PRODUCTION, EVOLUTION AND REPRODUCTIVE ENDOCRINOLOGY OF DUCKS

Y. Tanabe[1]

Azabu University, School of Veterinary Medicine
Fuchinobe, Sagamihara 229, Japan

Summary

Duck is an important domestic animal, especially in Asia. Eighty five percent of ducks in the world are kept in Asia, especially in the East and South Asia regions.

The ancestor of domesticated ducks was mallard (*Anas platylhynchos*), which are still migrating between north and southern parts in Eurasia. Ducks have been domesticated in China for at least 3000 years ago.

Phylogenetic studies on ducks, employing electrophoresis of blood proteins, indicate a marked difference of genetic constitution between duck breeds in southeast Asia and those in northeast Asia.

Duck embryonic ovary is much more active in secretion of sex steroid hormones especially estradiol than the embryonic testes. Estradiol secreted by the embryonic left ovary has an important role in female sexual differentiation in ducks. In the female ducks, plasma LH, estradiol and testosterone levels increase and reach peaks shortly before the first egg, while progesterone level reach a peak shortly after the first egg.

In laying ducks oviposition mostly occurs in the last 3 hr of darkness and first hr of light ranging 02:00-06:00 under 14 hr light (05:00-19:00) and 10 hr darkness photoperiodic condition. Measurements of plasma hormone levels reveal that onset of darkness is a major signal for LH release from the pituitary and the subsequent release of progesterone from ovary, and for induction of ovulation in the female duck.

(Key Words : Ducks, Production, Breeds, Phylogeny, Reproduction, Hormones)

Duck Production in Asia

Agriculture in Asia especially in developing countries can be characterized as (1) small land-holding, (2) low productivity, (3) rain-fed farming (4) labor intensive operation, and (5) mixed and integrated farming system. Although the production of rice and wheat are still the major food ingredient in most Asian countries, more attention is paid to livestock production to improve the quality of food for keeping good health for humans. Strategies for conservation and management of animal genetic resources as the Asian region are discussed by Tanabe (1989).

Livestock populations of 1987 in Asian-Australasian countries compiled by Sasaki (1989) based on FAO production year book are given in table 1. Shares of the Asia-Pacific region to the world are 29% for cattle, 96% for buffaloes, 49% for pigs, 40% for sheep, 51% for goats, 37% for chickens and 85% for ducks. Total population of ducks is estimated as 579 million in the world in 1986. China and South Asia including India are the major production sites for buffaloes, pigs, goats and ducks. The great majority (85%) of ducks in the world are kept in Asian countries. We should emphasize the importance of studies on ducks.

Breeds and duck industry in Japan

In Japan, ducks are of minor economic importance. Numbers of ducks kept in Japan were 353,000 in 1986. They are mainly kept for meat production and not for egg production. Major breeds are Khaki Campbell, Pekin and Kairyo Osaka. The former two breeds were originally imported from European countries and the United States of America. Kairyo Osaka breed originated from a hybrid between Japanese native ducks and Pekin, and the hybrid was backcrossed repeatedly with Pekin.

Breeds and duck industry in People's Republic of China

[1]Address reprint requests to Dr. Y. Tanabe, Azabu University, School of Veterinary Medicine, Fuchinobe Sagamihara 229, Japan.

Received August 8, 1990
Accepted January 9, 1992

TABLE 1. LIVESTOCK POPULATION IN ASIAN-AUSTRALASIAN COUNTRIES (UNIT:1,000 HEADS)

Country	Cattle	Buffalo	Pig	Sheep	Goat	Chicken	Duck
Developing countries							
1. Bangladesh	23,500	1,900	—	1,130	10,800	69,000	22,000
2. Bhutan	395	7	62	25	30	—	—
3. Burma	9,912	2,189	2,988	300	1,136	33,000	6,000
4. China	71,347	20,437	344,248	99,009	67,220	1,796,000	316,000
5. Cook Islands	—	—	18	—	3	—	—
6. Dem. Kampuchea	1,600	700	1,300	1	—	—	—
7. DPR. Korea	1,200	—	3,050	368	280	19,000	-
8. Fiji	159	—	29	—	59	6,000	—
9. India	199,300	74,260	8,800	55,482	105,000	175,000	9,000
10. Indonesia	6,470	2,994	6,216	5,300	12,900	400,000	28,000
11. Iran	8,350	230	—	34,500	13,600	105,000	145
12. Laos	593	1,050	1,565	—	74	8,000	—
13. Malaysia	620	245	2,200	75	347	50,000	—
14. Maldives	—	—		—	-		—
15. Mongolia	2,480	—	80	13,194	4,401	—	—
16. Nepal	6,374	2,890	467	821	5,070	10,000	—
17. Pakistan	16,951	13,698	—	26,640	31,882	140,000	1,000
18. Papua New Guinea	123	—	1,500	2	17	3,000	
19. Philippines	1,659	2,857	7,000	30	2,027	50,000	5,000
20. Rep. of Korea	2,800	—	3,347	4	217	56,000	1,000
21. Samoa, W	27	—	65	—	-		—
22. Solomon Island	23	—	51	—	—	—	—
23. Sri Lanka	1,807	1,008	97	28	502	9,000	—
24. Thailand	4,931	6,350	4,200	73	80	80,000	19,000
25. Tonga	8	—	1	—	11		
26. Vanuatu	103	—	73	—	12	—	—
27. Vietnam	2,775	2,666	11,796	—	432	70,000	30,000
Developed countries							
28. Australia	23,260	—	2,640	159,177	552	54,000	—
29. Japan	4,694	—	11,354	27	48	351,000	353
30. New Zealand	8,250	-	470	66,400	800	9,000	—
Asia-pacific total	399,751	133,516	413,679	462,608	257,737	3,503,000	440,498
World	1,277,729	138,375	839,852	1,157,643	501,762	9,445,000	519,498

China keeps 316 million ducks, occupying 61% of world duck population. For descriptions on Chinese duck breeds refer Tanabe (1985) and Qiu (1988).

Pekin, a meat type duck breed, having white plumage is popular in northern China. The body weight at 63 days of age is 2.5-2.8 kg, but improved lines reach 2.9 kg at 49 days of age. Average adult body weight is 3.5 kg. The egg production per year is 180, but improved lines produce 240 eggs weighing 95 g (Qiu, 1988).

Maya, egg type duck breeds, having wild plumage patterns of green head for males and brown feathers for females, is popular in middle and southern China. The body weights at maturity are 1.4-1.6 kg. Egg production per year under traditional husbandry is about 250 for Shaoxing duck and 260-300 for Jindin duck, both being typical Maya breeds (Qiu, 1988).

Breeds and duck industries in Indonesia

Indonesia keeps many ducks. The numbers are 28 millions. Many local breeds are kept in Indonesia; i.e., Alabio in Kalimantan; Medan in Sumatra; Lombok in Lombok; Mengwi in Bali; Tangerang, Tasikmalaya and Cerebon in West Java; Tegal and Magelang in middle Java; and Mojosari in east Java. The average age at first egg was 183 days with the range of 165-192 days. The fertility and hatchability were 86% and 76 %, respectively. The egg production per year under traditional husbandry is about 80-150 for the Tegal duck, and 200-240 for the Alabio ducks. The average egg weight for Tegal and Alabio eggs is 63 and 54 g, respectively. Average body weight at seven months of age of the female Alabio duck is 1.5 kg (Hardgosugroto and Atsuti, 1980).

Egg production is fairly good for such native breeds especially in the Alabio duck. They laid 245 eggs per duck in 360 days (Kingston et al., 1979). The high ability for these local breeds is entirely attributable to their history in the hands of peasants of Indonesia alone nothing to western breeding techniques (Clayton, 1984). Interestingly, Khaki Campbell duck breed, which is famous for high fecundity, has produced by mating between Indian Runner female, which was imported from Malaysia, and Rouen male (Clayton, 1984).

Breeds and duck industry in India

Numbers of ducks kept in India are 9 millions in 1986. Ducks constitute only 6% of the total poultry population. There are about 20 breeds of ducks. About 400 million duck eggs are produced in India per year. Ducks are not so important economically in India in comparison with chickens (Bhat et al., 1980).

Domestication and improvement of ducks

The ancestor of domesticated ducks was mallards, or green-head mallards, (*Anas platyrhynchos*) which are migrating between northern and southern parts in Eurasia. Ducks have been domesticated in China for at least 3000 years ago (Yeh, 1980). It is quite sure that the major center of domestication of ducks is the range from the east Asia to southeast Asia. However, the earliest evidence of domestic ducks in Europe is as recent as the 12th century A. D. (Delacour, 1964; Harper, 1972). It is possible that domestication of ducks occurred in various places in Eurasia, independently.

Evolutionary significance of domestication of ducks in Asia

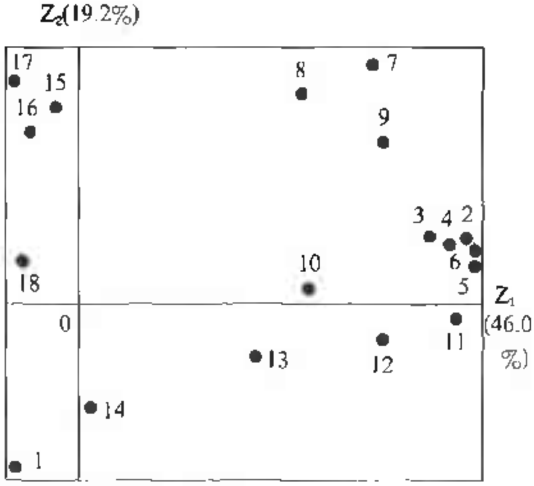
Domestication of mammals and birds is a recent event in human history and is defined as the condition where in the breeding care and feeding of animals and poultry are more or less controlled by man. But domestication involved profound morphological and physiological changes including the much higher reproductive fecundity. Clayton (1972) found that the egg production in captivity of the wild ancestral species of the domesticated birds was considerably high in some species, although the domesticated birds always produced more eggs than their ancestral wild ones. It is considered that the high productivity of the domesticated birds is an expression of natural fecundity given appropriate opportunity and owes little to artificial selection. The intervention of man introduces drastic environmental change and these changes which make possible the expression of genetic variability which, in the wild, would have been effectively forbidden by natural selection, and make possible to adapt the animal and birds to the new environment (Tanabe, 1980). This is the case either of ducks or the Japanese quail. Both of their ancestors were migrants. After captured, their reproductive fecundity has much improved during the domestication without so conscious selection in ducks (Kingston et al., 1979; Clayton, 1984; Tanabe, 1985), and in the Japanese quail (Kawahara, 1973; Tanabe, 1980). The fact that ducks were capable of extremely high levels of egg production and rapid growth in the rearing period before the application of modern selection and breeding techniques is related undoubtedly with the fact that their ancestors were migratory birds and not being residents.

These results strongly suggest that the improvement of productivity during the domestication of the species by recombination of pre-existing genes is much greater compared with that brought about by the utilization of mutation (Tanabe, 1980). Broodiness is very important instinct for survival of the wild bird species. But, with the advent of the incubator, this instinct is no longer necessary to the domesticated species for survival. In fact domestic ducks, quail and many flocks of chickens have lost this instinct during the demestication. The lost of the instinct has contributed to improve the egg productivity of these species.

Phylogenetic relationships of duck breeds

Extensive phylogenetic studies on duck breeds employing electrophoresis of blood proteins have been done by Tanabe et al. (1984, 1988, 1990). Phylogenetic relationships among 16 duck breeds, mainly Asian breeds, and two flocks of mallards in Japan (Mallard 1 is migrating one, and Mallard 2 is descendants of hybrids between mallards and indigenous breeds in Japan) are illustrated as two dimension scattered diagram drawn by principal component analysis of variance-covariance matrix of gene frequencies at 10 polymorphic loci (figure 1). The genetic constitutions of ducks in west (Cerebon, Tangelang and Tasikmalaya) and central Java (Tegal and Magelang), Sumatra (Medan) and Kalimantan (Alabio) and of Khaki Campbells are different from those in east Java (Mojosari), Bali (Mengwi) and Lombok (Lombock). More pronounced difference of the gene constitution was observed between the group of ducks in Indonesian islands and Khaki Campbells and the group of ducks in China and Japan such as Pekin imported from Denmark, the descendants of a hybrid between Pekin and Aylesbury, and Pekin imported from China, Tsaiya (White Tsaiya, Taiwan origin), Kairyo Osaka and two flocks of mallards kept in Japan, indicating a marked difference of genetic constitution between the duck breeds in southeast Asia.

It is reasonable that a close relationship is observed between Khaki Campbell and most of Indonesian duck breeds except east Indonesia, because Khaki Campbells produced by mating between Indian Runner female which was imported from Malaysia and Rouen male (Clayton, 1984). From the data described above, it is postulated that the Japanese Native breed originated from the hybridization of the Chinese ducks and semi-domesticated mallards in Japan about 800 years ago.



1. Tsaiya
2. Cirebon
3. Tangerang
4. Tasikmalaya
5. Tagel
6. Magelang
7. Majosari
8. Mengwi
9. Lombok
10. Medan
11. Alabio
12. Khaki Campbell (England)
13. Khaki Campbell (Japan)
14. Pekin (China)
15. Pekin (Denmark)
16. Kairyo Osaka
17. Mallard 1
18. Mallard 2

Figure 1. Phylogenetic relationships among 16 duck breeds and mallard. The position of 16 duck breeds and two mallards is defined by the first (Z_1) and the second (Z_2) principal components of the distance matrix based on variance-covariance analysis.

Ontogenetic endocrinology of ducks

Tanabe et al. (1983) and Nakamura et al. (1990) measured hormone concentrations by *radioimmunoassays* and showed that duck embryonic left ovary is much more active in production and secretion of sex steroid hormones especially estradiol than the embryonic testes, while right embryonic ovary is not active (figure 2, 3); suggesting that the sex of the avian species including duck is basically male having homozygosity of sex chromosome (ZZ), and that estradiol secreted by the embryonic ovary has an important role in female sex differentiation in ducks (Tanabe et al., 1983, 1986).

Effect of aging on plasma LH and sex-steroid

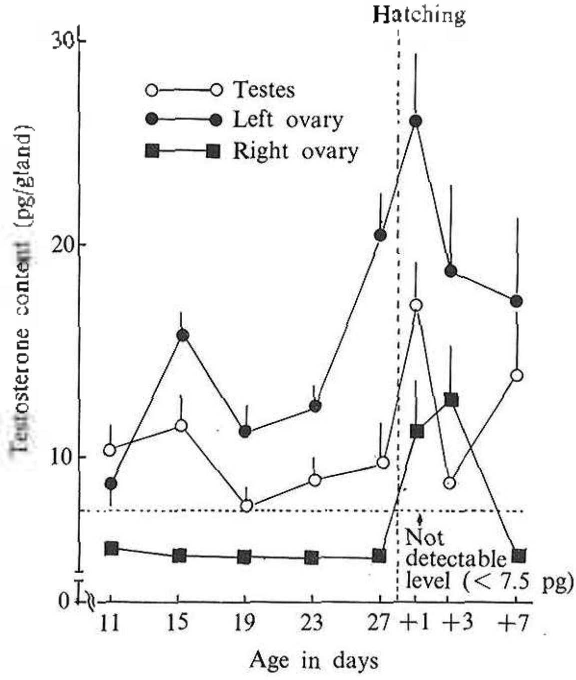


Figure 2. Testosterone content in testes, left ovary and right ovary of embryonic and postembryonic ducks. Each spot and vertical line represents an mean of 8-16 samples and SEM, respectively.

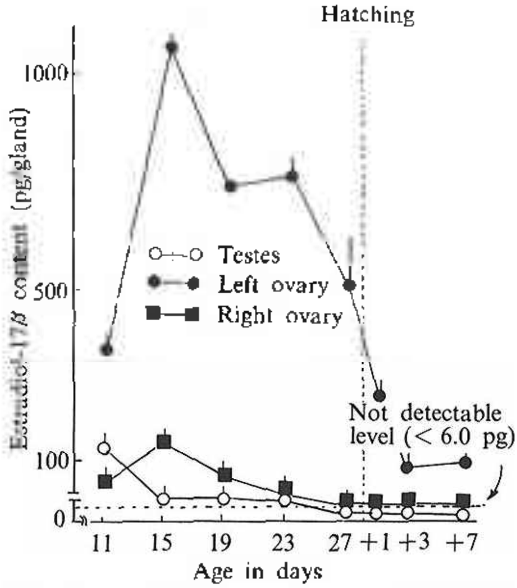


Figure 3. Estradiol-17 β content in testes, left ovary and right ovary of embryonic and post-embryonic ducks. Each spot and vertical line represents a mean of 8-16 samples and SEM, respectively.

hormone concentrations in ducks was studied (Tanabe, 1985). Changes in weekly rate egg production of 21 female Khaki Campbell ducks between 28 and 1442 days of age under the 14 hr light (05:00-19:00) and 10 hr darkness photoperiodic conditions are shown in figure 4. The egg production rate decreased with advancing in age. After hatching, plasma concentration of estradiol was higher in the male than the female at 56 days of age, but reduced to lower levels than the female at sexual maturity. The peaks of LH, estradiol and testosterone were observed shortly before the first egg, but a peak of progesterone was observed shortly after the first egg in the female ducks. At sexual maturity, high plasma levels of LH, estradiol and progesterone were observed in the female ducks, while a higher level of testosterone, and a similar level of LH, and lower levels progesterone and estradiol were observed in the plasma of the males in comparison with the female (figures 5, 6, 7, 8).

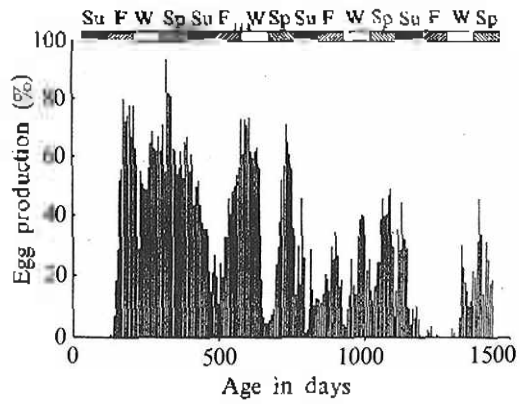


Figure 4. Effect of age on the weekly rate of egg production of 21 female duck between 28 and 1442 days of age. F. W. Sp and Su at the top represents fall (September to November), winter (December to February), spring (March to May) and summer (June to August), respectively. Birds were given 14 hour light (05:00-19:00) per day except the first interval of 4 weeks designated as ↓↓ 16 hour light (06:00-22:00) and the second one as ↓↓ 18 hour light (06:30-00:30) per day, respectively.

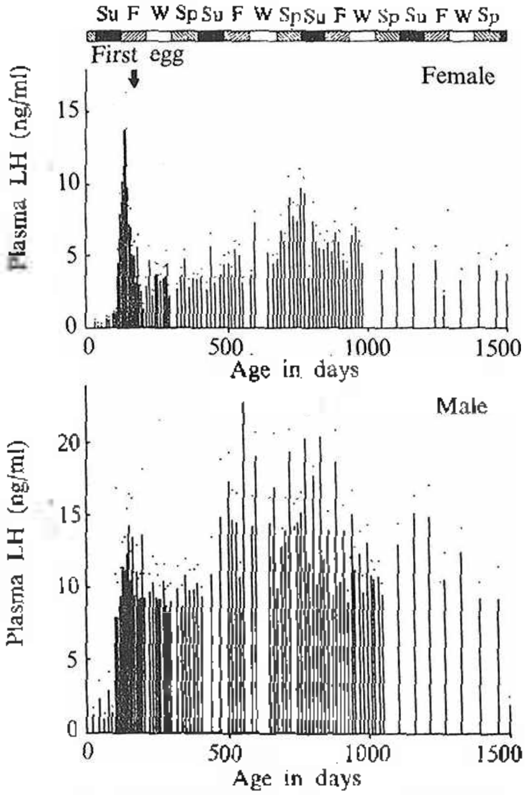


Figure 5. Effect of age on plasma LH and concentrations in the female and male ducks. Each line and spot represents a mean of 21 females or 11 males and SEM, respectively.

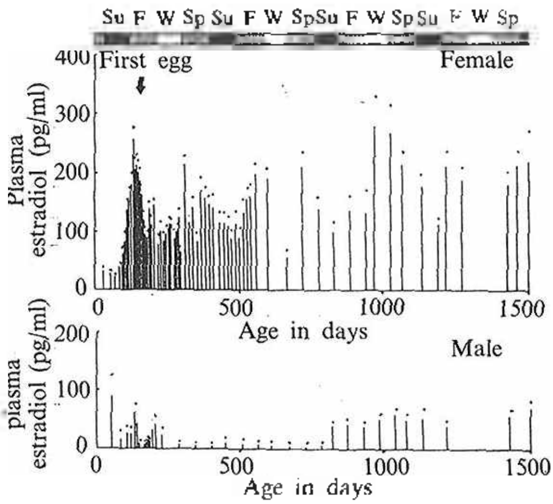


Figure 6. Effect of age on plasma estradiol concentration in the female and male ducks. Each line and spot represents a mean of 21 females or 11 males and SEM, respectively.

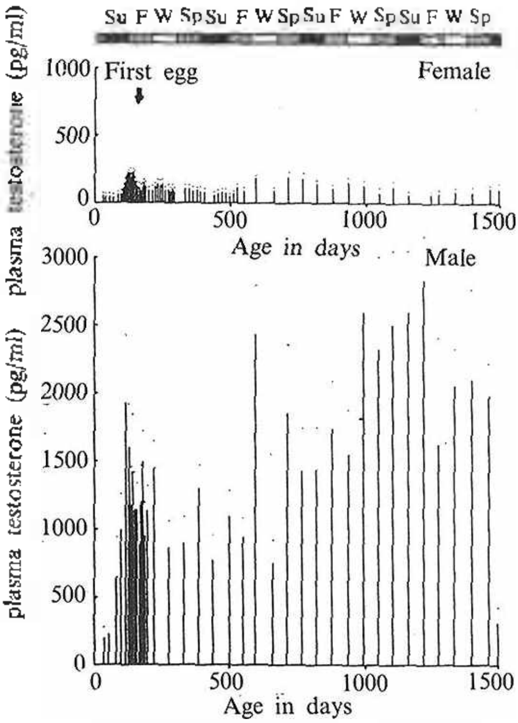


Figure 7. Effect of age on plasma testosterone concentrations in the female and male ducks. Each line and spot represents a mean of 21 females or 10 males and SEM, respectively.

Endocrine control of ovulation in ducks

A striking difference in egg-laying (oviposition) patterns was observed among chickens, the Japanese quail and ducks under 14 hr light (05:00-19:00) and 10 hr darkness photoperiodic conditions. Oviposition mostly occurred in the last 3 hr of darkness and the first hour of light ranging 02:00-06:00 for ducks, and in the first 8 hr of light except the first hour ranging from 06:00-14:00 for chickens, and in the last 5 hr of light ranging from 14:00-19:00 for quail (Tanabe and Nakamura, 1980). In laying ducks, plasma LH, progesterone and estradiol started to increase shortly after the time of lights off. Delaying the time of lights off for 3 hr and 5.5 hr resulted in delaying the time of oviposition for 2.5 and 3.5 hr, respectively. In all the cases of the ducks, increases of the hormones started to increase shortly after the time of lights off (Tanabe et al., 1980). Interestingly, a delay of the start of

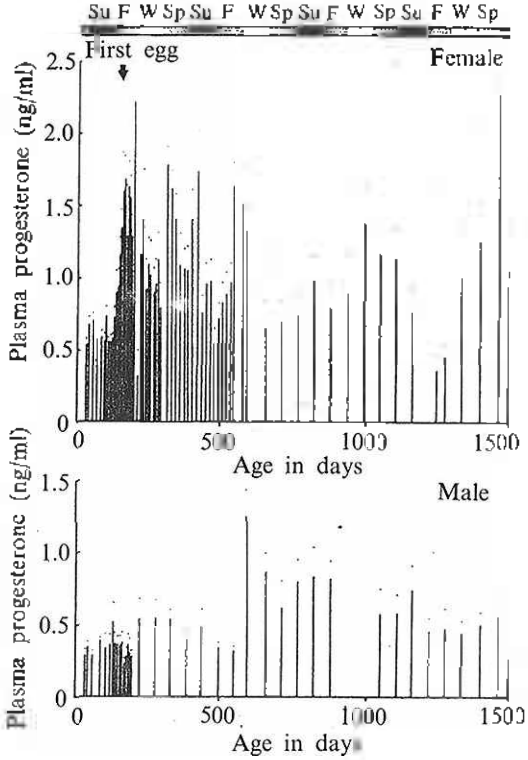


Figure 8. Effect of age on plasma progesterone concentrations in the female and male ducks. Each line and spot represents a mean of 21 females or 11 males and SEM, respectively.

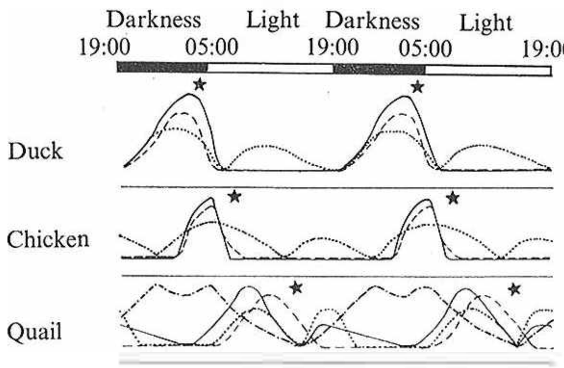


Figure 9. Diagrammatic presentation of changes in pituitary (– — –) and plasma (——) LH, and plasma progesterone (– – –) and estradiol (------) during the ovulatory cycle of female ducks, chickens and quail. ★ indicates the time of ovulation.

the increases in the hormones by 5-6 hr was noted chickens, while no such delay was observed in ducks. This is reason why chickens lay in the morning after dawn, whereas ducks lay usually before dawn or very early in the morning (Tanabe, 1980).

A diagrammatic presentation of the relationships between hormone levels and oviposition in ducks, quail and chickens is illustrated in figrue 9. It is plausible that onset of darkness is a signal for LH release from the pituitary and the increased production and the subsequent release of progesterone from the ovary either in ducks and

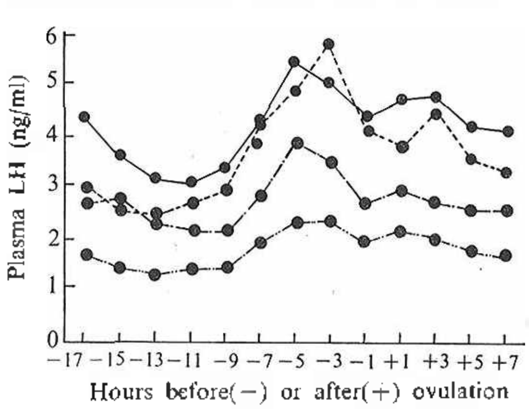


Figure 10. Effect of age on plasma LH concentrations during the ovulatory cycle of female ducks of 201, 308, 407 and 538 days of age. —·—·— 201 days (n=11); —·— 308 days (n=10); ······· 407 days (n=10); —— 538 (n=9) days.

chickens, and that contrarily the onset of light is a signal in the Japanese quail (Tanabe and Nakamura, 1980). However, it is possible that onset of light is a minor signal for LH increase, although onset of darkness is a major signal for it in chickens.

Effects of age on plasma levels of the hormones which are responsible for the induction of ovulation at ovulation in female Khaki Campbell ducks are studied by Tanabe and Nakamura (1980). A preovulatory LH surge always was observed 3-5 hr before ovulation in ovulating ducks of all ages. The peak was less prominent at 201 days of age, more prominent at 308 days of age, and most prominent at 407 and 537 days of age, furthermore, the basal levels of LH increased with advancing age (figure 10). However, no significant difference due to age either in the peak level or the basal level was observed in progesterone concentrations (figure 11). Egg production rates on a henday basis for one week prior to 201, 308, 407, and 538 days of age were 77.4, 66.7, 57.1 and 55.5%, respectively, indicating that the egg production rate decreased with advancing age. It is plausible that the sensitivity of the ovary to the production of sufficient amounts of progesterone due to LH stimulation decreases with advancing age, so that larger amounts of LH are necessary for the induction of ovulation in older ducks which have poor laying activity (Tanabe and Nakamura, 1980).

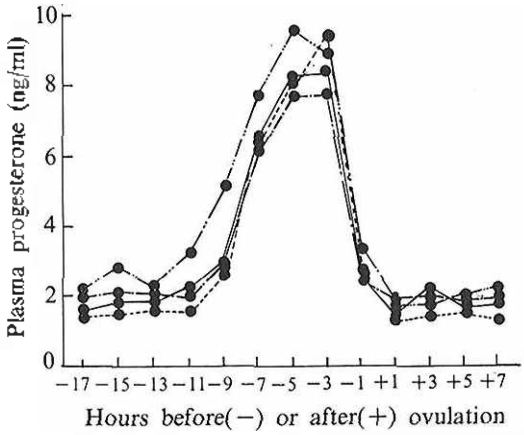


Figure 11. Effect of age on plasma progesterone concentrations during the ovulatory cycle of female ducks of 201, 308, 407 and 538 days of age. —— 201 days (n=11); ——— 308 days (n=10); --- 407 days (n=10); —— 538 days (n=9)

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