Sexual Selection in Zebra Dove *Geopelia striata* L.

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ชื่อวิทยานิพนธ์ การคัดเลือกทางเพศในนกเขาชวา (*Geopelia striata* L.)

ผู้เขียน นายพีรบูรณ์ พรหมจันทร์

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บทคัดย่อ

การคัดเลือกทางเพศในนกหลายชนิดนั้น การแสดงท่าทาง สีขน และเสียงร้องของเพศผู้เป็นข้อมูลที่เพศเมียใช้ในการเลือกคู่ ในนกเขาชวา (*Geopelia striata* L.) เพศผู้ใช้เสียงขันในการเกี้ยวเพศเมียก่อนการจับคู่ การศึกษาในครั้งนี้มีวัตถุประสงค์เพื่อศึกษาความสัมพันธ์ระหว่างเสียงขันของนกเขาชวาเพศผู้กับความพึงพอใจต่อคู่สืบพันธุ์ของเพศเมีย โดยดำเนินการทดลองเลือกคู่ในช่วงเวลาระหว่างเดือนเมษายน – พฤศจิกายน 2551 ในกรงที่มี 3 ห้องขนานกันโดยให้เพศเมียอยู่ตรงกลางเพื่อพิจารณาเลือกระหว่างเพศผู้ 2 ตัว ที่อยู่ด้านข้าง บันทึกเสียงขันของเพศผู้ และการตอบสนองของเพศเมียทุกชั่วโมงตลอดวันโดยใช้เทคนิค focal animal sampling จากนั้นเพศเมียจะถูกนำไปอยู่ร่วมกับเพศผู้ตัวใดตัวหนึ่งเพื่อเปรียบเทียบระยะเวลาที่นกเพศผู้และเพศเมียใช้ก่อนที่การผสมพันธุ์จะเกิดขึ้นในกลุ่มของเพศผู้ที่ถูกเลือกและเพศผู้ที่ไม่ถูกเลือก

จากการศึกษาเพื่อเปรียบเทียบความแตกต่างระหว่างกลุ่มของเพศผู้ที่ถูกเลือกและไม่ถูกเลือกโดยใช้ Mann-Whitney U Test พบว่าจำนวนพยางค์ของคำขันของนกเขาชวาเพศผู้ทั้งคำต้นซึ่งเป็นพยางค์เดี่ยว คำกลาง และคำปลาย ไม่มีความแตกต่างอย่างมีนัยสำคัญทางสถิติ ($p=0.758$ และ $p=0.232$ ตามลำดับ) ความถี่ของคำต้น คำกลาง และคำปลาย ในกลุ่มเพศผู้ที่ถูกเลือกต่ำกว่าในกลุ่มเพศผู้ที่ไม่ถูกเลือก แต่ไม่มีนัยสำคัญทางสถิติ ($p=0.217$,

p=0.072 และp=0.680 ตามลำดับ) ความยาวของคำต้น คำกลาง และคำปลายก็ไม่แตกต่างอย่างมีนัยสำคัญทางสถิติเช่นกัน (p=0.157, p=0.442 และ p=0.929 ตามลำดับ) จำนวนคำขันต่อชุดของกลุ่มที่ถูกเลือกสูงกว่ากลุ่มที่ไม่ถูกเลือกแต่ไม่มีนัยสำคัญทางสถิติ (p=0.203) อย่างไรก็ตามพบว่าการตอบสนองของเพศเมียด้วยการขันนั้นมีความสัมพันธ์เชิงบวกกับจำนวนคำขันต่อชุดของเพศผู้อย่างมีนัยสำคัญทางสถิติ (Pearson Correlation Coefficient: r_{99} =0.671, p=0.003)

เพศเมียขันตอบต่อเพศผู้ที่ถูกเลือกมากกว่าเพศผู้ที่ไม่ถูกเลือกอย่างไม่มีนัยสำคัญทางสถิติ (p=0.069) อย่างไรก็ตามพบว่าการตอบสนองด้วยการขันตอบนั้นมีความสัมพันธ์เชิงบวกกับอัตราการขันของเพศผู้ดังกล่าวข้างต้น เพศเมียบินไปหาเพศผู้ที่ถูกเลือกสูงกว่าเพศผู้ที่ไม่ถูกเลือก (p=0.000) และเพศเมียเดินไปหาเฉพาะเพศผู้ที่ถูกเลือกเท่านั้น (p=0.001) นอกจากนี้ยังพบว่าเฉพาะเพศเมียที่อยู่ร่วมกับเพศผู้ที่ถูกเลือกเท่านั้นที่ยอมรับการผสมพันธุ์ และเพศเมีย 1 ตัว ที่อยู่ร่วมกับเพศผู้ที่ไม่ถูกเลือกถูกทำร้ายบาดเจ็บในวันแรกของการอยู่ร่วมกัน

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ABSTRACT

Sexual selection in many birds, display, plumage colour and songs of males are the cues that females use for mate selection. In zebra doves *Geopelia striata*, male use acoustic display to court the female before pairing. This study discovered the relationship between male vocalization and female mate preference of the zebra dove. A mate choice trial was run in a mate choice cage during April-November 2008. This cage has 3 parallel chambers; a female was hold in the middle chamber allowing her to examine each call of the males in the other chambers. The male advertising calls and female responses were recorded every hour throughout the day time using focal animal sampling technique. Then a male from each mate choice trial were kept together with female and compared the time that the 2 groups of male spent before they could pair successfully.

From the comparison study between selected male and unselected male by using Mann-Whitney U Test, it was found that the introductory phrase of male zebra dove advertising call is the single syllable. The median number of syllable in the middle phrase and terminal phrase of the selected males was not significantly

higher than of the unselected males (p=0.758 and p=0.232 respectively). The median frequency in the introductory phrase, the middle phrase and the terminal phrase of the selected males was not significantly lower than of the unselected males (p=0.217, p=0.072 and p=0.680 respectively). The median call duration in the introductory phrase, the middle phrase and the terminal phrase of the selected and the unselected males was also not significantly different (p=0.157, p=0.442 and p=0.929 respectively). The median numbers of call per calling bout of the selected males was not significantly higher than of the unselected males (p=0.203). However, it was found that the calling response of females had positive correlation with number of call per bout of the males (Pearson Correlation Coefficient: r_{99} =0.671, p=0.003).

The females responded by calling to the selected groups and the unselected groups not significantly (p=0.069). However, it was found that the calling response of females had positive correlation with number of call per bout of the males as mentioned above. The females responded by flying toward the males in the selected groups higher than the unselected groups significantly (p=0.000) and the females walked toward the selected groups only and did not walk toward the unselected groups (p=0.001). Only the females that had been placed with the selected males accepted the copulation and the male in 1 of 4 unselected pairs injured the female severely in the first day of trial.

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CHAPTER 1

INTRODUCTION

1. Background and Rationale

Sexual selection is a special process that produces traits that affect an individual's ability to acquire mates. Sexual selection can be divided into 2 types: intersexual selection, in which members of one sex choose certain mates of the other sex and intrasexual selection, in which individuals of one sex compete among them in order to access to the other sex (Darwin 1871; Drickamer *et al*., 2002).

Males usually compete for access to females in order to mate with them, while females usually seem to be choosing among males as mates (Drickamer *et al.*, 2002). This difference between the sexes arises from the differences in the factors that limited their reproductive success. The fertility of females is limited by egg production while fertility of males is limited by the number of mates (Drickamer *et al.*, 2002). Another reason that controls sexual selection is parental investment which is any investment by the parents in an offspring that increase the offspring's chance of surviving and reproductive success. The reproductive success of the sex that invests less in offspring (usually males) is limited by their ability to mate with the sex that invests more (usually females). And the reproductive success of the sex that invests more is limited by resource necessary for investment, not by access to the other sex (Triver, 1972; Drickamer *et al.*, 2002). When the females invest more than males, selection should act on females to be choosiness for mates that will invest in offspring and/or will give good genetic material to offspring.

In many birds, display, plumage colour and songs of males are the cues that females use for mate selection. Nolan and Hill (2004) proposed that female captive house finches *Capodacus mexicanus* use males' songs to justify mate choice. By playback trials of male's songs, female house finches show preference for long songs and for songs presented at a faster rate. Song length and rate each seem likely to indicate a male's energy reserves, and thus could be important sources of information for females choosing mates. In addition, plumage colour also plays a role in mate

choice. Paired males are more colourful than unpaired male. Variation in male plumage colouration is a function of dietary intake of carotenoid pigments (Hill, 1990).

In barn swallow *Hirundo rustica*, white tail spots play an important role in female mate choice. White tail spots in the barn swallow are secondary sexual characters subject to sexual selection. Paternity studies of barn swallows have shown that males with long tail, and hence with large tail spots, give more offspring in their nests than short-tailed males (Kose *et al.*, 1999). Furthermore, non-feather part colouration is also an attractive trait. Female zebra finches *Taeniopygia guttata* prefer males with redder beaks and high song rate, which are both condition-dependent traits (Birkhead *et al.*, 1998; Rutstein, 2004).

In zebra doves *Geopelia striata*, males and females are not different in morphology (Lekakul and Round, 1991) but they are different in vocalization and display behaviour. Male zebra dove use acoustic display to court the female before pairing, the advertising calls is high in the initial phase of courting; it is increasing to the highest level in the second week of courtship. After pairing, nesting and copulation occur, the advertising calls decrease and be rarely found after the female laying eggs (Phromchan, 2004). The vocalization, therefore, of zebra dove may have the important role in sexual selection particularly for female mate choice.

2. Research questions

By comparing, the introductory phrase, the middle phrase and the terminal phrase, the numbers of syllable of the introductory phrase and the terminal phrase do not vary as much as the middle phrase. Moreover, call duration, frequency, and call rate differ throughout the male zebra doves.What are crucial characteristics of male zebra dove for female mate choice?

3. Objectives

To find out the relationship between male vocalization (e.g. number of syllable, duration, frequency, and call rate) and female mate preference of the zebra dove *Geopelia striata* L.

4. Hypothesis

Females choose the males with their attractive advertising call, which depend on the numbers of syllable, the call duration, the frequency of call and number of calls in one calling bout.

5. Literature review

5.1 Sexual selection

Sexual selection is a special process that produces traits that affect an individual's ability to acquire mates. Sexual selection can be divided into 2 types: intersexual selection and intrasexual selection (Krebs and Davies, 1981).

5.1.1 Intersexual selection

In intersexual selection, individuals of one sex (usually the males) advertise that they are worthy of an investment; then members of the other sex (usually the females) choose among them. Two explanations for the mate selection by females are Runaway selection hypothesis and Handicap hypothesis (Drickamer *et al*., 2002).

Runaway selection process

In runaway selection, females that mate with attractive males will tend to have attractive sons, provided the attractive characteristics are inherited. These sons, in turn, will be successful in attracting females and in reproductive themselves. Therefore, a female that chooses to mate with a male on the basis of his sexual attractiveness is likely to have more grandchildren than a female that mate with a less attractive male (Fisher, 1930; McFarland, 1993).

Handicap hypothesis

The trait favored by females may indicate male fitness. Sexual selection can produce traits that reduce the survival and they must be both costly to produce and linked to qualities in the males (Zahavi, 1975; Drickamer *et al.*, 2002). If a peacock can survive despite the encumbrance of his large tail, he must be a worthy male, since his good gene qualities will be passed on to the next generation(Zahavi, 1975; McFarland, 1993).

5.1.2 Intrasexual selection

Intrasexual selection involves competition with one sex (usually males), with the winner gaining access to the opposite sex. Competition may take place before mating, the winner gain dominance and so most of the mating, as it does with ungulate such as deer (family Cervidae) and antelope (family Bovidae). Typically, males live most of the year in all-male herds; as the breeding season approaches, males engage in highly ritualized battles with their antlers or horns. The winners of these battles gain dominance and so most of mating. Antlers are better developed in those cervid species where males compete strongly for large groups of females (Clutton-Brock *et al.*, 1982; Drickamer *et al.*, 2002)

It is difficult to determine which type of sexual selection is operating, since other member of both sexes may present during courtship. Some behaviour of the male both attracts females and intimidates other males.

5.2 Courtship behaviour of bird

Courtship behaviour is the sexual display behaviour leading to copulation and producing offspring. It may be displayed by conspicuous colours, repetitive movements or sounds (McFarland, 1981). The important function of courtship is the mate attraction. The signal that used in courtship differ in each species depend on their environment and nervous system that have been evolved for living. In bird, visual and auditory nervous system are well developed, it use display and vocalization to attracting mate. Furthermore, male courtship behaviour can influence female hormone level. In ring doves, a male begins courtship display shortly after being placed with a female. Male courtship stimulates pituitary release of FSH in the female dove; FSH in turn stimulates follicle development in the ovaries (Drickamer *et al.*, 2002).

5.3 Vocal communication in birds

Bird vocalizations are traditionally divided into calls and songs, and although there are considerable difficulties in exactly defining the two terms, the distinction still remains a useful one. As a general rule, songs are long, more complex

in structure and produced by males in the breeding season, whereas calls are short, simple and produced by both sexes throughout the year (Catchpole, 1979).

5.3.1 Calls

There is evidence from a number of species, that a call may also contain enough information to transmit the identity of a particular individual. Furthermore, it can also be shown that others in the population react to such calls in a manner which suggests that they are quite capable of individual recognition in sound alone. Calls vary in frequency and duration between different individual to give each bird its own distinctive call pattern. Calls, unlike songs are generally regarded as inherited, but clearly some species possess the ability to modify and extend their vocabulary by later learning, in this case to facilitate individual recognition within mated pair (Catchpole, 1979).

5.3.2 Songs

In song birds, the songs are extremely complex consisting of combinations of several different phrases and each phrase is quite a complicated structure. The variability is the keynote and a simple set of rules which appear to underlie their overall song organization; (1) all the phrases within the song are different, (2) in a run of consecutive song all the songs are different and (3) successive phrases alternate in pitch between high and low frequency (Catchpole, 1979).

In each species, several parameters appear to be involved in species recognition, and these differ from species to species in their relative importance. Whatever the features are, if the communication system is to function efficiently then they should be relatively constant within a population (Bremond, 1976; Catchpole, 1979).

Although the features of song important in species recognition must remain fairly constant, there is still considerable scope for individual variation. Each bird within a population may have its own particular version of the species song which is quite characteristic (Catchpole, 1979).

5.4 Zebra Dove, *Geopelia striata* L.

Zebra dove, which is a species of the Columbidae family and Columbiformes order, is very small (21 cm), with a fairy long, graduated tail with white tips to the outer feathers. The upperparts is brownish with broken black bars; dense black and white barring on sides of neck and breast. It has broad blue-grey orbital ring (Lekagul and Round, 1991) (Fig.1).

It feeds on small seeds and grains in open country, costal woodlands and around cultivated areas. It will be seen frequently in dry fields in the rural areas and along the roadsides. Occasionally, if will fly up and perches in a tree when pausing feeding bout or when disturbed. It is a popular bird valued for its singing (Strange, 2000). It distributes in Southeast Asia. Within the region, it is native to the Malay Peninsula, including Singapore; introduced and common in central Thailand, the Philippines and Borneo, including Brunei. Nesting has been reported in all months except July and August; clutch sire is 2 eggs (Medway and Wells, 1976).

Figure 1. Zebra dove *Geopelia striata* L. in captivity.

5.5 Previous Studies

There are many studies of female choice related to male plumage colouration. One of the fundamental predictions of sexual selection theory is that female mate preferences co-evolve with the degree of elaboration of male ornamental traits (Fisher, 1958; Lande, 1981; Hill and McGraw, 2002).

Many studies on bird plumages indicate that selection for male competitive ability and aggression might favour the evolution of conspicuous conventional signal of status in male plumages (Rohwer, 1977; Rohwer and Ewald 1981; Mateos and Carranza, 1997). In ring necked pheasant *Phasianus colchicus*, that some male ornaments, such as the red wattles, and even the small feathers in ear tufts, are signals that might be used by female to indicate the quality of the male (Mateos and Carranza, 1997).

In great tits *Parus major*, their head plumage pattern is used as an indicator of male quality that influences the decision in female mate choice (Ferns and Hinsley, 2004). In dark-eyed juncos *Junco hyemalis*, female ornamentations are attractive and have roles in male mate choice (Wolf *et al.*, 2003).

In songbird, song has been proposed to function in mate choice, and such a role has been demonstrated experimentally in number of species. In house finches *Carpodacus mexicanus*, females showed mate choice in male's song characteristics which reflected a male's energy reserves, and could be important sources of information for females choosing mates (Nolan and Hill, 2004). Birdsong has been shown to be subjected to female preferences for large repertoire size, high production rates or particular song variants (Catchpole *et al.*, 1984; Rehsteiner *et al.*, 1998; Vallet *et al.*, 1998; Gentner and Hulse, 2000; Neubauer, 2000; Secondi *et al.*, 2002).

The Columbidae family is particularly suited to conduct such studies as call is involved in both inter- and intra-sexual interactions. Most experimental evidence of the sexual function of call comes from a single species, the ringed dove *Streptopelia risoria*, in which call triggers endocrinological response. In this species, male call stimulates female vocalization, which in turn self-stimulates ovulation (Cheng, 1985, 1992; Secondi *et al.*, 2002).

In collared dove *Streptopelia decaocto*, the coo of male collared doves is different from female collared dove coo. Both sexes produce series of three-syllable coo, but the male sound is lower in pith and contains fewer overtones. Furthermore, no two adult males have exactly the same coo characteristics. One aspect that varies among them is whether the coo syllable shows only a gentle rise and fall in frequency or a discrete jump to a higher frequency. The number of syllables with such frequency jumps in a series of coos varies with body weight. Heavier males produce more jumps which suggest that they may not be easy to generate. The jumps emerge through a physical phenomenon related to size and shape of the vocal tract and speed of air flow during coo production. Doves those are able to produce many coo syllables with discrete frequency jumps may be in better shape, have stronger muscles or have a greater lung capacity, all of which are interesting factors to communicate to potential mates and rivals (Slabbekoorn, 2004).

Acoustic variation across cooing individuals may broadcast information about sex, age, and strength, but the message can only become available to the doves themselves if they are able to detect and recognize the variation (Slabbekoorn, 2004).

In zebra dove *Geopelia striata*, sound types are grouped into three classes according to the difference in sound frequencies of their advertising calls. Class A is the low-frequency-birds, class B is the medium-frequency-birds and class C is the high-frequency-birds. This classification is in accordance with the local practice which based solely on listening experience. All of these three groups' calls always consist of three phrases in each call; the introductory, the middle and the terminal phrases. In all doves, the introductory phrase has only one syllable as same as the terminal phrase. And the syllables of the middle phrase are between 1 to 5 syllables (Fig.2). But the number of syllables in the middle phrase is not difference among call classes (Liengpornpan and Meesawat, 2004).

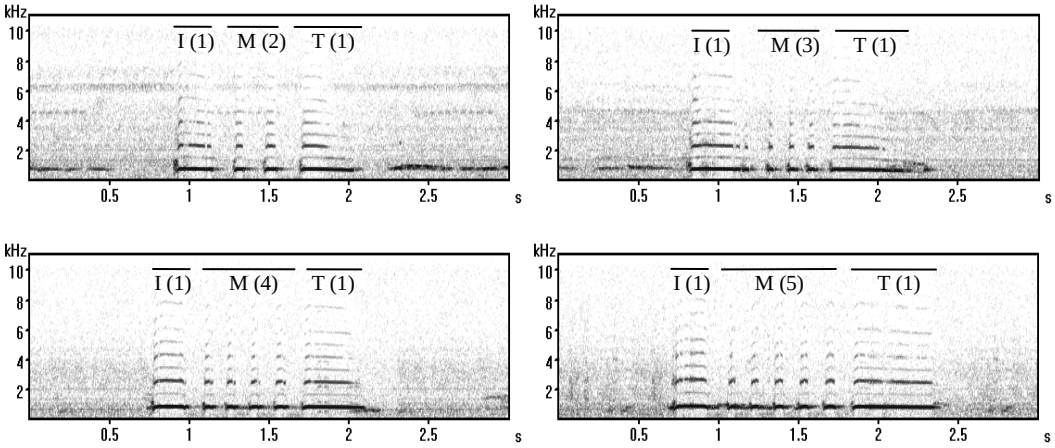

Figure 2. The spectrograms of a zebra dove advertising call. (generated by Avisoft-SASLab Pro Software (I=Introductory phrase, M=Middle phrase, and T= Terminal phrase), (The number in the bracket () is the number of each syllable in each phrase.)

Responsive behaviours of female zebra doves

From the pilot study, after the males and females were kept in the same cage and the males started to court the females, the female showed the calls in front of the male, responding to the male's call by doing calls, trying to reach the calling male then the copulations occur in 2-3 days.

CHAPTER 2

MATERIALS AND METHODS

1. Study location

This study has been carried out in an aviary in Mae Lan District, Pattani Province, southern Thailand.

2. Methodology

2.1 Definition

1) Advertising call

Advertising call of zebra dove has been defined as vocalizations that an adult male dove produces in each calling bout before pairing in order to attract female. The advertising call consists of 3 phrases; the introductory, the middle and the terminal phrase (Liengpornpan and Meesawat, 2004) (Fig.3).

The introductory phrase is the vocalization produced in first phrase of a call and contains 1 syllable.

The middle phrase is the second phrase of the call, consists of more than one repetitive syllables separated with interval between each syllable.

The terminal phrase comes after the middle phrase. It is usually consists of 1 syllable as same as the introductory phrase.

The male zebra doves produce advertising call in bouts containing one to more than hundred calls per calling bout. In this study, only advertising calls of male dove were considered in mate choice trial.

he variations of captive individual's advertising call are the numbers of syllable in the middle phrase, the frequency of each phrase, and the number of calls in a calling bout.

2) Settling call

Settling call is a vocalization that both male and female can produce. It is a repetitive of some syllables but not in a pattern like the advertising call that consists of three phrases. The settling call is produced singly not in a calling bout like advertising call (Fig.4). In this study, the settling calls of females have been considered as a responsive behaviour to the males.

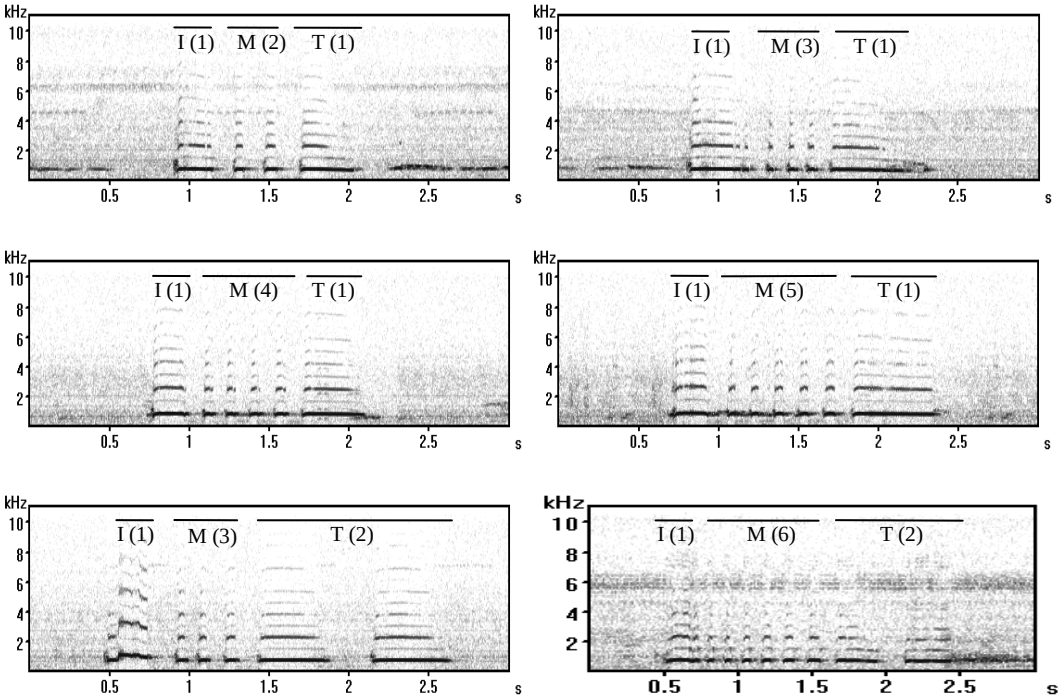

Figure 3. The male zebra dove advertising call spectrograms show the difference in numbers of syllable in the middle phrase and terminal phrase (I=Introductory phrase, M=Middle phrase, and T=Terminal phrase), (The number in the bracket () is the number of each syllable in each phrase.)

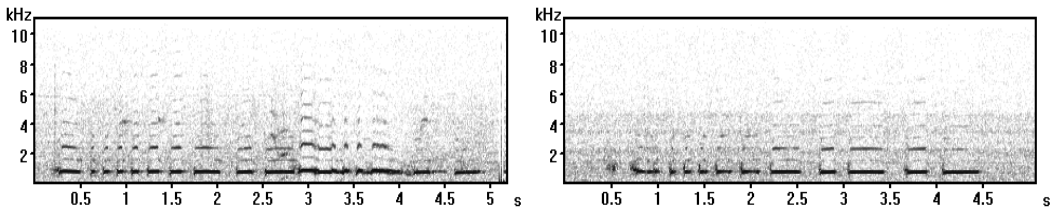

Figure 4. The male zebra dove settling call spectrograms with repetitive of some syllables but not in pattern like advertising call.

2.2 Subjects

Thirty domesticated 8-12 month-old zebra doves *Geopelia striata* L. (10 females and 20 males) had been purchased from a local breeder in Pattani Province in March 2008. All birds have never been mated before. Body size parameters; body weight, beak length, tarsus length, and inter pubic bones space, were measured (Fig.5).

Figure 5. Measuring body size parameters; body weight (a), beak length (b), tarsus length (c), and inter pubic bones space (d).

2.3 Captive maintenances

All zebra doves were housed single sex group in outdoor flight cages (1x1x2m) with natural day light at a temperature between 23-37 °c (Fig.6). Birds were provided with multi-vitamin supplemented mix seed (rice grain, millet, rye, ground mung bean) sand and water ad libitum (Fig.7). They were dewormed using Curazole 10% (Levamisole HCl product of Macrophar Co, Ltd.) under the veterinarian prescription.

After that, each bird was kept in a single cage which was made of bamboo and rattan in traditional style of zebra dove cage in Thailand. The single cage is a round shape, 45cm high and 35cm diameter of the base, containing one perch and cups of food and water inside (Fig.8).

The doves were visually isolated from birds of the opposite sex and the males were considered about the call elements to set a group of mate choice trial. All individuals had been maintained in these conditions before the experiments were conducted.

Figure 6. The outdoor flight cages for holding single sex group zebra dove.

Figure 7. Mix seed food provided; rice grain (a), millet (b), rye (c), ground mung bean (d), sand (e) and multivitamin (f)

Figure 8. Single cages which were made of bamboo and rattan in a traditional style

2.4 Sex determiniation

The zebra doves in this study were sex determined based on these criteria:

Vocalization; male zebra doves produce advertising calls which can be easily distinguished from females. The females cannot produce advertising call; they do just settling calls which contain repeat syllables. While the males advertising calls are more distinct pattern which contains introductory phrase, middle phrases, and terminal phrases, the males are more vocal than females.

Plumage coloration; the males have light blue-grayish face and forehead and grayish throat. The females have more brownish face than the males (Naphitaphat *et al*., 2007).

Behaviour; only the males do bow coo to both other males and females. When they were kept in an individually cage, some doves do bow coo toward the others and they were determined as male doves.

Pubic bones space; the female doves have wider pubic bones space than the males have in order to facilitate egg laying (Kananurak, 2006) (Fig. 9).

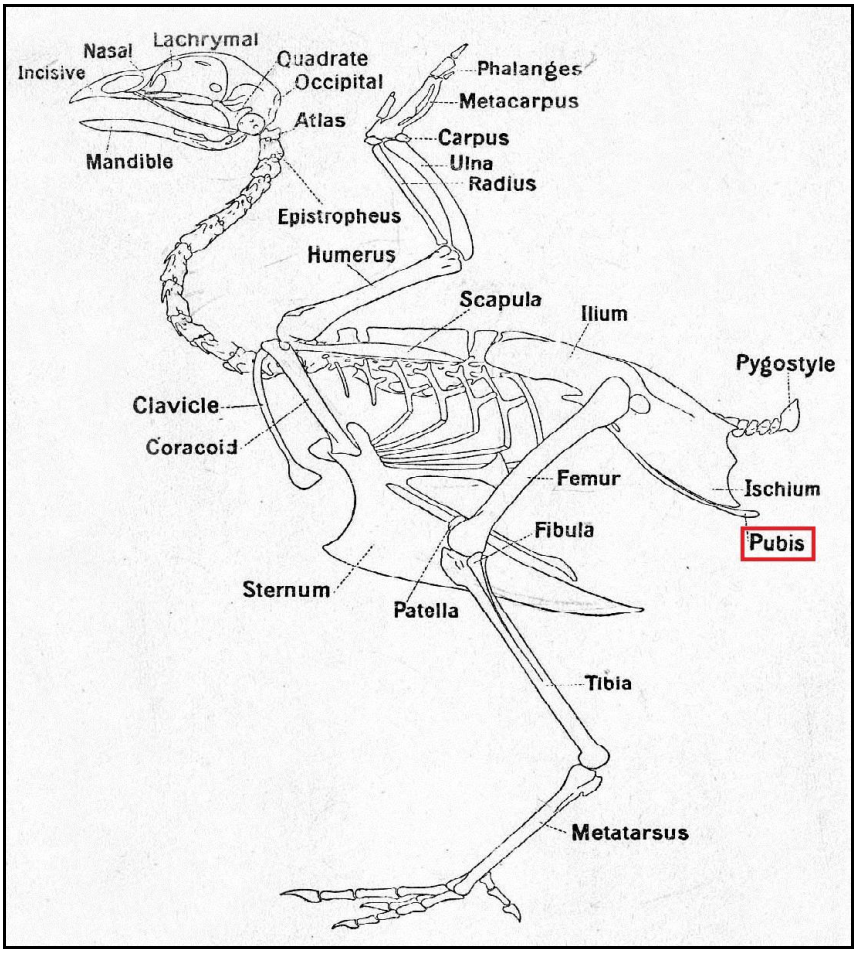

Figure 9. The avian skeleton (Bradley, 1915) showing the pubic bones used for sex determination of zebra dove in this study.

2.5 Mate choice trial

A mate choice trial was run between dawn and evening (0600-1800 hours) in a mate choice cage. This cage has 3 parallel chambers for holding males and females. A female was hold in the middle chamber, allowing her to examine each call of the males. Blind between each chamber with wooden boards 25 cm from the perch so that the males and female could not see each other directly. The two males of each group were different in the number of syllable of the middle phrase. The doves of each group were held in the same cage throughout the days of trial (Fig.10).

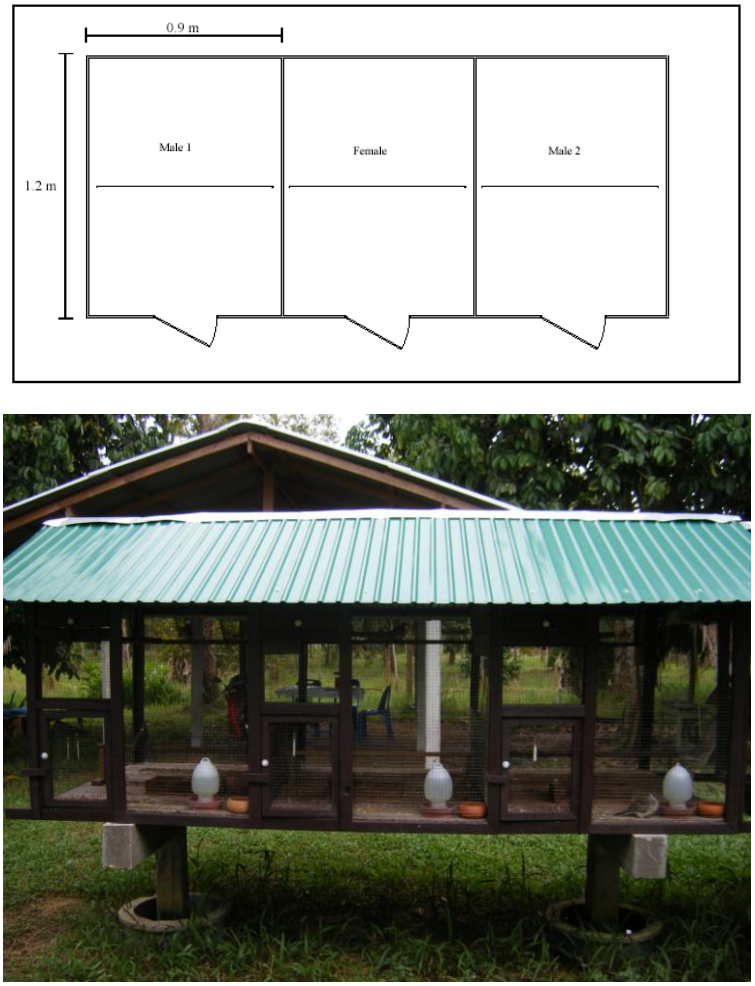

Figure 10. The mate choice cage with 3 parallel chambers for holding males and females.

To assess variation in the advertising calls, each male advertising call was recorded every hour throughout the day time (0600-1800) when they were held in the mate choice cages. The advertising calls of 20 male zebra doves were recorded with a Sony cassette recorder (SONY TCM-200DV) (Fig.11). All recordings were translated into the computerized sound spectrograms using Avisoft-SASLab Pro Software (Fig.12). The spectrograms were used to analyze the numbers of syllable, call duration and frequency of the male calls.

At the same time, the behaviours of the three doves (1 female and 2 males) were observed using focal animal sampling technique. With this technique, one animal or group of animals was chosen and watched for a set length of time (in this study

was 12 hours per day) (Rabinowitz 1999). The data received from focal animal sampling were male advertising calls rate (the number of call per calling bout) and female responsive behaviours in each day of mate choice trial.

The female responsive behaviours which refered to the female responses of the males in the time that the males doing advertising call were;

1) Settling call: the females respond to the male's call by calling immediately
2) Flying: the females fly toward the male to reach the calling male
3) Walking: the females walk back and forth on the side of the male wall

Throughout the days of mate choice trial, all responsive behaviours that the female responded to the calling male were counted. The female was considered that it chose the male whom it showed more responsive behaviours.

2.6 Insistent trial

To ensure that a male was really selected by female, a male from each mate choice trial (selected or unselected male) were kept together with female and let them pair in the same cage. Compared the time that the 2 groups of male spent before they could pair successfully (the copulation occurred).

Figure 11. Sony cassette recorder (SONY TCM-200DV) used in this study.

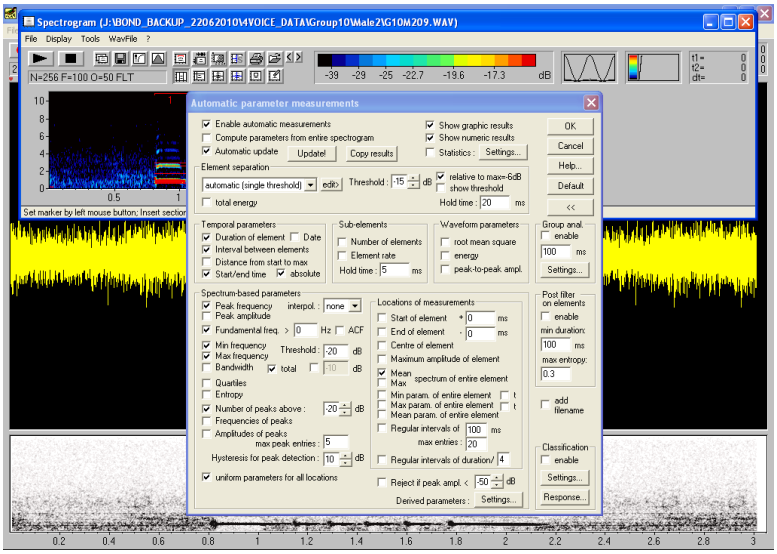

Figure 12. Avisoft-SASLab Pro Software used for translating records into the computerized sound spectrograms.

2.6 Data analysis

2.6.1 Male advertising calls

The advertising call of the male zebra doves was translated into computer using Avisoft-SASLab Pro Software (Fig.12). One call of each male has been randomly selected to represent the structure of these males' call. he spectrogram of each call was created and analyzed these parameters;

1) Syllable: the numbers of syllable of each phrase in the call
2) Frequency: the frequency of calls measured in kHz
3) Duration: the duration of each syllable in the call and of whole call measured in second

From animal focal sampling, the number of call in the biggest calling bout of each male were represented the male call rate.

2.6.2 Female responses

All responsive behaviours that the female responded to the calling male during the mate choice trial were counted and made on average per day. Then the average time per day of female responsive behaviours to each male was compared, which male received more time of response mean it was a selected male. The female was considered that it chose the male whom it showed more responsive behaviours.

2.6.3 Time used before copulation occurred

Compared the days that the male and female used before the copulation occurred between groups of selected male and unselected male to find the difference between the times that female spent with selected male and the time that female spent with unselected male.

2.6.4 Statistical analysis

The data of this study which was small sample size and not in the normal distribution has been analyzed by Mann-Whitney U Test to examine the difference between the median of selected and unselected groups. In addition, Pearson Correlation Coefficient has been used to examine the relationship between male parameters and female responses.

CHAPTER 3

RESULTS

3.1 General description

After the 7-10 day of habituation and readiness, each zebra dove could adapt to the mate choice cage during the mate choice trials. They consumed food normally, showed walking, flying, calling behaviours and perched on every provided perches (Fig. 13). Furthermore, they did not show the stress posture by motionless and stretch-neck perching.

Figure 13. The doves in the experiment showed relax postures perching and walking normally.

3.2 Body size parameters

The body size parameters in this study were body weight, beak length and tarsus length. These data give the information about the size of each male in the experiment in order to compare between the selected and unselected male groups.

1) Body weight

The median body weight of the selected males was 65.50 g and of the unselected was 66.00 g. The median body weight of the selected and unselected group was not significantly different (Mann-Whitney U Test; $z = -0.305$, $p = 0.761 > 0.05$) (Table 1).

2) Beak length

The median beak length of the selected males was 1.42 cm as same as the unselected (Mann-Whitney U Test; $z = -0.341$, $p = 0.733 > 0.05$) (Table 1).

3) Tarsus length

The median tarsus length of selected males was 2.11 cm and of the unselected males was 2.12 cm. There was no significant difference of the tarsus length between the selected group and the unselected group (Mann-Whitney U Test; $z = -0.191$, $p = 0.849 > 0.05$) (Table 1).

Table 1. Body size parameters consist of body weight, beak length and tarsus length of male zebra doves used in this study and the median weight, beak length and tarsus length of male zebra dove of selected and unselected males

Groups		**Body size**		
		Body weight (g)	**Beak length (cm)**	**Tarsus length (cm)**
Selected males	1	69.00	1.47	1.94
	2	68.00	1.49	2.11
	3	66.00	1.46	2.11
	4	66.00	1.42	2.12
	5	60.00	1.44	2.11
	6	65.00	1.39	2.25
	7	72.00	1.29	2.39
	8	62.00	1.41	2.12
	9	62.00	1.33	1.99
	10	60.00	1.25	1.99
	Median	**65.50**	**1.42**	**2.11**
Unselected males	1	71.00	1.43	1.96
	2	60.00	1.44	2.22
	3	69.00	1.37	2.21
	4	65.00	1.41	2.11
	5	68.00	1.59	1.99
	6	58.00	1.38	2.19
	7	66.00	1.31	1.99
	8	66.00	1.35	2.08
	9	65.00	1.59	2.12
	10	67.00	1.44	2.29
	Median	**66.00**	**1.42**	**2.12**
Mann-Whitney U Test	***p***	**0.761**	**0.733**	**0.849**

3.3 Male advertising calls

As mentioned before, the male zebra dove advertising calls consist of three phrases; the introductory phrase, the middle phrase and the terminal phrase (Fig. 14). In this study, four parameters of advertising calls were determined; the numbers of syllable, the frequency, the duration and the rate that advertising calls were produced per calling bout.

In this study, 3 of 20 male zebra doves did not show advertising call during the experimental period so the data of advertising call received from 17 male doves (Table 2: a). The data of each individual gained from the one-randomly-selected call of these 17 male.

3.3.1 Numbers of syllable

1) The introductory phrase

The introductory phrase of all male zebra dove advertising call is the single syllable (Table 2: a).

2) The middle phrase

The median numbers of syllable in the middle phrase of the selected males were 4 syllables and of the unselected were 3 syllables. The selected group had higher median numbers of syllable in the middle phrase than the unselected group however there was no significantly difference (Mann-Whitney U Test; $z = -0.308$, $p = 0.758 > 0.05$) (Table 2: a).

3) The terminal phrase

The median number of syllable in the terminal phrase of the selected males was 1 syllable as same as the unselected (Mann-Whitney U Test; $z = -1.195$, $p = 0.232 > 0.05$) (Table 2: a).

3.3.2 Frequency

1) The introductory phrase

The median frequency in the introductory phrase of the selected males was 800 Hz and of the unselected was also 800 Hz (Mann-Whitney U Test; z = -1.234, p = 0.217 > 0.05) (Table 2: b).

2) The middle phrase

The madian frequency in the middle phrase of the selected males was 770 Hz and of the unselected was 755 Hz. The selected group had higher median frequency in the middle phrase than the unselected group however it was not significantly different (Mann-Whitney U Test; z = -1.800, p = 0.072 > 0.05) (Table 2: b).

3) The terminal phrase

Between two groups, the median frequency in the terminal phrase of the selected males was 785 Hz and of the unselected was 800 Hz. The selected group had lower median frequency in the terminal phrase than the unselected group however there was no significant difference (Mann-Whitney U Test; z = -0.413, p = 0.680 > 0.05) (Table 2: b).

3.3.3 Call duration

1) The introductory phrase

The median call duration in the introductory phrase of the selected males was 0.325 second and of the unselected was 0.267 second. The selected group had longer median call duration in the introductory phrase than the unselected group however the difference was not significant (Mann-Whitney U Test; z = -1.417, p = 0.157 > 0.05) (Table 2: c).

2) The middle phrase

The median call duration in the middle phrase of the selected males was 0.092 second and of the unselected was also 0.092 second (Mann-Whitney U Test; z =-0.769, p = 0.442 > 0.05) (Table 2: c).

3) The terminal phrase

The median call duration in the terminal phrase of the selected males was 0.416 second and of the unselected was 0.385 second. The selected group had longer median call duration in the terminal phrase than the unselected group however the difference was not significant (Mann-Whitney U Test; z = -0.089, p = 0.929 > 0.05) (Table 2: c).

4) The total call duration

The median total call duration of the selected males was 2.14 second and of the unselected was 1.90 second. The difference of the median total call duration between the selected group and the unselected was not significant (Mann-Whitney U Test; z = -0.683, p = 0.495 > 0.05) (Table 2: c).

3.3.4 Call rate (The number of calls per bout)

The median numbers of calls per bout of the selected males were 81.00 calls and of the unselected were 5.00 calls. The selected group had higher median number of calls per bout than the unselected group however the difference was not significant (Mann-Whitney U Test; z = -1.273, p = 0.203 > 0.05) (Table 2: d).

Table 2. The advertising call of male zebra dove in this study received from 17 male doves showed the median call syllable, frequency and rate of each male call of the selected and unselected male groups gained from 1 call of each male.

a. Call syllable

Groups		**Call syllables (syllable)**		
		Introductory	**Middle**	**Terminal**
Selected males	1	1	3	1
	2	1	4	1
	3	1	7	1
	4	1	2	1
	5	1	4	1
	6	1	2	1
	7	1	4	1
	8	1	4	1
	9	1	3	1
	10	1	4	1
	Median	**1**	**4**	**1**
Unselected males	1	1	3	1
	2	1	4	1
	3	1	2	1
	4	1	3	2
	5	1	4	1
	6	-	-	-
	7	-	-	-
	8	1	6	1
	9	1	3	1
	10	-	-	-
	Median	**1**	**3**	**1**
	P	**1.000**	**0.758**	**0.232**

Table 2. Continued.

b. Call frequency (Hz)

Groups		Call frequency (Hz)								
		Intro	**Mid1**	**Mid2**	**Mid3**	**Mid4**	**Mid5**	**Mid6**	**Mid7**	**Terminal**
Selected males	1	770	710	680	740	-	-	-	-	740
	2	700	600	600	600	600	-	-	-	600
	3	800	800	800	800	800	800	800	800	800
	4	800	600	600	-	-	-	-	-	800
	5	800	800	800	800	800	-	-	-	800
	6	1000	800	800	-	-	-	-	-	800
	7	740	710	740	740	740	-	-	-	710
	8	770	330	770	770	770	-	-	-	770
	9	800	800	290	770	-	-	-	-	770
	10	860	860	830	830	830	-	-	-	830
	Median	**800**	**770**							**785**
Unselected males	1	940	830	390	770	-	-	-	-	800
	2	700	700	700	700	700	-	-	-	700
	3	800	700	700	-	-	-	-	-	700
	4	1000	900	800	800	-	-	-	-	800
	5	800	400	700	800	300	-	-	-	800
	6	-	-	-	-	-	-	-	-	-
	7	-	-	-	-	-	-	-	-	-
	8	770	740	770	330	740	740	740	-	680
	9	800	770	770	770	-	-	-	-	800
	10	-	-	-	-	-	-	-	-	-
	Median	**800**	**755**							**800**
	P	**0.217**				**0.072**				**0.680**

Table 2. Continued.

c. Call duration (second)

Groups		Call duration (second)									
		Intro	**Mid1**	**Mid2**	**Mid3**	**Mid4**	**Mid5**	**Mid6**	**Mid7**	**Terminal**	**Total**
Selected males	1	0.417	0.075	0.087	0.098	-	-	-	-	0.679	2.213
	2	0.386	0.092	0.098	0.148	0.130	-	-	-	0.255	2.245
	3	0.290	0.060	0.063	0.084	0.075	0.084	0.101	0.124	0.322	2.697
	4	0.313	0.121	0.124	-	-	-	-	-	0.542	1.748
	5	0.374	0.087	0.072	0.066	0.075	-	-	-	0.255	2.068
	6	0.336	0.113	0.107	-	-	-	-	-	0.467	1.848
	7	0.412	0.075	0.081	0.104	0.098	-	-	-	0.476	2.282
	8	0.168	0.069	0.087	0.075	0.127	-	-	-	0.313	1.910
	9	0.249	0.098	0.185	0.174	-	-	-	-	0.476	2.341
	10	0.249	0.081	0.081	0.092	0.092	-	-	-	0.365	1.916
	Median	**0.325**	**0.092**							**0.416**	**2.14**
Unselected males	1	0.267	0.052	0.063	0.058	-	-	-	-	0.383	1.842
	2	0.307	0.063	0.095	0.092	0.098	-	-	-	0.348	1.862
	3	0.214	0.098	0.130	-	-	-	-	-	0.522	1.674
	4	0.313	0.081	0.087	0.101	-	-	-	-	0.386	2.809
	5	0.296	0.040	0.063	0.072	0.063	-	-	-	0.374	1.896
	6	-	-	-	-	-	-	-	-	-	-
	7	-	-	-	-	-	-	-	-	-	-
	8	0.255	0.046	0.092	0.121	0.110	0.098	0.092	-	0.336	2.307
	9	0.174	0.139	0.145	0.166	-	-	-	-	0.452	2.200
	10	-	-	-	-	-	-	-	-	-	-
	Median	**0.267**	**0.092**							**0.385**	**1.90**
	P	**0.157**				**0.442**				**0.929**	**0.495**

Table 2. Continued.

d. Call rate (number of calls per calling bout)

Groups		Call rate Call/Bout
Selected males	1	93
	2	222
	3	3
	4	34
	5	20
	6	23
	7	78
	8	84
	9	100
	10	194
	Median	**81**
Unselected males	1	28
	2	150
	3	145
	4	5
	5	5
	6	-
	7	-
	8	3
	9	3
	10	-
	Median	**5**
	P	**0.203**

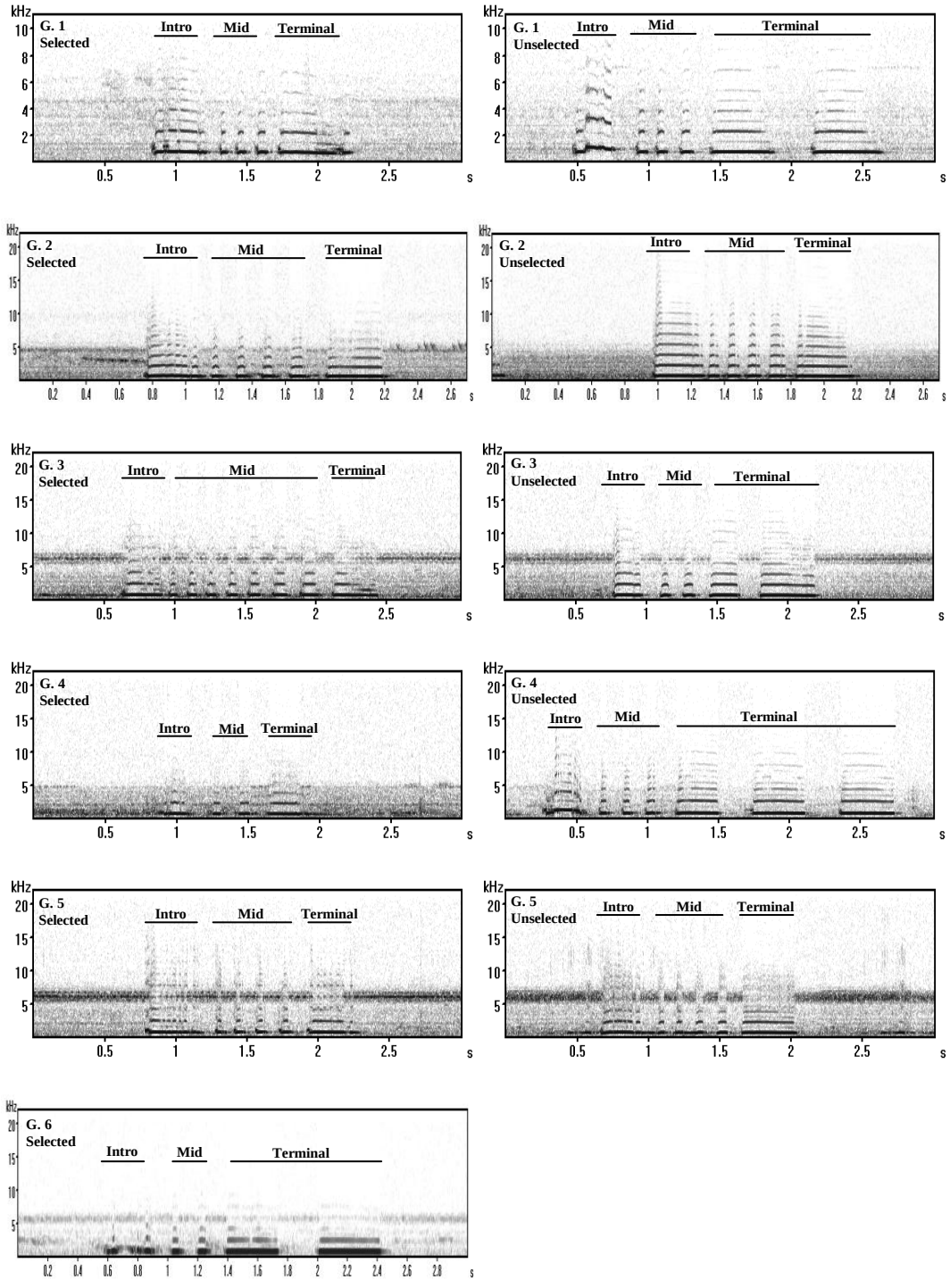

Figure 14. The spectrograms of 17 male zebra doves advertising calls in each group with consist of three phrases; Intro = the introductory phrase, Mid = the middle phrase, Terminal = the terminal phrase and G=Group).

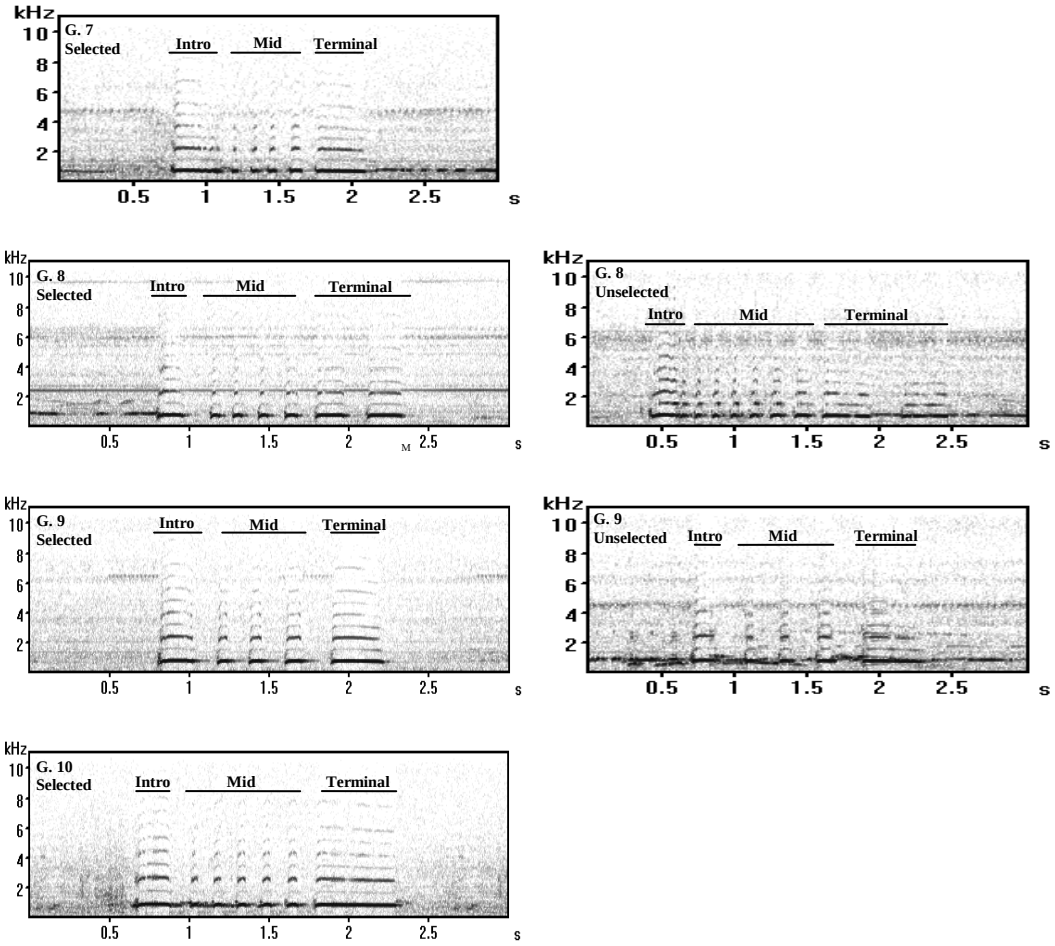

Figure 14. Continued.

3.3 Female responses

Throughout the days of mate choice trial, the female responded to the calling males by calling, flying and walking to reach the calling males. The time of these responsive behaviours were counted throughout the trial.

3.3.1 Calling

Females responded to the male's call by calling immediately. Between groups, the median number of calls that the females responded to the selected groups was 3.50 and to the unselected groups was 0.50 time. The difference of the average number of calls that the females responded to the males between the selected groups and the unselected groups was not significant (Mann-Whitney U Test; z = -1.819, p = 0.069 > 0.05) (Table 3).

However, it was found that the calling response of females had positive correlation with number of call per bout (Pearson Correlation Coefficient: r_{99}=0.671, P = 0.003 see Appendix table 1. d).

3.3.2 Flying

The females flied toward the male to reach the calling male. Between groups, the median times of flying that the females responded to the selected groups was 23.50 and to the unselected groups was 0.00 time per day. The females responded by flying toward the males in the selected groups higher than the unselected groups significantly (Mann-Whitney U Test; z = -3.764, p = 0.000 < 0.05) (Table 3).

3.3.3 Walking

The females also responded to the calling males by walking back and forth on the side of the male wall. Between groups, the median times of walking that the females responded to the selected groups was 8.50 time and the females did not walk toward the unselected groups. The females responded by walking toward the males in the selected groups higher than the unselected groups significantly (Mann-Whitney U Test; z = -3.413, p = 0.001 < 0.05) (Table 3).

Furthermore, the number of flying and walking time of females had significant positive correlation to each other (Pearson Correlation Coefficient: r_{99}=0.770, P=0.000 see appendix), the increasing of flying caused walking increased.

Table 3. The number of time that females showed responsive behaviours responded to the calling males in each group by calling, flying and walking toward the males

Groups		**Female responsive behaiours**		
		Calling	**Flying**	**Walking**
Selected males	1	4	28	11
	2	70	31	10
	3	3	1	2
	4	8	35	37
	5	2	12	0
	6	0	29	3
	7	0	11	8
	8	2	1	0
	9	17	20	9
	10	15	27	12
	Median	**3.50**	**23.50**	**8.50**
Unselected males	1	0	0	0
	2	89	0	0
	3	4	0	0
	4	0	0	0
	5	0	0	0
	6	1	1	0
	7	1	0	0
	8	1	0	0
	9	0	0	0
	10	0	1	0
	Median	**0.50**	**0.00**	**0.00**
	P	**0.069**	**0.000**	**0.001**

3.5 Time spent before the copulation occurred

Considering the difference between the times that each pair of zebra doves spent before the copulation occurred after they were placed together. The copulation occurred only in the selected group pairs. Within these selected group pairs, the median days spent was 1.00 days. In the unselected group pairs, they spent 15.00 days. Although the day spent differences between 2 groups was not significant (Mann-Whitney U Test; z = -1.691, p = 0.091 > 0.05) (Table 4), the entire zebra dove did not copulate and the male in 1 of 4 pairs injured the female severely in the first day of trial (Table4).

Table 4. The times that each pair of zebra doves spent before the copulation occurred after they were placed together.

Types of pairs	Groups	Days spent (day)	Copulation
With selected males	2	17	Copulated
	4	1	Copulated
	8	3	Copulated
	9	1	Copulated
	10	1	Copulated
	Median	1	
With unselected males	1	15	Not copulated
	3	-	-
	5	-	Not copulated, Female injured
	6	15	Not copulated
	7	20	Not copulated
	Median	15	
	P	0.091	

CHAPTER 4

DISCUSSION

1. General

In this study, the characteristics of male zebra dove *Geopelia striata* L. were concerned with female mate choice. The main characteristic was the male advertising call which was defined as vocalizations that an adult male dove produces in each calling bout before pairing in order to attract female. As mentioned before, the advertising call consists of 3 phrases with several syllables; the introductory, the middle and the terminal phrase. Furthermore, the calls were produced in different duration among male zebra doves. This call was grouped into three classes according to the difference in sound frequencies of their courtship calls. Class A is the low-frequency-birds, class B is the medium-frequency-birds and class C is the high-frequency-birds (Liengpornpan and Meesawat, 2004). The male zebra doves produce courtship call in bouts containing one to more than hundred calls per calling bout. The variations of captive individual's courtship call are the number of syllable, the frequency, and the numbers of call in a calling bout. Furthermore, there was body size parameter related with sexual selection or mate choice among bird species and this also included in this study.

2. Body size parameters

The parameters related with body size in this study were body weight, beak length and tarsus length. There was not significantly different for body size of the both selected and unselected male groups. It could be said that both groups of male dove in this study had not enough difference.

In most species, males with brighter plumage, bigger ornaments, and louder, longer, or more complex courtship displays have higher mating success than the average males (Bekoff, 2004). The large sizes of males are useful in fight and quite widespread among animals (Bell, 1997). The greater body size increase fighting success. It is advantageous when males engage in direct physical contests with each

other for access to fertile females. These males have high mating success, not because they are preferred by females, but because they win male-male fights and females are constrained to mate with winners because the winner prevent losers from mating (Bekoff, 2004).

In snow petrels *Pagodroma nivea*, adult males that produced more young had longer beak than other males. That could be a mechanism of intrasexual competition for nest or mate. For example, large body and bill size may constitute an advantage during physical combat for nest or mate. In addition, this also suggests that individuals with a large bill size would be in a better condition (Barbraud, 2000). In pied flycatchers, *Ficedula hypoleuca*, males with a long tarsus, large white wing patch and versatile song were favoured by females (Sirkia and Laaksonen, 2009).

In zebra finches *Taeniopygia guttata*, the body size influences the outcome of competition; the large males are more aggressive than small males. The males with high tarsus length and body mass were dominant to the small males (Bolund *et al*. 2007).

In zebra dove, we have no evidence to confirm how body size parameter influence mating success. The possible explanation for body size effect on mating success could be, firstly, the larger males take the advantage of being larger in physical fighting. The large males are dominant to the smaller males, they chase the smaller males away from the female. Secondly, the larger male could produce louder, longer or more frequently call than the smaller male do and they can be more attractive to females than the smaller males can.

Furthermore, the entire doves in this study were collected from only one farm and could be descended from the same parents or be relatives to each other thus made them not vary in many genetically depended parameters. The body structures are typically genetic and environmental dependent, the doves which may have close genetic and were kept with the same condition could make they have not different body weight, beak and tarsus length.

3. Male advertising calls

3.1 Numbers of syllable

From the results, the selected male groups had more syllables in their calls than the unselected groups although the difference was not significant. The introductory phrase of male zebra dove advertising call is the single syllable, so the number of syllable in the introductory phrase of all male zebra dove in this study was 1syllable in both groups. The selected group had not significant higher numbers of syllable in the middle phrase than the unselected group. Moreover, the number of syllable in the terminal phrase of the selected groups was 1 syllable as same as the unselected groups.

Consistent with Bengalese finches *Lonchura striata* var. *domestica*, female shows more copulation displays to the playback of a 6-element song over a 4-element song (Clayton and Prove, 1989; Honda and Okanoya, 1999). Female Bengalese finches perch-hopped more often when stimulated with a song with more elements rather than a song with a few elements (Nakamura *et. al.*, 1985; Honda & Okanoya, 1999). These results suggest that female choice might favor upon more variety on song element types. Furthermore, some specific elements are the signal of dominance in males. he Snarr' element of male water pipit *Anthus spinoletta*, is indicated male condition and mating success. The males with high Snarr scores mate more often than males with low scores (Rehsteiner *et al.* 1998).

The number of syllable of zebra dove call may be influenced by genetic. In this study, all doves are from the same population form same farm which may have not different genetic make they have not different in the number of syllable. There is needed to find the relation between number of syllable and genetic heritability.

3.2 Frequency

In this study, the 2 groups of male dove showed no significant difference in their calls frequency. However the frequency of calls in the selected groups was lower than the unselected groups in the middle and terminal phrases.

In zebra dove, calls are grouped into 3 classes according to the difference in frequencies of their courtship calls. Class A is the low-frequency-birds (Large Tone), class B is the medium-frequency-birds (Middle Tone) and class C is the high-frequency-birds (Small Tone). This classification is in accordance with the local practice which based solely on listening experience (Liengpornpan and Meesawat, 2004) and used for classification in contest. The contests are usually divided into different categories: Class A, Class B, Class C, and New Comers in All Tone in separated category (Kananurak, 2006). The selected male groups had quite lower frequency than the unselected groups. It means that the selected groups were larger tone doves than the unselected groups according to the categories used in the vocal contest. However, there was no evidence for male-male competition on the frequency of zebra dove advertising call.

3.3 Call duration

The median total call duration of the selected groups had not significantly higher than of the unselected groups. In addition, the selected groups had not significantly longer median call duration than the unselected groups in the introductory phrase and the terminal phrase. However, the duration of the middle phrase of both groups was equal.

In other species, female zebra finches *Taeniopygia guttata* prefer males with long song and song presented at a faster rate (Nolan and Hill, 2004). Song length is flexible in barn swallow *Hirundo rustica*, songs are shorter and less varied in highly competitive situations and longer and varied in less competitive situations. In competitive context, male song may serve to promote female choice for dominant male who provide short, harsh and aggressive displays whereas long and varied song may have evolved through a female preference for male displaying more attractively in less competitive contexts (Galeotti *et al*., 1997). Long calls have a potential to serve as a signal for male quality in brown skuas *Catharacta antarctica lonnbergi*, a non-passerine species. The females choose males on the basis of long call performance that are more difficult to produce and these males having a high reproductive output (Janicke *et al.*, 2008).

Call duration of zebra dove may be influenced by genetic as mentioned above. It could be that the difference was not enough for female to detect which male has long or short call. Another possible reason is that the call duration in dove is not the key that females use to justify the males.

3.4 Call rate

The median number of call per calling bout of the selected group had not significantly higher than of the unselected group. The median numbers of calls per bout of the selected males were 81.00 calls and of the unselected were 5.00 calls.

The numbers of call per calling bout are the interesting signal produced from males sent to the other individuals. However, it was found that the calling response of females had positive correlation with number of call per bout (Pearson Correlation Coefficient: r_{99}=0.671, P = 0.003).

From the results, there is the positive correlation between calling response of females and the rate of call per bout of males which imply that the call rate of male zebra dove play a role in female mate choice. Female zebra dove may choose a mate with high call rate per bout.

In budgerigars *Melopsittacus undulates,* females choose their mates on the basis of the time that they invest in courtship singing. Males of self-selected pairs performed courtship singing at higher rate than those of random pairs. Male courtship singing is responsible for nest inspection activity, ovarian development, and egg-laying in female budgerigars (Brockway, 1965; Massa *et al*., 1996). The female response was related to time spent by the male in courtship singing. Male courtship singing may then be a trait related to male fitness (Massa *et al*., 1996).

High song rate males are also more preferred in female zebra finches *Taenopygia guttata* (Collins and Hubbard, 1994). The females solicit and perform extra-pair copulations with males that are more attractive than their mates. Attractive males have higher song rate that appear to be heritable and correlate with offspring viability by having heavier offspring (Houtman, 1992).

In many avian species, mating is associated with elevated testosterone concentration (Moore 1982; Wilson *et al*., 2008). In male fowl *Gallus gallus*, mating

and reproductive success is related to the rate that males produce alarm calls (Wilson *et al.*, 2008) which is testosterone dependent (Gyger *et al*., 1988; Wilson *et al*., 2008).

In zebra dove, crowing behavior in male is under the influence of testosterone by increase more crowing. This hormone deals with sperm production and secondary sex characteristics as well as reproductive behavior of the animal (Supasi *et al*., 2005) and high levels of testosterone are known to increase immune function (Evans and Goldsmith, 2000).

In this study, the selected males with high call rate may affect that they have high level of testosterone which make them have superior health and be more attractive to the females.

4. Female response

emale ebra doves responded to males' advertising calls by calling, flying and walking to the males. By calling, the difference of the median number of calls that the females responded to the males between the selected groups and the unselected groups was not significant. However, it was found that the calling response of females had positive correlation with number of call per bout of the males. By flying, the females responded by flying toward the males in the selected groups higher than the unselected groups significantly. Moreover, the females did not walk toward the unselected groups. Furthermore, the number of flying and walking time of females had significant positive correlation to each other.

Traditionally, copulation solicitation displays are used to assess female song preferences. In the study of Nagle *et al.* (2002), proposed that calling of female canaries *Serinus canaria*, could both provide information about their sexual interest and attract the attention of particular males.

From the positive correlation between calling response of females and call per bout of males, it could be implied that the call rate of male zebra dove play a role in female mate choice. Female zebra dove may choose a mate with high call rate per bout. Since the number of flying and walking time of female zebra doves in this study had significantly positive correlation to each other, both flying and walking used as responsive behaviours in the zebra doves. Finally, the female calling, flying

and walking are the responsive behaviours that female use to respond to the attractive male.

5. Time spent before the copulation occurred

Considering the difference between the times that each pair of zebra doves spent before the copulation occurred after they were placed together. The copulation occurred only in the selected group pairs and the entire zebra dove in unselected group pairs did not copulate. Moreover, the male in 1 of 4 pairs of unselected groups injured the female severely in the first day of trial.

According to the female's responses, the female responded to the selected males higher than the unselected. The females accept the copulation of selected males only. Consistent with female budgerigars *Melopsittacus undulates*, those have opportunity to mate with their own selected males, lay more promptly, produce a higher number of eggs and rear a higher number of fledging than females that mated at random (Massa *et al.*, 1996).

In this study, the day used between the selected and unselected groups was not significant difference caused by the pairs of dove that lived together without copulation were ended artificially after 15 days passed. In appropriate approach, the experiment should not be ended until the copulation occurred in the unselected groups as same as in the selected groups. Although the day spent between the selected and unselected pairs was not significant different, only the females that placed with the selected males accepted the copulation.

CHAPTER 5

CONCLUSIONS

The main characteristic of the male zebra dove *Geopelia striata* L. concerned with female mate choice was the male advertising call which was defined as vocalizations that an adult male dove produces before pairing in order to attract female. The advertising call consists of 3 phrases with several syllables; the introductory, the middle and the terminal phrase and produced in different duration among male zebra doves. The male zebra doves produce courtship call in bouts containing one to more than hundred calls per calling bout. The variations of captive individual's courtship call are the number of syllable, the frequency, and the rate of call. Furthermore, there was body size parameter is also included in this study.

Firstly, there was no difference for body size: body weight, beak length and tarsus length of the both selected and unselected male groups.

Secondly, for the male advertising calls, the number of syllable in the introductory phrase, the middle phrase and the terminal phrase of the selected males and the unselected males was not different. For calls frequency, the frequency in the introductory phrase, the middle phrase and the terminal phrase of the selected males and the unselected males was not different. The call duration in the introductory phrase, the middle phrase and the terminal phrase of the selected and the unselected males was also not different. The call rate of males in the selected and unselected groups was not different. However, it was found that the calling response of females had positive correlation with number of call per bout of the males.

hirdly, the female ebra doves responded to males' advertising calls by calling, flying and walking to the males. By calling, the females had not difference in response of the selected and the unselected groups. However, it was found that the calling response of females had positive correlation with number of call per bout. The females responded by flying toward the males in the selected groups higher than the unselected groups and the females walk toward the selected groups only and did not walk toward the unselected groups. Furthermore, the number of flying and walking time of females had significant positive correlation to each other.

Finally, although the day spent between the selected and unselected pairs was not different, only the females that placed with the selected males accepted the copulation and the male in 1 of 4 unselected pairs injured the female severely in the first day of trial.

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APPENDIX

Table 1. Correlations between male parameters and female responses of zebra dove *G. striata* L. (W = weight, B = beak length, TL = tarsus length, N-I = No. of introductory phrase syllable, N-M = No. of middle phrase syllable, N-T = No. of terminal phrase syllable, D-T = total call duration, F-I = introductory phrase frequency, F-M = middle phrase frequency, F-T = terminal phrase frequency, C/B = No. of call per bout, Call = calling, Fly = flying and Walk = walking)

a. Body size parameters

Pearson Correlations																		
		W	B	TL	N-I	N-M	N-T	D-T	F-I	F-M1	F-M2	F-M3	F-M4	F-T	C/B	Call	Fly	Walk
W	r	1	.162	.050	.[a]	-.111	-.036	.041	.024	-.091	-.216	-.163	-.428	-.296	-.143	-.222	.006	.091
	P		.494	.834	.	.671	.890	.877	.927	.728	.406	.578	.250	.249	.584	.348	.980	.702
	N	20	20	20	17	17	17	17	17	17	17	14	9	17	17	20	20	20
B	r	.162	1	-.126	.[a]	.003	-.027	.020	-.133	-.361	.031	.116	-.732*	.041	-.340	.101	-.161	-.138
	P	.494		.597	.	.990	.918	.939	.612	.154	.906	.693	.025	.877	.182	.671	.497	.561
	N	20	20	20	17	17	17	17	17	17	17	14	9	17	17	20	20	20
TL	r	.050	-.126	1	.[a]	-.060	.007	-.044	-.131	-.015	.384	-.105	.272	-.306	.036	.087	-.119	-.089
	P	.834	.597		.	.818	.980	.867	.617	.953	.128	.721	.479	.233	.891	.717	.617	.708
	N	20	20	20	17	17	17	17	17	17	17	14	9	17	17	20	20	20

a. Cannot be computed because at least one of the variables is constant.

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Table 1. Continued.

b. Number of syllable and total call duration

Correlations																		
		W	B	TL	N-I	N-M	N-T	D-T	F-I	F-M1	F-M2	F-M3	F-M4	F-T	C/B	Call	Fly	Walk
N-I	r	.[a]	.[a]	.[a]	.[a]	.[a]	.[a]	.[a]	.[a]	.[a]	.[a]	.[a]	.[a]	.[a]	.[a]	.[a]	.[a]	.[a]
	P	.	.	.		.	.	.	.	.	.	.	.	.	.	.	.	.
	N	17	17	17	17	17	17	17	17	17	17	14	9	17	17	17	17	17
N-M	r	-.111	.003	-.060	.[a]	1	-.126	.505*	-.364	-.024	.303	-.403	.264	-.152	-.131	.077	-.362	-.312
	P	.671	.990	.818	.		.629	.039	.151	.928	.238	.154	.493	.559	.616	.770	.153	.223
	N	17	17	17	17	17	17	17	17	17	17	14	9	17	17	17	17	17
N-T	r	-.036	-.027	.007	.[a]	-.126	1	.563*	.538*	.322	.189	.157	.[a]	.173	-.234	-.126	-.217	-.149
	P	.890	.918	.980	.	.629		.019	.026	.208	.468	.592	.000	.506	.366	.630	.403	.567
	N	17	17	17	17	17	17	17	17	17	17	14	9	17	17	17	17	17
D-T	r	.041	.020	-.044	.[a]	.505*	.563*	1	.080	.387	.124	-.079	.282	-.036	-.272	-.107	-.171	-.195
	P	.877	.939	.867	.	.039	.019		.760	.125	.635	.790	.462	.892	.291	.682	.513	.453
	N	17	17	17	17	17	17	17	17	17	17	14	9	17	17	17	17	17

a. Cannot be computed because at least one of the variables is constant.

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Table 1. Continued.

c. Frequency of the introductory phrase, the middle phrases and the terminal phrase

Correlations																		
		W	B	TL	N-I	N-M	N-T	D-T	F-I	F-M1	F-M2	F-M3	F-M4	F-T	C/B	Call	Fly	Walk
F-I	r	.024	-.133	-.131	.[a]	-.364	.538[*]	.080	1	.482	.051	.372	.170	.619[**]	-.430	-.500[*]	-.004	-.139
	P	.927	.612	.617	.	.151	.026	.760		.050	.847	.190	.663	.008	.085	.041	.988	.594
	N	17	17	17	17	17	17	17	17	17	17	14	9	17	17	17	17	17
F-M1	r	-.091	-.361	-.015	.[a]	-.024	.322	.387	.482	1	-.019	.063	.607	.219	-.093	-.091	.067	-.088
	P	.728	.154	.953	.	.928	.208	.125	.050		.941	.830	.083	.399	.721	.729	.800	.738
	N	17	17	17	17	17	17	17	17	17	17	14	9	17	17	17	17	17
F-M2	r	-.216	.031	.384	.[a]	.303	.189	.124	.051	-.019	1	-.015	.619	.114	-.153	-.164	-.163	-.241
	P	.406	.906	.128	.	.238	.468	.635	.847	.941		.960	.076	.662	.557	.528	.532	.352
	N	17	17	17	17	17	17	17	17	17	17	14	9	17	17	17	17	17
F-M3	r	-.163	.116	-.105	.[a]	-.403	.157	-.079	.372	.063	-.015	1	-.006	.714[**]	-.020	-.202	.040	.071
	P	.578	.693	.721	.	.154	.592	.790	.190	.830	.960		.988	.004	.945	.490	.892	.809
	N	14	14	14	14	14	14	14	14	14	14	14	9	14	14	14	14	14
F-M4	r	-.428	-.732[*]	.272	.[a]	.264	.[a]	.282	.170	.607	.619	-.006	1	.124	.125	-.088	.150	.176
	P	.250	.025	.479	.	.493	.000	.462	.663	.083	.076	.988		.750	.748	.821	.700	.650
	N	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
F-T	r	-.296	.041	-.306	.[a]	-.152	.173	-.036	.619[**]	.219	.114	.714[**]	.124	1	-.536[*]	-.588[*]	-.049	.054
	P	.249	.877	.233	.	.559	.506	.892	.008	.399	.662	.004	.750		.027	.013	.850	.835
	N	17	17	17	17	17	17	17	17	17	17	14	9	17	17	17	17	17

a. Cannot be computed because at least one of the variables is constant.

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Table 1. Continued.

d. The number of call per calling bout of male and the responsive behaviours of female

Correlations																		
		W	B	TL	N-I	N-M	N-T	D-T	F-I	F-M1	F-M2	F-M3	F-M4	F-T	C/B	Call	Fly	Walk
C/B	r	-.143	-.340	.036	.[a]	-.131	-.234	-.272	-.430	-.093	-.153	-.020	.125	-.536*	1	.671**	.392	.186
	P	.584	.182	.891	.	.616	.366	.291	.085	.721	.557	.945	.748	.027		.003	.119	.475
	N	17	17	17	17	17	17	17	17	17	17	14	9	17	17	17	17	17
Call	r	-.222	.101	.087	.[a]	.077	-.126	-.107	-.500*	-.091	-.164	-.202	-.088	-.588*	.671**	1	.199	.094
	P	.348	.671	.717	.	.770	.630	.682	.041	.729	.528	.490	.821	.013	.003		.400	.692
	N	20	20	20	17	17	17	17	17	17	17	14	9	17	17	20	20	20
Fly	r	.006	-.161	-.119	.[a]	-.362	-.217	-.171	-.004	.067	-.163	.040	.150	-.049	.392	.199	1	.770**
	P	.980	.497	.617	.	.153	.403	.513	.988	.800	.532	.892	.700	.850	.119	.400		.000
	N	20	20	20	17	17	17	17	17	17	17	14	9	17	17	20	20	20
Walk	r	.091	-.138	-.089	.[a]	-.312	-.149	-.195	-.139	-.088	-.241	.071	.176	.054	.186	.094	.770**	1
	P	.702	.561	.708	.	.223	.567	.453	.594	.738	.352	.809	.650	.835	.475	.692	.000	
	N	20	20	20	17	17	17	17	17	17	17	14	9	17	17	20	20	20

a. Cannot be computed because at least one of the variables is constant.

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

VITAE

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B. Sc. (Biology)	Prince of Songkla University	2004

List of Publication and Proceedings

Proceedings

Oral presentation

Phromchan, P., Wattanasit, S. and Sitasuwan, N. 2010. Sexual Selection Mechanisms in Zebra Dove (*Geopelia striata* L.). Proceeding of the 11th Graduate Research Conference. Khon Kaen University, Khon Kaen, Thailand, February 12, 2010. pp. 641-646.

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