Note on the influence of extraneous forces upon the proportion of the sexes produced by canaries / by Walter Heape.

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Note on the influence of extraneous forces upon the proportion of the sexes produced by Canaries. By WALTER HEAPE, M.A., F.R.S., Trinity College, Cambridge.

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The careful records on which the following note is based were very kindly supplied to me by two breeders of canaries, Mr Needham and Mr Gentry.

Their results show a remarkable difference in the proportion of the sexes of the young birds produced in these two aviaries, which is consistent both in detail and in the totals.

Such consistent variation, when considered in relation to the food supplied and to the temperature and surroundings to which the birds were subjected, may be interpreted as evidence of the exercise of extraneous forces on the proportion of the sexes produced and of selective action on the generative elements dehisced by the parent birds.

In a former paper ("Note on the proportion of the sexes in Dogs," *Proc. Camb. Philosoph. Soc.*, 1907) I have indicated my reasons for believing that extraneous forces do influence the proportion of the sexes produced by certain animals, and the evidence now presented is, I judge, confirmatory of that view.

In the following account Mr Needham's records will be referred to as *N*, Mr Gentry's as *G*.

Results as shown in Table I.

N. During the years 1888—1893, 11 cocks and 22 hens were bred from. One cock and one hen were "London Fancy" breed, a second hen was cross bred, all the rest were "Lizard" canaries.

These birds formed 71 nests and laid 313 eggs, from which 87 cocks and 113 hens were hatched—a total of 200 chicks. That is, with a loss of 36·1 °/₀ of eggs the proportion of the sexes produced was at the rate of 76·99 cocks per 100 hens.

G. During the year 1892 bred from 4 cocks and 8 hens, all of which were "Lizards" with the exception of one cross bred hen.

These birds made 20 nests, laid 84 eggs from which 53 cocks and 15 hens, a total of 68 chicks, were hatched. That is, with a loss of 19·05 °/₀ of eggs the proportion of the sexes produced was at the rate of 353·3 cocks per 100 hens.

But certain data are available where no loss of eggs occurred.

N had 4 cocks and 9 hens making 11 nests and laying 48 eggs, *all* of which were hatched. These produced 22 cocks and 26 hens, that is at the rate of 84·61 cocks per 100 hens.

G had 4 cocks and 6 hens making 11 nests and laying 48 eggs, *all* of which were hatched. These produced 35 cocks and 13 hens, that is at the rate of 269·23 cocks per 100 hens.

Thus *G*'s birds hatched, and must have produced, a very large excess of cocks, while *N*'s birds are responsible for a marked excess of hens.

Regarding the unfertilised or addled eggs, *N* suffered a much greater proportion of loss than *G*.

The difference between the proportion of cocks and hens produced in *N*'s total results and in the results obtained from those of his nests in which all the eggs laid were hatched, is 7·62 in favour of the latter, and it may therefore be inferred that his losses include more cocks than hens.

G's accurate results, on the other hand, show a decrease of 84·07 cocks per 100 hens when compared with his total results, it may therefore be inferred that he loses more hens than cocks.

At the same time, when the detailed results of both breeders are compared, there is no room for doubt that the losses each experience are not responsible for the wide difference between their results, and it is clear that some influence is at work which profoundly affects the proportion of the sexes produced in these two aviaries.

Details are given in the following Table.

Breeders		Year	Breeding				Produce			Cocks per 100 hens	% of eggs not hatched
			Cocks	Hens	Nests	Eggs laid	Cocks	Hens	Total		
Total Produce	*N*	1888	2	2	5	23	5	7	12	71·43	47·83
		1889	3	5	14	57	14	23	37	60·87	35·09
		1890	4	5	13	61	23	25	48	92·0	21·31
		1891	5	6	14	64	15	25	40	60·0	37·5
		1892	4	5	14	58	12	21	33	57·14	43·1
		1893	3	4	11	50	18	12	30	150·0	40·0
		Totals	11	22	71	313	87	113	200	76·99	36·1
	G	1892	4	8	20	84	53	15	68	353·3	19·05
Produce of nests in which *all* eggs are hatched	*N*	1888	1	1	1	4	1	3	4	33·3̇	
		1889	2	2	2	8	4	4	8	100·0	
		1890	3	4	6	28	14	14	28	100·0	
		1891	1	1	1	5	2	3	5	66·6̇	
		1892	1	1	1	3	1	2	3	50·0	
		Totals	4	9	11	48	22	26	48	84·61	
	G	1892	4	6	11	48	35	13	48	269·23	

Conditions under which birds were kept.

N's birds were kept in a room facing N. and E., heated by a fire when necessary. In winter the temperature might go down to freezing point; in spring, during breeding time, down to 45° on cold nights. During the day in spring it was usually from 55° to 60°, in summer from 70° to 80°.

There was always a plentiful supply of canary seed in the hoppers; and hemp, rape, and maw seeds, hard boiled egg and biscuit crumb, and green food, was also given in plenty.

With the exception of 2 cocks, which were not hardy, all birds were strong and healthy.

The dates of hatching—taking all years collectively—were as follows: 19·72°/₀ of the nests in April, 29·58°/₀ in May, 28·17°/₀ in June, 21·12°/₀ in July, and 1·41°/₀ in August.

The cocks fail in vigour and commence to moult earlier, generally at least a month earlier, than the hens; counting each bird separately each year, 15 cocks moulted in July and 4 in August. Of the hens, 2 moulted in July, 12 in August, 5 in September, and 1 in October.

During 1893 *N* made an experiment with regard to food. Less hard food of all kinds was given, no hard boiled egg at all, and plenty of green food.

This is the only year in which *N*'s produce shows an excess of cocks; viz. at the rate of 150 cocks per 100 hens, with a loss of 40°/₀ of the eggs laid.

Among the birds used for breeding this year were a pair of birds obtained from *G*. They made 3 nests, laid 15 eggs, and reared 5 cocks and 3 hens, a total of 8 chicks. It is to be noted, however, that two pairs of *N*'s own birds this year reared 8 cocks and 3 hens, a total of 11 chicks, out of 15 eggs.

G's birds were kept in a room facing S., heated by hot water pipes when necessary. In winter the temperature might go down to freezing point, in summer up to 100°. During the breeding time it was kept regularly at 60°.

Similar food was given, but these birds were not so plentifully fed as *N*'s birds, and care was especially taken to avoid over-feeding. Green food was supplied in plenty.

All the birds were strong and healthy.

The dates of hatching were as follows: 25°/₀ in April, 35°/₀ in May, 30°/₀ in June, and 10°/₀ in July.

One bird moulted exceptionally early, in May, 7 in July, and 4 in August. There was not such a marked difference between the dates of moulting of cocks and hens as in *N*'s aviary.

One pair of these birds, obtained from *N*, made 3 nests, laid 12 eggs, and produced 9 cocks and 1 hen, a total of 10 chicks. The

same cock with one of *G*'s hens is responsible for 3 nests, and 13 eggs, which produced 11 cocks and 2 hens.

Thus to compare the two. In *G*'s aviary a more regular temperature was kept during the breeding time; there was more light and sun in the room; less food was given; hatching and moulting took place earlier as a rule; only about half the percentage of loss was experienced; and from the nests in which all eggs were hatched, the proportion of cocks produced was more than three times the proportion obtained in *N*'s aviary.

It seems clear that while *N*'s birds were highly fed, possibly with the idea of counteracting the uncongenial aspect of the aviary, *G*'s birds attained breeding condition earlier with less food.

While *N*'s birds laid 4·4 eggs per nest, *G*'s laid 4·2; but although *N*'s birds laid more eggs a very much larger percentage of them did not hatch, and it may be concluded *G*'s birds had much the greater reproductive power.

From a comparison of the dates of nesting and of the moulting of the cocks, I am inclined to think the large percentage of loss among *N*'s eggs is principally due to the cocks.

It might be argued that the marked tendency of *G*'s birds to produce an excess of cocks was due to the particular strain of birds he bred from. It is true that when *N* bred from a pair of *G*'s birds the produce hatched was at the rate of 166·6 cocks per 100 hens (more than double the average proportion he gets); but during that year the birds were subject to special feeding and that same year another pair of *N*'s own birds hatched eggs in the proportion of 200 cocks per 100 hens (a proportion which had only three times been equalled by any pair of his birds during the 5 preceding years), and in a third pair, also of *N*'s birds, 400 cocks per 100 hens was the proportion hatched (a unique experience for him). Thus under *N*'s treatment the birds obtained from *G* did not hatch so high a proportion of cocks as did other birds of his own rearing that particular year.

On the other hand, when *G* bred from a pair of birds obtained from *N*, the proportion hatched was at the rate of 900 cocks per 100 hens, and when the cock of this pair was mated with one of his own hens 550 cocks per 100 hens was the proportion actually produced.

So far as the evidence goes therefore it does not appear that the high proportion of cocks hatched in *G*'s aviary is due to the strain of his birds, but to some other factor or factors which influenced all birds kept by him, a conclusion which is borne out by *N*'s experience during 1893.

In a recent paper "On the proportion of the sexes in Dogs," published in the *Proceedings* of this Society, I have suggested that in all animals in which only a limited number of ovarian ova

mature during each breeding season, these ova are subject to selective action, an action with which the quantity or quality of the nutriment supplied has much to do.

Here I suggest that the factors which mainly governed the results shown for these two aviaries were, for *G*, a temperature and aspect which conduced to early breeding and the early maturation of ova which had not received specially rich nutrition. The generative functions of these birds was in fact "forced" without being richly fed and they produced males in great excess.

N's birds, on the other hand, were kept back, they both nested later and moulted later than *G*'s birds, their generative functions were not stimulated, the ova matured more slowly and were at the same time more highly fed, and these birds produced a marked excess of females.

A similar result, obtained by forcing and retarding development in plants, is recorded by Meehan and by Bordage, whose works are noted in my paper on Dogs referred to above.

As a rule in nature the climatic forces which stimulate the activity of the generative functions are also associated with a plentiful supply of food, the conditions which excite the one ensure the supply of the other. Among domesticated animals living in the open air, on the other hand, any forcing of the breeding time is brought about by special feeding. In neither case are the results obtained comparable to those we have now before us, where both the quality and the quantity of the food supplied is regulated entirely independently of the other causes which stimulate the activity of the generative system.

It is to this peculiar combination I attribute the regularity of the remarkable differences shown in these two aviaries.