

ON THE CROSSING OF SOME SPECIES OF COLUMBIDAE, AND THE INHERITANCE OF CERTAIN CHARACTERS IN THEIR HYBRID OFFSPRING.

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I. INTRODUCTION AND BRIEF STATEMENT OF RESULTS.

The experiments herein described form part of a larger series on heredity in pigeons, of which three accounts have already been published, namely in the *P. Z. S.* for 1905, Vol. II. p. 550, the *P. Z. S.* for 1908, p. 67, and the *Journal of Genetics*, Vol. II. p. 131. The first of these papers deals with the characters of the webbed foot and "shell," the other two with colour. In the two reports on colour the experiments are numbered consecutively, Exps. 1-46 being described in the *P. Z. S.*, and Exps. 47-91 in the *Journal of Genetics*, and reference is made in the present report to birds raised in these experiments.

The crossings with which this account deals were made between wild species either mated *inter se* or with domestic pigeons, and are not numbered in series with the rest.

The experiments were brought to a conclusion by the war, and I had hoped that, before publishing an account of them, I should have been able to investigate the matter further. As this has not been possible, I think it best to give the present account of the crossings as far as they were carried.

Hybrids of the Stock Dove (*C. aenas*) and the Woodpigeon (*C. palumbus*) respectively with domestic pigeons have from time to time been obtained, and descriptions of them have appeared. A notable instance was a paper by P. St M. Podmore in the *Zoologist* for November 1903 in which he described a fertile ♂ hybrid between *C. palumbus* and a domestic pigeon, which, when mated to a domestic ♀, gave a fertile ♀ hybrid. In 1908 he presented to the British Museum a hybrid produced from the ♂ and ♀ hybrids mentioned in his paper. More recently Ghigi¹ has succeeded in obtaining fertile ♂ hybrids from domestic pigeons and *Columba leuconota*, which, when mated to domestic ♀s, gave offspring fertile *inter se*.

I was fortunate in having some undoubtedly pure specimens of the Rock Dove (*C. livia*) and, apart from the question of fertility, there thus appeared to be a good opportunity of testing further the character of the white rump, with which I have already dealt in my second report on the inheritance of colour. The other species used, *C. schimperi* (the Egyptian Rock Dove), *C. aenas*, and *C. palumbus*, have no white on the rump. On the other hand *C. palumbus* has a patch of white on each side of the neck, and a broad edge of white to the wing-coverts, forming a conspicuous bar, two characters which are absent in *C. livia*.

In other respects the species differ in the colour of the breast, which is a rich vinous purple in *C. palumbus*, and the same colour, though in a less degree, in *C. aenas*. In *C. livia*, however, there is hardly any tinge of vinous, the breast being grey. Again the well-marked black wing bars seen in *C. livia* are considerably reduced in *C. aenas*, and completely absent in *C. palumbus*. The species also differ in size, shape and note.

The other object I had in view was to compare the result of mating these various species to white pigeons, with the series of experiments already described in the *Journal of Genetics* on the mating of *C. livia* to white pigeons, with reference to the possibility of other colours or patterns segregating out.

The results obtained may be summarised briefly as follows:

As regards behaviour of the species, the mating of *C. schimperi* with a domestic pigeon (Exp. 1) was only carried far enough to show the readiness with which these birds breed. *C. aenas* (Exps. 2-7) also paired with *C. livia* and domestic pigeons. When mated with domestic pigeons, it produced hybrid ♂s which were fertile, but bred more readily in their second or third year. These F_1 hybrid ♂s, when themselves mated to domestic pigeons, produced a weakly F_2 generation, which, however, con-

¹ *Revista Italiana di Ornitologia*, 1919.

tained one ♂ which showed unusual sexual precocity. It was found to be difficult to get *C. palumbus* to breed either with *C. livia*, or with domestic pigeons (Exps. 8-12). Only one hybrid was obtained from these matings, this was ♀ and showed no inclination to breed even in its second year.

The shape and, to some extent, the size of *C. palumbus* was dominant, as was also the note and attitude of the male *C. œnas*, in the F_1 hybrids. The vinous colour of the breast of *C. palumbus* and *C. œnas*, and the black wing bars of *C. livia* were present in the F_1 hybrids, but in less degree. The patch of white feathers at the side of the neck of *C. palumbus* was never developed in the hybrid, but the broad white edge to the wing-coverts was present.

The inheritance of the white rump character of *C. livia* gave an altogether unexpected result. As has previously been shown, this character is dominant to the blue rump. The hybrid, however, produced from the mating of *C. palumbus* with *C. livia* in Exp. 9, and probably also those from the mating of *C. œnas* with *C. livia* in Exp. 2, had no white on the rump. On the other hand the mating of a white domestic pigeon to *C. œnas* in Exp. 3 gave F_1 hybrids with white on the rump.

In the mating of *C. œnas* with a white domestic pigeon (Exps. 3-7) the white character was found to behave as an ordinary Mendelian recessive as before. A chequer character, in which the blue feathers of the wing-coverts and back are dappled with black, was introduced by the white pigeons used, and was again seen to behave as an ordinary dominant to the non-chequered form, but the numbers obtained in Exp. 7 differ somewhat from the expected ratio.

As many of the young hybrids died in the nest when only a few days old, their sexes were not determined, but, of those that were reared, it was noticed that the great majority were male, and, in Exp. 6, a family of seven birds was raised, of which every one was male. The fact that no female hybrid from *C. œnas* ever reached maturity, either in F_1 or in the generation produced from the mating of F_1 with domestic pigeons, prevented the testing of the fertility of the hybrids when mated *inter se*.

II. WILD SPECIES USED IN EXPERIMENTS.

C. livia ♂ (a) and *C. livia* ♂ 26 were both bred in captivity from a pair taken at Achill Island. The former was previously used in Exp. 50¹, the latter had not been mated before.

¹ *Journal of Genetics*, Vol. II, p. 144.

C. schimperi ♀ was taken from the nest in Egypt.

C. œnas ♂ (*a*) and *C. œnas* ♀ (*b*) were bred in captivity from a pair taken at Fen Ditton, Cambridgeshire.

C. palumbus ♂ (*a*) and *C. palumbus* ♀ (*b*) were taken from the nest at Fairford, Gloucestershire.

III. DOMESTIC PIGEONS USED IN EXPERIMENTS.

White ♀ 4 was raised in Exp. 54¹, being in F_2 from a cross between a white Fantail ♀ and a typical *C. livia* ♂ bred from a pair obtained from Lincolnshire, the F_1 generation being blue chequer with some white feathers. This ♀ was mated to *C. livia* ♂ (*a*) in Exp. 50² and gave two blues with white feathers, of which one, Blue w. f. ♀ 7 (*v. infra*) was used in Exp. 7 of the present series.

White ♀ 9 was raised in Exp. 8³ in F_3 from a cross between black Barb and white Fantail pigeons, the F_1 and F_2 birds in its ancestry being black with some white feathers.

White ♀ 31 and *white* ♂ 10 were produced in Exp. 66⁴ from a pair of blue chequers with white feathers, derived from the original crosses of black Barbs and white Fantails, and also from Lincolnshire *C. livia* and white Fantail.

White ♂ 53 was raised in an experiment which has not yet been described. As no offspring were produced from its mating, the details of its ancestry are unimportant.

Blue w. f. ♀ 7 was produced in Exp. 50⁵ from the mating of white ♀ 4 with *C. livia* ♂ (*a*). It was blue with black wing and tail bars, and had some white feathers on the rump and thighs, and also some white flights and tertiaries. No trace of chequering was seen. This ♀ was mated to its brother Blue w. f. ♂ 6, a bird of exactly similar appearance in Exp. 51⁶ and gave 2 typical *C. livia*, 4 blue with much white, and 1 white. From the results of Exps. 50 and 51 it was presumed that white ♀ 4 was homozygous for the non-chequer character, but the result of its mating with *C. œnas* in Exp. 3 of the present series suggests that it was heterozygous for that character, and that, had Exp. 50 been prolonged, chequered birds would have appeared.

The pedigree (p. 158) of the Domestic Pigeons used shows the

¹ *Journal of Genetics*, Vol. II, p. 147.

² *Ibid.* p. 144.

³ *P. Z. S.* 1908, p. 79.

⁴ *Journal of Genetics*, Vol. II, p. 152.

⁵ *Ibid.* p. 145.

⁶ *Ibid.* p. 145.

above mentioned birds in heavy type. The following abbreviations are used:

- Wh. Fan. = White Fantail.
 Bk Barb = Black Barb.
 Bk w. f. = Black, with some white feathers.
 Blue w. f. = Blue, with some white feathers.
 B. C. = Blue, chequered with black.
 B. C. w. f. = Blue, chequered with black, and having some white feathers.

IV. MATINGS.

Table I shows the twelve matings of *C. schimperi*, *C. œnas* and *C. palumbus* respectively to *C. livia* and domestic pigeons, and the further matings of the hybrid offspring. The experiments are arranged for each species in the order in which they were made.

They fall naturally into two classes:

- (1) The mating of wild species together.
- (2) The mating of wild species to domestic pigeons.

The mating of wild species together is shown in Exps. 2, 9, and 12, and that of F_1 hybrid to a species in Exp. 10.

The mating of wild species to domestic pigeons is shown in Exps. 1, 3, 8, and 11, and that of F_1 hybrids to domestic pigeons in Exps. 4, 5, and 6, and of F_2 hybrid to domestic pigeon in Exp. 7.

The table also shows the number of eggs laid by each pair, of young hatched, and those reared to maturity.

V. BEHAVIOUR AND FERTILITY OF THE WILD SPECIES.

(a) *When mated together.*

1. *C. œnas* ♀ (b) × *C. livia* ♂ (a). Exp. 2.

This pair was mated on February 2. One unfertile egg was laid on May 15. Subsequently a pair of eggs was laid which hatched on June 29, but the young only survived a few days. *C. livia* ♂ was extremely pugnacious with *C. œnas* ♀, and on two occasions the pair had to be separated for a few days. On July 16 the ♀ died.

2. *C. palumbus* ♀ (b) × *C. livia* ♂ (a). Exp. 9.
- C. palumbus* ♀ (b) × *C. livia* ♂ 26. Exp. 12.

Pedigree of Domestic Pigeons used in these Crosses.

(Birds used are in heavy type.)

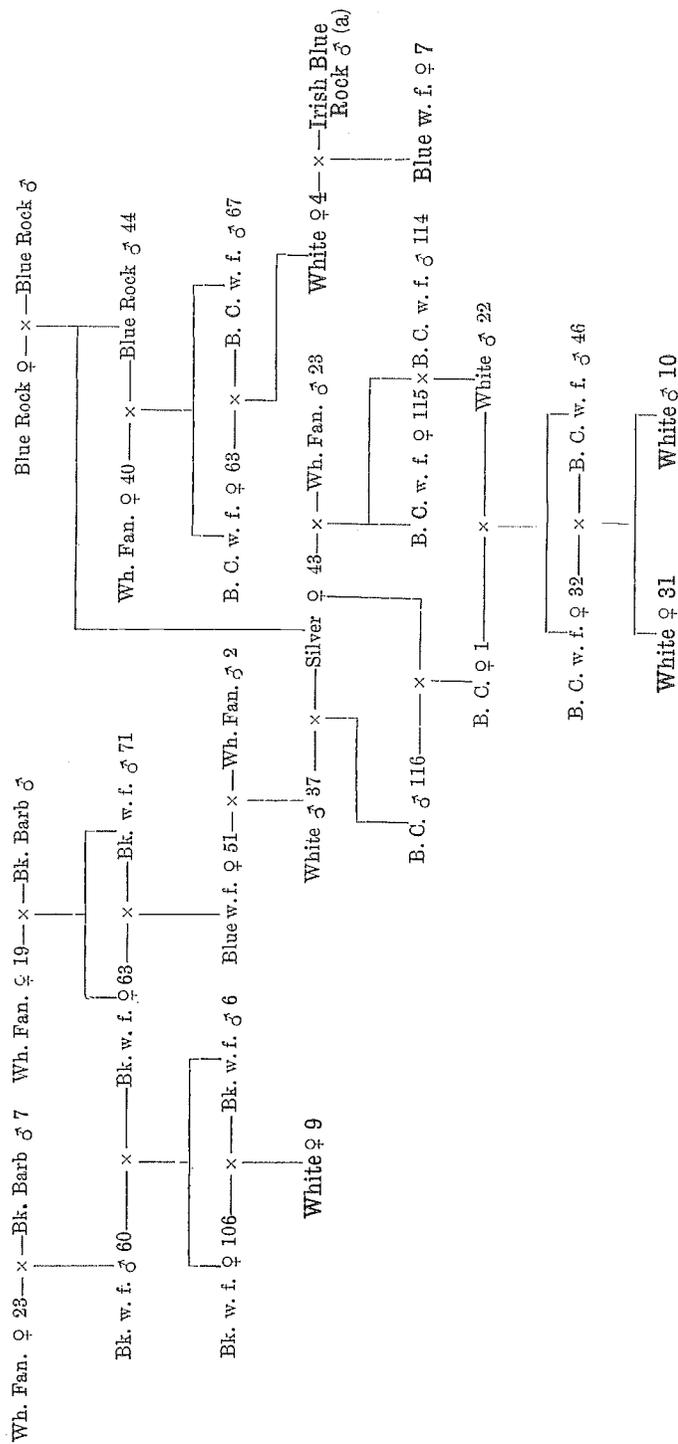


TABLE I.

Experiment Number	Females	Raised in Experiment	Also used in Experiment	Males	Raised in Experiment	Also used in Experiment	Eggs laid	Eggs fertile	Birds hatched	Colour visible	Birds reared
1	<i>C. schampersi</i> ...	—	—	White 10	... Rep. II. 66	—	2	2	0	0	0
2	<i>C. enas</i> (b) ...	—	—	<i>C. livia</i> (a)	... Rep. II. 66	—	3	2	2	2	0
3	White 4	Rep. II. 54	4, 8	<i>C. enas</i> (a)	... Rep. II. 66	—	10	8	8	3	2
4	White 4	Rep. II. 54	3, 8	Hybrid 13	... Rep. II. 66	—	2	0	0	0	0
5	White 9	Rep. I. 8	—	Hybrid 37	... Rep. II. 66	—	8	2	2	2	0
6	White 31	Rep. II. 66	—	Hybrid 13	... Rep. II. 66	—	4	7	7	7	6
7	Blue w. f. 7	Rep. II. 50	—	Hybrid 1818	... Rep. II. 66	—	12	12	12	12	9
8	White 4	Rep. II. 54	3, 4	<i>C. patambus</i> (a)	... Rep. II. 66	—	0	0	0	0	0
9	<i>C. patambus</i> (b)	—	11, 12	<i>C. livia</i> (a)	... Rep. II. 66	—	6	1	1	1	1
10	Hybrid 60	9	—	<i>C. livia</i> 26	... Rep. II. 66	—	12	0	0	0	0
11	<i>C. patambus</i> (b)	—	9, 12	White 53	... Rep. II. 66	—	4	0	0	0	0
12	<i>C. patambus</i> (b)	—	9, 11	<i>C. livia</i> 26	... Rep. II. 66	—	13	0	0	0	0

Note. Rep. I = "First report on the inheritance of colour in Domestic Pigeons with special reference to reversion," *P. Z. S.* 1908, p. 67.
 Rep. II = "Second report on the inheritance of colour in pigeons, together with an account of some experiments on the crossing of certain races of doves, with special reference to sex-limited inheritance," *Journal of Genetics*, Vol. II. p. 131.

TABLE II.

Experiment Number	Females	Raised in Experiment	Also used in Experiment	Males	Raised in Experiment	Also used in Experiment	Offspring				
							Blue no white	Blue some white	Blue checker no white	Blue checker some white	
2	<i>C. enas</i> (b)	—	—	<i>C. livia</i> (a)	—	9	2?	—	—	—	—
3	White 4	Rep. II. 54	—	<i>C. enas</i> (a)	—	—	—	—	—	3	—
5	White 9	Rep. I. 8	—	Hybrid 37	3	—	—	—	—	—	2
6	White 31	Rep. II. 66	—	Hybrid 13	3	—	—	—	—	4	3
7	Blue w. f. 7	Rep. II. 50	—	Hybrid 1818	6	—	—	—	—	1	4
9	<i>C. patambus</i> (b)	—	—	<i>C. livia</i> (a)	—	2	—	—	—	—	—

Note. The above table includes only those matings from which young birds were hatched.

The ♂ used in Exp. 9 is the one which had previously produced young with *C. aenas* ♀ in Exp. 2. The birds were mated on March 30, the first pair of eggs was laid about June 10, and the second on July 2. Both pairs of eggs were unfertile. Of the third pair of eggs, one proved unfertile, and the other hatched on August 18, the hybrid (♀ 60) being reared to maturity.

During the next two years *C. palumbus* ♀ (*b*) was mated to a white domestic ♂. (Exp. 11, *v. infra*.)

In the fourth year this ♀ was mated to *C. livia* ♂ 20 (Exp. 12). Thirteen eggs were laid, but none of them was fertile.

(*b*) *When mated to domestic pigeons.*

1. *C. schimperi* ♀ × *white* ♂ 10. Exp. 1.

This pair was mated on March 6, and eggs were laid about March 26. On April 13 the ♀ was found dead on the nest. The eggs were removed to foster parents, but failed to hatch, a dead bird being found in each.

2. *White* ♀ 4 × *C. aenas* ♂ (*a*). Exp. 3.

Mated on February 2, ten eggs were produced by these birds, of which eight were fertile. One egg of each of the first two pairs, laid respectively on March 14 and April 18, was unfertile. Only two of the young reached maturity (hybrid ♂ 13 and hybrid ♂ 37) and these were used subsequently in later experiments. The fifth pair of eggs was laid on July 23, and *C. aenas* ♂ died on July 31.

3. *White* ♀ 4 × *C. palumbus* ♂ (*a*). Exp. 8.

The white ♀ used in this experiment was that which had produced young with *C. aenas* ♂ in Exp. 3 the year before. It was mated to *C. palumbus* ♂ on March 27, and the pair remained together till August 2. During the whole of this period the ♂ was never observed to take any notice of the ♀, and no eggs were laid.

4. *C. palumbus* ♀ (*b*) × *White* ♂ 53. Exp. 11.

C. palumbus ♀ (*b*) had previously produced a hybrid with *C. livia* ♂ (*a*) in Exp. 9 (*v. supra*). It was mated for two years to *White* ♂ 53. During the first year no eggs were laid, and during the second, four unfertile ones.

This ♀ was kept for four years, during which time it was mated to three ♂s, and produced in all 23 eggs, of which only one proved fertile.

VI. BEHAVIOUR AND FERTILITY OF THE HYBRIDS.

(a) *From the mating together of the wild species.*

Hybrid ♀ 60 from *C. palumbus* ♀ (b) × *C. livia* ♂ (a).

This bird, raised in Exp. 9, showed no inclination to mate. When two years old it was put up with *C. livia* ♂ 26 (Exp. 10). The ♂ apparently took no notice of the hybrid, and no eggs were laid. On dissection the ovary was found fully developed.

(b) *From the mating of wild species with domestic pigeons.**F₁ Generation.*

Hybrid ♂ 13 and *Hybrid* ♂ 37.

These two birds were raised in Exp. 3 from White ♀ 4 × *C. anas* ♂ (a), and were reared to maturity. Only one (No. 13) showed any inclination to pair the following summer. It was therefore mated on August 2 to its own mother, White ♀ 4 (Exp. 4) and two eggs were laid about the 16th. These were unfertile. The following year it showed no inclination to breed, but, in its third year, it was mated to White ♀ 31 (Exp. 6). Eight eggs were laid, of which only one proved unfertile. Of the seven young produced, all but one reached maturity, but only hybrid ♂ 1818 survived during the next summer.

Hybrid ♂ 37 showed no desire to breed until two years old. It was then mated to White ♀ 9 (Exp. 5). Four pairs of eggs resulted, the first two pairs being unfertile. One egg of the third and one of the fourth pair were fertile, and two birds were hatched, but that from the third pair only survived a week. The bird raised from the fourth pair of eggs lived four months. Hybrid ♂ 37 died a fortnight after the last young bird was hatched.

F₂ Generation.

In striking contrast to the behaviour of the *F₁* ♂ hybrids was that of *F₂* hybrid ♂ 1818, produced in Exp. 6, which, although hatched as late as August 1, was, nevertheless, seen to make an attempt to tread a ♀ during the same winter. It was put up in the next spring with another hybrid which was believed at the time to be ♀, but subsequently proved not to be so. On August 1 it was mated to a domestic pigeon, Blue w. f. ♀ 7 (Exp. 7), and a pair of young was hatched on September 8. After the breeding season the pair was separated and remated the following January, when they produced five pairs of fertile eggs, the first pair hatching on

February 26, and the last on August 11. No unfertile egg was laid, and nine of the twelve young were raised to maturity.

VII. DESCRIPTION OF THE HYBRIDS.

(a) *From the mating together of wild species.*

F₁ Generation.

C.enas ♀ (b) × *C. livia* ♂ (a). Exp. 2.

The two hybrids for this cross only survived a few days. The quills were dark and suggested that the plumage would have been blue *without the white rump*. Unfortunately the weather was hot at the time of their death and, when the specimens reached the taxidermist, they were found to be unfit for preservation, and so were lost.

C. palumbus ♀ (b) × *C. livia* ♂ (a). Hybrid ♀ 60. Exp. 9.

In general appearance this bird resembled *C. palumbus* more closely than *C. livia*. The length was 16 inches; that of the mother being 17 inches. The length of the neck and characteristic carriage of the head of *C. palumbus* was noticeable in the hybrid. The plumage also resembled that of *C. palumbus* except that the mantle, breast, and under parts were of a bluer tinge, and the vinous colour of the breast was not so marked. The conspicuous patch of white feathers, seen on the neck of the adult *C. palumbus* after the first moult, was never assumed by the hybrid, but, on the other hand, the broad white edge of the wing-coverts of the mother was equally developed in the offspring. On other parts of the plumage white feathers were entirely absent. *The rump was slate-grey*. The two black wing bars, present in *C. livia* but absent in *C. palumbus*, were seen in the hybrid, but the black was not nearly so pronounced or extensive as in *C. livia*. The upper bar was present only on the inner part of the wing. The tail feathers were, as in *C. palumbus*, nearly black, except at their bases.

(b) *From the mating of wild species with domestic pigeons.*

F₁ Generation.

White ♀ 4 × *C.enas* ♂ (a). Exp. 3.

The eight birds hatched from this experiment had dark down in the nest, and would therefore have had coloured plumage. Only three feathered. The remaining five died very soon after hatching. The general colour of those which were raised was blue heavily chequered with black on the wing-coverts and back, and having *some white feathers which were especially noticeable on the rump*. The vinous colour of the breast

of *C. aenas* could be traced in the hybrids but was not pronounced. The black wing bars were present, as also the tail bar. In the case of hybrids Nos. 13 and 37, the tail bar was double, this feature being most marked on the more external tail feathers. The blue colour between the terminal and subterminal bars was identical with that of the basal part of the tail feathers. Hybrid No. 52 died before the tail was fully developed and consequently this feature was not visible. A slight bronzing or rustiness of some of the black colour was seen, and this did not entirely disappear at the first or any subsequent moult, as is frequently the case in domestic pigeons when it occurs in the next plumage.

The white rump was a most conspicuous feature in all three hybrids. The boundaries of the white patch were not so clearly defined as in *C. livia*, the edges being irregular, and some coloured feathers were present in the midst of the white. The amount of white on the rump varied in the three hybrids. In hybrid ♂ 13 the extent was about the same as in *C. livia*. In the other two it was less. *The amount of white on other parts of the plumage was directly proportional to the amount of white on the rump.* Hybrid ♂ 13 had a few white feathers on the head and neck, at the angle of the wings and on the thighs. Hybrid ♂ 37 had two white feathers on the head and very few on the thighs. Hybrid 52, with least white on the rump, had none elsewhere.

The plumage of these birds was softer than that of *C. livia* or the domestic pigeons, so that they, like *C. aenas*, could easily be identified by touch.

In the case of the two hybrid ♂s which were raised to maturity it was observed that the note and mating attitude were identical with those of *C. aenas*.

F₂ Generation.

White ♀ 9 × F₁ Hybrid ♂ 37. Exp. 5.

White ♀ 31 × F₁ Hybrid ♂ 13. Exp. 6.

As will be seen in Table II, two young birds were produced in Exp. 5 both of which were white. Of the seven raised in Exp. 6, three were white and four were blue chequers with some white feathers, making a total of four blue chequers to five whites for the two matings. The whites resembled their ♀ parent in all respects. The coloured birds varied in the depth of chequering, one being more lightly marked than the others. There was no duplication of the tail bar.

In no case did the amount of white on the rump approach that in *C. livia* or in the *F₁* generation of hybrids, but, as in Exp. 3, the amount

of white on other parts of the plumage varied directly with that on the rump. The details of the distribution of white feathers were as follows :

- F*₂ hybrid 1808. None on rump, very few on thighs.
 „ 1818. 8 on rump, 2 flights, 1 tertiary.
 „ 1828. About 15 on rump, 3 flights and a few on abdomen,
 thighs, and at angle of wing.

*F*₂ hybrid 1292 was a deformed and very weakly bird. The left wing was rudimentary and the left foot consisted of two digits only. It died when less than two months old, and the body, when found, had been trampled on by other pigeons, so that the details of white markings were not clear.

*F*₃ Generation.

Blue with some white feathers ♀ 7 × *F*₂ Hybrid ♂ 1818. Exp. 7.

Twelve young were obtained from this mating, of which two were blue chequers, six blue with black wing and tail bars, and four white. The plumage of the blue chequers resembled that of the birds raised in the preceding experiments. The blue birds were not uniform in colouring, some being of a darker shade than others, and one (*F*₃ hybrid 2013) being conspicuously dark and smoky in plumage.

As regards white feathers, two showed none either on the rump or elsewhere, five showed some white feathers, and one (*F*₃ hybrid 5720) had a considerable amount of white. The details of the distribution of white feathers, when present, were as follows :

- F*₃ hybrid 2013. None on rump, 1 on head.
 „ 2014. Few on rump, 8 primaries, 5 tertiaries and few on
 head and thighs.
 „ 5713. None on rump, 2 primaries.
 „ 5716. 2 on rump, few on thighs.
 „ 5717. Few on rump, streak behind each eye, 7 primaries,
 6 tertiaries, and few on thighs.
 „ 5720. Rump white. Head and throat conspicuously white
 with a few coloured feathers. Ten flight feathers in the right wing and
 eight in the left, together with the tertiaries over them white. Large
 patch of white on the abdomen and thighs.

VIII. INHERITANCE OF WHITE AND CHEQUERING.

Table II shows the numbers of coloured and white birds obtained from the mating of *C. œnas* with a white pigeon, as described above. It will be observed that the inheritance is according to the usual Men-

delian expectation. In F_1 a uniform generation of coloured birds was produced (Exp. 3), and these hybrids, mated to whites (Exps. 5 and 6), gave approximate equality of coloured and white. In Exp. 7 F_2 hybrid mated to blue containing white, gave a result of practically 3 coloured : 1 white.

The chequer character appeared first in Exp. 3 and was presumably introduced by white ♀ 4. Although, as shown in Exp. 50¹, this bird was not homozygous for the character, still the three F_1 hybrids obtained were all chequered. The mating of F_1 hybrid ♂ 13 to white ♀ 31 in Exp. 6 produced no coloured birds without chequering, so we may presume this ♀ also was at least heterozygous in chequering. The mating of F_2 chequered hybrid ♂ 1818 to a blue ♀ containing white in Exp. 7, gave 2 chequers, 6 blues, and 4 whites. Here the number of chequers is low and that of blues high, as the three types would be expected to appear from this mating in the proportion of 3 chequers : 3 blues : 2 whites. Had the mating been continued it is probable that the figures would have approximated more closely to that ratio.

IX. INHERITANCE OF THE WHITE RUMP.

I have previously shown that, in breeding *C. livia*, the typical white-rumped form is dominant to the whole-coloured blue. In the present series of experiments, when *C. livia* is hybridised with *C. palumbus* (Exp. 9) and probably also with *C. œnas* (Exp. 2) *the reverse is the case*. On the other hand white ♀ 4 mated to *C. œnas* ♂ in Exp. 3, gave young with white feathers on the rump.

We may presume that white ♀ 4 was at least heterozygous for the white-rump character, and its ancestry shows this to be possible, it being produced in F_2 from a cross between a typical *C. livia* and a white Fantail, but in the later matings of this series (Exps. 6 and 7) no bird was produced showing the white rump of *C. livia*, the white feathers being distributed as already described. In Exp. 7, however, two coloured birds were produced showing no white feathers.

In the case of whole-coloured pigeons (black Barbs) mated to whites, the F_1 generation obtained was black with some white feathers on the rump and elsewhere (see *P. Z. S.* 1908, p. 77, Table I), these giving in F_2 whole-coloured birds, coloured birds with white feathers, and whites. The fact that coloured birds carrying white generally show a certain

¹ *Journal of Genetics*, Vol. II, pp. 144 sq.

amount of white in their plumage, more especially on the rump, tends to obscure the inheritance of the rump character.

X. THE SEX-RATIO OF THE HYBRIDS.

It is a matter for regret that the sex of every hybrid was not ascertained by dissection. This, however, was not done, as, in the earlier experiments many of the young hybrids died soon after hatching, in my absence, and were not preserved. Also, when the birds from the last experiment were killed, I was unable to be present and so no dissections were made.

Of the 31 hybrids from the cross with *C. œnas*, the sexes of 14 only were determined. These however show a very great preponderance of males, the total numbers being twelve males to two females. The two birds reared in the F_1 generation (Exp. 3) were both male, and when they were mated to domestic pigeons, in Exps. 5 and 6, only male offspring were reared, thus giving no opportunity for testing the fertility of the hybrids when mated *inter se*. In Exp. 5 one bird was hatched which proved to be female, but it did not survive long enough to be mated. In Exp. 6 the seven birds hatched were male, thus giving for that generation seven males, one female and one undetermined. The F_2 hybrid mated to a domestic pigeon in Exp. 7 gave a family of twelve, but the sexes of only four of these were ascertained, of which three proved to be male and one female.

In the cross with *C. palumbus* the only hybrid hatched was female, and showed no inclination to mate.

Doncaster¹ has pointed out the frequency with which excess of males is produced in hybrid offspring, and gives instances of this in pheasants and ducks among birds². The results here obtained suggest a similar deviation from equality in the case of hybrid pigeons.

XI. CONCLUSION.

I am indebted to Sir Reginald Oakes Bait for the specimen of *C. schimperi*, and to the late Mr J. L. Bonhote for those of *C. livia* and *C. œnas* used in these experiments.

¹ *The determination of Sex*, 1914, p. 86.

² Cf. also Haldane, J. B. S. *Journal of Genetics*, Vol. XII. Pt