Partial Infertiliyt of Intergeneric Hybrid Eggs between the Muscovy Drake and the Common Duck

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(Tables 1-4; Plate 1)

Since 1955, a routine work on the artificial insemination in birds has been going on in this laboratory under the direction of Prof. emer. Dr. J. YAMANE, former Dean of the Faculty of Fisheries and Animal Husbandry, Hiroshima University. At first, the possibility of artificial insemination in the Common duck was tested with the semen collected by massage, the insemination being performed by palpating the orifice of oviduct (WATANABE & SUGIMORI, 1957). It was confirmed that there was no difference in the fertility rate of the Common duck between the artificial insemination and the natural mating. Nevertheless, it was found that the success of massage method depended exclusively upon psychology of the drake. It was an elaborate work to train a drake for 10～15 days until it showed a response to the massage. Also, the time required for inducing ejaculation and the volume of semen obtained varied exceedingly according to the individual bird. At the injection of semen, the palpation of the orifice of oviduct required a considerable skillfulness on the part of the operator. To eliminate these disadvantages, the author has developed a new technique of artificial insemination to the Common duck. It revealed that the absolute and relative fecundities were 80% and 85% respectively, which did not differ from those of Common duck naturally mated in the same season (WATANABE, 1957).

Based upon two series of experiments above mentioned, the author has proceeded to solve the problem of the alleged partial infertility of intergeneric hybrid eggs between the Muscovy drake and the Common ducks by employing his new technique. The present paper is aimed to report the results of his experiments carried out along this line.

The author wishes to express his sincere thanks to Prof. emer. Dr. J. YAMANE for giving this theme as well as for constant guidance and encouragement in the course of the work.

(I) MATERIALS AND METHODS

A. Birds used for the experiments

The birds experimented upon consisted of an adult Colored Muscovy drake and five 2-year-old White Common ducks, the so-called Osaka-ducks of Pekin strain; the former was raised in Okayama Prefecture and the latter in our laboratory.

B. Collecting the Muscovy semen

It was found that the semen collection from the Muscovy by massage is absolutely impossible because of its nervous temperament and extraordinary wing strength. The collection of semen by means of interrupted copulation, as ONISHI & KATO (1955) described, was found to be very troublesome for practical use and not always successful. On the contrary, the method of electro-ejaculation reported in the previous paper (WATANABE, 1957) proved that it was very simple to apply to the Muscovy drake with a regular success. The procedure was as follows: the drake was fixed on a small wooden table with a height of 25 cm, a width of 21 cm and a length of 25 cm, with a side plate of 45 cm in height and 8 cm in width. An electric pole, a sharp needle of an electro-ejaculator manufactured by FHK Co, Ltd., Tokyo, was inserted into the hypoderm of sacral region and the other pole, a blunt rod, into the vent. Instead of 30 volts and 0.06～0.08 amperes applied in the previous experiments, in the present experiment, 20 volts and 0.04～0.05 amperes of an alternating current was applied, as it was later found to be strong enough. The current was repeatedly turned on for three to four times for 3 seconds a time with an interval of 5 seconds. At every turning of the current the drake showed a momentary rigidity. Upon sufficient stimulation, the drake flapped reflexibly its tail revealing the emission of semen. By pressing the stiff penis by hand, the semen was received in a graduated tube of funnel shape. All the responses of the Muscovy drake did not differ from those of the Common duck previously described. No maleffect due to the electro-stimulation on the Muscovy drake has so far been observed.

C. Examination of semen characteristics

Every ejaculate thus secured once a week throughout the year was examined in respect to its characteristics: volume of semen, sperm concentration per unit volume, total number of sperms per ejaculate and motility of the sperm.

D. Insemination of Common ducks with Muscovy's semen

An ejaculate recovered from the Muscovy drake on September 23, 1958 was alloted for insemination to 5 Common ducks which were beforehand proved to be good layers and strictly isolated from drakes. The semen secured was immediately diluted by ten times with 0.85% physiological saline solution and each 0.3 ml of this mixture was simultaneously injected to the 5 ducks. Since the total volume of the ejaculate was 0.5 ml and contained 102,000 sperms per cubic millimeter, the number of sperms each duck received was approximately 3,060,000. At the microscopical examination, about 85% of sperms exhibited very active motility. For inducing the inseminator through the vaginal orifice, a metallic speculum specially deviced for the duck was used. With regard to all the other procedures of insemination technique, the author would like to refer to his previous paper (WATANABE, 1957).

E. Incubation test

All the eggs laid during two weeks following the insemination were put into an in-

cubator at 10:00 a. m. every day and candled on the 5th day of incubation which lasted a week after the apparent cessation of development.

(II) RESULTS OF EXPERIMENTS

A. Semen characteristics of the Muscovy drake in comparison with that of the Common drake

The semen characteristics of these two species were determined every week throughout the year and summarized in the Tables 1 and 2.

In comparing these two tables the most conspicuous fact was that the total number of sperms per ejaculate of the Muscovy drake was strikingly small compared with that of the Common drake, in spite of the same method of semen collection. It showed a wide variation and the difference was always incomparably enormous.

Further, the testicular activity reflected by the total number of sperm per ejaculate[1] of the Muscovy seemed to be at its highest in June, and at its lowest in November and December, although the curve from January to October did not slope smoothly. On the contrary, the testicular function of the Common drake was most active from April to June, rising to a peak in May. From September to February the spermatogenic activity was at its lowest, but the sperm number at its minimum exceeded that of the Muscovy at its peak in May.

B. Fertility test

Fertility of the Common ducks simultaneously inseminated with a fraction of one and the same ejaculate of Muscovy drake was tested by incubation of the hybrid eggs. Table 3 gives the results of this heteroinsemination. The insemination was performed at 6.30 a.m., September 23, 1958. The eggs laid in the following morning were unexceptionally infertile. The first fertile eggs always appeared in the morning of the second day before 6.00 a.m. This phenomenon was in accordance with the homoinsemination i.e. insemination of the Common ducks *inter se* as shown in Table 4. The maximum duration in which the Muscovy semen released in the duck's genital tract remained fertile was 7 days after the insemination (No. 49). This did not differ from the homologous semen injecetd (Table 4). The absolute fecundity, the percentage of the number of the ducks which produced fertile eggs to the total number of ducks inseminated, was also the same both in heteroinsemination and homoinsemination. As far as the daily fertility rate was concerned, however, the semen of these two species were not the same. On the second day after the insemination, when the maximum fertility rate was obtained, it showed 75% in the heteroinsemination, and 80% in the homoinsemination. On the third day it went down to 50% in both cases. The ratio of the number of fertile eggs to the total number of eggs produced during the whole week following a single insemination with heterologous semen was 27.6% (8:29), whereas it was 33.3% (22:66) with the

1) Neither the semen volume nor the sperm concentration per unit volume of an ejaculate does not reflect the real testicular activity; the absolute total number of sperms per ejaculate is only a mirror for it.

Table 1. Seasonal variation of characteristics of semen obtained by electro-ejaculation in a Muscovy duck (from December 1957 to November 1958)

Week No.		Volume per ejaculate (ml)	Sperm concentration per mm^3	Total number of sperm per ejaculate	Monthly average
Jan.	1.	0.18	599,000	107,820,000	77,368,000
	2.	0.35	305,000	106,750,000	
	3.	0.32	220,000	70,400,000	
	4.	0.35	70,000	24,500,000	
Feb.	1.	0.35	430,000	150,500,000	99,625,000
	2.	0.50	190,000	95,000,000	
	3.	0.20	90,000	18,000,000	
	4.	0.30	450,000	135,000,000	
Mar.	1.	0.50	240,000	120,000,000	100,780,000
	2.	0.30	300,000	90,000,000	
	3.	0.20	380,000	76,000,000	
	4.	0.32	366,000	117,120,000	
Apr.	1.	0.35	32,000	11,200,000	13,950,000
	2.	0.30	22,000	6,600,000	
	3.	0.40	45,000	18,000,000	
	4.	0.40	50,000	20,000,000	
May	1.	0.20	61,000	12,200,000	51,850,000
	2.	0.60	114,000	68,400,000	
	3.	0.50	64,000	32,000,000	
	4.	0.60	158,000	94,800,000	
June	1.	0.60	330,000	198,000,000	154,300,000
	2.	0.70	298,000	208,600,000	
	3.	0.30	134,000	40,200,000	
	4.	0.60	284,000	170,400,000	
July	1.	0.20	208,000	41,600,000	40,800,000
	2.	0.40	96,000	38,400,000	
	3.	0.50	80,000	40,000,000	
	4.	0.40	108,000	43,200,000	
Aug.	1.	0.30	236,000	70,800,000	81,550,000
	2.	0.50	294,000	147,000,000	
	3.	0.30	142,000	42,000,000	
	4.	0.40	166,000	66,400,000	
Sep.	1.	0.40	158,000	63,200,000	90,300,000
	2.	0.50	102,000	51,000,000	
	3.	0.50	218,000	109,000,000	
	4.	0.30	460,000	138,000,000	
Oct.	1.	0.30	80,000	24,000,000	13,750,000
	2.	0.20	4,000	800,000	
	3.	0.30	96,000	28,800,000	
	4.	0.10	14,000	1,400,000	
Nov.	1.	0.10	20,000	2,000,000	1,025,000
	2.	0.30	3,000	900,000	
	3.	0.10	10,000	1,000,000	
	4.	0.20	1,000	200,000	
Dec.	1.	0.20	35,000	7,000,000	8,075,000
	2.	0.10	83,000	8,300,000	
	3.	0.05	128,000	6,400,000	
	4.	0.05	212,000	10,600,000	

Table 2. Seasonal variation of characteristics of semen obtained by electroejaculation in the Common ducks (from April 1957 to May 1958). Each number is an average of 4 ducks.

Week No.		Volume per ejaculate (ml)	Sperm concentration per mm^3	Total number of sperm per ejaculate	Monthly average
Jan.	1.	0.10	2,640,000	264,000,000	246,200,000
	2.	0.10	3.210,000	321,000,000	
	3.	0.10	1,240,000	124,000,000	
	4.	0.10	2,760,000	276,000,000	
Feb.	1.	0.20	4,080,000	816,000,000	641,500,000
	2.	0.20	3,120.000	624,000,000	
	3.	0.20	2,490,000	498,000,000	
	4.	0.20	3,140,000	628,000,000	
Mar.	1.	0.20	1,348,000	269,600,000	1,607,550,000
	2.	0.30	8,362,000	2,508,600,000	
	3.	0.20	16,710,000	3,342,000,000	
	4.	0.20	1,550,000	310,000,000	
Apr.	1.	0.60	6,460,000	3,876,000,000	3,079,000,000
	2.	0.40	7,900,000	3,160,000,000	
	3.	0.40	4,620,000	1,848,000,000	
	4.	0.60	5,720,000	3,432,000,000	
May	1.	0.40	14,100,000	5,640,000,000	3,570,500,000
	2.	0.30	6,740,000	2,022,000,000	
	3.	0.50	7,960,000	3,980,000,000	
	4.	0.40	6,600,000	2,640,000,000	
June	1.	0.20	2,520,000	504,000,000	1,731,250,000
	2.	0.30	5,140,000	1,542,000,000	
	3.	0.50	4,270,000	2,135,000,000	
	4.	0.80	3,430,000	2,744,000,000	
July	1.	0.40	5,580,000	2,232,000,000	1,126,750,000
	2.	0.20	4,850,000	970,000,000	
	3.	0.10	7,560,000	756,000,000	
	4.	0.10	5,490,000	549,000,000	
Aug.	1.	0.20	2,620,000	524,000,000	431,500,000
	2.	0.10	3,390,000	339,000,000	
	*3.	—	—	—	
	*4.	—	—	—	
Sep.	1.	0.10	1,240,000	124,000,000	159,400,000
	2.	0.10	2,577,000	257,700,000	
	3.	0.10	1,310,000	131,000,000	
	4.	0.10	1,250,000	125,000,000	
Oct.	1.	0.10	2,810,000	281,000,000	319,750,000
	2.	0.10	1,570,000	157,000,000	
	3.	0.20	2,890,000	578,000,000	
	4.	0.10	2,630,000	263,000,000	
Nov.	1.	0.20	2,800,000	560,000,000	524,000,000
	2.	0.20	3,180,000	636,000,000	
	3.	0.10	3,380,000	338,000,000	
	4.	0.20	2,810,000	562,000,000	
Dec.	1.	0.10	3,080,000	308,000,000	330,750,000
	2.	0.10	2,840,000	284,000,000	
	3.	0.10	4,170,000	417,000,000	
	4.	0.10	3,410,000	314,000,000	

* In spite of electro-stimulation, no ejaculation occurred.

Table 3. Results of a simultaneous insemination of Common ducks with a fraction of a Muscovy ejaculate

Days following insemination	Common ducks inseminated					Number of eggs laid	Number of fertile eggs	Fertility rate (%)
	No. 32	No. 38	No. 49	No. 54	No. 58			
								per day
1	0	–	0	–	–	3	0	0
2	0	+	+	–	+	4	3	75
3	+	–	+	–	0	4	2	50
4	+	–	+	–	–	5	2	40
5	–	–	–	–	–	5	0	0
6	–	0	0	–	–	3	0	0
7	–	–	+	–	–	5	1	20
Total						29	8	per week 27.6

Table 4. Results of a simultaneous insemination of Common ducks with a fraction of a Common duck's ejaculate

Days following insemination	No. of Common ducks inseminated										Number of eggs laid	Number of fertile eggs	Fertility rate (%)
	1	2	3	4	5	6	7	8	9	10			
													per day
1	–	–	–	0	–	–	–	–	–	–	9	0	0
2	–	+	+	+	+	+	+	+	–	+	10	8	80
3	–	+	–	–	+	+	–	+	–	+	10	5	50
4	–	+	–	0	+	+	–	+	–	+	9	5	55
5	–	+	–	+	0	–	–	–	–	–	9	2	22
6	–	–	–	+	–	–	–	–	–	0	9	1	11
7	–	–	–	–	–	–	–	+	–	–	10	1	10
Total											66	22	per week 33.3

homologous semen. It was clearly seen that the length of time during which the Muscovy's semen remained fertile was shorter than that the Common duck's semen did.

C. Hatchability

The length of incubation period of the hybrid eggs occupied an intermediate position between those of the two parental species, ranging from 29 to 32 days with an average of 31 days. In the Common duck here employed, it varied from 27 to 29 days with an average of 28 days, while that of the Muscovy varied from 35 to 37 days with an average of 36 days.

From 8 fertile eggs 6 hybrid ducklings (4 males and 2 females) were procured whereas the other two eggs stopped developing by the time of candling on the twelfth day of incubation. This showed about 74% of hatchability. All ducklings, except one which was killed by accident, are now growing on with a great vitality (Pl. 1, Figs. 3, 4, 5).

(III) DISCUSSION

It is a popular custom among the inhabitants in South-Eastern Asia such as Taiwan (Formosa), South China, Philippines, etc. to raise hybrid birds between the Mallard or Common ducks (*Anas platyrhyncha* var. *domestica*) and the Muscovy drakes (*Cairina moschata*). They are commonly known as mule-ducks[1]. The mule-duck, although completely sterile in both sexes, has much merit as a meat producer, exhibiting a rapid growth, a strong constitution and good foraging qualities due to the heterosis. The bottleneck in the mule-duck production is, however, that the fertility of intergeneric eggs is exceedingly low. According to a report of the Taichung Animal Industry Association, Taiwan (1943), of 4,952 hybrid eggs incubated only 2,094 eggs were fertile, showing a fertility rate of 42.3%, although the eggs tested were random samples. This seems to be caused by a difference in mating behavior between the parental species: the Common duck has a water-copulatory habit and the Muscovy, a land-copulatory habit. It was observed by the present author that the Muscovy drake covered the Common duck on the land and strived to stabilize his body on the duck's back, becaue of a great difference between the two species in body size and weight. From this standpoint, it is considered that the artificial insemination may serve effectively for promoting the fertility rate of hybrid eggs.

YAMASHINA (1950) was the first investigator who attempted to apply the artificial insemination to the mule-duck production; he secured 6 birds out of 14 intergeneric eggs produced by mating the female Muscovy ducks with a male Common duck, showing a fertility rate of 42.8%. However, a reciprocal cross, namely a cross between the Common ducks with a Muscovy drake brought no satisfactory results in fertility. The cause of this failure was ascribed to the sterility of the male Muscovy employed, because the semen was found to be deprived of sperm cells. Later, ONISHI & KATO (1955) succeeded in obtaining fertile eggs by artificial insemination of Common ducks with Muscovy semen. However, no marked increase in the fertility rate of hybrid eggs was attained by artificial insemination beyond that secured by natural mating, the rate of the former being 34.2% (26:76) and that of the latter 32.1% (96: 300). Thus, the fertility rate of hybrid eggs was whether artificially inseminated or naturally mated, lower than that of pure Common duck's eggs procured by the artificial insemination in the other experiments (ONISHI, KATO & FUTAMURA, 1955). In the latter experiments, the fertility rate was 54.2% (130 fertile eggs to 240 produced). The author's present experiments also showed that the fertility of the Muscovy's semen was much lower than that of the Common duck and that an insemination did not help to increase the fertility rate of the hybrid eggs (Tables 3 & 4).

From all the data above cited, it can be said that a physical hindrance in mating of the Common ducks with the Muscovy drake does not fully explain the partial infertility of hybrid eggs. Furthermore, the results of the present study on the semen characteristics revealed that there was a considerable difference in testicular activity of the

1) The mule-duck is also known in binominal terms as *Anas hybrida, Anas maxima* and *Anas sterilis* (Kuroda, 1958).

two species. This was perceived in the total number of sperms per ejaculate: the maximum number of sperms of the Muscovy was smaller than the minimun number of sperms of the Common duck. The infertility of the "oligospermic" semen has been so far confirmed by a great number of artificial breeders of other domestic animals. Besides, the Muscovy seems to keep more or less its wild habit of breeding in a certain months.

It is known that the Mallard drake in its domesticated state is polygamous and exhibits a high testicular activity almost throughout the year, whereas its wild ancestor is monogamous and breeds only in a certain season. A conversion from monogamy into polygamy and an aquisition of a habit of breeding all through the year are undoubtedly the effects of constant selection with respect to its high fecundity to which this species has been subjected from time immemorial. In contrast to this, the Muscovy duck of South American origin, though domesticated prior to the importation to Europe, seems to have not yet been selected with respect to its fecundity so intensively as the Mallard. This is to be seen in the less total number of sperms per ejaculate and in a greater seasonal variation of sperm productivity in the Muscovy.

Hence, the inevitable conclusions for promoting the fertility of hybrid eggs between the two species by means of artificial insemination are: 1. An ejaculate of the Muscovy drake should not be alloted to too many ducks in order to keep a certain sperm concentration, and 2. An adequate dilutor specific to the duck should be newly devised.

(IV) SUMMARY

1. The female Common ducks were artificially inseminated: in one series of experiments the semen of its own breed was used; and in the other, the semen of the Muscovy drake was used.

2. Both in homo- and heteroinsemination, the maximum fertility rate was obtained on the second day following the insemination: 80% in the former and 75% in the latter. On the third day, the fertility rate went down to 50% in both cases.

3. The maximum length of time during which the semen remained capable of fertilizing was likewise 7 days in both the species.

4. There is a marked difference, however, in the fertility resulted during the whole week following the insemination, between the heterologous semen and the homologous semen: the fertility rate in the former being 27.6% and in the latter 33.3%.

5. The partial infertility of the Muscovy drake in producing the mule-duck is thus experimentally proved.

6. It seems to be unjustified to ascribe this partial infertility to the copulatory hindrance caused by the differences in mating habits of the two duck species, because the fertility rate in the hybrid eggs could not be raised even with artificial insemination.

7. The testicular activity shown by the total number of sperms per ejaculate of the Muscovy throughout the year is strikingly low compared with that of the Common duck. This suggests that the Muscovy duck, though domesticated prior to the importa-

tion to Europe, has not yet so much changed in its breeding habit as the Common duck which acquired habits of polygamy and of breeding all the year.

8. For the purpose of increasing the fertility rate of hybrid eggs, in artificial insemination too high a dilution of the Muscovy's semen should be avoided and an adequate dilutor for the duck should be newly devised.

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EXPLANATION OF PLATE I

Fig. 1. A Muscovy drake employed for collecting the semen.

Fig. 2. A Common duck (No. 32) artificially inseminated with the Muscovy semen.

Fig. 3. Five hybrid ducklings procured by artificial insemination, 2 weeks old.

Fig. 4. A male mule-duck (No. 1), procured by artificial insemination.

Fig. 5. A female mule-duck (No. 2), procured by artificial insemination.


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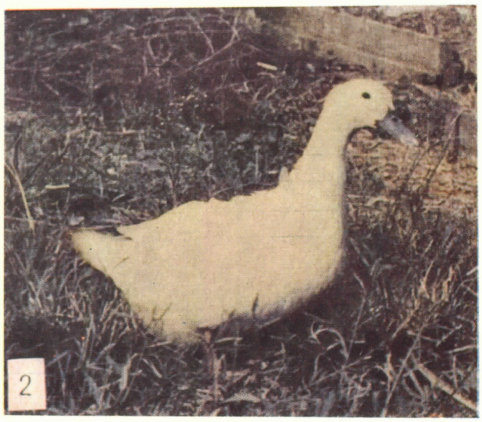
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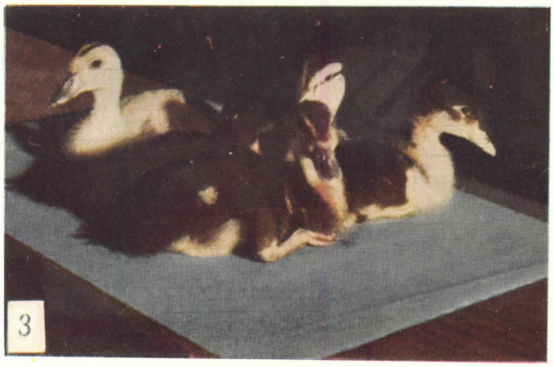
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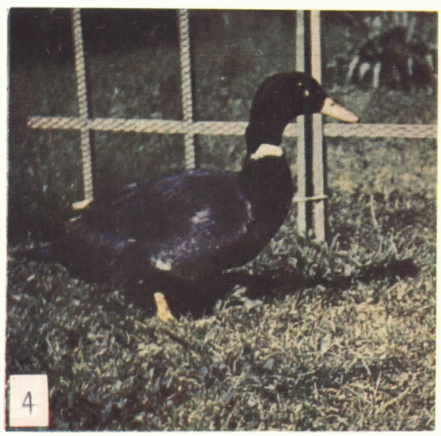
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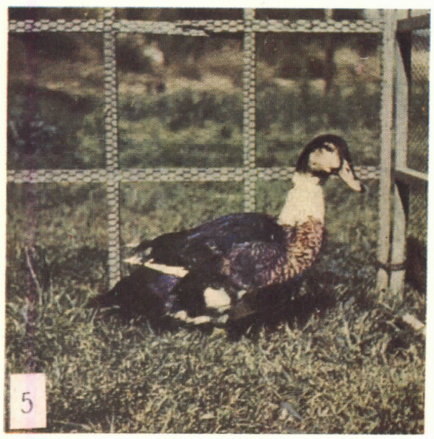
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