000*	1.926E-15	.000	-2.4000	-2.4000
daily minimum temperature	1	4	-1.0000*	.0000	.000	.	.
		5	2.5000*	.0000	.000	.	.
	4	1	1.0000*	.0000	.000	.	.
		5	3.5000*	.0000	.000	.	.
	5	1	-2.5000*	.0000	.000	.	.
		4	-3.5000*	.0000	.000	.	.
daily mean relative humidity	1	4	1.0000*	.0000	.000	.	.
		5	-5.0000*	.0000	.000	.	.

Multiple Comparisons

Tukey HSD

Dependent Variable	(I) group	(J) group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
daily mean relative humidity	4	1	-1.0000*	.0000	.000	.	.
		5	-6.0000*	.0000	.000	.	.
	5	1	5.0000*	.0000	.000	.	.
		4	6.0000*	.0000	.000	.	.
daily precipitation	1	4	.3000*	8.298E-18	.000	.3000	.3000
		5	.3000*	8.298E-18	.000	.3000	.3000
	4	1	-.3000*	8.298E-18	.000	-.3000	-.3000
		5	.0000	8.298E-18	1.000	-1.9787E-17	1.979E-17
	5	1	-.3000*	8.298E-18	.000	-.3000	-.3000
		4	.0000	8.298E-18	1.000	-1.9787E-17	1.979E-17
average of two month of mean temperature	1	4	1.2500*	1.827E-15	.000	1.2500	1.2500
		5	2.0500*	1.827E-15	.000	2.0500	2.0500
	4	1	-1.2500*	1.827E-15	.000	-1.2500	-1.2500
		5	.8000*	1.827E-15	.000	.8000	.8000
	5	1	-2.0500*	1.827E-15	.000	-2.0500	-2.0500
		4	-.8000*	1.827E-15	.000	-.8000	-.8000
average of . .onth of maximum temperature	1	4	[illegible]	[illegible]	.000	1.0000	1.0000
		5	3.5500*	1.657E-15	.000	3.5500	3.5500
	4	1	-1.0000*	1.657E-15	.000	-1.0000	-1.0000
		5	2.5500*	1.657E-15	.000	2.5500	2.5500

Multiple Comparisons

Tukey HSD

Dependent Variable	(I) group	(J) group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
average of two month of maximum temperature	5	1	-3.5500*	1.657E-15	.000	-3.5500	-3.5500
		4	-2.5500*	1.657E-15	.000	-2.5500	-2.5500
average of two month of minimum temperature	1	4	.9000*	1.361E-15	.000	.9000	.9000
		5	1.8000*	1.361E-15	.000	1.8000	1.8000
	4	1	-.9000*	1.361E-15	.000	-.9000	-.9000
		5	.9000*	1.361E-15	.000	.9000	.9000
	5	1	-1.8000*	1.361E-15	.000	-1.8000	-1.8000
		4	-.9000*	1.361E-15	.000	-.9000	-.9000
average of two month of relative humidity	1	4	-6.0000*	.0000	.000	.	.
		5	-8.0000*	.0000	.000	.	.
	4	1	6.0000*	.0000	.000	.	.
		5	-2.0000*	.0000	.000	.	.
	5	1	8.0000*	.0000	.000	.	.
		4	2.0000*	.0000	.000	.	.
average of two month of precipitation	1	4	3.1300*	5.336E-16	.000	3.1300	3.1300
		5	3.6800*	5.336E-16	.000	3.68	3.6800
	4	1	-3.1300*	5.336E-16	.000	-3.1300	-3.1300
		5	.5500*	5.336E-16	.000	.5500	.5500
	5	1	-3.6800*	5.336E-16	.000	-3.6800	-3.6800
		4	-.5500*	5.336E-16	.000	-.5500	-.5500

*. The mean difference is significant at the .05 level.

Appendices V

ANOVA test of morphological data of pigeons

caught during June-July 2000

Oneway ANOVA test of morphological data of pigeon caught from Lumpinee Park (1), Dusit Zoo (2), Sanam Luang (3), Chonburi (4) and Sriracha (5) during June-July 2000

ANOVA

		Sum of Squares	df	Mean Square	F	Sig
weight	Between Groups	26693.333	4	6673.333	6.099	.000
	Within Groups	158656.667	145	1094.184		
	Total	185350.000	149			
wing	Between Groups	25.282	4	6.321	5.555	.000
	Within Groups	164.991	145	1.138		
	Total	190.274	149			
tail	Between Groups	11.264	4	2.816	4.	.004
	Within Groups	99.672	145	.687		
	Total	110.936	149			
tarsus	Between Groups	1.396	4	.349	4.831	.001
	Within Groups	10.477	145	7.226E-02		
	Total	11.873	149			

Multiple Comparisons Table by Oneway ANOVA test of morphological data of pigeon caught from Lumpinee Park (1), Dusit Zoo (2), Sanam Luang (3), Chonburi (4) and Sriracha (5) during June-July 2000

Tukey HSD

Dependent Variable	(I) group	(J) group	Mean Difference (I-J)	Std. Error	Sig.
wing	5	1	-.330	.275	.752
		2	-1.020*	.275	.002
		3	-1.083*	.275	.001
		4	-.597	.275	.193
tail	1	2	.227	.214	.828
		3	.643*	.214	.022
		4	.153	.214	.953
		5	.687*	.214	.012
	2	1	-.227	.214	.828
		3	.417	.214	.293
		4	-7.333E-02	.214	.997
		5	.460	.214	.200
	3	1	-.643*	.214	.022
		2	-.417	.214	.293
		4	-.490	.214	.148
		5	4.333E-02	.214	1.000
	4	1	-.153	.214	.953
		2	7.333E-02	.214	.997
		3	.490	.214	.148
		5	.533	.214	.093
	5	1	-.687*	.214	.012
		2	-.460	.214	.200
		3	-4.333E-02	.214	1.000
		4	-.533	.214	.093
tarsus	1	2	9.933E-02	6.941E-02	.607
		3	.1653	6.941E-02	.120
		4	.2970*	6.941E-02	.000
		5	.1393	6.941E-02	.262
	2	1	-9.933E-02	6.941E-02	.607
		3	6.600E-02	6.941E-02	.877
		4	.1977*	6.941E-02	.036
		5	4.000E-02	6.941E-02	.979
	3	1	-.1653	6.941E-02	.120
		2	-6.600E-02	6.941E-02	.877
		4	.1317	6.941E-02	.319
		5	-2.600E-02	6.941E-02	.996

Multiple ComparisonsTable by Oneway ANOVA test of morphological data of pigeon caught from Lumpinee Park (1), Dusit Zoo (2), Sanam Luang (3), Chonburi (4) and Sriracha (5) during June-July 2000

Tukey HSD

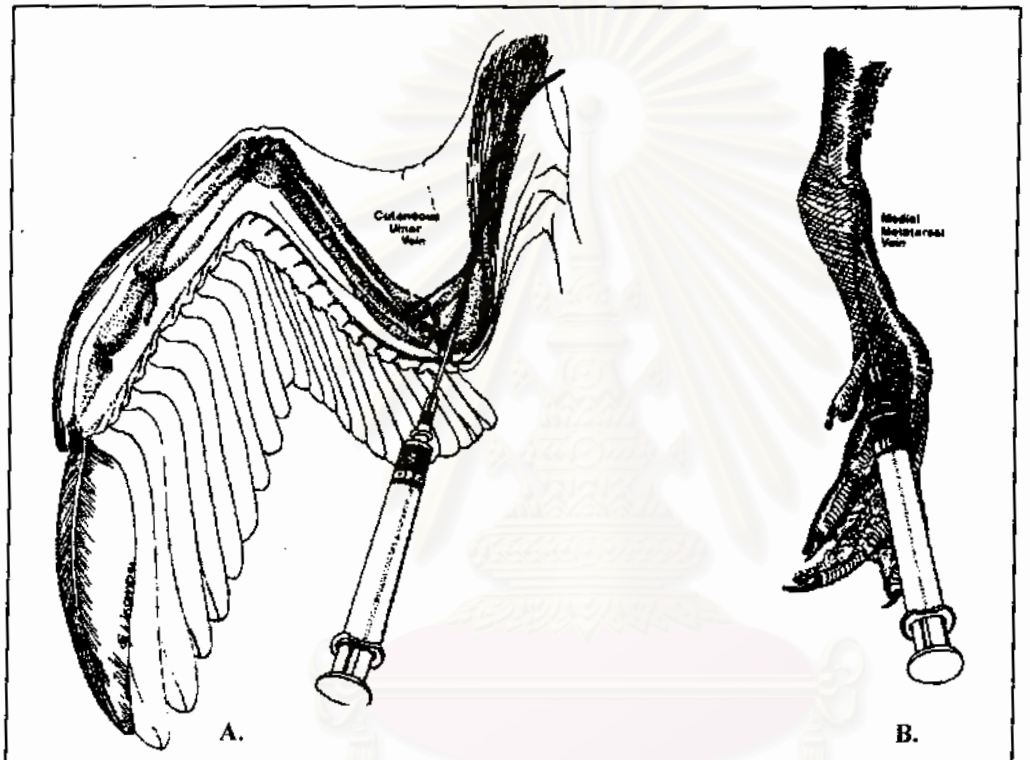
Dependent Variable	(I) group	(J) group	Mean Difference (I-J)	Std. Error	Sig.
tarsus	4	1	-.2970*	6.941E-02	.000
		2	-.1977*	6.941E-02	.036
		3	-.1317	6.941E-02	.319
		5	-.1577	6.941E-02	.154
	5	1	-.1393	6.941E-02	.262
		2	-4.0000E-02	6.941E-02	.979
		3	2.600E-02	6.941E-02	.996
		4	.1577	6.941E-02	.154

Appendices VI

Basic information in blood smear preparation

Collecting blood samples from venipuncture

Blood is commonly collected from medium to large birds by venipuncture of the cutaneous ulnar vein. The cutaneous ulnar vein crosses the ventral surface of the humeral-radioulnar joint (elbow) directly beneath the skin. This procedure will minimize the formation of a hematoma in small birds. A needle with an extension tube to assist in the stabiliztion of the needle during blood collection will also minimize hematoma formation when using a syringe (Campbell, 1995).



A. Cutaneous ulnar vein, easily accesible for injection in waterbirds and other species. Injection in waterbirds and other species. Injection is made near the point of the elbow on the ventral side of the wing.

B. Large, accessible medial metatarsal vein, recommended for blood sampling and injecting medication in waterbirds and some other species, as hematomas are less likely to develp at this site. (Drawing in Burr, 1987 by Genevieve M. Wilson)

A syringe with an attached microfine needle like those used by human diabetics is best for blood collection in small avian; being hubless, these needles avoid waste and dilution of the sample. An anticoagulant solution, if desired, can be aspirated and expelled through the syringe before blood collection. The feathers are easily separated along their respective tracts to allow visualization of the brachial vein. A cotton-tipped applicator dipped in alcohol can be used to clean the venipuncture site. The needle is inserted using standard venipuncture technique and

the sample slowly aspirated. After about 30 seconds there is seldom need for further pressure, but the bird should not be released until the bleeding has stopped. The brachial vein, located on the ventral aspect of each wing, can be used for blood sampling but is better suited for administration. This type of venipuncture requires an assistant, as the wing must be extended as well as the contained. Light pressure in the axillary area will distend the vein, as will tension on the skin in the same area. Gentle cleansing of the area and pressure applied to the puncture site is again recommend. One disadvantage following the use of brachial venipuncture is hematoma formation. Other veins may occasionally lend themselves to sampling and should be treated in similar manner (Fig.1 and 2) (Burr, 1987).

Preparation of the blood film

Blood films should be made should be made using blood containing no anticoagulant or EDTA. Heparin should be avoided for hematological samples, if possible, since it interferes with the proper staining of the blood cells. EDTA causes hemolysis in blood samples obtained from some group of birds (i.e., Corvidae). Prolonged exposure to EDTA may cause cellular artifacts in blood of some species of birds, therefore, a blood film should be made immediately following blood collection when using an anticoagulant. The standard two-side wedge technique commonly used for preparing mammalian blood slides can be used. When this method is used with avian blood, however, it occasionally results in a marked amount of cellular rupture (smudging) if excessive pressure is applied to the spreader slide. The use of bevel-edged microscope slides and proper attention to technique minimize the cell damage. A small drop to avian blood to decrease cell damage when preparing blood films (Campbell, 1995).

To make the blood film, the corner of a second slide is dipped into the blood drop and then placed near the base of the slide on the smearing block. The slide on the smearing block. The slide, held by the thumb and forefinger of the right hand at an angle of 30 - 45°, pull the two slides apart horizontally to produce the blood film. The blood should not be allowed to spread to the edge of the slide before initiating the spread of the film, and the upper slide should not be pulled away from the surface of the lower slide when pulling it apart form the slide (Bennett, 1970 and Campbell, 1995).

After the film is made, it should be immediately air-dried and, if possible, fixed in 100% methanol or ethanol. This ensures that subsequent hazards such as accidental splashing with water and feeding by muscid flies do not ruin the blood film by hemolysis. Slides are conveniently stored in the field in slotted boxes which prevent contact between slides. Microscope slides with frosted ends are recommended so that data can be inscribed directly in the field.

Films not fixed in 100% alcohol in the field should be fixed as soon as possible on return to a laboratory. Long delay in fixation results in deterioration of the smear and poor stain contrast with Giemsa's stain. This is particularly noticeable in the cytoplasm of the erythrocytes which stain progressively more blue as the time between making and fixing the smear increases. Overly blue cytoplasm makes identification of the blue-staining parasites difficult and leads to overlooking lightly infected samples.

Although the best smears are made from living bird, smears can be made form some dead birds. Blood smears from dead birds should be taken from the heart buy smearing the blood clot from one of the chambers over the slide. Smears can be obtained from birds stored in a deep freezer at any time they are thawed. However, material of this sort is at best difficult to interpret. Rounded stages equivalent to those properly formed in the early invertebrate host-phase are often present, and identification beyond the generic level is seldom possible (Bennett, 1970).

Description of normal leukocytes in avian peripheral blood

Heterophils

Heterophils (Fig.) are the most common leukocyte in the blood peripheral blood of some avain species. They tend to be round cells with a colorless cytoplasm containing eosinophilic rod-shaped granules (the granules may be spherical in some species). Heterophil granules usually have a distinct central body that appears refractile. Mature heterophils have a lobed nucleus (usually two or three lobes) with a coarse, clumped chromatin that stains purple. The nucleus is often partially hidden by the cytoplasmic granules.

frequently contain one or more red granules at the poles of the cell. Thrombocytes play a primary role in hemostasis and tend to clump in peripheral blood films, which aids in their identification. Thrombocytes may also have a phagocytic function and aid in the removal of foreign material from the blood (Campbell, 1995).

Giemsa Stain (Stock) (Crampton, Beard and Louis, 1997)

Add 3 g of Giemsa, 270 ml of absolute methyl alcohol, and 140 ml of glycerine to a clean, dry 500 ml brown bottle. The quality will improve with age. Be sure to keep tightly closed. Before use, filter an aliquot of stain through a Whatman #1 filter paper into a small dry brown glass bottle. Keep tightly capped. Never use wet or dirty pipette in the Giemsa. Be sure to shake the bottle before filtering.

Phosphate buffer (Sorensen) pH 5.29-8.04

Stock solutions:

M/15 dibasic sodium phosphate (Na_2HPO_4) 9.465 gm. made up to 1000 ml. with distilled water

M/15 potassium acid phosphate (KH_2PO_4) or NaH2PO4 9.08 gm. made up to 1000 ml. with distilled water.

For desired pH mix correct amounts as indicated below

pH	Na_2HPO_4 m/15 dibasic sod. Phosphate	KH_2PO_4 m/15 pot. Acid phosphate
5.29	2.5	97.5
5.59	5.0	95.0
5.91	10.0	90.0
6.42	20.0	80.0
6.47	30.0	70.0
6.64	40.0	60.0
6.81	50.0	50.0
6.98	60.0	40.0
7.17	70.0	30.0
7.38	80.0	20.0
7.73	90.0	10.0
8.04	95.0	5.0

Buffered solution

Na_2HPO_4 (anhydrous) 0.54 gm. (If use the hydrate salt required) 1.1 gm.

KH_2PO_4 0.2 gm. distilled water 500.0 ml.

Appendices VII

Statistic Methods

Parametric or nonparametric methods (Daniel, 1995)

Analysis of variance is called a parametric statistical method because it is based on estimates of the two population parameters, the mean and standard deviation (or variance), that completely define a normal distribution. Given the assumption that the samples are drawn from normally distributed populations, one can compute the distributions of the F- or t-test statistics that will occur in all possible experiments of a given size when the treatments have no effect. The critical values that define a value of F or t can then be obtained from that distribution. When the assumptions of parametric statistical methods are satisfied, they are the most powerful tests available.

If the populations the observations were drawn from are not normally distributed (or are not reasonably compatible with other assumptic s of a parametric method, such as equal variances in all the treatment groups), parametric methods become quite unreliable because the mean and standard deviation, the key elements of parametric statistics, no longer completely describe the population. In fact, when the population substantially deviates from normality, interpreting the mean and standard deviation in terms of a normal distribution produces a very misleading picture.

The same thing is true of statistical tests that are based on the normal distribution. When the population the samples were drawn from does not at least approximately follow the normal distribution, these tests can be quite misleading. In such cases, it is possible to use the ranks of the observations rather than the observations themselves to compute statistics that can be used to test hypotheses. By using ranks rather actual measurements, it is possible to retain much of the information about the relative size of responses without making ar_ assumptions about how the population the samples were drawn from is distributed. Since these tests are not based on the parameters of the undistributed. Since these tests are not based on the parameters of the undistributed. Since these tests are not based on the parameters of the underlying population, they are called nonparametric or distribution-free methods. All the methods we will discuss require only that the distributed populations, the nonparametric methods in this chapter are 95 to 95

percent for these tests can be estimated by computing the power of the analogous parametric test. When the observations are drawn from populations that are normally distributed, nonparametric methods are not only more reliable but also more powerful than parametric methods.

Unfortunately, you can never observe the entire population. So how can you tell whether the assumptions such as normality are met, to permit using the parametric tests like analysis of variance? The simplest approach is to plot the observations and look at them. Do they seem compatible with the assumptions that they were drawn from normally distributed populations with roughly the same variances, i.e., within a factor of 2 to 3 each other? If so, you are probably safe in using parametric methods. If, on the other hand, the observations are heavily skewed or appear to have more than one peak, you probably will want to use nonparametric method. When the standard deviation is about the same size or larger than the mean and the variable can take on only positive values, this is an indication that the distribution is skewed. In practice, these simple rules of thumb are often all you will need.

There are two ways to make this procedure more objective. The first is to plot the observations on normal-probability graph paper. Normal-probability graph paper has a distorted scale that makes normally distributed observations plot as a straight line (just as exponential functions plot as a straight line on semilogarithmic graph paper). Examining how straight the line is will show how compatible the observations are with a normal distribution. One can also construct a χ^2 statistic to test how closely the observed data agree with those expected if the population is normally distributed with the same mean and standard deviation (Glantz, 1997).

Advantages of nonparametric statistics

1. They allow for the testing of hypotheses that are not statements about population parameter values. Some of the chi-square tests of goodness-of-fit and the tests of independence are examples of tests possessing this advantage.
2. Nonparametric tests may be used when the form of the sampled population is unknown.

3. Nonparametric procedures tend to be computationally easier and consequently more quickly applied than parametric procedures. This can be a desirable feature in certain cases, but when time is not at a premium, it merits a low priority as a criterion for choosing a nonparametric test.
4. Nonparametric procedures may be applied when the data being analyzed consist merely of rankings or classifications. That is, the data may not be based on a measurement scale strong enough to allow the arithmetic operations necessary for carrying out parametric procedures. The subject of measurement scales is discussed in more detail in the next section.

Although nonparametric statistics enjoy a number of advantag : their disadvantages must also recognized.

1. The use of nonprametric procedures with data that can be handled with a parametric procedure results on a waste of data.
2. The application of some the nonparametric tests may be laborious for large samples.

Median test (Daniel, 1990)

Assumptions

A. Each sample is a random sample of size n_i drawn from one of $_c$ populations of interest with unknown medians $M_1, M_2, \ldots, .$
B. The observations are independent both within and among samples.
C. The measurement scale employed is at least ordinal.
D. If all populations have the same median, then for each population the probab... p is the same that an observed value exceeds the grand median.

Hypothesis

$H_0 : M_1(x) = M_2(x) = \ldots = M_c$

H_A : At least one population has a median different from at least one of the others.

$H_0 : F_1(x) \geq F_2(x)$ for all x

$H_A : F_1(x) < F_2(x)$ for at least one value of x

Test Static

Let $S_1(x)$ and $S_2(x)$, respectively, designate the sample or empirical distribution functions of the observed X's and the observed Y's.

$S_1(x)$ = (number of observed X's $\leq$ x)/m

$S_2(x)$ = (number of observed Y's $\leq$ x)/n

The test statistic for our three sets of hypotheses are as follow:

A. (Two-sided): $D = \text{maximum } |S_1(x) - S_2(x)|$

B. (One-sided): $D^+ = \text{maximum } |S_1(x) - S_2(x)|$

C. (One-sided): $D^- = \text{maximum } |S_2(x) - S_1(x)|$

Decision Rule

If two samples have been drawn from identical populations, $S_1(x)$ and $S_2(x)$ should be fairly close for all values of x. The test statistics D, D^+, and D^- are measures of the extent to which $S_1(x)$ and $S_2(x)$ fail to agree. If the test statistic, which is equal to the maximum difference at some x between $S_1(x)$ and $S_2(x)$, is small, differences at all other values of x are also small, and H_0 is upported (if D is sufficiently small). On the other hand, if D is sufficiently large (that is, too large to be a reasonable occurrence when is H_0 true), we reject H_0. To determine whether we should reject H_0, we observe the following decision rule

Reject H_0 at the α level of significance if the appropriate test statistic D, D^+, or D^- exceeds the 1-α quantile given in quantiles of the Smirnov test statsitic for two-sample tables.

SPSS interpretation of Komolgorov-Smirnov Test (Kanlaya Wanishbancha, 2000)

Most Extreme Differences	Absolute Different	=	D
	Positive	=	D^+
	Negative	=	D^-
Kolmogorov-Smirnov Z		=	Statistic-test value

Asymp. Sig. (2-tailed) = Significance of Kolm gorov-Smirnov Z

sig. calculated ≥ sig. at α level ∴ H_0 is true.

The Spearman Rank Correlation

The measure of correlation compute by this method is called the Spearman rank correlation computed by this method is called the Spearman rank correlation coefficient and is designated by r_s. This procedure makes use of the sets of rankds that may be assigned to the sample values of X and Y, the independent and continuous variable of a bivariated distribution.

Hypotheses The usually tested hypotheses and their alternatives are as follows:

a. H_0 : X and Y are mutually independent.
H_A : X and Y are not mutually independent

b. H_0 : X and Y are mutually independent.
H_A : There is a tendency for large values of X and large values of Y to be paired together.

c. H_0 : X and Y are mutually independent.
H_A : There is a tendency for large values of X and large values of Y to be paired with small value of Y.

The hypotheses specified in (a) lead to a two-sided test and are used when it is desired to detect any departure from independence. The one-sided tests indicated by (b) and (c) are used, respectively, when investigators wish to know if they can conclude that the variables are directly or inversely correlated.

The Procedure The hypothesis-testing procedure involves the following strps.

1. Rank the value of X from 1 to n (number of pairs of values of X and Y in the sample). Rank the balues of Y from 1 to n.
2. Compute d_i for each pair of observations by subtracting the rank of Y_i from the rank of X_i.
3. Square each d_i and compute $6\sum d_i^2$, the sum of squared value
4. Compute $r_s = \frac{6\sum d_i^2}{\sum i^2}$

5. If n is between 4 and 30 compare the computed value of r_s with the critical values, r_s^* with the critical values, For the two-sided test H_0 is rejected at the α sinificane level if r_s is greater r_s^* than or less than r_s^* where is at the intersection of the column headed $\alpha/2$ and the row corresponding to n. For the one-sided test with H_A specifying direct correlatin, H_0 .. rejected at the α significance level if r_s is greater than for α and n. The null hypothesis is rejected at the α significance level in the other one-sided test if if r_s is less than for α and n.
6. If n is greater than 30, one may compute $z = r_s\sqrt{n-1}$ and use Table of Z values to obtain critical values (Daniel, 1995).

Biography

Miss Phimphann Ngoented was born on the 7nd of December 1975 in Sagolnakorn Province Thailand. She graduated her's bachelor's degree of science in biology from the Faculty of Science, Burapha University in 1996. She continued her graduated study for a master's degree of science in zoology from Chulalongkorn University in 2000.