การเปลี่ยนแปลงทางสัณฐานวิทยาที่สัมพันธ์กับการเติบโตของไก่ป่าตุ้มหูแดง *Gallus gallus spadiceus* ในกรงเลี้ยงที่สถานีเพาะเลี้ยงสัตว์ป่าห้วยขาแข้ง

นายฐาปนา จ้อยเจริญ

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิทยาศาสตรมหาบัณฑิต
สาขาวิชาสัตววิทยา ภาควิชาชีววิทยา
คณะวิทยาศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย
ปีการศึกษา 2552

MORPHOLOGICAL CHANGES RELATED TO THE GROWTH OF RED JUNGLEFOWL *Gallus gallus spadiceus* IN CAPTIVITY AT HUAI KHA KHAENG WILDLIFE BREEDING STATION

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A Thesis Submitted in Partial Fulfillment of the Requirements
for the Degree of Master of Science Program in Zoology
Department of Biology
Faculty of Science
Chulalongkorn University
Academic Year 2009

Thesis Title	MORPHOLOGICAL CHANGES RELATED TO THE GROWTH OF RED JUNGLEFOWL *Gallus gallus spadiceus* IN CAPTIVITY AT HUAI KHA KHAENG WILDLIFE BREEDING STATION
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ฐาปนา จ้อยเจริญ : การเปลี่ยนแปลงทางสัณฐานวิทยาที่สัมพันธ์กับการเติบโตของไก่ป่าตุ้มหูแดง *Gallus gallus spadiceus* ในกรงเลี้ยงที่สถานีเพาะเลี้ยงสัตว์ป่าห้วยขาแข้ง. (MORPHOLOGICAL CHANGES RELATED TO THE GROWTH OF RED JUNGLEFOWL *Gallus gallus spadiceus* IN CAPTIVITY AT HUAI KHA KHAENG WILDLIFE BREEDING STATION) อาจารย์ที่ปรึกษาวิทยานิพนธ์หลัก : รศ.วีณา เมฆวิชัย, 101 หน้า.

การศึกษาการเปลี่ยนแปลงทางสัณฐานวิทยาที่สัมพันธ์กับการเจริญเติบโตของไก่ป่าตุ้มหูแดง *Gallus gallus spadiceus* จากลักษณะและตำแหน่งของขน สีจะงอยปาก และสีแข้ง รวม 19 ลักษณะ และจากการวัดสัดส่วนของลักษณะสัณฐานวิทยาทั้งหมด 13 ลักษณะ ผลการศึกษาพบว่าในระยะแรกตั้งแต่ฟักออกจากไข่จนถึง 7 วันแรก ลูกไก่มีลักษณะทางสัณฐานวิทยาเปลี่ยนแปลงไปอย่างรวดเร็ว ระยะที่ 2 ตั้งแต่ 2-20 สัปดาห์ จะมีการผลัดขนจากขนครั้งแรก จาก ชุดขนแรกเกิด (natal plumage) ไปเป็น ชุดขนวัยเด็ก (juvenal plumage) ระยะนี้สามารถแยกเพศลูกไก่ได้จากลักษณะสัณฐานวิทยาของขนและการเปลี่ยนแปลงของสีแข้ง และเมื่อไก่ป่าอายุ 20 สัปดาห์จะมีการผลัดขนครั้งที่สองเปลี่ยนจากขน ชุดขนวัยเด็ก (juvenal plumage) ไปเป็น ชุดขนก่อนฤดูผสมพันธุ์ (prenuptial plumage) ระยะที่ 3 ตั้งแต่ 21-48 สัปดาห์ พบว่าไก่ป่ามีการผลัดขนครั้งที่สามทั้งในเพศผู้และเพศเมียจาก ชุดขนก่อนฤดูผสมพันธุ์ (prenupital plumage) เป็น ชุดขนฤดูผสมพันธุ์ (nupital plumage) มีการเปลี่ยนแปลงของรูปร่าง และสีขนเข้มขึ้น มันวาวขึ้นในเพศผู้ โดยเฉพาะขนคอ ขนคลุมปีก ขนหลังและขนหาง ตลอดจนหงอนมีขนาดใหญ่ขึ้น และมีสีแดงสด ส่วนในเพศเมียพบว่ามีขนสีเหลืองน้ำตาล มีลายแถบสีน้ำตาลหรือดำตลอดทั้งตัว

ผลการศึกษาสัณฐานวิทยาจากการวัดสัดส่วนทั้งหมด 13 ลักษณะ เมื่อทดสอบด้วยสถิติพบว่าในไก่ป่าเพศผู้และเพศเมียมีความแตกต่างกันอย่างมีนัยสำคัญ ($p<0.05$) ในทั้ง 13 ลักษณะ และทดสอบด้วยสมการถดถอยเพื่อหาสมการทำนายอายุของไก่ป่าตุ้มหูแดงทั้งในเพศผู้และเพศเมีย พบว่าอัตราการเติบโตของลักษณะทั้ง 5 ลักษณะ สามารถใช้หาสมการทำนายอายุของไก่ป่าตุ้มหูแดงได้ดี

การเติบโตของแข้งมีความสัมพันธ์กับการเติบโตของไก่ป่า โดยสามารถแบ่งการเติบโตจากลักษณะความยาวของแข้งได้เป็น 3 ระยะ โดยระยะที่ 1 (1-10 สัปดาห์) พบว่าไก่ป่ามีการเติบโตอย่างรวดเร็วมาก ในระยะที่ 2 (11-24 สัปดาห์) อัตราการเติบโตไม่สม่ำเสมอมีการเพิ่มขึ้นและลดลงเป็นช่วง และในระยะที่ 3 (25-40 สัปดาห์) เป็นช่วงที่อัตราการเติบโตของแข้งลดลงจนเกือบคงที่

ภาควิชา ชีววิทยา ลายมือชื่อนิสิต .....

สาขาวิชา สัตววิทยา ลายมือชื่ออาจารย์ที่ปรึกษาวิทยานิพนธ์หลัก .....

ปีการศึกษา 2552

497 2629623: MAJOR ZOOLOGY
KEYWORDS: MORPHOMETRIC / DESCRIPTIVE MORPHOLOGY / RED JUNGLEFOWL

THAPANA CHOICHAROEN: MORPHOLOGICAL CHANGES RELATED TO THE GROWTH OF RED JUNGLEFOWLS, *Gallus gallus spadiceus*, IN CAPTIVITY AT HUAI KHA KHAENG WILDLIFE BREEDING STATION. THESIS ADVISOR: ASSOC.PROF. WINA MECKVICHAI, 101 pp.

Morphological changes related to the growth of the Red Junglefowl, *Gallus gallus spadiceus*, were studied using 19 descriptive and 13 morphometrical characteristics on a captive bred population during their first year of development. The results showed that the descriptive characteristics can be used for age classification, especially at the first (0 - 7 days old) and second (2 - 20 weeks old) growth periods, whilst the morphometrical characteristics were valid for age estimation in all three growth periods over the first year of life, but were more accurate in the second and the third (6 - 12 months old) periods. During the first growth period, the morphological characteristics changed rapidly. At the first molting the natal plumages changed to juvenile plumage during the second growth period and the sexes could be differentiated by the color pattern of the feathers and the comb. The second molting occurred when the chicks were twenty weeks old, when their juvenile plumage changed to that of the prenuptial plumage. In the third growth period, chicks began their third molting, changing from the prenuptial plumage to that of the nuptial plumage, and at this stage males become more colorful with a brighter color and more glossy plumage feathers at the neck, wing covert, back and tail. In addition, the male's red fleshy comb becomes enlarged in size, whilst in females, most of the plumage changed into a yellowish brown with mottled brown color, except for the neck feathers that have a dark-brown or black strip.

The 13 morphometrical characteristics were all significantly different ($p<0.05$) between age cohorts in both males and females, and were found to be positively correlated to the growth by nonlinear regression. This method can predict the age cohort in Red Junglefowls with 95 – 98% accuracy. Analysis of the tarsal growth rate revealed three distinct growth periods over the year. In first period (1 - 10 weeks old) the tarsal growth rate increased rapidly, but it fluctuated in the second period (11 - 24 weeks old), and became stable in the last period (24 - 40 weeks old).

Department : Biology Student's Signature T. Choicharoen

Field of Study : Zoology Advisor's Signature Wina Meckvichai

Academic Year : 2009

ACKNOWLEDGEMENTS

With my respect and heartfelt appreciation, I would like to express my sincere thanks to Associate Professor Wina Meckvichai, my thesis advisor, for her encouragements, kind supports and all invaluable suggestions throughout my entire study. I also express my special thanks to Professor Dr. Toshinori Endo and Mr. Tarasuk Nipanun for their kindness in providing helpful suggestions, references and ideas during my field and laboratory experiments. Besides, I gratefully acknowledge the valuable discussions and comments from the chairman, Associate Professor Dr. Kumthorn Thirakhupt, Assistant Professor Dr. Wichase Khonsue and Dr. Boripat Siriaroonrat, for supporting and reviewing my work.

Moreover, I wish to thank member of Ornithology Research Laboratory, Mr. Sittichock Tongsukmark and Ms. Chuthaborn Amarapala for teaching and assisting me with the statistical analyses of the results. This project was also supported by the Thai government budget 2008, under the Research Program on Conservation and Utilization of Biodiversity and the center of Excellence in Biodiversity, Faculty of Science, Chulalongkorn University (CEB_M_48_2008). In addition, I gratefully acknowledge the Graduate School, Chulalongkorn University, for ptoviding a partial support.

I am particularly grateful to all authors whom I quoted and referred their articles, journals and books in my thesis. I also sincerely thanks all the previous and present professors, lecturers and teachers who have assembled me all the knowledge along with interesting life attitudes. Eventually, for Mr. Anukul Radsamrong who has inspired me and my beloved family, there is one speech from the deepest of my heart that is "*Thank you very much for all supports and always being in each step of my achievements*".

CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I
INTRODUCTION

1.1 Theoretical Background

Humans and Red Junglefowls, *Gallus gallus spadiceus* Bonnaterre, 1792, have been closely associated for a long time. For example, pictures of this bird have been found in many ancient places, including in Thailand, and it is believed that Red Junglefowls originated in Southeast Asia and might be the ancestor or, if not, the main contributory ancestor, of domesticated chickens all over the world (Fumihito *et al.*, 1994). Red Junglefowls are resident birds of Southwestern Yunnan, Burma, Northern Laos, Malaysia and Northern Sumatra (Wayre, 1969). Two subspecies of Red Junglefowls are found in Thailand, *Gallus gallus gallus,* which is distributed in Eastern part of Thailand, and *Gallus gallus spadiceus*, which is distributed in other parts of Thailand except in Northeastern and Eastern parts of Thailand (Lekagul and Round, 1991). Although Red Junglefowls are not a conservation problem at present, they are, however, useful for natural resources in the ecosystem (Johnsgard, 1999). Humans can potentially benefit from them in many ways, such as cultural, religious (Liu *et al.*, 2005), fighting, game bird (Macdonald and Blench, 2000) decoration, hobbyist, as fancy fowls for pets (Tsudzuki, 2009; Fernandes *et al.*, 2007,) and commercial purposes (Aini, 1990). They are also locally of important economic value for food, both for egg production and as meat as a protein resource (Cooper, 1995; Morathop *et al.*, 2006). Indeed, they may be breed in a manner similar to village chicken farms in the near future in Thailand and elsewhere (Choprakarn and Wongpichet, 2007).

In previous days, Red Junglefowls were generally considered to be a common bird found over a relatively wide geographical range and in diverse habitats, such as evergreen forests, deciduous forests, secondary forests, bamboo forests and agricultural areas (Arshad and Zakaria, 2009; Collias and Collias, 1967; Javed and Rahmani, 2000). However, nowadays the populations have declined due to various factors, such as

overhunting (Hansel, 2004; Samnang, 2006 and Suthipong Arsirapoj, 2008), and habitat lose and fragmentation (Fuller and Garson, 2000). At present, there is a strong possibility that a large number of this wild junglefowl has breed with native chickens or feral domestic chickens (Suthipong Arsirapoj, 2008; Moiseyeva *et al.*, 2003; Pyle and Pyle, 2009). The level of threat to the native wild Red Junglefowls that such hybrids and their introgression presents is unclear and, along with most aspects of their population ecology, are required to be evaluated and monitored in natural habitats (Brickle *et. al,* 2008).

As Red Junglefowl are thought to be facing a serious threat of extinction in the near future, studying Red Junglefowl in their natural habitats is necessary for conservation plan. By studying of Red Junglefowl in their natural habitats, the population structure must be identified into groups so that accurate results can be obtained.

However, much of that information would require the ability to discriminate the age and gender of birds in the field populations to partition and understand sex and age specific effects upon the population structure. Thus the ability to age wild birds in any given population, and especially by non-lethal or non-invasive means, so as to allow the sex and age composition to be determined is important to any evaluation of their population dynamics. This is because both age and sex differentially effect many biological parameter, including reproductive success, survival probability and breeding status (Woodburn *et al.*, 2006; Johnsgard, 2008). As a consequence, ornithologists, taxonomists, technicians and applied biologists are often called upon to estimate the age of Red Junglefowls when observing them in the wild or studying specimens, but age estimation is usually hard to study or is limited to the determination of accurate ages only in adult birds (Gower, 1939).

The growth of Red Junglefowls and other birds is related to their age and sex. Some biologists have used the patterns of the wing feathers and wing coverts to differentiate the sex of birds, including Pheasants (Linder, Dahlgren and Elliott, 1971).

Previous researchers have used many ways to estimate the age of birds, such as the leg bone histology (Stone and Morris, 1981) but it is highly invasive and can only be used on dead birds (Woodburn, 2006). Likewise, a jaw test was used in field (Linduska cited in Woodburn, 2006), where the force required to break the lower jaw is lower in

juveniles because of their incomplete bone calcification (Nelson, 1948), but again the extreme invasiveness of this method restricts its use to dead birds (Woodburn, 2006). Eye lens weight has been used in some birds species (Payne, 1961; Cambell and Tomlinson, 1962 cited in Woodburn, 2006), but asides being invasive it not been found to be useful in Galliforme birds (Dahlgren *et. al.*, 1965). The presence or absence and the size of the Bursa of Fabricius is a good indicator of age and is easy to perform the evaluation, but it may be quite stressful to the subject (Woodburn, 2006), requires calibration for each species and is subject to some environmental variability.

Hegyi *et al.*, (2007) said that plumage is important to birds as an indicator of individual quality, and feather replacement show similar stages of growth (Mississippi agricultural and forestry experiment station, 2009). Larson and Taber (1980) reported that the observation of feather development is the best way to determine the sex and age of the birds, whilst Macmullan (1948) reported that the age of juvenile Pheasants can be ascertained by plumage and morphological characteristics. In the same way with Pheasant and some birds, the development of plumage length may be the rapid and simple way to determine sex and age of Gallinaceous such as Red Junglefowl without catching them all to study (Schemnitz, 1980).

Indeed, morphometric techniques have been commonly used to estimate the sex, age and to identify unknown bodies (Akman, Karakas and Bozkir, 2006). However, the information on Red Junglefowl plumage with respect to their age is not very clear (Takada *et al.*, 2006). Although there are many articles about the biology of these birds, the information on their morphological data with respect to their life cycle is still not available. This includes the growth and morphology of the chick during the first year developmental period, and also in the breeding season, because almost all available data have been derived from the interviews with local people and observations or visits to the study sites only in some periods and not covering the whole year round.

The detail in the morphological changes in Red Junglefowls is very difficult to observe from the natural habitats because these birds are shy and alert, becoming highly sensitive when approached by humans (Väisänen and Jensen, 2004). This makes Red Junglefowls hard to observe for long periods of time (Kual, Shah and Charabrity, 2004).

The age of wild chicks in Galliformes have been based on molt-progression, which can estimated from known-age captive birds (Davis, 1968). However, Brisbin (1969) reported that these birds are also extremely easily agitated and frightened. They usually injure themselves by flying against their pen walls if anywhere near a great deal of public activity or disturbance, and so it is required to study their descriptive morphology in captivity.

From the reasons outlined above, the development of the plumage pattern and morphological changes in Red Junglefowls as they age 9develop0 over their first year was evaluated in this study as it is viewed as important and could be used to support the ability of researchers to non-invasively estimate the age of this bird in field work. The estimation of the age of specimens in formulating suitable conservation and management strategies for this bird in particular.

1.2 Objectives

1.2.1 To study and describe the morphological changes in Red Junglefowls related to the growth of the chicks from hatching until 1 year old.

1.2.2 To select for and evaluate the ability of different morphological characteristics to be able to determine the gender and developmental age categories of Red Junglefowls.

1.3 Scope of the Study

1.3.1 Red Junglefowls were collected from a stock reared in captivity at the Huai Kha Khaeng Wildlife Breeding Station, Uthai Thani Province.

1.3.2 The study period is from the first day after hatching until 1 year old.

1.4 Advantages

1.4.1 This study provides the morphological changes in Red Jungfowls in captivity over their first year of development.

1.4.2 This study provides the criteria for the non-invasive classification the age of Red Junglefowls by morphological characteristics.

1.4.3 This study provides the basic knowledge for further breeding and husbandry of Red Jungfowls as a livestock for economic purposes and wildlife conservation.

CHAPTER II
LITERATURE REVIEWS

Junglefowls are common tropical wild fowl that can crossbreed fertilely with domesticated chickens (Morathop, 2005). Junglefowls are a local resident in the Himalayas in India through South China and the Indochina Peninsula. From archaeological evidence, it would seem that the Junglefowl was first domesticated in India as much as 5,200 years ago and at the 6th century Before Christ. it had entered Europe (Columbia Encyclopedia, 2003). The junglefowl is classified in Genus *Gallus sp*. In these genus can separate in 4 species (Johnsgard, 1999) as follows;

Red junglefowl (*G. gallus* Linnaeus, 1758)

Green junglefowl (*G. varius* Shaw and Nodder, 1798)

Ceylon junglefowl (*G. lafayettei* Lesson, 1831)

Grey junglefowl (*G. sonnerati* Temmnick, 1813)

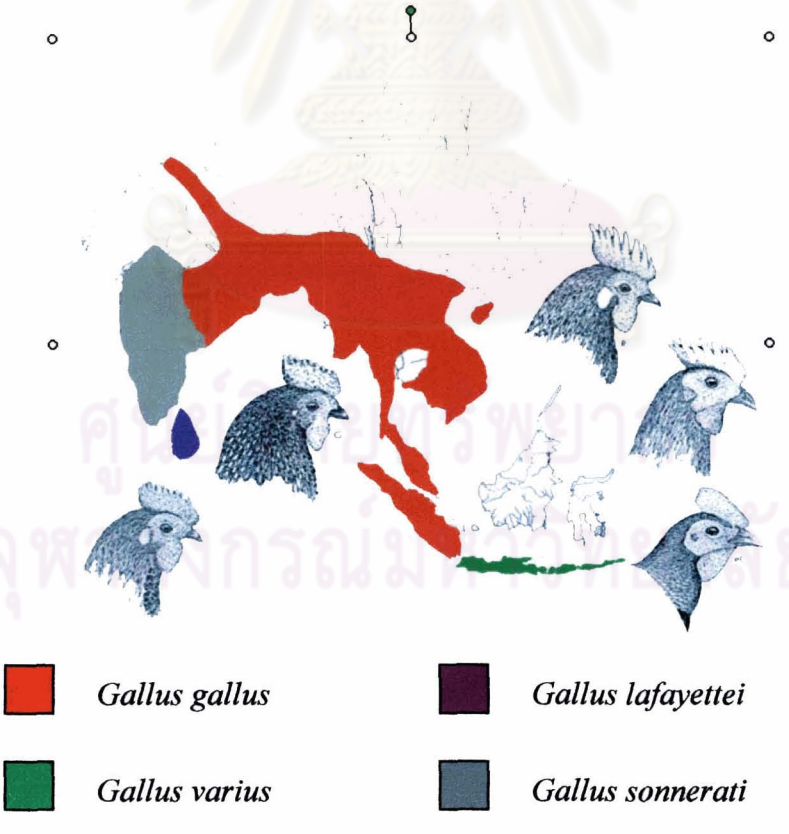

Figure 2.1 Distribution of 4 subspecies of Junglefowl after Johnsgard (1999)

2.1 Distribution and Ecology of Red Junglefowl

Red Junglefowl distribute in tropical and subtropical regions. It ranges attitudinally from sea level to 1,830 meters. This bird is native in Southeast Asia especially Burma, Laos, Thailand (except in the East), Malaysia and North Sumatra (Wayre, 1969), and some past of East Asia such as Yunnan (Johnsgard, 1999). Male and female Red Junglefowl show strong sexual dimorphism and they typically live in territorial groups consist of one dominant male. Female and their offspring are in group with male which has an important role in territory protected while female has to take care the chicks.

Red Junglefowl lives on wide rang habitats consist of evergreen forest, deciduous forest, secondary forest, bamboo forest and agricultural area at the boarder as well as roaming around villages forests for food (Robson, 2002).

Suthipong Arsirapoj (2008) studied habitat use of Red Junglefowl in forest area of Huai Kha Khaeng Wildlife Breeding Station. He found that adult Red Junglefowls often use secondary forest and dry dipterocarp forest in dry season (November to April), but they more often use bamboo forest and agricultural area in rainy season (May to October). The habitat use of this fowl is depending on biological factors (predation risk and human disturbance) and food abundance.

2.2 Taxonomy

Order: Galliformes

Family: Phasianidae

Genus: *Gallus*

Species: *Gallus gallus spadiceus* Bonnaterre, 1792

Figure 2.2 Red Junglefowl (*G. g. spadiceus*) Male (left) and Female (right)

2.3 Morphological Description and Topology

Study of Brisbin and Peterson (2007) found that the size of adults Red Junglefowl vary from 43 to 76 cm. The males have eclipse and multicolored plumage, after they are molted, neck feather have yellowish red or golden yellow. Long hackles after molted will replace with spatulate black feathers during June until September (Pak and Peter, 2001) and often that the brightly reddish back feathers occur while the arched tail and wing feathers are glossy green. The wild Red Junglefowl can be distinguishing from domesticated chicken by the characteristics of male. Red Junglefowls have white patch at the base of the rump whilst female Red Junglefowls have dull brown with the follow molted plumage and the comb are completely absence, most of them have slender black or gray leg. Carriage of the tail is in fan shape and horizontal position and they have an annual eclipse and molt like the male (Meckvichai, 2009).

Topography of Red Junglefowl

Proctor and Lynch (1993) classified types of feathers especially in Red Junglefowl in 4 main types compose of contour feathers, semiplumes, down feathers and filoplumes.

Contour feathers or pluma are the feathers of the body, wings and tails.
The structure of this feather compose of calamus, rachis and vane. Vane of pluma consist of barbs and barbules. Contour feathers can be separated into 4 types as follows;

Coverts or quill feathers, this feathers covered body, wing and tail (Figure 2.3 a).

Remiges are the flight feathers of the wing including the primaries, secondaries, and tertiaries (Figure 2.3 d).

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Rectrices are flight feathers of the tail and helping birds remain vertical as they forage on tree trunks (Figure 2.3 e).

Bristles are develop from contour feathers for helping the sensory organ. Not all birds have bristles. This feathers are found mostly around the eye (for protection), the lores, the nostrils, and the rictus of the mouth (rictal bristles) of insectivorous birds such as night jars (Figure 2.3 g).

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Semiplumes are locate between down feathers and contour feathers, they are seldom exposed but lie under the surface contour feathers. These feathers help insulating the body and aerodynamic (Figure 2.3 c).

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Down feathers or plumula found under the contour feathers and tougher exterior feathers. New born birds are clad only in down and down feathers can separate in to 3 type; natal down, adult down and powder down.

Natal down are common in birds, most species of birds are covered with down feathers when they were new born bird. Natal down are appears as tufts at the tips of new feathers (Figure 2.3 i).

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Adult down are extremely plumulaceous feathers that provide a layer of insulation underneath the contour feathers on a bird's body (Figure 2.3 f).

Powder down a specialized type of down feathers found only in some kind of birds. These feathers help the bird in grooming and waterproof and down is a fine thermal insulator and padding. These feathers growth continuously (Figure 2.3 b).

Filoplumes or pin feathers are slender, glistening and that are hairlike structures, These feathers can detect fine movements of the there shaft. This kind of feather is associated with contour feathers and may be sensory in monitor the position and movement of the remiges during flight and perhaps warning the bird when wind disrupts the smooth outer surface of the plumage (Weichert and Presch, 1977) (Figure 2.3 h).

Figure 2.3 Feathers types of birds after Proctor and Lynch (1993).

Feather Structures of Red Junglefowl

Feather structures of Red Jungfowl are classified into seventeen positions as follows (Meckvichai, 2009).

Wing feathers or Remiges

Primaries are long feather and that the major of flight feathers. These feathers are attached to the Manus of forelimb, vane are asymmetry with point tip. Primary wing feathers are helping individual airfoil, most birds have ten primaries and eight to nine primaries in Red Junlgfowl.

Secondaries are also long feather and function as the minor flight feathers of the birds. This feather attached to the ulna, vane are symmetry with round tip. Secondary wing feathers are function in cover the surface area of the wing. Number of secondary wing feathers in a species are depend on wing length.

Wing coverts can classifies into 6 positions

Greater primary wing coverts are a single row of large covert feathers with round tip and these coverts shied to the bases of primary wing feathers. Vane are asymmetry, outer web smaller than inner web and calamus are 1/3 of primary greater covert long.

Median primary wing coverts are several rows of small covert feathers with round tip locate at anterior the primary greater wing coverts base on primary wing feathers. Vane is asymmetry, outer vane is smaller than inner vane and no hooks at 1/4 of barbules at the base of feathers.

Lesser primary wing coverts are two or three rows of a smallest wing covert with round tip, these covert locate on proximal to primary median wing coverts. Vane is asymmetry, outer vane is smaller than inner vane and no hooks at 1/4 of barbules at the base of feathers.

Greater secondaries wing coverts are a single row of large covert feathers with round tip and these coverts shied to the bases of Secondary wing feather. Vane is symmetry middle of father larger than base and tip. These feathers have no hooks at 1/3 of barbules at the base of feathers and calamus are 1/7 of secondary greater covert long.

Median secondaries wing coverts are a several rows of small covert feathers with round tip, these coverts locate on anterior of secondary greater wing covert base on secondary wing feathers. Vane is symmetry and no hooks at 1/2 of barbules at the base of feathers.

Lesser secondaries wing coverts are two or three rows of a smallest of feather with round tip, wing covert locate on proximal to secondary median wing coverts. Vane is symmetry and no hooks at 1/2 of barbules at the base of feathers.

Other plumage patterns

*Neck or hackle*s are locate on neck, size are medium and no hooks at 1/2 of barbules in the base of feathers. Shape are oval or lanceolate depend on season.

Upper backs are lanceolate shape feather that can found between neck and back of bird, 1/2 of barbules in the base of feathers have no hooks.

Backs and saddle are the medium size feather, vane is symmetry and no hooks at 1/2 – 2/3 of barbules at the base of feathers. Saddle are lanceolate shape, located between back and base of upper tail covert.

*Upper tail covert*s are medially long lanceolate shape. Vane is symmetry and no hooks at 1/2 – 1/3 of barbules at the base of feathers.

Tail or Rectrices are long shape, vane of middle pair of tail is symmetry whist outer vane are smaller than inner vane in other tail feathers.

*Under Tail covert*s are located under tail feather, vane is symmetry and under

tail covert are round shape. No hooks at 1/2 – 2/3 of barbules at the base of feathers.

Thighs are medium size feather, they are no hooks at 2/3 of barbule at the base of feather and cover the tibial region or leg of the bird.

Flanks are the medium size feather, locate on the lateral portion of the bird from abdominal to the base of the wings, no hooks at 1/2 – 2/3 of barbules at the base of feathers.

Breasts are the medium size feather locate on breast of the bird and hooks absent at 1/2 of barbules at the base of feathers.

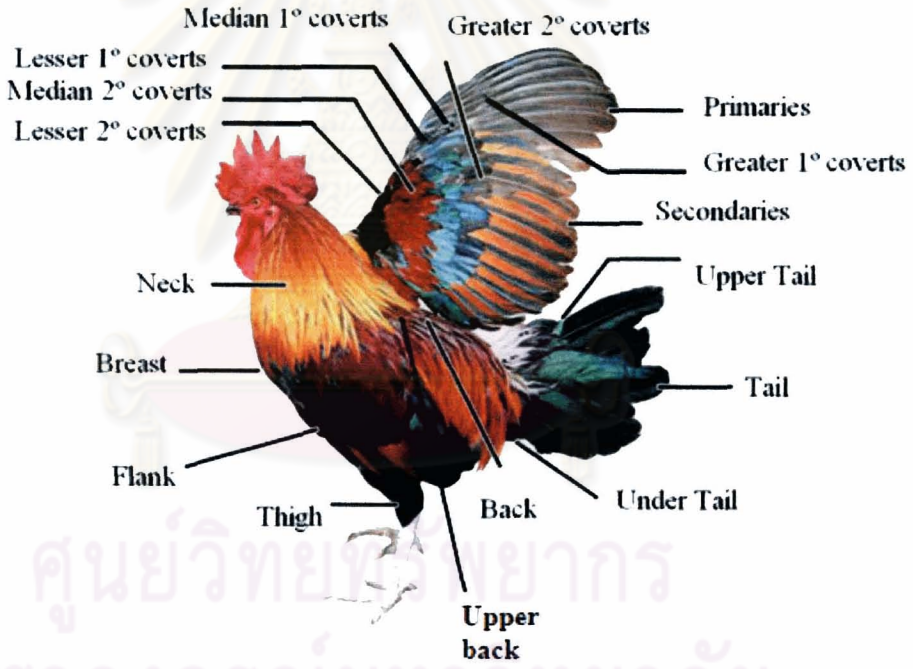


Figure 2.4 Plumage at 17 positions of Red Junglefowl after Meckvichai (2010).

2.4 Diet

Red Junglefowl is omnivorous, they feed on variety of food items such as seeds, buds, fruit, and many kind of invertebrates, such as ants, termites and others. They are oftenly scratching the ground search for feed (Pak and Peter, 2001).

2. 5 Reproduction

Breeding seasons of Red Junglefowl on the Malay Peninsular is from December to May (Medway and Wells, 1976), and in Western, Thailand is from November to May (Suthipong Arsirapoj, 2008). Mating behavior occurs when the Red Junglefowl became to 5-6 months old (Kruijt, 1964). The eggs are creamy white in color laid in shallow depression scraped in the ground. Female incubate and brood their young alone. A typical clutch has between five to seven eggs. Male begin their crowing from November and previous study of vocalization in this specie shows that the highest frequency of crowing occurred during breeding season in March (Suthipong Arsirapoj, 2008).

2.6 Growth and Plumage Development

Mattana Srigrajang (1983) was studied growth and development of Red Junglefowl *G. g. gallus* and the result showed that sexual dimorphism of plumage during the 6^{th} week. Juvenal plumage completely changes to the adult plumage at 20^{th} week. White ear patch could be clearly identified at 9^{th} week and tarsal growth rate could divide in to 3 stages; the first stage was in 1^{st}-4^{th} week, this stage tarsus was growth rapidly, second stage was in 5^{th}-10^{th} week, growth rate decreased ununiformly and the last stage was in 11^{th}-20^{th} week, the growth absolutely decreased. The average male's tarsal length at 20 week was 7.6 cm. whilst in female was 6.6 cm. and average weight of new born male and female were 25.2 ± 2.12 gram and 22.5 ± 3.14 gram, respectively.

Feather Tracts

Feather tracts are part of a bird's skin from which feathers growth, the feathers being confined to these tracts. Feather tracts are divided in to seven patterns follow by Proctor and Lynch (1993).

Capital tract is located on the dorsal surface from head over the back of skull to nape and includes auricular feathers, feathers around the eyelids, bristles, and other head's feather (Figure 2.5a).

Spinal tract is a complex and highly variable series of tracts and located on the dorsally along the midline of the back (Figure 2.5 a).

Humeral tract is a band of that over the humerus on the dorsal side of the wing of the bird (Figure 2.5 a and b).

Alar tract is composed of a series of smaller pterylae that cover both the dorsal and ventral surfaces of the outer wing feathers and wing coverts, except those coverts within the humeral tracts (Figure 2.5 a).

Femoral tract and Crural tract are covered outer surface of thigh to base of tail. The rest of the leg contour feathers are included within the crural tract, an additional metatarsal tract is identified, covering the lower leg area (Figure 2.5 a and b).

Ventral tract is covered the ventral neck, breast, and abdomen. It courses posteriorly along the ventral midline of of the thorax and abdomen (Figure 2.5 b).

Caudal tract is included the major flight feathers of the tail, the rectrices, also includes the upper tail coverts of the dorsal caudal tract and lower tail coverts of the ventral caudal tract (Figure 2.5 b).

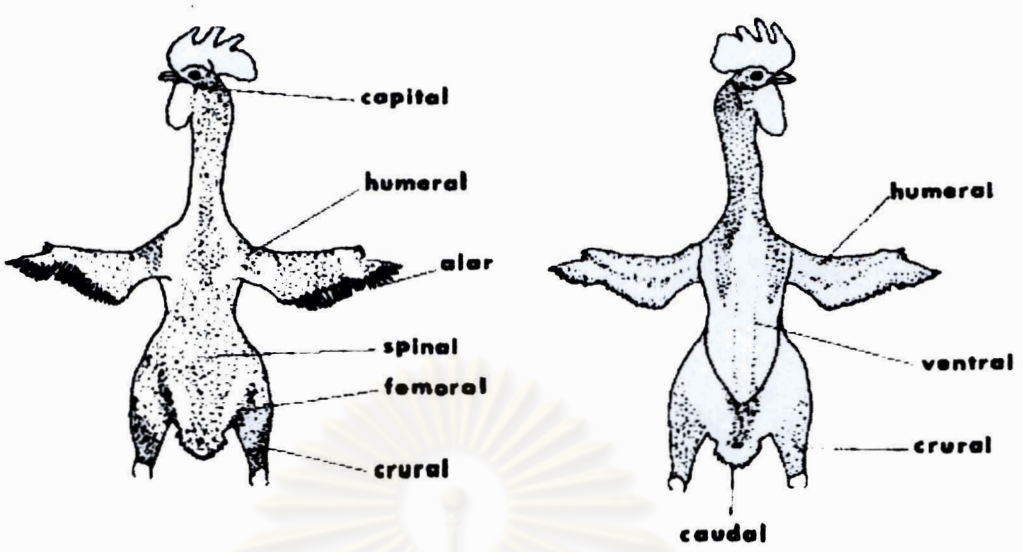


Figure 2.5 The seven types of feather tracts after Biological Science Department, California State polytechnic University (2009), (a) is dorsal and (b) is ventral.

Molts

Plumages covere all part of body except beak, tarsus and feet and feather are not permanent structure. A replacement feather starts before the old feathers is loose (Wastson, 1963).

The process of shed and replacement of feather calls molting (Proctor and Lynch, 1993).

Chicks are covered with natal downs when they are hatching and typically molt into their first set of contour feathers when they are 1-3 week old. This set is replaced with a few month by other set of feather , which is held until one years of age. Some species of bird replaced body feathers before breeding season every years (Stettenhem, 2000; Percival, 1942). Concept of feather replacement can descript in table 2.1.

Table 2.1 Plumage sequence and replacement of Humphrey and Parkes (1959) and Dwinght (1990).

Humphrey and Parkes (1959)	Dwinght (1990)
Natal down	Natal down
Prejuvenal molt	Postnatal molt
Juvenal plumage	Juvenal plumage
First prebasic molt	Postjuvenal molt
First basic molt	First winter plumage
First prealternate molt	First prenuptial molt
First alternate plumage	First nuptial plumage
Second prebasic molt	First postnuptial molt
Second basic plumage	Second winter plumage
Second prealternate molt	Second prenuptial molt
Second alternate plumage	Second nuptial plumage
Third prebasic molt	Second postnuptial plumage
Etc.	Etc.

CHAPTER III
MATERIALS AND METHODS

3.1 Materials

1. Vernier caliper
2. Measuring tape
3. Balance
4. Digital camera
5. Incubator
6. Cages
7. Enclosures
8. Color leg rings
9. Plastic leg ring with serial Numbers

3.2 Methods

The Red Junglefowls used in this study were the F2 offspring from parents that came from captivity and were reared at 37 – 39 °C and a relative humidity of 75 - 85% for 19 - 21 days (Clary, 2001) (Figure 3.1). All fowls were reared at the Huai Kha Khaeng Wildlife Breeding Station, Uthai Thani Province. After the chicks hatched, 30 healthy males and 30 healthy females were selected for this study (Figure 3.2), based on the criteria of having no visible deformed characteristics (Clauer, n.d.). All of the selected chicks were banded with color rings when the chicks were one day old (Figure 3.3), and at six weeks old they were banded with plastic rings with their individual serial number, in order to allow individual identification (The North American Banding Council Publications Committee, 2001). They were initially reared in indoor cages of 0.5 × 0.6 × 0.5 meters in size (Figure 3.4) at twenty birds per enclosure and each enclosure had straw bedding. Upon reaching the age of six weeks old, they were transferred into larger outdoor enclosures, sized 1.2 × 1.5 × 2.0 meters (Figure 3.4), and housed at fifteen

birds per enclosure. Each enclosure had sand bedding, which is suitable for activities such as walking, running and dust bathing and others. The whole year average temperature and rainfall was 24.4 °C and 1,552 mm, respectively. All fowls were fed with excess commercial chicken food and water *ad libitum* as described (Håkansson, Bratt and Jensen, 2006; Knížetová *et. al*, 1995).

Figure 3.1 The incubator (left) and incubated eggs (right).

Figure 3.2 New born chicks hatched within the incubator.

Figure 3.3 The individual chick was identified by color ring at left and right shank.

Figure 3.4 New born chicks were rearing in indoor enclosure (left) and outdoor enclosure after six weeks old (right).

3.3 The Characteristics of Red Junglefowl

Data were collected from March, 2008, to February, 2009. The characteristics of 30 male and 30 female Red Junglefowls were assayed from one day after the chicks had hatched until they were one year old. In order to study the characteristics related to the growing stage of the chicks, the chicks were arbitrarily separated into three age periods, using the definition of Knížetová *et al.* (1995), and detailed below.

The First period was defined as from one to seven days old (inclusive) and birds were studied every two days for evaluating their descriptive and morphometric characteristics.

The Second period was defined as from two weeks old until twenty weeks old (inclusive), and birds were evaluated once a week for both descriptive and morphometric characteristics.

The Third period was defined as six months old until one year old (inclusive), and birds were evaluated once a month for both descriptive and morphometric characteristics.

Thus this provides coverage of the full year, bar weeks 1 – 2 and 20 – 26, albeit at decreasing frequency with each of the three increasing developmental stages.

The detail of color patterns was evaluated at nineteen positions; primary, secondary, greater primary wing covert, median primary wing covert, lesser primary wing covert, greater secondary wing covert, median secondary wing covert, lesser secondary wing covert, neck (hackle), upper back, back, upper tail covert, tail, under tail covert, thigh, flank, breast, bill color and tarsal color. All these descriptive characteristics were recorded and photographed (Meckvichai *et al.*, 2005).

The thirteen morphometrical characteristics measured were; the bill length, bill-nape length, eye length, head width, comb height, comb length, wing length, half-wing span length, tarsal length, third digit length, claw length, spur length and body weight (Meckvichai, 2006; Nishida *et al.*, 1983; The North American Banding Council Publications Committee 2001).

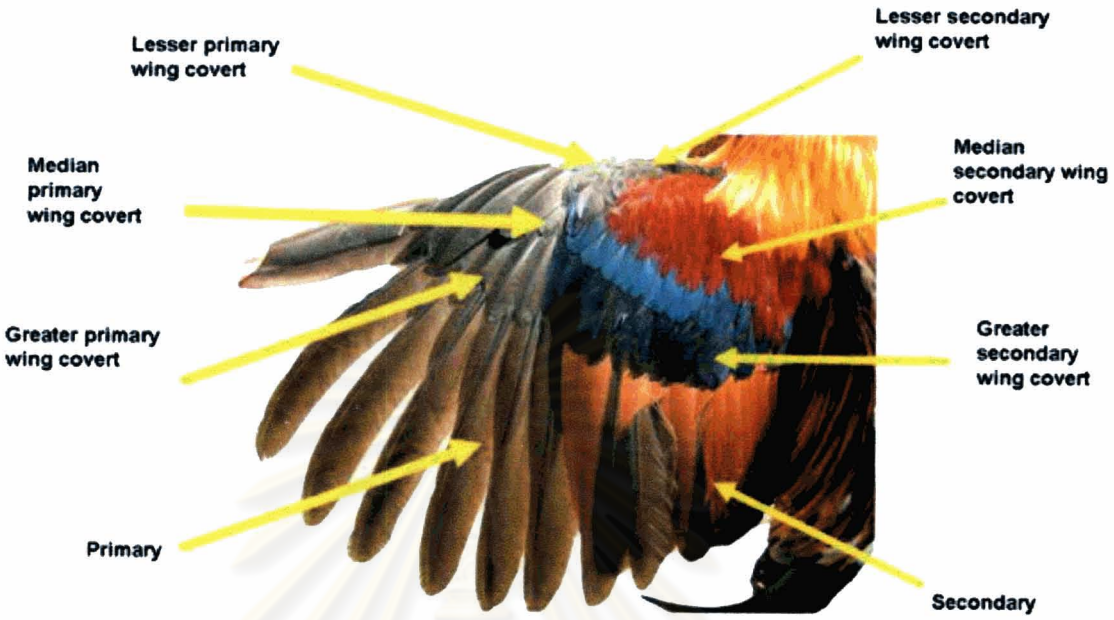


Figure 3.5 Wing feather at eight positions of Red Junglefowl.

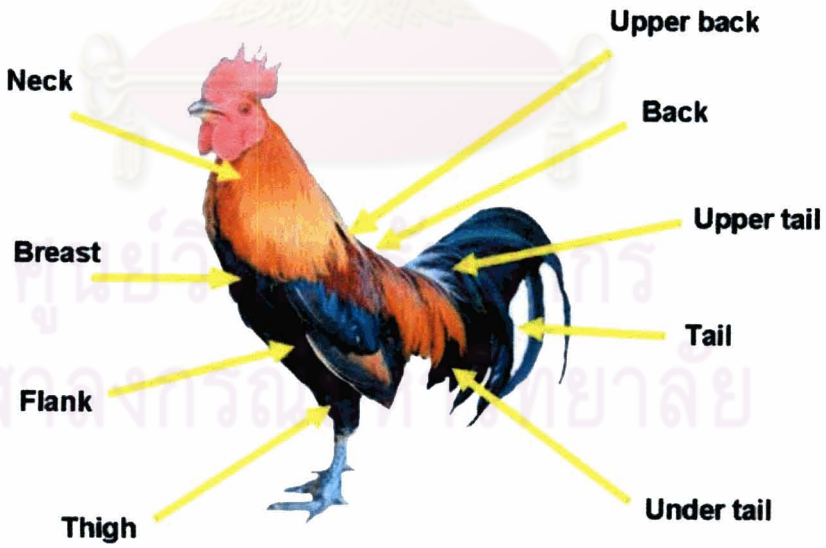


Figure 3.6 Nine feather positions of Red Junglefowl.

Figure 3.7 Thirteen morphologically measurements; bill length (a), bill-nap length (b), eye length (c), head width (d), comb height and comb length (e), wing length (f), half-wing span length (g), tarsal length (h), third digit length (i), claw length (j), spur length (k) and body weight were shown (l).

3.4 Data analyses

The 19 descriptive and 13 morphometrical characteristics of the Red Junglefowls were analyzed for any relationship to the growing stages as follows:

1. All data were analyzed for males and females separately.
2. The Kolmogorov Smirnov test and Shapiro Wilk test were used to test the Normal distribution of the data from all morphometrical characteristics (Park, 2008).
3. Descriptive statistics were used to analyze the mean and standard deviation of the data from all the morphometrical characteristics (Priss, 2010).
4. Comparisons of the means of all morphometrical characteristics between males and females were performed by Independent-Sample t-tests, with significant differences being accepted at the $p < 0.05$ level (Zar, 1999).
5. Regression analysis and Curve estimation were used to fit the data to regression models for the age estimates of Red Junglefowls using a coefficient determination (R^2) above 0.75 and a $p < 0.05$ level (Garson, 2009; Kaw and Trahan, n.d.; Lani, 2009; Sinn, n.d.; Urroz, n.d.). All of the modeling procedures were completed using SPSS, version 16.0 (SPSS Inc, 2004).
6. The growth rate of the male and female chicks were followed by measuring the average tarsal length and analyzing the data by the Roe and Lewentin (1960) formula as follows;

$$Kg = \left(\frac{Log_e Y_1 - Log_e Y_0}{T_1 - T_0} \right) \times 100$$

Where Kg is the growth rate of the tarsal length (%), Y_1 and Y_0 are the tarsal length in week T_1 and T_0, respectively, and T_1 and T_0 are the two sequential time points under study (e.g. the week of study and the previous one), respectively.

CHAPTER IV
RESULTS

The characteristics of Red Junglefowls that were related to the age class over the first year of development are outlined and discussed below.

4.1 Descriptive Characteristics

In the first period, at one day old, the chicks have yellow down feathers covering the whole body with a dark brown strip from both sides of each eye passing down to the neck and along the side of the body. They also have a large dark brown strip from the middle of the frontal pass through the nape, back and to the distal end of the body. The wings are covered with brown down feathers with feather sheaths (Table 4.1 and Figure 4.1 a - f). When the chicks are three days old, wing feathers and wing coverts emerged from their respective feather sheaths (Table 4.1 and Figure 4.2 a - f). By five untile seven days old, the body is still covered with yellow down feathers and the color pattern at their head and body is still present. Feathers at the wing, wing covert and tails are longer. (Table 4.1, Figure 4.3 a - f and Figure 4.4 a - f).

In the second period, starting at two weeks old, the chicks still have yellow down feathers covering all parts of the body and the color patterns have not changed. Wing feathers and wing coverts are much longer than in the first week (Table 4.2 and Figure 4.5 a - f).

At three weeks old, the body and wing feathers are similar to that at two weeks old, but they now have eight to ten primaries. When the chicks are four and five weeks old the body feathers start to change from down to contour feathers (Table 4.2 and Figure 4.6 a - f).

The first molt is in the sixth and seventh week old chicks, where upon the down feathers on the body start molting from the head, and on each side of the body, and are then followed by the molting of the dorsal and ventral side of the body. At this stage the brown strip on the front and both sides of the eye disappear (Table 4.2 and Figure 4.7 a - f).

At eight to nine weeks old The comb becomes visible but only in male birds and remains a gender-specific trait (Table 4.2 and Figure 4.8 a - f).

At ten to eleven weeks old, the birds start changing from their natal plumage to the juvenile plumage, that is downy birds change to feathered birds. The body plumage changes to contour feathers and sexual dimorphism can be differentiated in this period (Table 4.2 and Figure 4.9 a - d).

At twelve to thirteen weeks old, the birds in this period the sexes can easily be differentiated from each other by plumage (Table 4.2 and Figure 4.10 a - f).

Fourteen and fifteen week old birds have similar colored body, wings and wing covert feathers as those of twelve weeks old birds (Table 4.2 and Figure 4.11 a - d).

At sixteen to nineteen weeks old, they have a dark colored plumage. The wing coverts of males are reddish brown, whilst and in females they are dark brown with a yellow mottle, the bill and tarsi are similar in color as that for twelve week old chicks (Table 4.2, Figure 4.12 a - d and Figure 4.13 a - d).

When birds are twenty weeks old, they begin the second molt and change from their juvenile plumage to a prenuptial plumage (Table 4.2 and Figure 4.14 a - d).

The third period, starting from aged six months old, is the start of the third molting period when they change from their prenuptial plumage to their nuptial plumage (Table 4.3 and Figure 4.15 a – d).

From seven to ten months old, both males and females have the same color as in the respective sexes at sixth months of age, but males have a larger and fleshier red comb and a longer golden-yellow or orange hackle than that present in six months old males (Table 4.3 and Figure 4.19 a - d).

By eleven to twelve months of age, male Red Junglefowls have a redder face with a fleshy enlarged red comb. The plumage is a brighter color. Females have a pale red face and brighter plumage than younger females month. (Table 4.3, Figure 4.20 a - d and Figure 4.21 a - d).

Table 4.1 The descriptive morphological characteristics of Red Junglefowls (*Gallus gallus spadiceus*) in the first developmental period for the first week since birth.

Age	Male	Female	Notes
1st period at 1 day old	Yellow down feathers, a feather sheath and a dark brown strip from the eyes across the body to the vent. The bill and tarsi are yellow.	Females have the same characteristics as males.	Natal plumage
3 days old	Yellowish-brown down feathers cover the whole body except wing feathers. The primary, greater primary, secondary and greater secondary coverts begin to grow out leaving fewer sheaths. Brown down remains at the wing coverts. Bill and tarsi are light brown.	Females have the same characteristics as males.	Primary, greater primary, secondary, greater secondary coverts become visible
5 days old	They have two white bars at the wing, the tail feathers have started to grow from the feather sheaths, whilst the color of the bill and tarsi have changed from yellow to light brown	Females have the same characteristics as males.	
7 days old	Rapid growth of wing feathers, median primary wing coverts are more grown whilst tail feathers started to emerge from tail feather sheath. Males have light brown bill and tarsi.	Female chicks have the same characteristics as in male.	-median primary wing coverts, median secondary wing coverts, tail feathers occurred

Table 4.2 The descriptive morphological characteristics of Red Junglefowl (*Gallus gallus spadiceus*) in the second development period are summarized for birds of 2 – 20 weeks old.

Age	Male	Female	Notes
2nd period at 2 weeks old	Primary feathers now black. Primary wing coverts changed to dark brown contour feathers, but other parts are still covered with down feathers. The lesser primary and lesser secondary wing coverts changed to dark brown contour feathers. Light brown bill and brown tarsi.	Females have the same characteristics as males.	Primary, lesser primary and lesser secondary wing coverts become visible
3 weeks old	They now have eight to ten primaries.	Females have the same characteristics as males.	
4-5 weeks old	The wing feathers and coverts are longer. The bill color is brown whilst the tarsi are grey	Females have the same characteristics as males.	
6 -7 weeks old	Down feathers molt from all the body. Feather tracts at the ventro cervical tract, spinal tract and ventro sternal tract appear. Dark brown bill and grey tarsi.	Females have the same characteristics as males.	**1st molting period**

Table 4.2 The descriptive morphological characteristics of Red Junglefowl (*Gallus gallus spadiceus*) in the second development period are summarized for birds of 2 – 20 weeks old.

Age	Male	Female	Notes
8-9 weeks old	Primary and primary wing coverts are grown and black in color. Secondary and wing coverts are dark brown. Dark brown bill and grey tarsi. Comb is visible	Females have the same characteristics as males except for having no comb	Comb occurs in males. This characteristic can be used for sex discrimination
10-11 weeks old	Dark brown head and contour feathers at the upper back, back and breast. Black-brown color at the wing feathers and wing coverts. Flanks and thighs are now a grey semiplume. Dark brown bill and grey tarsi.	Females have dark yellow head feathers, and brown contour feathers over the whole body. Other characteristics are the same as males.	Downy birds changed to feathered birds
12-15 weeks old	Dark brown head feathers. Body covered with black and dark brown feathers. Primary and wing coverts are black. Secondary and wing coverts are reddish-brown with black, the tail is black. A dark brown bill and grey tarsi.	Females have dark yellow head feathers and brown contour feathers in the whole body, brown wing feathers and wing coverts. They have a dark tail, dark brown bill and grey tarsi.	Juvenal plumage
16-19 weeks old	They have dark color plumage. Wing coverts of males are reddish brown, bill and tarsi are similar color as the chicks at twelve week old.	Females are dark brown with yellow mottle, bill and tarsi are similar color as the chicks at twelve week old.	

Table 4.2 The descriptive morphological characteristics of Red Junglefowl (*Gallus gallus spadiceus*) in the second development period are summarized for birds of 2 – 20 weeks old.

Age	Male	Female	Notes
20 weeks old	After molt, males have long dark yellowish-brown hackle, metallic reddish brown at wing coverts, back, tail and breast are black whilst grey thigh and flank. They have dark brown bill and tarsi are grey.	After molt, females have dark yellow neck feather whilst plumage of body, wings and wing coverts are brown mottled. They have dark brown tail, brown breast, grey thigh and flank. In addition, they still have dark brown bill whist grey tarsi.	**2nd molting period** - Prenuptial plumage

Table 4.3 The descriptive morphological characteristics of Red Junglefowl (*Gallus gallus spadiceus*) in the third period are summarized from the age of the sixth month until the twelfth month.

Age	Male	Female	Notes
3rd period at 6 months old	After molting, males have red face and red comb whilst hackle is long with golden yellow. They have black color at breast, primary wing coverts and tail. Secondary wing feathers are black with brown color at the outer web, wing coverts are crimson with metallic sheen whilst tail is black with metallic green. Central pair of tail is longer than others. They have reddish brown color at back and upper back whilst at flank and thighs are grey. They have dark brown bill and tarsi are grey.	After molting, females have red face yellowish brown neck, reddish brown at upper back, back and breast are light brown. They have brown mottled in the whole part of body, wings and wing coverts whilst flank and thigh are grey. They have dark brown bill whilst tarsi are grey.	**3rd molting period** -Central pair of tail feathers are longer than other

Table 4.3 The descriptive morphological characteristics of Red Junglefowl (*Gallus gallus spadiceus*) in the third period are summarized from the age of the sixth month until the twelfth month.

Age	Male	Female	Notes
7-10 months old	Male have the same color as in the sixth month but male have larger and fleshy red comb and more longer golden-yellow or orange hackle than in six months old.	Female have the same color as in the sixth month.	
11-12 months old	Male have a redder face, a fleshy enlarged red comb, a brighter plumage and long golden yellow to yellowish-orange hackles. The breast and primary feathers are black. The primary and secondary wing coverts are black with brown in the outer web. Wing coverts are crimson or reddish brown with a metallic sheen, and the back and upper back are reddish brown. The base of the tail has a white patch with more black and metallic green at the shaft. The flanks and thighs are grey. The bill is dark brown and the tarsi are grey.	Females have a pale red face and a brighter plumage than in the other months. They have a yellowish-brown hackle, a brown mottling over the whole body, a light brown breast, dark brown tail, and grey flanks and thighs. The bill is dark brown bill and the tarsi are grey.	Nuptial plumage

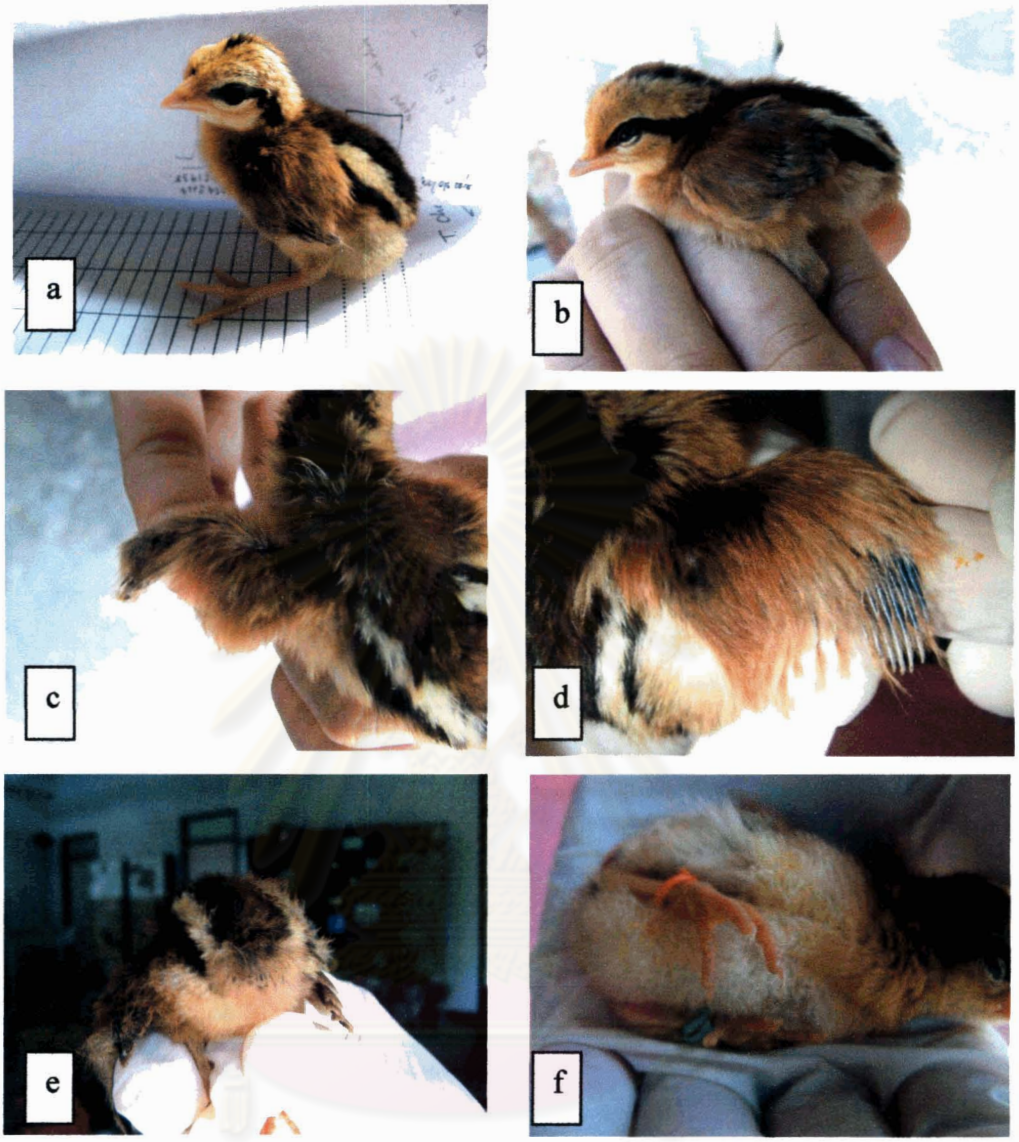


Figure 4.1 Morphological characteristics of Red Junglefowls related to the growth when the chicks are one day old. Male in the right column and female in the left column; whole part of body (a, b), dorsal part and wing (c, d), vent (e) and tarsi (f).

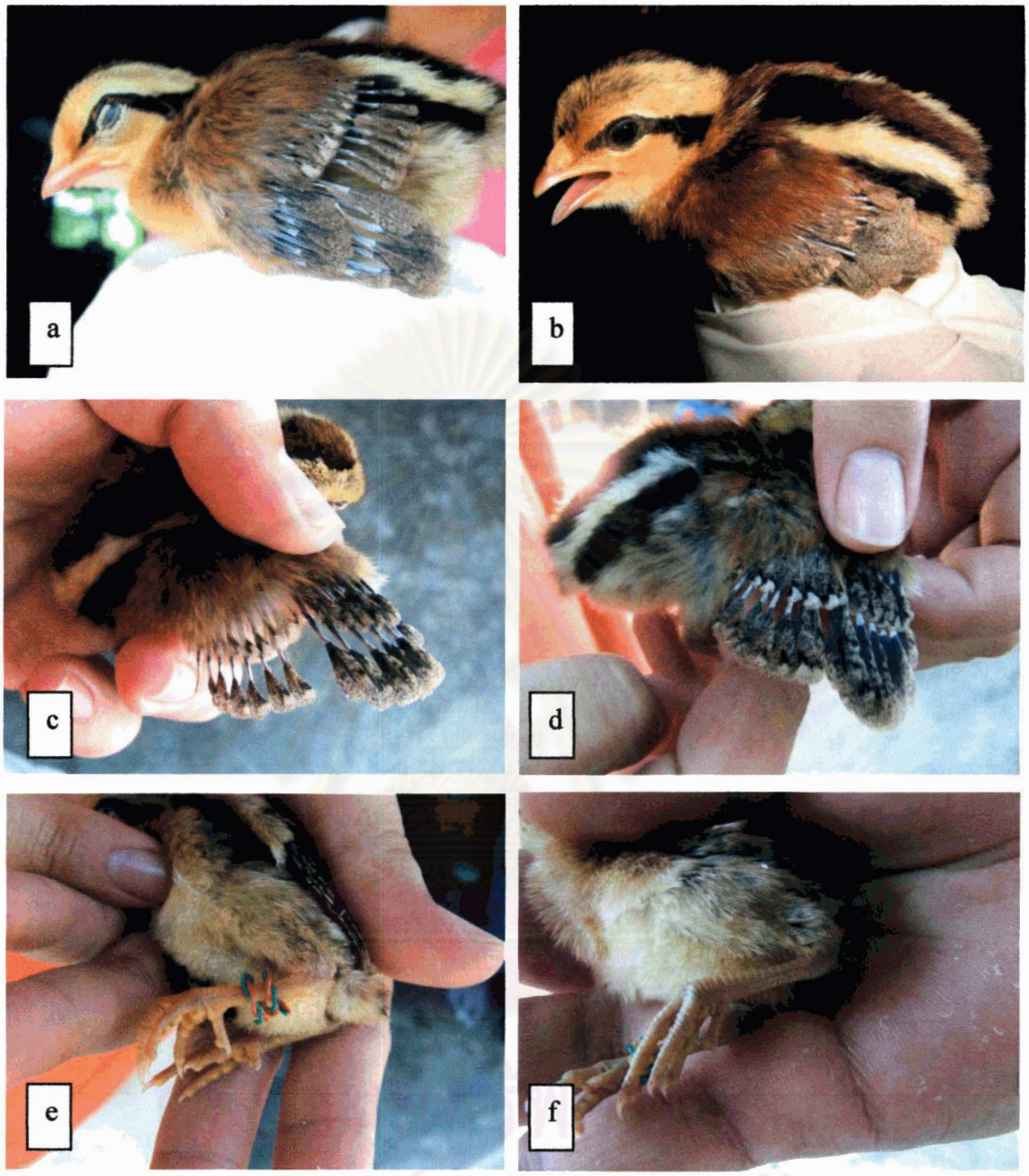


Figure 4.2 Morphological characteristics of Red Junglefowls related to the growth when the chicks are three days old. Male in the right column and female in the left column; whole part of body (a, b), dorsal part and wing (c, d) and tarsi (e, f).

Figure 4.3 Morphological characteristics of Red Junglefowls related to the growth when the chicks are five days old. Male in the right column and female in the left column; whole part of body (a, b), dorsal part and wing (c, d) and tarsi (e, f).

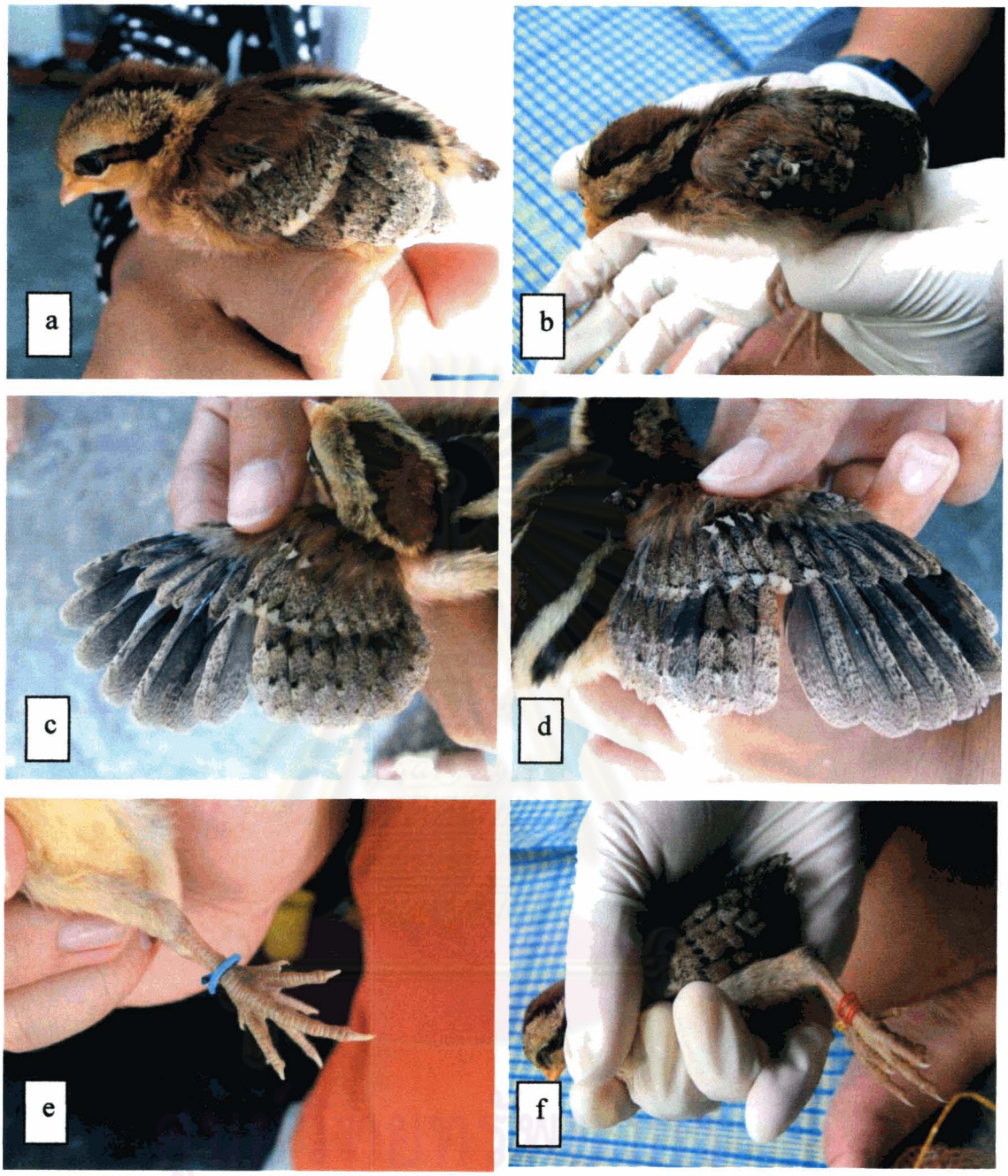


Figure 4.4 Morphological characteristics of Red Junglefowls related to the growth when the chicks are seven days old. Male in the right column and female in the left column; whole part of body (a, b), dorsal part and wing (c, d) and tarsi (e, f).

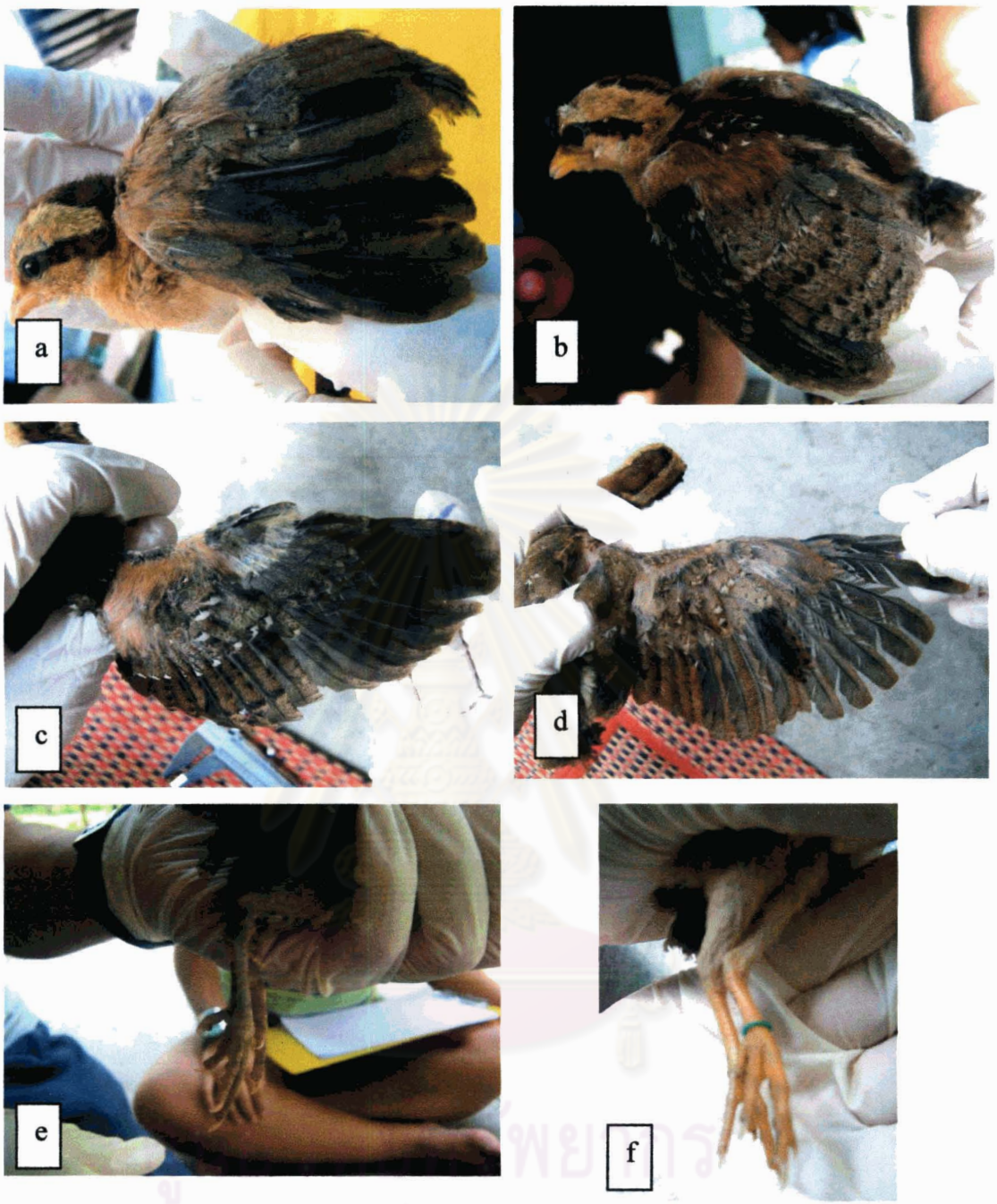


Figure 4.5 Morphological characteristics of Red Junglefowls related to the growth when the chicks are two weeks old. Male in the right column and female in the left column; whole part of body (a, b), dorsal part and wing (c, d) and tarsal (e, f).

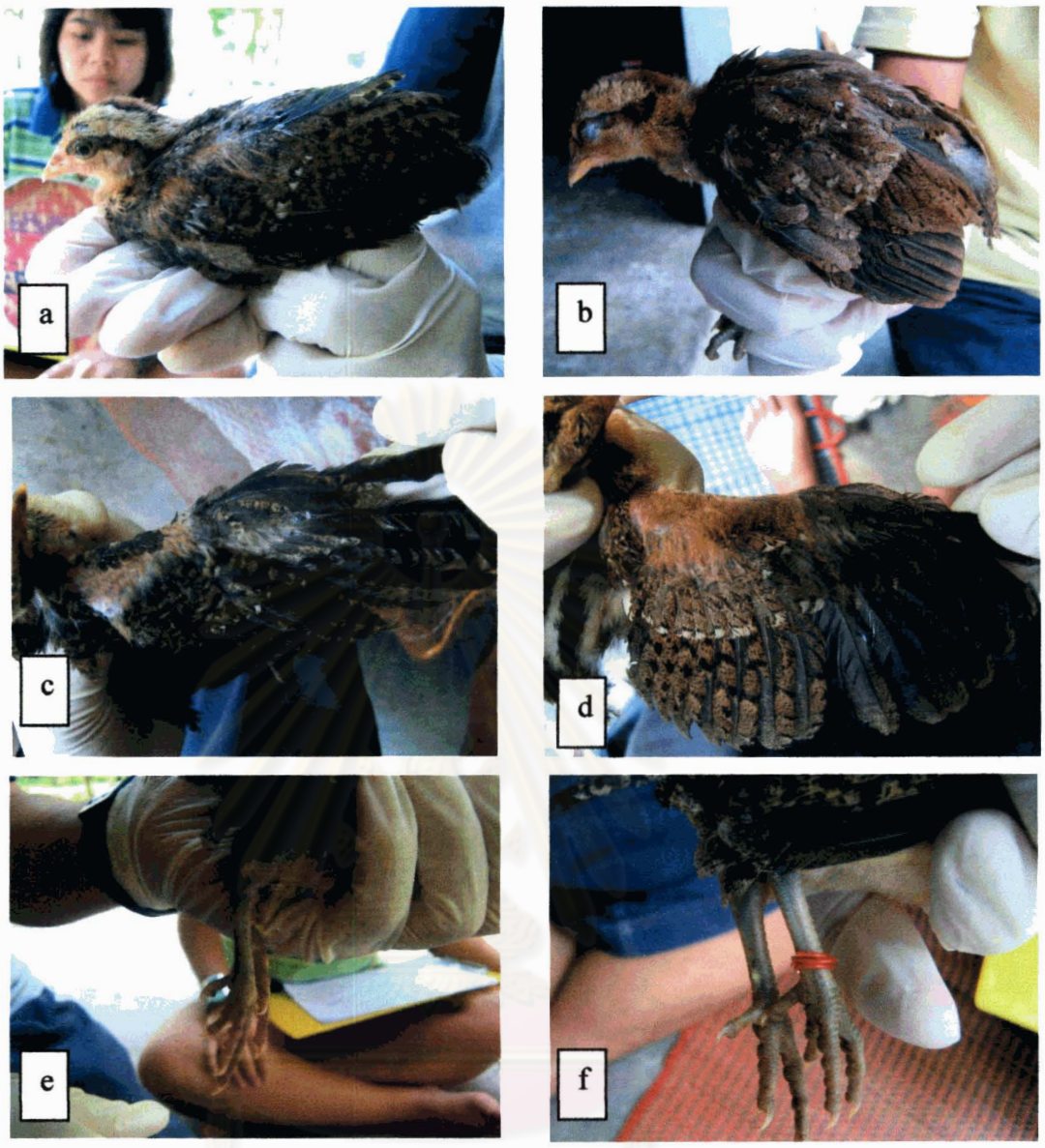


Figure 4.6 Morphological characteristics of Red Junglefowls related to the growth when the chicks are four weeks old. Male in the right column and female in the left column; whole part of body (a, b), dorsal part and wing (c, d) and tarsi (e, f).

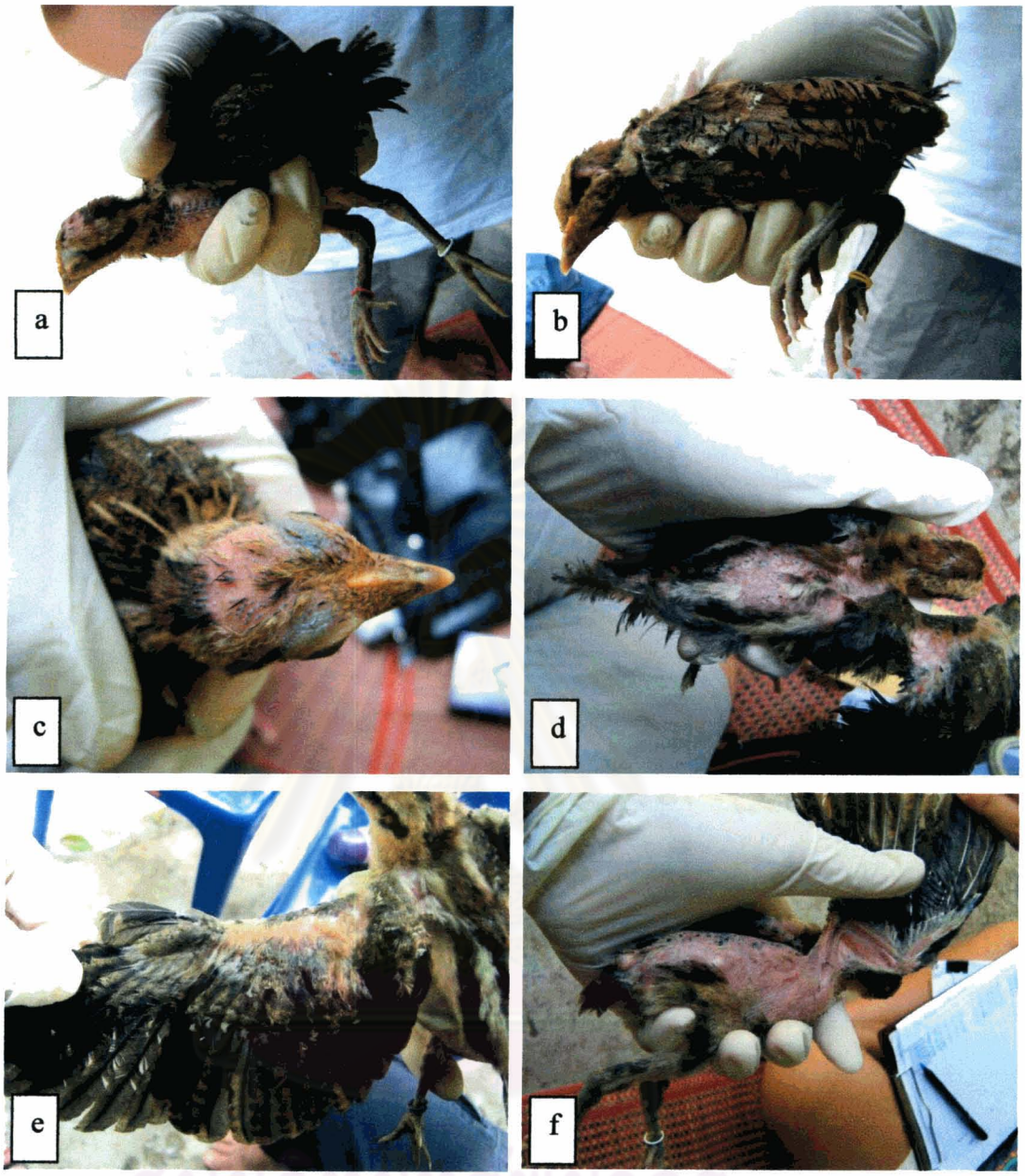


Figure 4.7 Morphological characteristics of Red Junglefowls related to the growth when the chicks are six weeks old. Male in the right column and female in the left column; whole part of body (a, b), head (c), back (d), wing (e) and side of body (f).

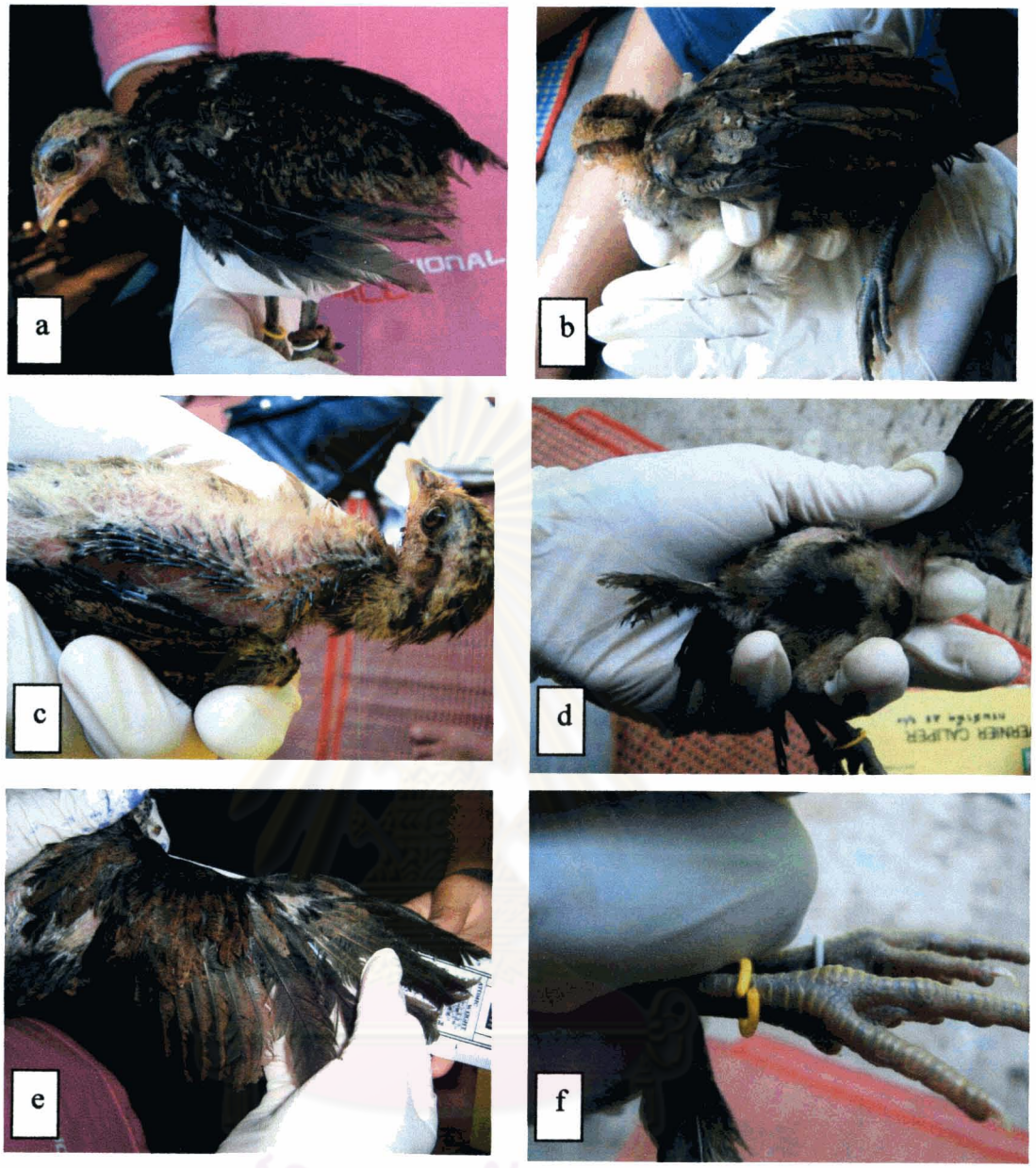


Figure 4.8 Morphological characteristics of Red Junglefowls related to the growth when the chicks are eight weeks old. Male in the right column and female in the left column; whole part of body (a, b), feather tract (c), side under wing covert (d), wing covert (e) and tarsi (f).

Figure 4.9 Morphological characteristics of Red Junglefowls related to the growth when the chicks are ten weeks old. Male in the right column and female in the left column; whole part of body (a, b) and wing (c, d).

Figure 4.10 Morphological characteristics of Red Junglefowls related to the growth when the birds are twelve weeks old. Male in the right column and female in the left column; whole part of body (a, b), wing (c, d) and breast feather (e, f).

Figure 4.11 Morphological characteristics of Red Junglefowls related to the growth when the birds are fourteen weeks old. Male in the right column and female in the left column; whole part of body (a, b) and wing (c, d).

Figure 4.12 Morphological characteristics of Red Junglefowls related to the growth when the birds are of sixteen weeks old. Male in the right column and female in the left column; whole part of body (a, b) and wing (c, d).

Figure 4.13 Morphological characteristics of Red Junglefowls related to the growth when the birds are of eighteen weeks old. Male in the right column and female in the left column; whole part of body (a, b) and wing (c, d).

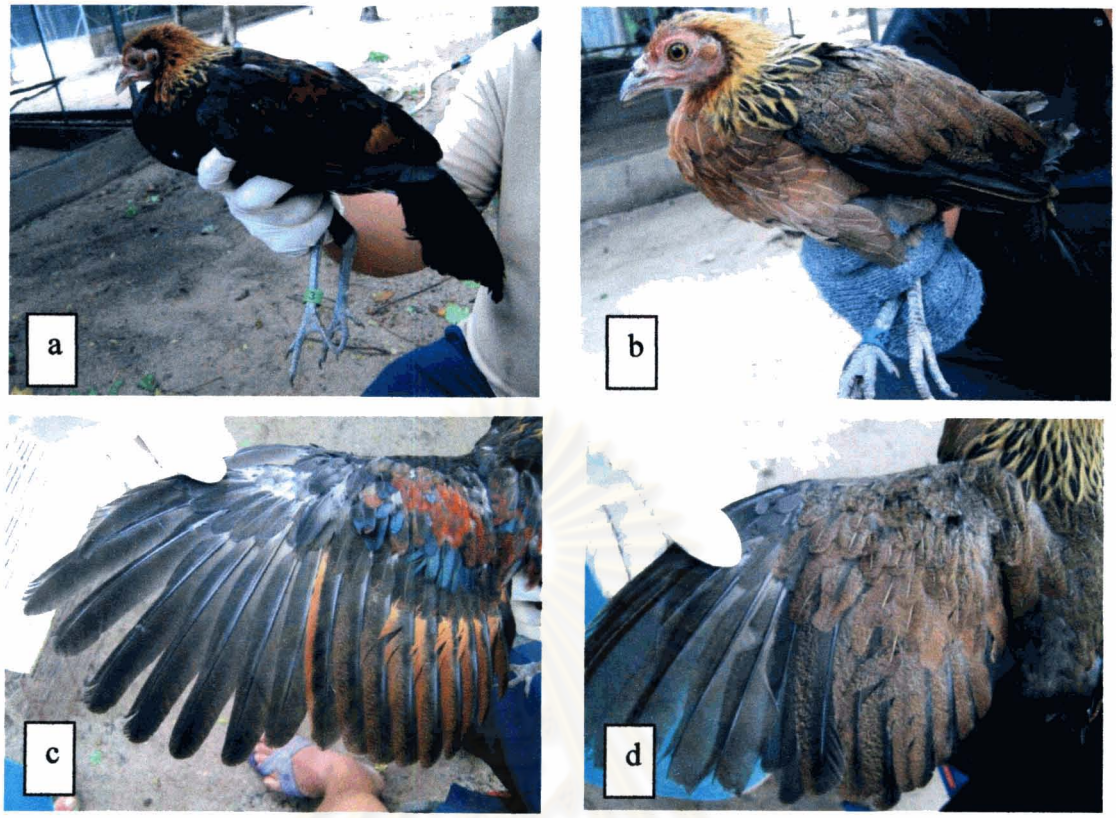


Figure 4.14 Morphological characteristics of Red Junglefowls related to the growth when the birds are of twenty weeks old. Male in the right column and female in the left column; whole part of body (a, b) and wing (c, d).

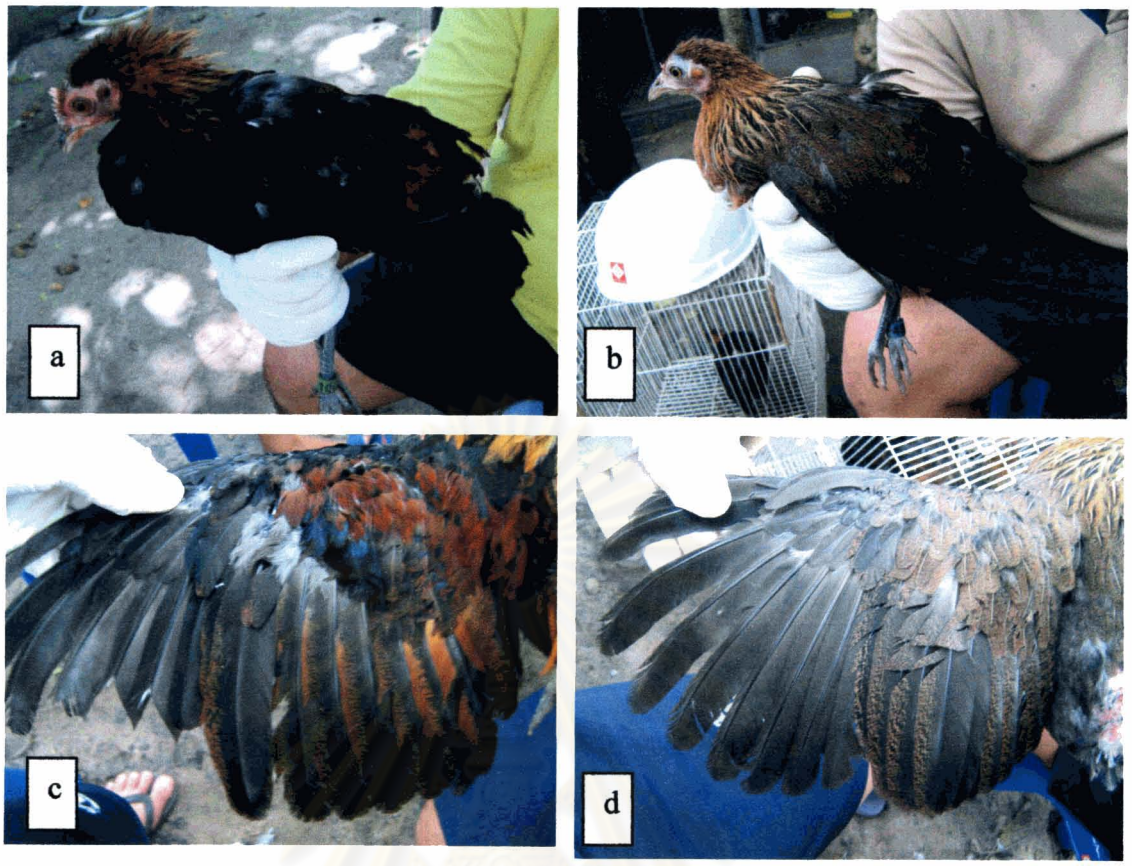


Figure 4.15 Morphological characteristics of Red Junglefowls related to the growth when the Birds are six months old. Male in the right column and female in the left column; whole part of body (a, b) and wing (c, d).

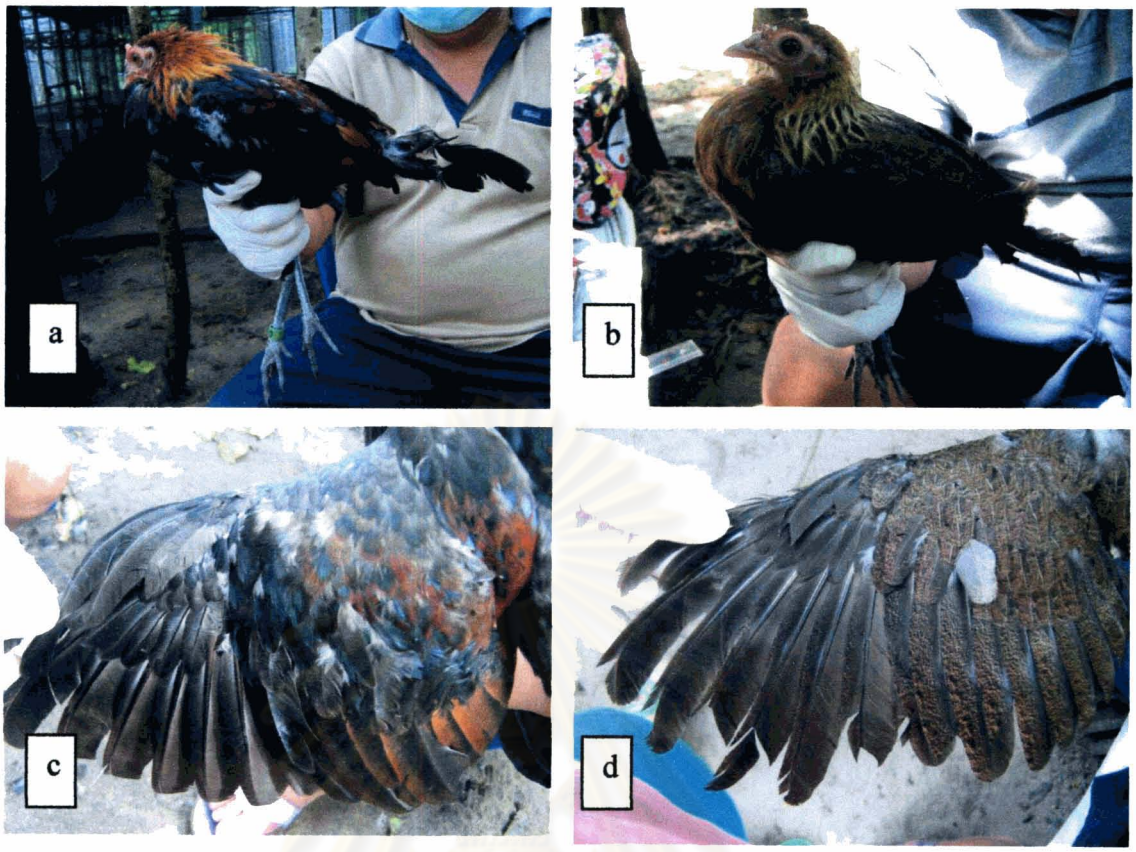


Figure 4.16 Morphological characteristics of Red Junglefowls related to the growth when the birds are seven months old. Male in the right column and female in the left column; whole part of body (a, b) and wing (c, d).

Figure 4.17 Morphological characteristics of Red Junglefowls related to the growth when the birds are eight months old. Male in the right column and female in the left column; whole part of body (a, b) and wing (c, d).

Figure 4.18 Morphological characteristics of Red Junglefowls related to the growth when the birds are nine months old. Male in the right column and female in the left column; whole part of body (a, b), tail of male (c) and wing (d).

Figure 4.19 Morphological characteristics of Red Junglefowls related to the growth when the birds are of ten months old. Male in the right column and female in the left column; whole part of body (a, b) and wing (c, d).

Figure 4.20 Morphological characteristics of Red Junglefowls related to the growth when the birds are eleven months old. Male in the right column and female in the left column; whole part of body (a, b) and wing (c, d).

Figure 4.21 Morphological characteristics of Red Junglefowls related to the growth when the birds are twelve months old. Male in the right column and female in the left column; whole part of body (a, b) and wing (c, d).

Table.4.4 Key to identify age of Red Junglefowl (*Gallus gallus spadiceus*).

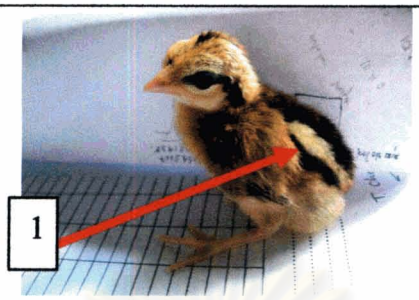
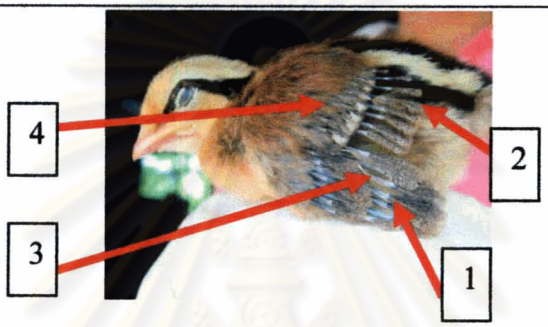
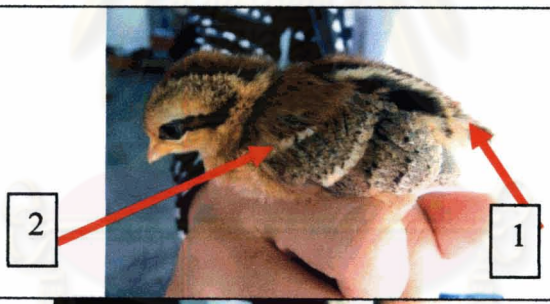
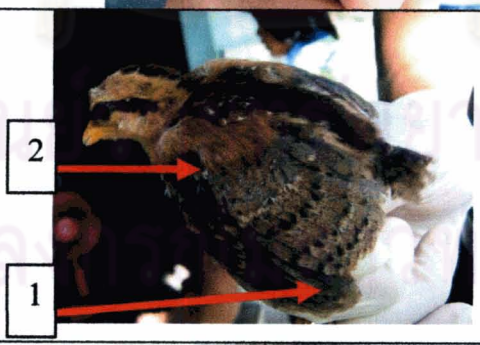
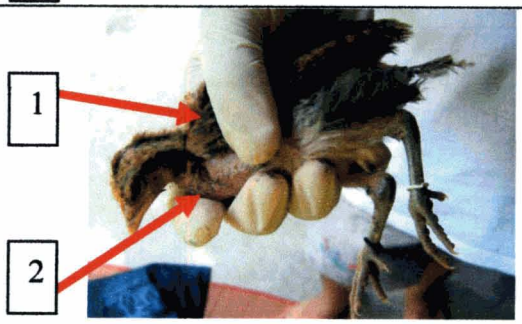
Age	Morphological Characteristics Male and Female	
1 day old		1. yellow down feathers covering the whole body.
3 days old		1. 1st-7th Primary occurred. 2. Secondary occurred. 3. Greater primary wing coverts occurred. 4. Greater secondary wing coverts occurred.
7 days old		1. Tail occurred. 2. Median primary and secondary wing coverts occurred.
2 weeks old		1. Primaries are changed to black. 2. Lesser primary and secondary wing coverts occurred.
6 weeks old		1. Down feathers are changed to contour feathers. 2. Feather tracts occurred.

Table.4.4 Key to identify age of Red Junglefowl (*Gallus gallus spadiceus*) (continued).

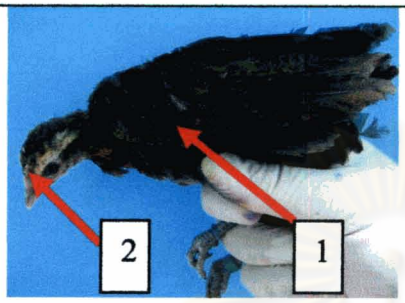
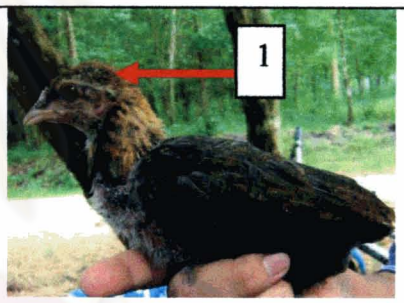
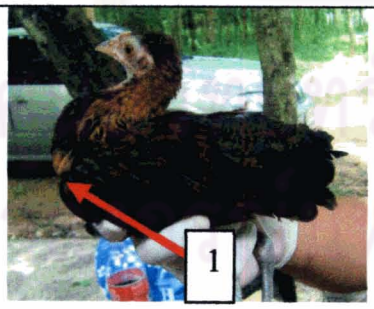
Age	Morphological Characteristics	
	Male	Female
8 weeks old	 1. Wing feathers and coverts are complete occurred. 2. Comb occurred only in male.	 1. Wing feathers and coverts are complete occurred.
10 weeks old	 1. Males have dark brown head feathers.	 1. Females have dark yellow head feathers.
12 weeks old	 1. Male have black breast feather.	 1. Female have brown breast feather.

Table.4.4 Key to identify age of Red Junglefowl (*Gallus gallus spadiceus*) (continued).

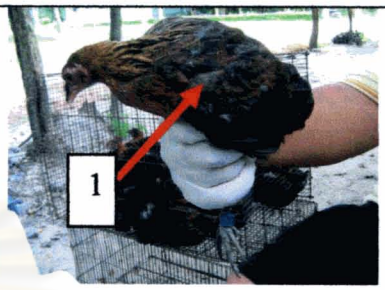
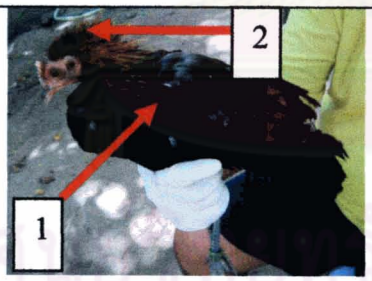
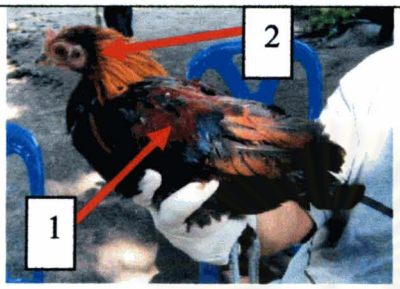
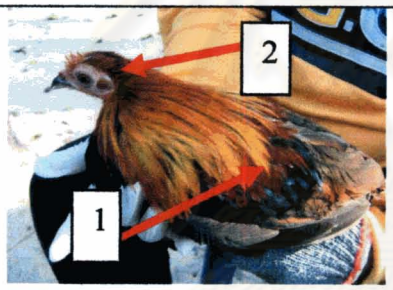
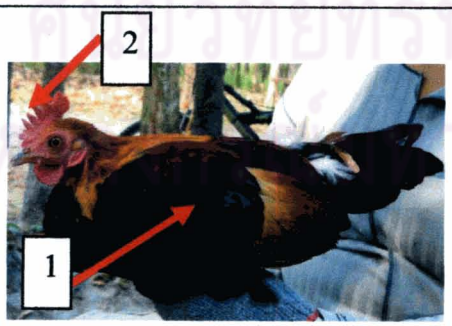
Age	Morphological Characteristics	
	Male	Female
18 weeks old	 1. Males have dark color plumage.	 1. Females have dark color plumage.
20 weeks old	 1. Males have crimson with metallic sheen at wings and wing coverts.	 1. Females have dark brown wings and wing coverts.
6 months old	 1. Males have crimson with metallic sheen at wing coverts. 2. Males have long golden – yellow hackle.	 1. Females have dark brown wings and wing coverts.

Table.4.4 Key to identify age of Red Junglefowl (*Gallus gallus spadiceus*) (continued).

Age	Morphological Characteristics	
	Male	Female
8 months old	 1. Males have reddish-brown with metallic sheen at wing coverts. 2. Males have orange hackle.	 1. Females have dark brown wings and wing coverts.
10 months old	 1. Males have reddish-brown with metallic sheen at wing coverts. 2. Males have long golden-yellow hackle.	 1. Females have more brightly plumage.
12 months old	 1. Males have brightly plumage, reddish-brown with metallic sheen at wing coverts. 2. Males have red face with fleshy enlarge red comb.	 1. Females have more brightly plumage.

4.2 Morphometrical Characteristics

All of the morphometrical characteristics were normally distributed, as determined by the Kolmogorov Smirnov and Shapiro Wilk tests. In addition, the only distinctive male characteristics were the comb height and length, plus the spur length. The morphometrical characteristics between male (n = 27) and female (n = 17) Red Junglefowls, as related to their growth, started from their hatching until one year old, as shown in Tables 4.5 - 4.19.

In the first period, the morphometrical characteristics of male and female chicks, when the chicks were one day old, were significantly different on head width, half-wing span length and third digit length (Table 4.5). When the chicks reached three days old, male and females were significantly different only in terms of the head width and third digit length (Table 4.5). When the chicks were five days old, males and females were only significantly different in terms of head width and third digit length (Table 4.6). When seven days old, male and female chicks were significantly different from each other in terms of head-width and third digit length (Table 4.6).

In the second period (2 - 20 weeks old), the morphometrical characteristics of males and females in at two weeks old were only significantly different for the bill length, half-wing span length and tarsal length (Table 4.7). When the chicks were from between three weeks to thirteen weeks old, males and females were significantly different from each other at all thirteen characteristics (Tables 4.7 - 4.12). By fourteen weeks of age males differed from females in all 13 morphometrical characteristics except for the half-wing span length (Table 4.13). Then at fifteen weeks old up to twenty weeks old, males and females significantly differed at all thirteen characteristics (Tables 4.13 - 4.16).

In the third period, when the chicks were between six and nine months old, all thirteen morphometrical characteristics were significantly different between males and females (Tables 4.16 - 4.18). From ten to twelve months of age males and females were significantly different on 12 out of the 13 characters, with claw length showing no significant difference (Tables 4.18 and 4.19).

Table 4.5 The morphometrics of thirteen characteristics in male and female Red Junglefowl (*Gallus gallus spadiceus*) from one day old until three days old of the first period.

Morphological characters	Morphometrics mean(cm.)±SD			
	1 day old		3 days old	
	Male (n=27)	Female (n=17)	Male (n=27)	Female (n=17)
1.Weight (g)	21.45±3.93	20.81±2.30	23.55±4.39	22.94±2.61
2.bill length	1.12±0.13	1.10±0.11	1.18±0.14	1.14±0.08
3.Bill-nape length	3.00±0.35	2.94±0.21	3.09±0.33	2.98±0.22
4.Eye length	0.63±0.13	0.60±0.07	0.65±0.12	0.63±0.08
5.Head width	1.47±0.13*	1.30±0.09*	1.50±0.12*	1.35±0.10*
6.Comb height	-	-	-	-
7.Comb length	-	-	-	-
8.Wing length	3.40±0.88	3.45±0.37	3.80±1.2	3.64±0.35
9.Half-wing span	5.82±1.15*	5.19±0.64*	6.42±1.59	5.43±0.72
10.Tarsal length	2.29±0.28	2.21±0.15	2.38±0.27	2.29±0.15
11.Claw length	0.31±0.09	0.29±0.04	0.32±0.06	0.3±0.05
12.Third digit length	1.63±0.11*	1.43±0.19*	1.68±0.19*	1.45±0.20*
13.Spur length	-	-	-	-

* are significantly different between male and female at $p<0.05$ Independent sample t-test.

Table 4.6 The morphometrics of thirteen characteristics in male and female Red Junglefowl (*Gallus gallus spadiceus*) from five days old until seven days old of the first period.

Morphological characters	Morphometrics mean(cm.)±SD			
	5 days old		7 days old	
	Male (n=27)	Female (n=17)	Male (n=27)	Female (n=17)
1.Weight (g)	25.54±4.81	26.23±5.49	28.96±3.93	30.93±2.30
2.bill length	1.26±0.28	1.18±0.08	1.29±0.13	1.21±0.11
3.Bill-nape length	3.18±0.33	3.04±0.23	3.27±0.33	3.10±0.25
4.Eye length	0.66±0.18	0.65±0.08	0.72±0.14	0.68±0.10
5.Head width	1.53±0.12*	1.37±0.12*	1.58±0.11*	1.40±0.12*
6.Comb height	-	-	-	-
7.Comb length	-	-	-	-
8.Wing length	4.13±1.33	3.84±0.46	5.22±1.88	4.70±1.24
9.Half-wing span	6.93±1.79	5.58±0.84	8.30±2.44	6.96±1.92
10.Tarsal length	2.47±0.28	2.36±0.17	2.63±0.36	2.46±0.24
11.Claw length	0.34±0.07	0.33±0.06	0.39±0.09	0.34±0.07
12.Third digit length	1.76±0.20*	1.50±0.21*	1.87±0.23*	1.56±0.24*
13.Spur length	-	-	-	-

* are significantly different between male and female at $p<0.05$ Independent sample t-test.

Table 4.7 The morphometrics of thirteen characteristics in male and female Red Junglefowl (*Gallus gallus spadiceus*) from two weeks old until three weeks old of the second period.

Morphological characters	Morphometrics mean(cm.)±SD			
	2 weeks old		3 weeks old	
	Male (n=27)	Female (n=17)	Male (n=27)	Female (n=17)
1.Weight (g)	58.92±13.81	50.82±12.37	85.94±20.84*	65.99±17.82*
2.Bill length	1.56±0.19*	1.33±0.15*	1.72±0.17*	1.44±0.15*
3.Bill-nape length	3.52±0.42	3.31±0.20	3.74±0.36*	3.44±0.18*
4.Eye length	0.80±0.12	0.75±0.10	0.85±0.11*	0.77±0.10*
5.Head width	1.66±0.11	1.53±0.10	1.75±0.12*	1.58±0.08*
6.Comb height	-	-	-	-
7.Comb length	-	-	-	-
8.Wing length	8.17±1.74	6.43±1.45	9.75±1.66*	7.43±1.34*
9.Half-wing span	11.15±1.9*	9.38±2.08*	13.55±2.19*	10.97±1.92*
10.Tarsal length	3.17±0.44*	2.80±0.23*	3.67±0.48*	3.05±0.31*
11.Claw length	0.45±0.10	0.40±0.05	0.51±0.10*	0.43±0.06*
12.Third digit length	2.17±0.30	1.79±0.21	2.43±0.36*	1.94±0.27*
13.Spur length	-	-	-	-

* are significantly different between male and female at $p<0.05$ Independent sample t-test.

Table 4.8 The morphometrics of thirteen characteristics in male and female Red Junglefowl (*Gallus gallus spadiceus*) from four weeks old until five weeks old of the second period.

Morphological characters	Morphometrics mean(cm.)±SD			
	4 weeks old		5 weeks old	
	Male (n=27)	Male (n=27)	Male (n=27)	Female (n=17)
1.Weight (g)	112.90±25.69*	112.90±25.69*	140.46±30.43*	94.05±20.39*
2.Bill length	1.85±0.15*	1.85±0.15*	1.95±0.29*	1.60±0.15*
3.Bill-nape length	3.98±0.42*	3.98±0.42*	4.21±0.39*	3.68±0.24*
4.Eye length	0.91±0.10*	0.91±0.10*	0.95±0.09*	0.83±0.10*
5.Head width	1.80+0.11*	1.80+0.11*	1.88±0.13*	1.69±0.10*
6.Comb height	-	-	-	-
7.Comb length	-	-	-	-
8.Winglength	11.32±1.60*	11.32±1.60*	12.49±1.61*	9.49±1.19*
9.Half-wing span	15.95±2.12*	15.95±2.12*	17.93±2.29*	13.86±1.90*
10.Tarsal length	4.10±0.54*	4.10±0.54*	4.61±0.60*	3.57±0.35*
11.Claw length	0.54±0.08*	0.54±0.08*	0.58±0.08*	0.48±0.06*
12.Third digit length	2.72±0.37*	2.72±0.37*	2.99±0.34*	2.25±0.31*
13.Spur length	-	-	-	-

* are significantly different between male and female at $p<0.05$ Independent sample t-test.

Table 4.9 The morphometrics of thirteen characteristics in male and female Red Junglefowl (*Gallus gallus spadiceus*) from six weeks old until seven weeks old of the second period.

Morphological characters	Morphometrics mean(cm.)±SD			
	6 weeks old		7 weeks old	
	Male (n=27)	Female (n=17)	Male (n=27)	Female (n=17)
1.Weight (g)	172.93±36.98*	109.27±21.43*	213.42±49.37*	113.05±22.26*
2.Bill length	2.07±0.21*	1.70±0.18*	2.14±0.16*	1.83±0.19*
3.Bill-nape length	4.43±0.37*	3.88±0.30*	4.75±0.42*	4.15±0.35*
4.Eye length	0.99±0.08*	0.87±0.10*	1.02±0.08*	0.91±0.09*
5.Head width	1.96±0.13*	1.74±0.11*	2.03±0.14*	1.81±0.12*
6.Comb height	-	-	-	-
7.Comb length	-	-	-	-
8.Wing length	13.51±1.47*	10.22±1.19*	14.69±2.48*	11.27±1.60*
9.Half-wing span	20.58±3.06*	15.43±2.30*	23.12±2.90*	17.95±3.53*
10.Tarsal length	4.97±0.63*	3.81±0.41*	5.40±0.71*	4.23±0.62*
11.Claw length	0.60±0.08*	0.51±0.08*	0.63±0.08*	0.53±0.09*
12.Third digit length	3.21±0.33*	2.41±0.37*	3.53±0.74*	2.62±0.44*
13.Spur length	-	-	-	-

* are significantly different between male and female at $p<0.05$ Independent sample t-test.

Table 4.10 The morphometrics of thirteen characteristics in male and female Red Junglefowl (*Gallus gallus spadiceus*) from eigth weeks old until nine weeks old of the second period.

Morphological characters	Morphometrics mean(cm.)±SD			
	8 weeks old		9 weeks old	
	Male (n=27)	Female (n=17)	Male (n=27)	Female (n=17)
1.Weight (g)	262.07±64.27*	168.40±46.02*	295.60±61.93*	199.72±57.05*
2.Bill length	2.21±0.16*	1.89±0.18*	2.28±0.17*	1.95±0.19*
3.Bill-nape length	4.92±0.41*	4.29±0.37*	5.05±0.41*	4.42±0.34*
4.Eye length	1.05±0.07*	0.94±0.09*	1.08±0.06*	0.96±0.08*
5.Head width	2.11±0.14*	1.87±0.12*	2.18±0.13*	1.96±0.13*
6.Comb height	-	-	-	-
7.Comb length	-	-	-	-
8.Wing length	14.98±1.44*	11.85±1.56*	15.60±1.52*	12.50±1.55*
9.Half-wing span	24.54±2.59*	19.03±3.36*	25.97±2.38*	20.32±3.12*
10.Tarsal length	5.87±0.65*	4.49±0.68*	6.18±0.64*	4.80±0.74*
11.Claw length	0.66±0.08*	0.56±0.09*	0.63±0.08*	0.53±0.09*
12.Third digit length	3.56±0.39*	2.79±0.38*	3.75±0.31*	2.93±0.37*
13.Spur length	-	-	-	-

* are significantly different between male and female at $p<0.05$ Independent sample t-test.

Table 4.11 The morphometrics of thirteen characteristics in male and female Red Junglefowl (*Gallus gallus spadiceus*) from ten weeks old until eleven weeks old of the second period.

Morphological characters	Morphometrics mean(cm.)±SD			
	10 weeks old		11 weeks old	
	Male (n=27)	Female (n=17)	Male (n=27)	Female (n=17)
1.Weight (g)	333.48±64.45*	216.57±66.26*	356.03±77.41*	239.30±70.96*
2.Bill length	2.36±0.15*	2.01±0.18*	2.43±0.13*	2.10±0.18*
3.Bill-nape length	5.18±0.40*	4.53±0.29*	5.38±0.36*	4.68±0.25*
4.Eye length	1.10±0.05*	0.98±0.08*	1.13±0.05*	1.01±0.06*
5.Head width	2.23±0.22*	2.02±0.12*	2.31±0.11*	2.09±0.13*
6.Comb height	0.3±0.14	-	0.28±0.16	-
7.Comb length	1.6±0.28	-	1.5±0.36	-
8.Wing length	16.51±2.26*	13.22±1.53*	16.79±1.35*	13.94±1.31*
9.Half-wing span	27.13±2.58*	21.52±2.73*	28.01±2.46*	22.71±2.48*
10.Tarsal length	6.56±0.70*	5.03±0.70*	6.86±0.59*	5.34±0.69*
11.Claw length	0.73±0.08*	0.61±0.10*	0.76±0.07*	0.63±0.10*
12.Third digit length	3.87±0.30*	3.14±0.41*	3.99±0.25*	3.26±0.40*
13.Spur length	-	-	-	-

* are significantly different between male and female at $p<0.05$ Independent sample t-test.

Table 4.12 The morphometrics of thirteen characteristics in male and female Red Junglefowl (*Gallus gallus spadiceus*) from twelve weeks old until thirteen weeks old of the second period.

Morphological characters	Morphometrics mean(cm.)±SD			
	12 weeks old		13 weeks old	
	Male (n=27)	Female (n=17)	Male (n=27)	Female (n=17)
1.Weight (g)	385.40±82.02*	268.54±73.24*	418.16±84.33*	292.91±68.96*
2.Bill length	2.49±0.15*	2.17±0.15*	2.53±0.14*	2.23±0.14*
3.Bill-nape length	5.49±0.32*	4.82±0.21*	5.59±0.29*	4.98±0.15*
4.Eye length	1.15±0.05*	1.03±0.05*	1.16±0.05*	1.06±0.04*
5.Head width	2.35±0.09*	2.13±0.10*	2.40±0.09*	2.19±0.09*
6.Comb height	0.24±0.08	-	0.28±0.18	-
7.Comb length	1.44±0.36	-	1.34±0.39	-
8.Wing length	17.41±1.29*	14.67±1.32*	18.07±1.14*	15.38±1.21*
9.Half-wing span	28.81±2.40*	24.39±1.99*	29.86±1.98*	25.98±2.29*
10.Tarsal length	7.08±0.63*	5.68±0.52*	7.30±0.58*	5.97±0.41*
11.Claw length	0.79±0.07*	0.66±0.10*	0.81±0.07*	0.69±0.10*
12.Third digit length	4.09±0.23*	3.41±0.39*	4.15±0.22*	3.53±0.30*
13.Spur length	-	-	-	-

* are significantly different between male and female at $p<0.05$ Independent sample t-test.

Table 4.13 The morphometrics of thirteen characteristics in male and female Red Junglefowl (*Gallus gallus spadiceus*) from fourteen weeks old until fifteen weeks old of the second period.

Morphological characters	Morphometrics mean(cm.)±SD			
	14 weeks old		15 weeks old	
	Male (n=27)	Female (n=17)	Male (n=27)	Female (n=17)
1.Weight (g)	436.07±72.69*	319.42±57.47*	461.90±76.89*	339.38±52.84*
2.Bill length	2.57±0.14*	2.30±0.10*	2.63±0.16*	2.37±0.13*
3.Bill-nape length	5.70±0.22*	5.16±0.12*	5.77±0.22*	5.23±0.14*
4.Eye length	1.18±0.05*	1.07±0.04*	1.20±0.05*	1.08±0.048
5.Head width	2.43±0.09*	2.24±0.08*	2.46±0.09*	2.26±0.08*
6.Comb height	0.33±0.04	-	0.40±0.12	-
7.Comb length	1.52±0.14	-	1.58±0.17	-
8.Wing length	18.70±1.06*	16.02±1.11*	19.03±1.03*	16.57±0.78*
9.Half-wing span	29.94±5.65	27.10±1.96	31.91±1.66*	28.02±1.27*
10.Tarsal length	7.49±0.47*	6.18±0.35*	7.65±0.45*	6.34±0.30*
11.Claw length	0.84±0.07*	0.71±0.10*	0.86±0.07*	0.75±0.10*
12.Third digit length	4.24±0.19*	3.64±0.26*	4.29±0.20*	3.69±0.25*
13.Spur length	-	-	-	-

* are significantly different between male and female at $p<0.05$ Independent sample t-test.

Table 4.14 The morphometrics of thirteen characteristics in male and female Red Junglefowl (*Gallus gallus spadiceus*) from sixteen weeks old until seventeen weeks old of the second period.

Morphological characters	Morphometrics mean(cm.)±SD			
	16 weeks old		17 weeks old	
	Male (n=27)	Female (n=17)	Male (n=27)	Female (n=17)
1.Weight (g)	499.69±81.07*	357.28±48.85*	512.56±134.13*	371.51±45.49*
2.Bill length	2.66±0.13*	2.40±0.11*	2.70±0.12*	2.43±0.10*
3.Bill-nape length	5.83±0.18*	5.28±0.15*	5.87±0.18*	5.34±0.17*
4.Eye length	1.21±0.06*	1.10±0.04*	1.23±0.06*	1.11±0.05*
5.Head width	2.49±0.08*	2.29±0.08*	2.52±0.08*	2.32±0.08*
6.Comb height	0.55±0.26	-	0.56±0.06	-
7.Comb length	1.51±0.54	-	1.68±0.26	-
8.Wing length	19.50±0.67*	16.98±0.92*	19.77±0.89*	17.13±0.57*
9.Half-wing span	33.30±1.41*	29.11±0.98*	33.48±2.25*	29.50±0.79*
10.Tarsal length	7.84±0.49*	6.46±0.29*	7.93±0.42*	6.56±0.28*
11.Claw length	0.89±0.08*	0.77±0.10*	0.91±0.08*	0.80±0.09*
12.Third digit length	4.35±0.19*	3.73±0.23*	4.39±0.20*	3.78±0.19*
13.Spur length	-	-	-	-

* are significantly different between male and female at $p<0.05$ Independent sample t-test.

Table 4.15 The morphometrics of thirteen characteristics in male and female Red Junglefowl (*Gallus gallus spadiceus*) from eighteen weeks old until nineteen weeks old of the second period.

Morphological characters	Morphometrics mean(cm.)±SD			
	18 weeks old		19weeks old	
	Male (n=27)	Female (n=17)	Male (n=27)	Female (n=17)
1.Weight (g)	557.53±96.19*	396.31±46.09*	603.84±95.36*	418.51±44.81*
2.Bill length	2.73±0.11*	2.46±0.09*	2.77±0.11*	2.49±0.09*
3.Bill-nape length	5.93±0.18*	5.39±0.15*	5.95±0.18*	5.43±0.14*
4.Eye length	1.25±0.06*	1.13±0.05*	1.27±0.05*	1.15±0.05*
5.Head width	2.55±0.08*	2.33±0.08*	2.57±0.07*	2.35±0.08*
6.Comb height	0.61±0.04	-	0.53±0.23	-
7.Comb length	1.69±0.25	-	1.43±0.57	-
8.Wing length	20.10±0.83*	17.39±0.49*	20.36±0.66*	17.55 ±0.42*
9.Half-wing span	33.95±2.27*	29.84±0.65*	33.95±2.27*	29.84 ±0.65*
10.Tarsal length	8.03±0.45*	6.63±0.27*	8.18±0.48*	6.70±0.27*
11.Claw length	0.93±0.08*	0.82±0.09*	0.97±0.08*	0.84±0.09*
12.Third digit length	4.44±0.22*	3.84±0.18*	4.49±0.21*	3.88±0.16*
13.Spur length	-	-	-	-

* are significantly different between male and female at $p<0.05$ Independent sample t-test.

Table 4.16 The morphometrics of thirteen characteristics in male and female Red Junglefowl (*Gallus gallus spadiceus*) from twenty weeks old of the second period until six months old in the third period.

Morphological characters	Morphometrics mean(cm.)±SD			
	20 weeks old		6 months old	
	Male (n=27)	Female (n=17)	Male (n=27)	Female (n=17)
1.Weight (g)	639.05±110.29*	451.03±40.80*	692.08±91.41*	485.64±55.19*
2.Bill length	2.79±0.10*	2.52±0.10*	2.83±0.09*	2.55±0.11*
3.Bill-nape length	6.04±0.18*	5.51±0.16*	6.09±0.21*	5.54±0.15*
4.Eye length	1.28±0.06*	1.15±0.06*	1.29±0.06*	1.17±0.05*
5.Head width	2.59±0.07*	2.39±0.10*	2.59±0.07*	2.41±0.09*
6.Comb height	0.54±0.20	-	0.54±0.30	-
7.Comb length	1.41±0.59	-	1.36±0.48	-
8.Wing length	20.67±0.62*	17.82±0.45*	20.86±0.56*	18.05±0.44*
9.Half-wing span	34.37±2.23*	30.36±0.52*	34.97±1.96*	30.69±0.64*
10.Tarsal length	8.33±0.47*	6.82±0.32*	8.51±0.48*	6.88±0.32*
11.Claw length	0.99±0.09*	0.89±0.07*	1.05±0.11*	0.95±0.09*
12.Third digit length	4.53±0.21*	3.91±0.17*	4.58±0.24*	3.92±0.16*
13.Spur length	0.55±0.00	-	0.48±0.09	-

* are significantly different between male and female at $p<0.05$ Independent sample t-test.

Table 4.17 The morphometrics of thirteen characteristics in male and female Red Junglefowl (*Gallus gallus spadiceus*) from seven months old until eight months old in the third period.

Morphological characters	Morphometrics mean(cm.)±SD			
	7months old		8 months old	
	Male (n=27)	Female (n=17)	Male (n=27)	Female (n=17)
1.Weight (g)	780.54±84.82*	581.94±61.35*	823.12±84.04*	599.42±63.88*
2.Bill length	2.85±0.10*	2.58±0.11*	2.88±0.10*	2.63±0.11*
3.Bill-nape length	6.14±0.22*	5.63±0.16*	6.20±0.21*	5.65±0.16*
4.Eye length	1.31±0.05*	1.19±0.06*	1.33±0.06*	1.22±0.08*
5.Head width	2.63±0.08*	2.44±0.09*	2.65±0.09*	2.48±0.08*
6.Comb height	0.8±0.56	-	1.36±0.78	-
7.Comb length	1.66±0.61	-	2.26±1.52	-
8.Wing length	21.00±0.59*	18.18±0.43*	21.22±0.57*	18.44±0.57*
9.Half-wing span	35.36±1.63*	31.15±0.62*	36.10±0.84*	31.25±0.63*
10.Tarsal length	8.61±0.47*	6.96±0.34*	8.70±0.45*	7.02±0.34*
11.Claw length	1.08±0.11*	0.98±0.09*	1.08±0.08*	1.00±0.09*
12.Third digit length	4.62±0.24*	3.96±0.18*	4.66±0.23*	3.99±0.16*
13.Spur length	0.67±0.22	-	0.77±0.27	-

* are significantly different between male and female at $p<0.05$ Independent sample t-test.

Table 4.18 The morphometrics of thirteen characteristics in male and female Red Junglefowl (*Gallus gallus spadiceus*) from nine months old until ten months old of the third period.

Morphological Characters	Morphometrics mean(cm.)±SD			
	9 months old		10 months old	
	Male (n=27)	Female (n=17)	Male (n=27)	Female (n=17)
1.Weight (g)	879.10±76.31*	641.5±51.47*	921.42±59.15*	662.26±39.90*
2.Bill length	2.90±0.11*	2.65±0.113*	2.93±0.11*	2.66±0.12*
3.Bill-nape length	6.24±0.21*	5.68±0.17*	6.29±0.24*	5.79±0.21*
4.Eye length	1.34±0.07*	1.24±0.08*	1.36±0.07*	1.25±0.07*
5.Head width	2.68±0.10*	2.49±0.08*	2.72±0.11*	2.52±0.08*
6.Comb height	1.75±0.85	-	2.45±1.01	-
7.Comb length	2.83±1.61	-	3.59±1.94	-
8.Wing length	21.44±0.51*	18.54±0.49*	21.56±0.45*	18.72±0.55*
9.Half-wing span	36.61±0.86*	31.54±0.63*	37.08±0.83*	31.80±0.51*
10.Tarsal length	8.79±0.43*	7.09±0.34*	8.89±0.42*	7.14±0.34*
11.Claw length	1.10±0.08*	1.03±0.08*	1.15±0.19	1.11±0.13
12.Third digit length	4.70±0.25*	4.06±0.16*	4.73±0.23*	4.12±0.17*
13.Spur length	0.93±0.21	-	1.12±0.25	-

* are significantly different between male and female at $p<0.05$ Independent sample t-test.

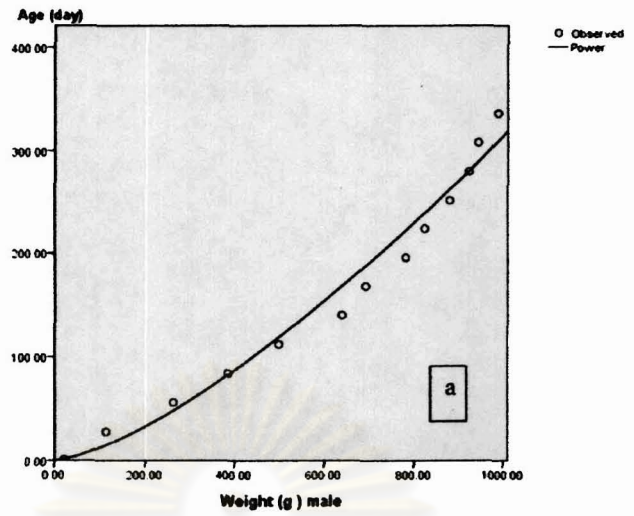
Table 4.19 The morphometrics of thirteen characteristics in male and female Red Junglefowl (*Gallus gallus spadiceus*) from eleven months old until twelve months old of the third period.

Morphological Characters	Morphometrics mean(cm.)±SD			
	11 months old		12 months old	
	Male (n=27)	Female (n=17)	Male (n=27)	Female (n=17)
1.Weight (g)	942.05±74.40*	670.23±49.19*	987.91±70.71*	670.17±47.96*
2.Bill length	2.96±0.11*	2.69±0.10*	3.02±0.13*	2.72±0.12*
3.Bill-nape length	6.35±0.26*	5.82±0.19*	6.45±0.26*	5.90±0.17*
4.Eye length	1.39±0.07*	1.27±0.08*	1.41±0.07*	1.29±0.09*
5.Head width	2.75±0.11*	2.54±0.08*	2.79±0.10*	2.58±0.09*
6.Comb height	3.88±4.01	-	4.32±3.86	-
7.Comb length	6.01±7.00	-	6.86±6.77	-
8.Wing length	21.76±0.44*	18.87±0.57*	22.02±0.38*	19.18±0.63*
9.Half-wing span	37.47±0.75*	32.34±0.66*	38.05±0.86*	32.68±0.66*
10.Tarsal length	9.01±0.39*	7.20±0.41*	9.11±0.40*	7.26±0.39*
11.Claw length	1.18±0.19	1.11±0.13	1.24±0.19	1.14±0.12
12.Third digit length	4.79±0.25*	4.14±0.26*	4.83±0.24*	4.23±0.28*
13.Spur length	1.39±0.30	-	1.60±0.39	-

* are significantly different between male and female at $p<0.05$ Independent sample t-test.

The average weight, bill length, bill-nape length, eye length, head width, comb height, comb length, wing length, half wing span length, tarsal length, claw length, third digit length and spur length of male and female Red Junglefowls from hatching until one year old were analyzed by regression analysis. The result shows a significant difference at the $p<0.05$ level for all 13 characteristics. With respect to the changes with age, it was found that of the regression models the power model best fitted the changes in the weight, eye length, head width and claw length. The exponential model explained the changes in the bill length, bill-nape length, wing length, half wing span length, tarsal length and third digit length. The cubic model explained the changes in comb height. Finally, the invest model best explained the comb length whilst the logarithm model explained the changes with age in the spur length.

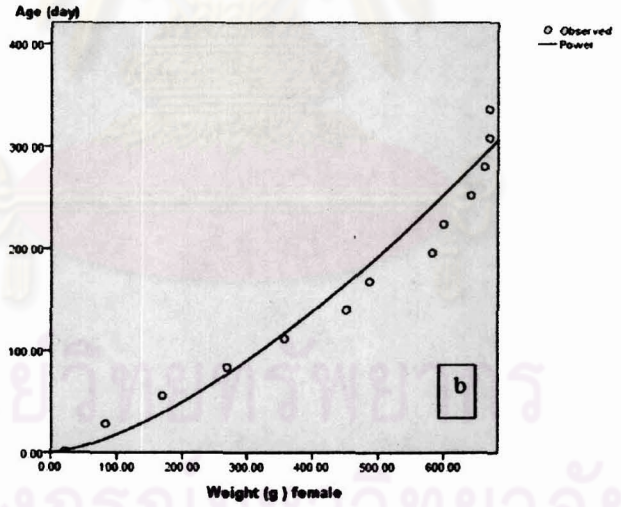
The medium-high to high coefficients of determination (R^2 = 0.874 - 0.983) indicated the regression model of all morphometrical characteristics can be a reasonable determinate of the age of male and female Red Junglefowls (Figures 4.22 a & b and 4.34 a & b).



a. Male $y = 0.0196x^{1.4018}$ $R^2 = 0.978$ $p = 0.000$

If x = weigth (g)

y = age (day)

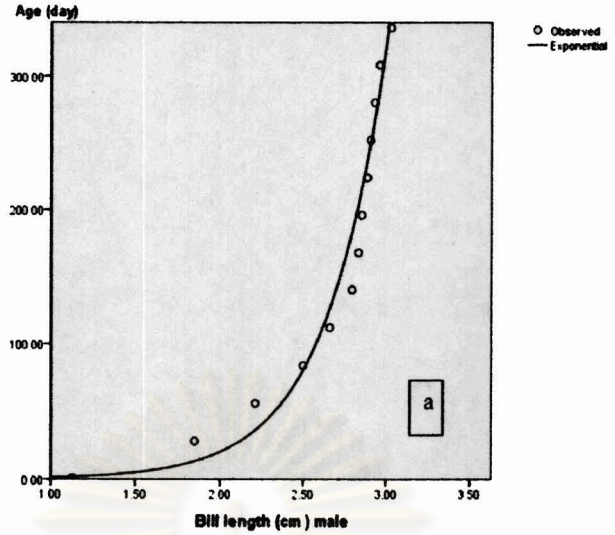


b. Female $y = 0.0199x^{1.4772}$ $R^2 = 0.9612$ $p = 0.000$

If x = weigth (g)

y = age (day)

Figure 4.22 The regression model of weight of male (a) and female (b) Red Junglefowl after hatching until 1 year old.

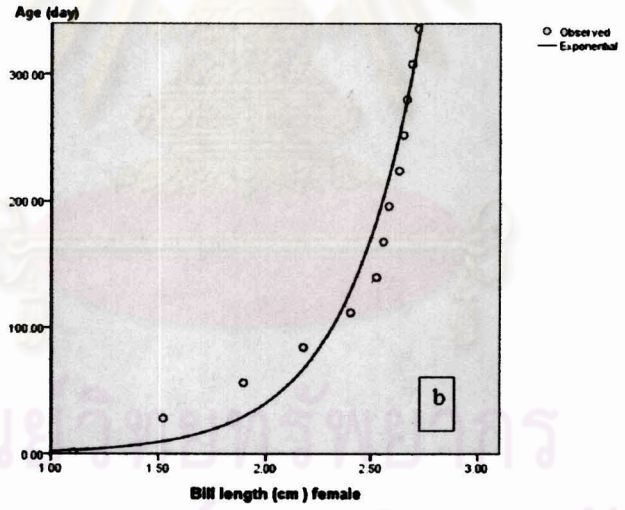


a. Male $y = 0.0775e^{2.778x}$ $R^2 = 0.958$ $p = 0.000$

If x = bill length (cm)

y = age (day)

e = 2.71828



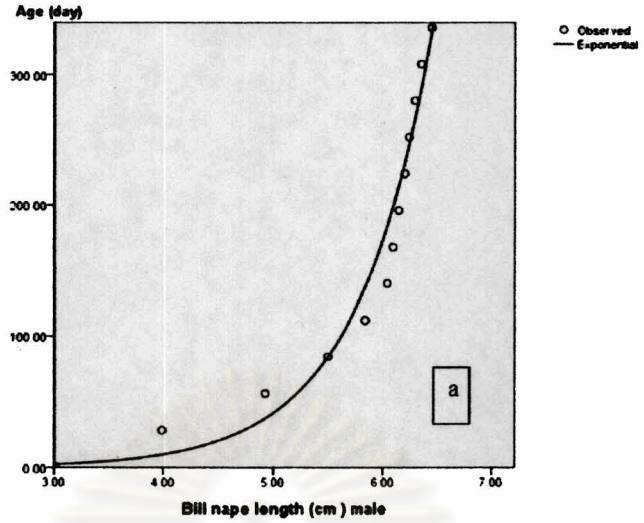
b. Female $y = 0.1166e^{2.9179x}$ $R^2 = 0.902$ $p = 0.005$

If x = bill length (cm)

y = age (day)

e = 2.71828

Figure 4.23 The regression model of bill length of male (a) and female (b) Red Junglefowl after hatching until 1 year old.

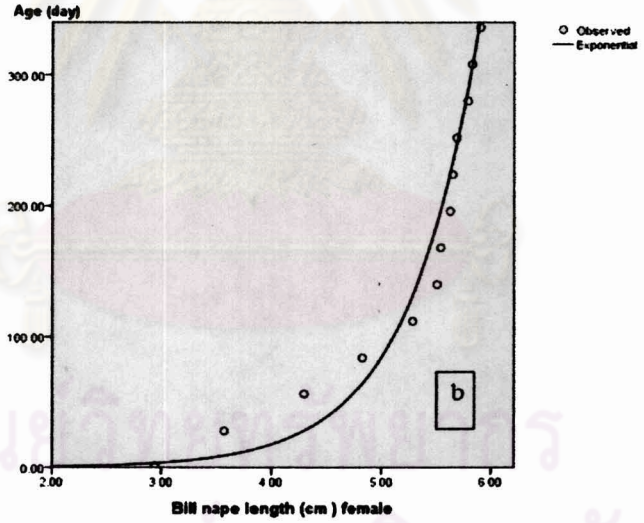


a. Male $y = 0.0311e^{1.4379x}$ $R^2 = 0.925$ $p = 0.000$

If x = bill-nape length (cm)

y = age (day)

e = 2.71828



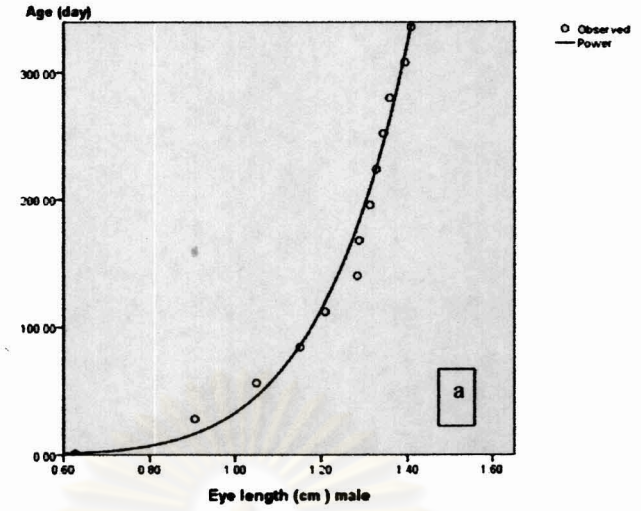
b. Female $y = 0.0356e^{1.5543x}$ $R^2 = 0.881$ $p = 0.000$

If x = bill-nape length (cm)

y = age (day)

e = 2.71828

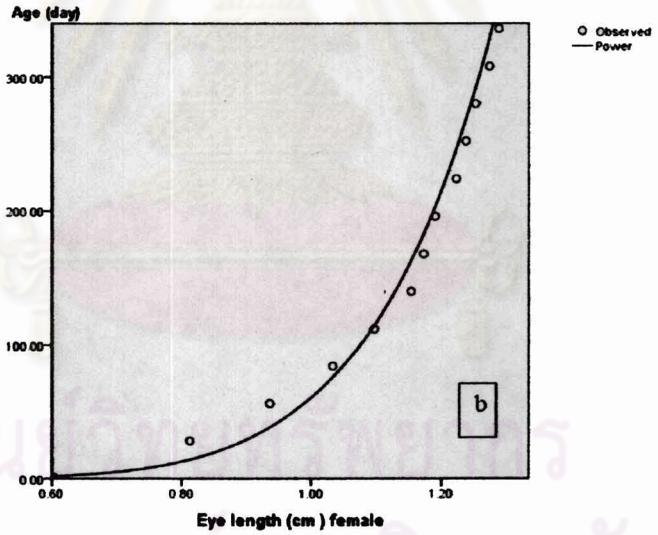
Figure 4.24 The regression model of bill-nape length of male (a) and female (b) Red Junglefowl after hatching until 1 year old.



a. Male $y = 32.705x^{6.816}$ $R^2 = 0.9835$ $p = 0.000$

If x = eye length (cm)

y = age (day)

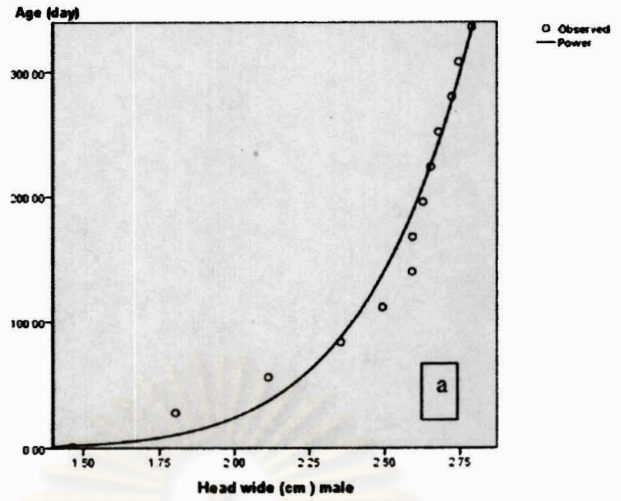


b. Female $y = 60.163x^{6.9994}$ $R^2 = 0.966$ $p = 0.000$

If x = eye length (cm)

y = age (day)

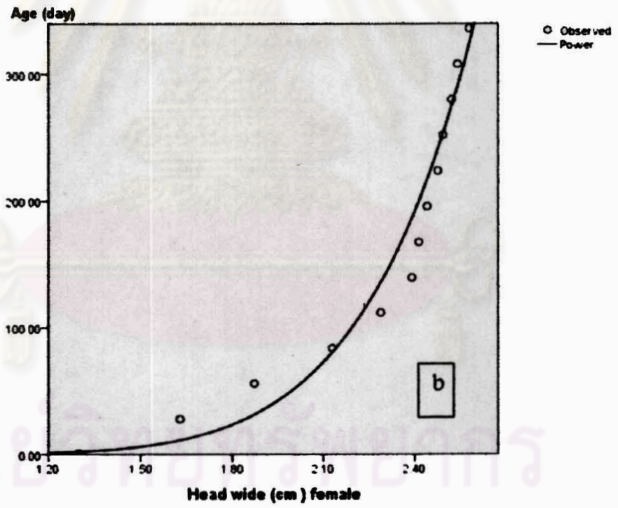
Figure 4.25 The regression model of eye length of male (a) and female (b) Red Junglefowl after hatching until 1 year old.



a. Male $y = 0.1015x^{7.899}$ $R^2 = 0.9394$ $p = 0.000$

If x = head width (cm)

y = age (day)

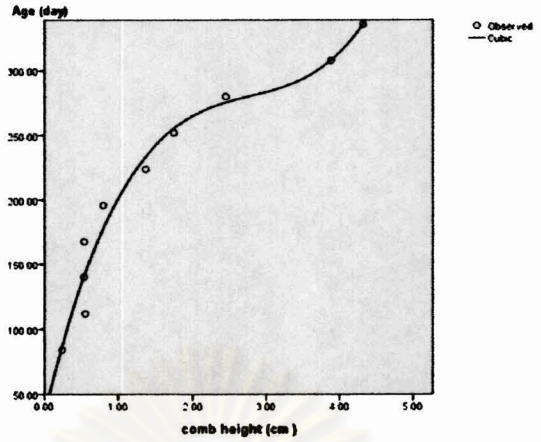


b. Female $y = 0.3269x^{7.2855}$ $R^2 = 0.9335$ $p = 0.000$

If x = head width (cm)

y = age (day)

Figure 4.26 The regression model of head width of male (a) and female (b) Red Junglefowl started from hatching until 1 year old.

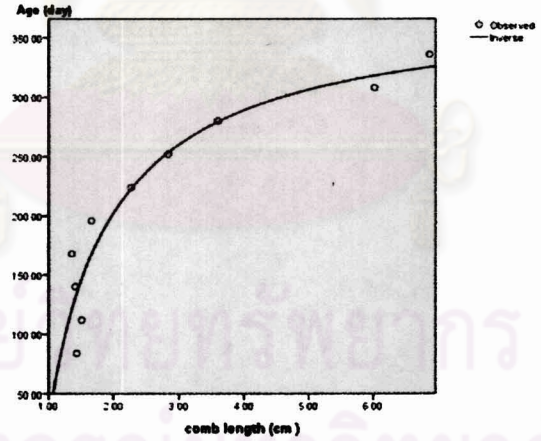


$y = 9.556x^3-79.937x^2+236.760x+34.849$ $R^2 = 0.966$ $p = 0.007$

If x = comb hight (cm)

y = age (day)

Figure 4.27 The regression model of comb height of male Red Junglefowl after hatching until 1 year old.

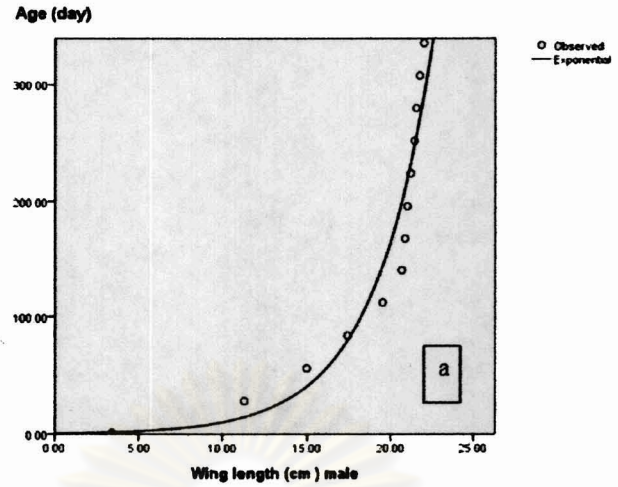


$y = 375.991+(-347.505/x)$ $R^2 = 0.890$ $p = 0.000$

If x = comb length (cm)

y = age (day)

Figure 4.28 The regression model of comb height of male Red Junglefowl after hatching until 1 year old.

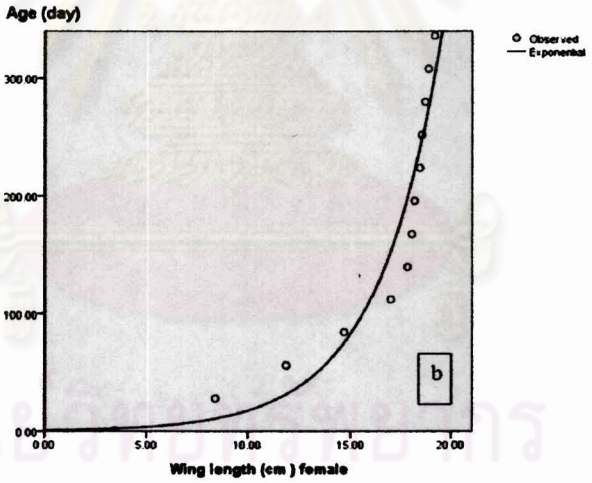


a. Male $y = 0.5982e^{0.2811x}$ $R^2 = 0.964$ $p = 0.000$

If x = wing length (cm)

y = age (day)

e = 2.71828



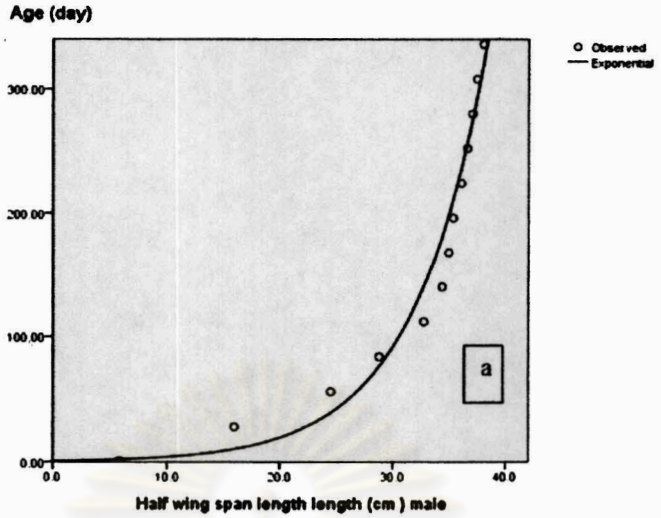
b. Female $y = 0.8094e^{0.3087x}$ $R^2 = 0.9216$ $p = 0.045$

If x = wing length (cm)

y = age (day)

e = 2.71828

Figure 4.29 The regression model of wing length of male (a) and female (b) Red Junglefowl after hatching until 1 year old.

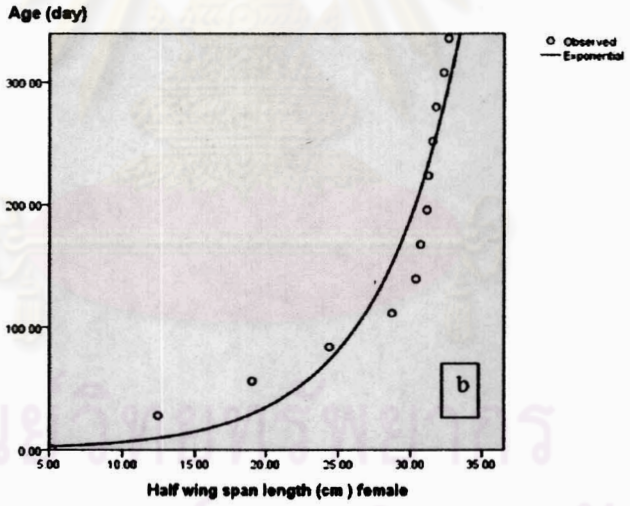


a. Male $y = 0.8716e^{0.1552x}$ $R^2 = 0.9363$ $p = 0.00$

If x = half wing span length (cm)

y = age (day)

e = 2.71828



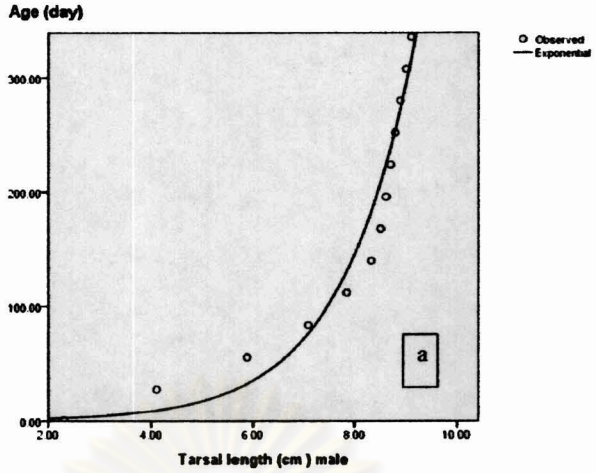
b. Female $y = 1.1783e^{0.1693x}$ $R^2 = 0.8982$ $p = 0.00$

If x = half wing span length (cm)

y = age (day)

e = 2.71828

Figure 4.30 The regression model of half wing span length of male (a) and female (b) Red Junglefowl after hatching until 1 year old.

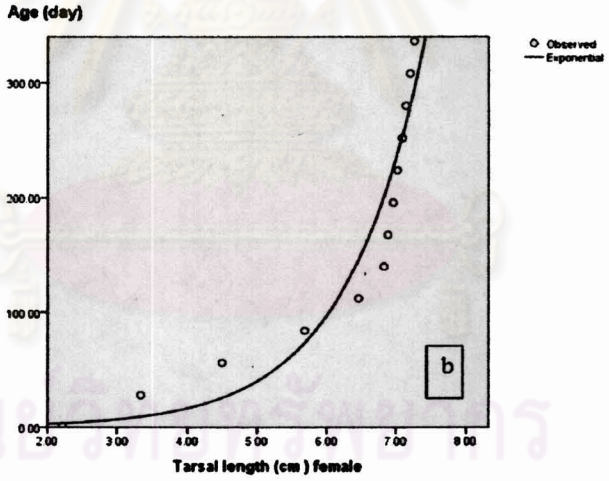


a. Male $y = 0.5353e^{0.7005x}$ $R^2 = 0.9112$ $p = 0.00$

If x = tarsal length (cm)

y = age (day)

e = 2.71828



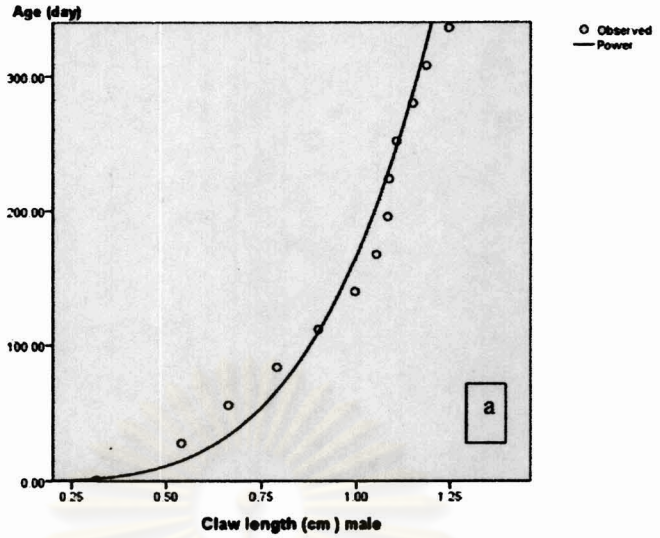
b. Female $y = 0.4852e^{0.8828x}$ $R^2 = 0.8743$ $p = 0.00$

If x = tarsal length (cm)

y = age (day)

e = 2.71828

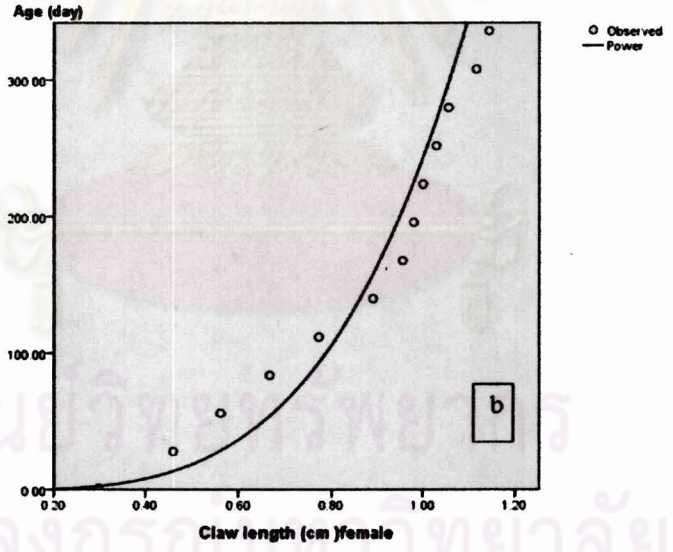
Figure 4.31 The regression model of tarsal length of male (a) and female (b) Red Junglefowl after hatching until 1 year old.



a. Male $y = 166.28x^{3.8918}$ $R^2 = 0.9596$ $p = 0.00$

If x = claw length (cm)

y = age (day)

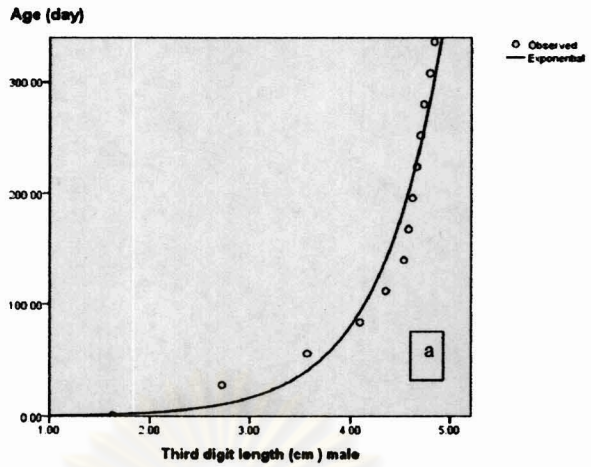


b. Female $y = 242.96x^{3.7163}$ $R^2 = 0.9203$ $p = 0.00$

If x = claw length (cm)

y = age (day)

Figure 4.32 The regression model of Claw length of male (a) and female (b) Red Junglefowl after hatching until 1 year old.

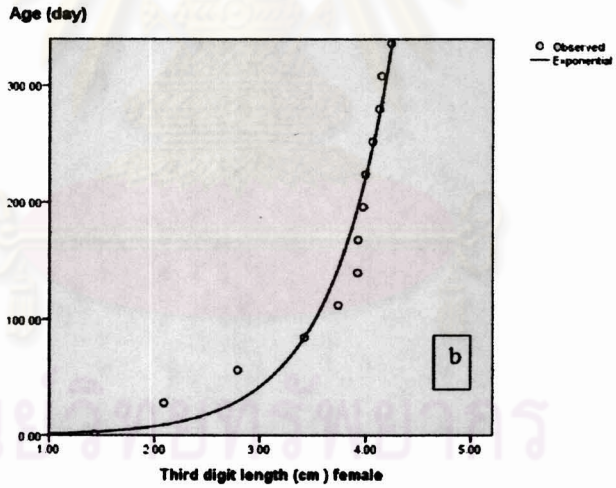


a. Male $y = 0.1461e^{1.5783x}$ $R^2 = 0.9437$ $p = 0.02$

If x = third digit length (cm)

y = age (day)

e = 2.71828



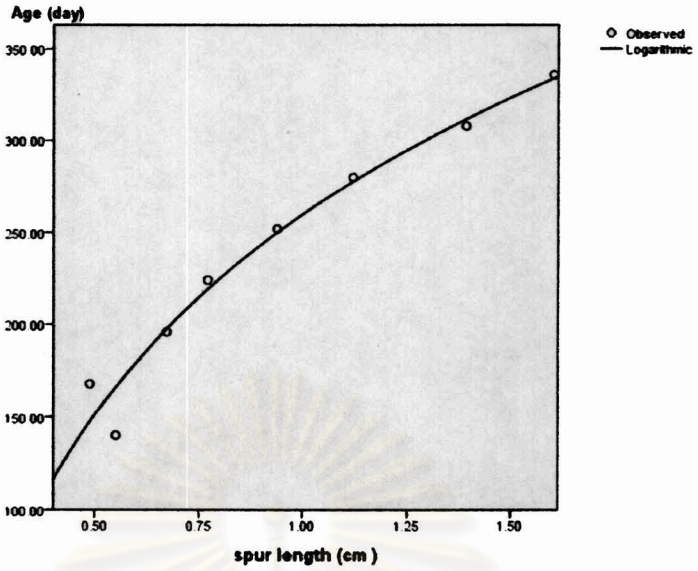
b. Female $y = 0.2711e^{1.6788x}$ $R^2 = 0.8941$ $p = 0.048$

If x = third digit length (cm)

y = age (day)

e = 2.71828

Figure 4.33 The regression model of third digit length of male (a) and female (b) Red Junglefowl after hatching until 1 year old.



Male $y = 156.774\log(x)+259.870$ $R^2 = 0.965$ $p = 0.00$

If x = spur length (cm)

y = age (day)

Figure 4.34 The regression model of spur length of male Red Junglefowl after hatching until 1 year old.

The tarsal growth rate could divide into three periods; first period (one week old to ten week old) the growth rate was increase rapidly. The second period (eleven to the twenty-four week old) the growth decreased ununiformly and the third period (twenty five week old to forty week old) the growth was stop decreased (Table 4.20 and Figure 4.35-4.36).

Table 4.20 Average Growth rate of tarsal length of Red Junglefowl from hatching until 48 week old.

Time (week)	Average Growth rate of tarsal length (%)	
	Male (n=27)	Female (n=17)
1	13.62	10.66
4	11.17	8.82
8	8.30	5.91
12	3.13	6.09
16	2.44	1.89
20	1.75	1.76
24	2.19	0.82
28	1.21	1.09
32	1.03	0.85
36	0.01	0.98
40	1.16	0.71
44	1.30	0.84
48	1.07	0.84

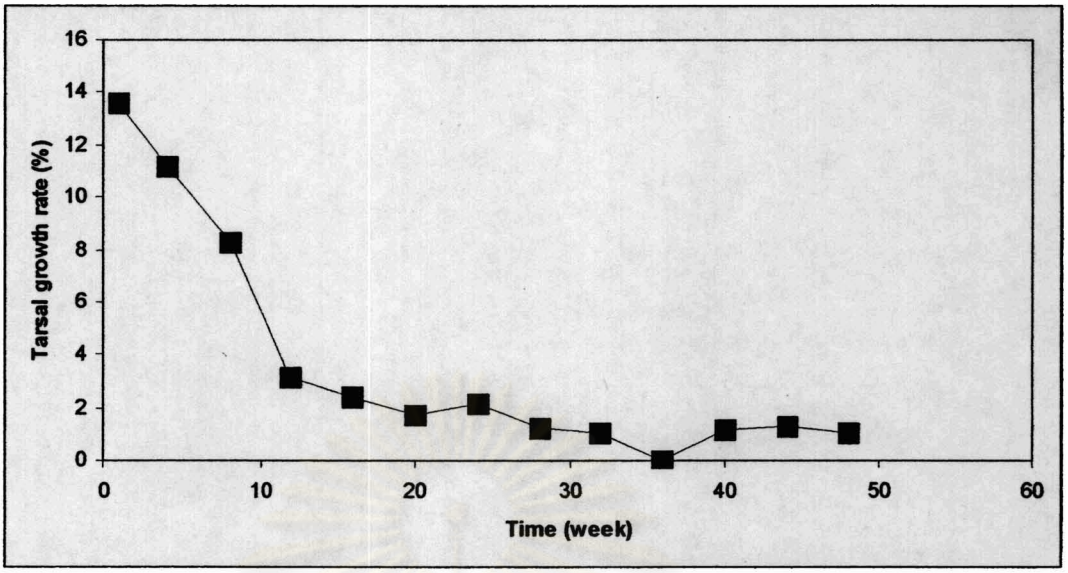


Figure 4.35 Growth rate of tarsal length of male Red Jungle fowl from hatching until 48 weeks old.

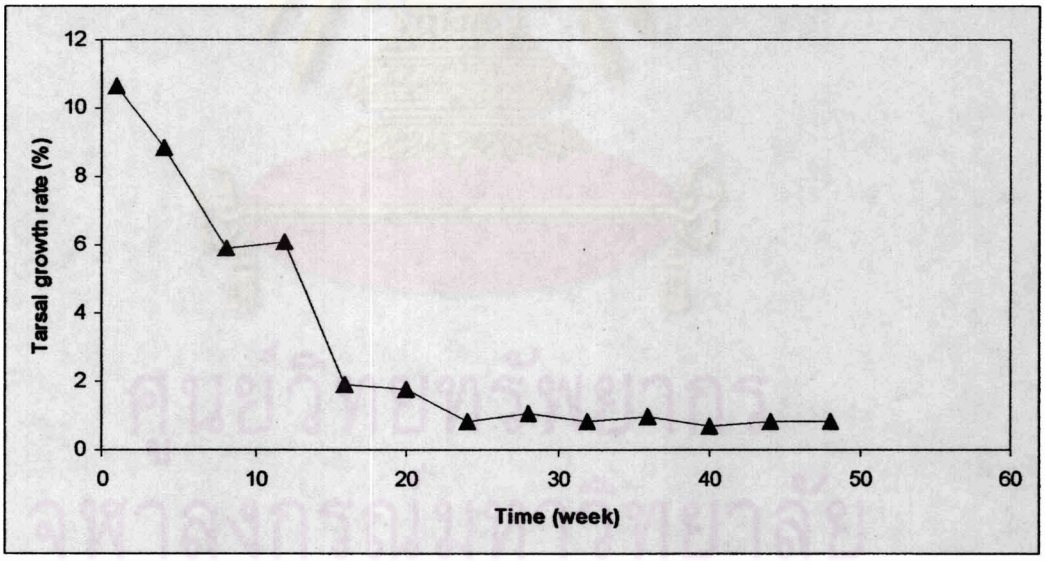


Figure 4.36 Growth rate of tarsal length of female Red Jungle fowl from hatching until 48 weeks old.

CHAPTER V
DISCUSSION

In this exploratory work into the morphological characteristics of the Red Junglefowl (*G. g. spadiceus*) it was found that all of descriptive characteristics evaluated could be used for age identification and especially between and within the first (1 - 7 days old) and the second (2 - 20 weeks old) growth periods. For the morphometrical characteristics, all 13 characteristics evaluated were validated in their ability to estimate the age of Red Junglefowls at all three growth periods, even at the second and the third (6 - 12 months old) growth periods. The age determination in this study revealed similar results to that of previous studies in other Galliform birds, such as the Blue Grouse (*Dendragapus obscurus*) at British Columbia (Bendell, 1955), In that study, morphometrics was developed for estimation of the age of juvenile and adult grouse, whilst descriptive characteristics, such as plumage and body mass development were used for the age determination of just hatched Blue Grouse chicks up to the first molting period.

The descriptive characteristics and morphometrical characteristics for the Red Junglefowl evaluated here are summarized as follows;

5.1 Descriptive Characteristics

In the first developmental growth period, the age estimation of Red Junglefowls can be estimated when the chicks were only one day old. The whole body was covered with yellow down feathers. When they were three days old, the age can be discerned by the emergence of primary and secondary wing feathers and also *the* greater primary and greater secondary wing coverts. These results are similar to those in a previous study on the wing and tail molts of Reeve Pheasants (*Syrmaticus reevesii*), where the primary feathers appeared at the first to the twenty eighth day of age, and the first to the seventh primaries appeared when the chicks were one to three days old Muller and Seiber, 1966).

In this study, when the Red Junglefowl chicks were five days old the tail feathers became visible, whilst by seven days after hatching the color of bill and tarsi (shanks), the visible presence of wing feathers, wing coverts and tail feathers were all informative characters that allowed discrimination of this age group. These

characteristics (traits) show similar results to that reported in the white ear lobed Red Junglefowl (*Gallus gallus gallus*) by Mattana Srigrajang (1983), where the primary and secondary wing feathers were reported to appear when the chicks were aged between four to five days old, and the tail appeared at one to two weeks after hatching. However, Muller and Seibert (1966) reported that the tail feathers of the Reeve Pheasant emerged in 12 days old chicks in both sexes, and Crawford (1986) reported that the tail feather replacement in Ruffed Grouse (*Bonsana umbellus*) could be used to estimate their age from 2 to 17 weeks old by the order of their sequential replacement. Thus, from these studies of only partial developmental time windows it is unclear how much variation in this pattern may occur between related species or within populations of a species subject to different genetics and environmental conditions.

In the second growth period, when chicks were two to four weeks old, the number of primaries could clearly be used to estimate their age. In addition to this study, Muller and Seibert (1966) reported that the ninth and the tenth primaries of the Reeve Pheasant appeared on the sixteenth to the twenty-eighth day after hatching and that the date of primary feather appearance could be used to estimate age of Reeve Pheasants and Galliformes birds in general.

In addition, the color of the primary wing feathers were found to be suitable to estimate the age of the Red Junglefowls and Hazel Grouse (*Bonasa bonasia*, whilst the color of primary wing feathers, the number of dark bars on the ninth primary and the width of the clear band of the tip of the first primary could also be used to classify juvenile and adults of Galliformes birds (Larson and Taber, 1980; Montadert and Léonard, 2009).

Furthermore, the replacement of the primary, secondary and tail feathers along with the number of bands of the flight feathers can all be used to create a key to estimate the age of American Kestrels (*Falco sparverius*) (Smallwood, 1989).

Moreover, this study here found that the color pattern of the secondary wing feathers of the Red Junglefowl can be used for estimation of the age of these birds in the first and early part of the secondary growth period for both male and female Red Junglefowls.

When the chicks were four weeks old, the age could be estimated by the median of both the primary and secondary wing coverts. This result is congruent with the reports of Ward (2007) and Kaczmarek *et al.* (2007), who found that wing coverts

could be used to predict the age of waterfowls and the common Snipe (*Gallinago gallinago*).

After four weeks the color of the tarsi and feet of these captive Red Junglefowls became darker. However, the field study of Delacour (1977) reported that the tarsi and feet of Red Junglefowls were grey when the birds were one week old and become darker as they aged over a broader time span than that seen here. The different changing period of tarsal color may be related to many factors, such as genetic variation (the study birds are from a single, potentially genetically bottlenecked, captive population), recent evolution and epigenetic or environmental effects, such as latitudinal or climate factors (Kimball *et al.*, 1997; Thompson and Taber, 1948).

When the chicks were six weeks old, the lesser primary and lesser secondary wing coverts could be sued to discriminate their age. This molting pattern of Red Junglefowls agrees with the study of Bendell (1955), who found that the plumage change in the body molt of Blue Grouse (*Dendragapus obscurus*) begins from head, neck and extends over the back side and legs.

At eight weeks old, the comb of male Red Junglefowls gradually appears but remains absent in females, becoming a character of use for sex discrimination. The first molting period occurs at 10 weeks of age in these captive bred birds in this study, but in contrast the Red Junglefowls (*G. g. gallus*) at Bangphra Wildlife Breeding Station, Chonburi Province, started to molt after six weeks old (Mattana Srigrajang, 1983). The different results in the onset of the first molting period between *G. g. spadiceus* of this study and *G. g. gallus* above is possibly caused by two reasons. First, each subspecies of Red Junglefowl may have a different growth rate according to their different genetics, or each may represent a different extreme within their own heterogeneous background. In addition, these two study sites are located in different latitudes (Huai Kha Khaeng: N 15° 35' 37" and Bangphra: 13° 13' 13") and altitudes (Huai Kha Khaeng: 650 m. amsl and Bangphra: 12 - 35 m. amsl), with consequentially different environmental conditions such as day length and average temperatures. These two reasons are in accord with the previous study of Davis (1968), who reported that the wing and tail molts of Ruffed Grouse (*Bonasa umbellus*) in Ohio were later in the year and age of birds than that for Ruffed Grouse in New York, suggesting that the duration or onset of the molting period in this bird maybe related with location and latitude, although of course this does not exclude the potential involvement of different genetics as well as or instead of such

environmentally influenced epigenetics. Watson (1962) studied the molt and age determination in an American Galliformes bird; the Cuban Bobwhite (*Colinus virginanus cubanensis*), and reported that the duration of the molting period is perhaps related to additional environmental factors, such as the temperature, humidity and diet.

After the first molting (postnatal molt), the sexual dimorphism of Red Junglefowls appeared at eight to ten weeks of age and it is more pronounced at twelve weeks of age (in terms of plumage and so excluding the sex comb). Mattana Srigrajang (1983) reported that sexual dimorphism of the Red Junglefowl subspecies, *Gallus gallus gallus*, occurred when the chicks were seven to ten weeks old, whilst in the Siamese fireback (*Lophura diardii*) the sexes can be differentiated when the fowl are five weeks old (Bonsanong, 2007). The different time of sexual dimorphism may be effected from growth, geographic distribution and is usually connected to their movement, supply of nutrients and water, photoperiod and day length and their hormonal control in each species (Berry, 2003; Crawford, 1990; Zuk, 1995).

In this study, in the second molting period (post-juvenile molt), the juvenile plumage started to change to the prenuptial plumage when the chicks were twenty weeks old, the same age as in the subspecies *Gallus gallus gallus,* Mattana Srigrajang (1983). Red Junglefowls shed and replaced all their wing feathers and wing coverts in the same molting pattern as that reported for the Ring-neck Pheasant (Petrides, 1945).

In this study, the third molting period (prenuptial molt) started when the birds were six months old, with the first winter plumage changing to the first nuptial plumage. These results are in accord with that reported for the Cock Pheasant (*Phasianus colchicus*) were the adult plumage was complete in all parts of the body at the twenty-sixth week of age (Macmullan,1948). At this period, the central pair of tail feathers in the male was longer than the other tail feathers. In the Reeve Pheasant, there is no prenuptial molt, but after the tail feathers have molted, the new feathers appeared progressively from the middle of the tail progressing with age to the outside (Muller and Seibert, 1966). However, Sukcharoen (1979) found that the tail feathers of the Great Argus (*Argusianus argus*) were longer than the other feathers when they were seven months old.

The plumage colors are much brighter when the birds were eleven to twelve months old. Males had more red on their face compared to females of the same age or younger birds of either sex, and also had a fleshier and enlarged red comb. When Red

Junglefowls were in an end of their breeding season (in June to July), both sexes were molted. This result is congruent with that of Kaul *et al.* (2004) who found that male Red Junglefowls in India shed off their long neck-hackles and tail feathers after the breeding season (March-June). Suthipong Arsirapoj (2008) reported that in Red Junglefowls in Huai Kha Khaeng wildlife sanctuary in the western Thailand, the neck feathers were short and black in early non breeding season (June-August), whilst Collias and Collias (1967) reported that, in the last week of June, some male Red Junglefowls in the northern part of India molted their golden neck feathers.

5.2 Morphometrical characteristics

From the study of thirteen morphometrical characters in the captive bred Red Junglefowls of this study, it was found that, in the first growth period when the birds were one day old, there were only two sex-specific significant differences; the half-wing span and third digit lengths. When the birds were three to seven days old, the significant differences between males and females were the head widths and third digit lengths.

In the second growth period, the morphometrical characteristics of male and female Red Junglefowls at two weeks of age were significantly different only in the lengths of their bills, wings, half-wing spans and tarsi, whilst at 3 – 20 weeks old sex-specific differences occurred in twelve to thirteen of the thirteen characteristics, with the only exception being that of the half-wing span lengths of fourteen week old individuals.

In the third growth period, when the chicks were six to nine months old, all thirteen morphometrical characteristics were significantly different between males and females, and this remained the case throughout this period except for the claw length, which was not significantly different between the sexes at ten to twelve months of age.

Therefore, it was found that these 13 morphometrical characters of Red Junglefowls could be used for reliable age and sex estimation, at least in these captive bred specimens. it of course remains to be established if this is true for wild specimens across their range, that is across the range of genetic and environmental diversity encompassed in this species, but it would be expected that the developmental patterns of at least some of these characters would likely be fairly

robust and so a combination of all 13 characters may provide a robust key to age within each sex.

The estimation of age by the morphometrical characters in these Red Junglefowls can be determined by regression analysis of the age estimation curve (Garson, 2009; Kaw and Trahan, n.d.; Lani, 2009; Sinn, n.d.; Urroz, n.d.). The results showed that all 13 of the evaluated morphological characteristics could be used for age estimation, but 5 of them, namely the weight, bill length, eye length, wing length and spur length, were the most reliable or suitable characters to estimate their age with coefficients of determination at the 95 – 98% of level accuracy (R^2 = 0.958-0.983).

The previous study of Mattana Srigrajang (1983), reported that both the body weights and tarsal lengths of red Junglefowls were correlated to their growth and so could be used to estimate their age by Regression analysis.

However, some morphometrical characteristics appear to be susceptible to variation induced by environmental factors (Sage, Roberson and Wise, 200; Woodburn, 2006; Kokoszynski, Bernackiand and Cisowska, 2010). For example, the weight of prairie-chickens (*Tympanuchus pallidicinctus*) can be affected by seasonal factors, latitude, and the quality and quantity of food (Bell *et al.*, 2007), but in contrast diet was reported to have no effect on body weight in the Common Pheasant, *Phasianus colchicus* (Sage, Putaala and Woodburn, 2002: Draycott *et al.*, 2002). Interestingly, the growth rate of wild grouse in captivity was higher than that in natural populations (Redfield and Swickkel, 1976, cited in Mattana Srigrajang, 1983), albeit only at the 9% of level accuracy. Likewise, the differences in diet did not cause any significant differences in the growth rate and body mass of mountain ducks in the wild and in captivity (Riggert, 1977). So this character may be used for age determination.

Although study reported here found that comb heights and comb lengths can be used as an age estimated model, it may not be a practical criteria because the comb size are different in the breeding and non-breeding season, due to differences in testosterone levels or secretion (Hasselquist, 1999; Rintamäki *et al.*, 1999; Zuk, 1995), and so potential likely to be subject to both genetic and, importantly, environmental variables within and between populations in addition to the age-specific affects.

Other morphometrical characteristics in this study were valuable and can be used as age estimators. in accord with the study of Gates (1966) who reported that the spur appearance can be used as an age estimation criterion in the Ring-necked Pheasant and was subsequently further supported by Woodburn *et al.*, (2006) along with the observation that Spur length was also an important predicting variable. In addition, the bill length, bill-nape length, tarsal length and wing length can all be used to separate the sex and the age of Balearic Shearwaters (*Puffinus mauretanicus*) at a 95 % confidence level (Genovart *et al.*, 2008).

When comparing the growth curve between domestic chickens (*Gallus gallus domesticus*) and Red Junglefowls (Appendix figure I) (Knížetová *et al.*, 1995), the growth rate of both subspecies are different. Red Junglefowls have a lower growth rate than domesticated chickens (as expected given the selection pressure during the domestication of chickens), and white ear lobed Red Junglefowls have a higher growth rate than red ear lobed Red Junglefowls (Appendix figure II) (Mattana Srigrajang, 1983).

When the tarsal growth rate equation was applied to the data from Red Junglefowls of this study, the growth was clearly separated into three periods. These results agree with those of Mattana Srigrajang (1983) who reported that in the first developmental growth period (1 - 10 weeks old) the tarsal growth rate increased rapidly, followed by a fluctuating growth rate in the second period (11 - 24 weeks old), and then a stable growth rate in the last developmental growth period (25 - 40 weeks old).

CHAPTER VI
CONCLUSIONS

1. Descriptive characteristics can be used for the age-identification, especially in the first and second growth periods, whilst morphometrical characteristics are valid for age estimation in every growth period over the first year of life, but are more accurate in the second and third growth periods.
2. The best criteria for use in the age determination of Red Junglefowls in the first growth period were the growing stages of the primary and secondary wing feathers.
3. At two weeks old, the primary feathers, beak and tarsi were all dark and can be used for age determination.
4. At six weeks old the first molting occurred replacing the down feathers with contour feathers. The second and third molting periods started when the chicks were twenty weeks and six months old, respectively.
5. Sexual dimorphism (in terms of the plumage) occurred when the chicks became twelve weeks old.
6. All thirteen morphometric characters evaluated in this studied were significantly different ($p<0.05$) between males and females from the third week of age.
7. Regression models of all 13 morphometrical characteristics can be used for age determination in the Red Junglefowl at 95 – 98% accuracy.
8. When the tarsal growth rate equation was applied to Red Junglefowls, the growth can be divided into three clear phases or periods. In the first period (1 - 10 weeks old) the tarsal growth rate increased rapidly, but its rate of increase then fluctuated in the second period (11 - 24 weeks old), before becoming stable and linear in the last period (25 - 40 weeks old).

Recommendations

1. measure total length or snout-vent length of Red Junglefowl to calculate the ratio of total length or snout-vent length and other morphometrical characteristics to use in predictive equations for age of Red Junglefowl.
2. Show multiple regression between morphological changes and ages to find out the accurate model or equation.
3. Control parameters to be nearest to the natural conditions, such as genetic factors, environmental factors, and food.
4. Study further on some characters, for example, spur which can increase in length after the age of one year old.

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APPENDIX

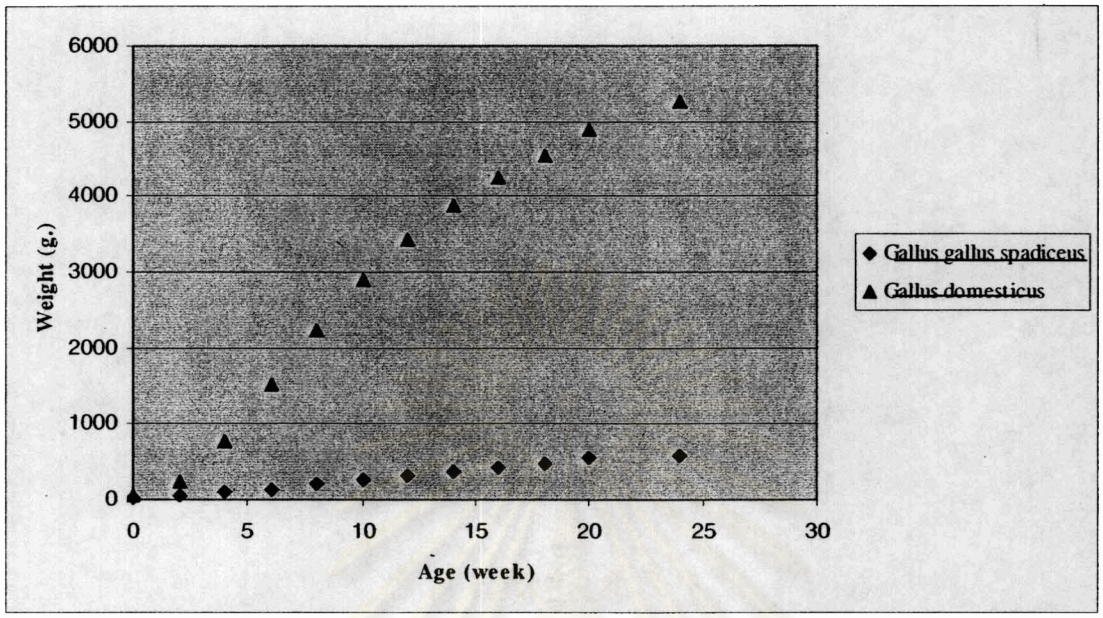

Figure I Comparative growth between Red Junglefowl (*Gallus gallus spadiceus*) and Domestic chicken (*Gallus gallus domesticus*) (Knížetová *et. al.*, 1995).

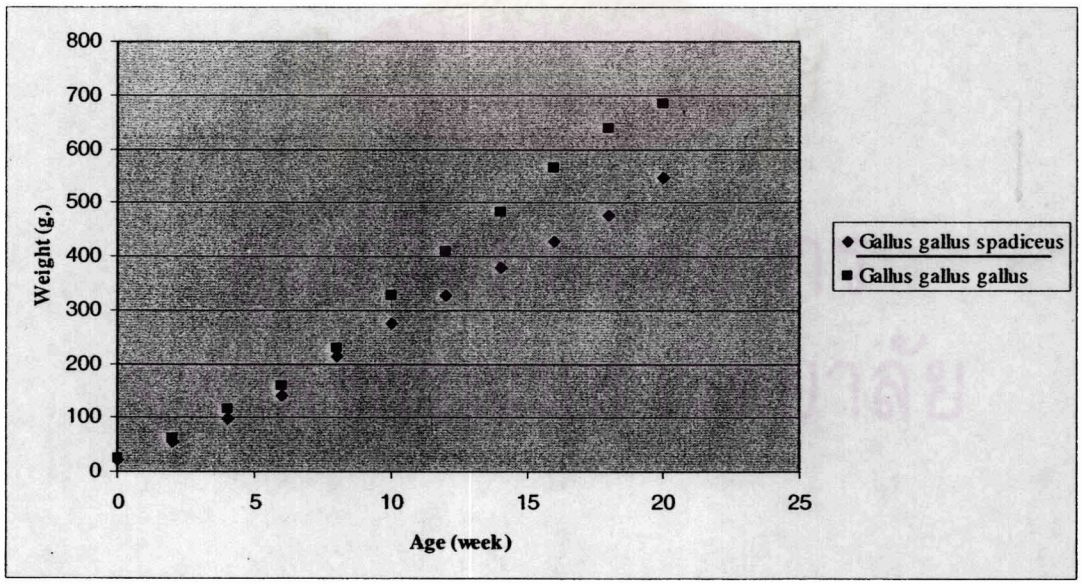

Figure II Comparative growth between Red Junglefowl (*Gallus gallus spadiceus*) and Red Junglefowl (*Gallus gallus gallus*) (Mattana SrikraJang, 1983).

No.	No.ring	Sex	weight (g)	Bill L (cm)	Bill-nape L (cm)	Eye L (cm)	Head W. (cm)	Comb H.X L (cm)	Wing L (cm)	Half-wing span (cm)	Tarsi L (cm)	Claw L (cm)	Toe L (cm)	Spur L (cm)	Tarsi color	Bill color	

Date..... Time.....

Note.....

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NO.	ring no.	Prim.	Sec.	1 greater	1 median	1 lesser	2 greater	2 median	2 lesser	neck	up back	back	up tail	tail	un tail	flank	thight	breast	sex

Date.....Time.....

Note.....

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BIOGRAPHY

Thapana Choicharoen was born on the 15th November, 1983, in Bangkok, Thailand. He received a high school certificate in Math-Science Program from Taweethapisek School in 2002. After that, he received a Bachelor degree in Education, majoring in Biology, in 2006, from the Faculty of Education, Chulalongkorn University and he received a Bachelor degree in Art, majoring in History, in 2008, from the Faculty of Humanity, Ramkhamhaeng University. Then, he continued his study in the Master Program in Zoology at Faculty of Science, Chulalongkorn University in 2006 and completed in 2009.

Work experient

Spacial instructor of Department of Science, Taweethapisek School in 2008.

Publications

Choicharoen, T. and Meckvichai, W. 2008. Morphological changes of Red Junglefowl (*Gallus gallus spadiceus*) in captive condition. *Abstracts.* 13th Biological Science Graduate Congress. National University of Singapore. December 15-17, 2008. Singapore.

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