

GENETIC STUDIES IN POULTRY

XI. THE LEGBAR

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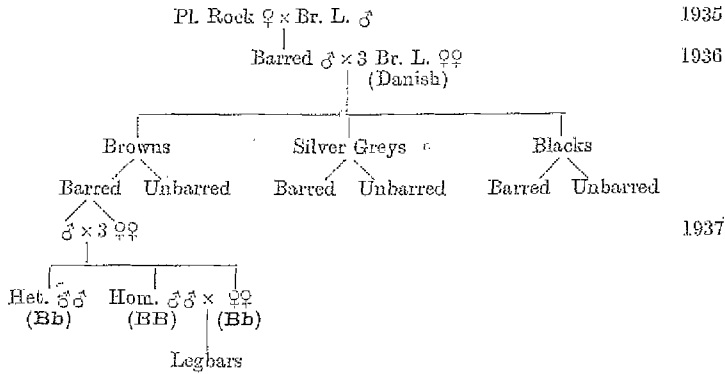
(With Plate 1 and Two Text-figures)

IN a paper which appeared in this *Journal* in 1930 Mr M. S. Pease and I showed that the barring factor, **B**, produces a markedly different visible effect on the down of the Campine fowl according as it is present in a homozygous or heterozygous condition. In the homozygous bird the production of pigment in the down is far more strongly inhibited, with the result that **BB** chicks are markedly paler than **Bb** ones. Since **B** is sex-linked all male chicks are **BB** and all female chicks **Bb**, and the former can at once be distinguished from the latter by the difference in colour (cf. *J. Genet.* 22, Pl. 17). Moreover we pointed out at the time that a stock of "pure" Cambar hens, for so we have named the breed, could be rapidly increased by mating the **BB** cock to Campine hens. For all hens so bred would be **Bb** on a Campine basis and would breed as Cambars.

More recently Fisher (1935) showed that the barring factor behaves similarly with regard to the brown striped down of *Gallus bankiva*, while Hagedoorn (1935, 1936) has published briefly in connexion with the formation of auto-sexing breeds founded on Barnevelders and Leghorns. The general principle underlying the formation of such breeds has been discussed in more detail by Pease (1936).

The present paper records some further experiments of a similar nature on the brown-striped down of the Brown Leghorn. For the introduction of the barred factor into the Leghorn use was made of the Plymouth Rock, and in 1935 a hen of this variety, imported from Canada, was mated with a Brown Leghorn cock. In 1936 one of the barred cocks from this mating was run with three Brown Leghorn ♀♀, reared from eggs imported from Denmark in the previous year. The Danish strain was made use of because in that country it is a favourite breed and has been brought to a high pitch of excellence both for hardiness and egg production. It turned out to be somewhat darker in colour than the usual run of Brown Leghorns in this country, and the down colour of the chicks

was also darker and sharper in the striping. From the mating between the F_1 ♂ and the Brown Leghorn ♀♀ three main colour classes appeared, viz. blacks, silver greys and browns. The actual numbers were 57 blacks,



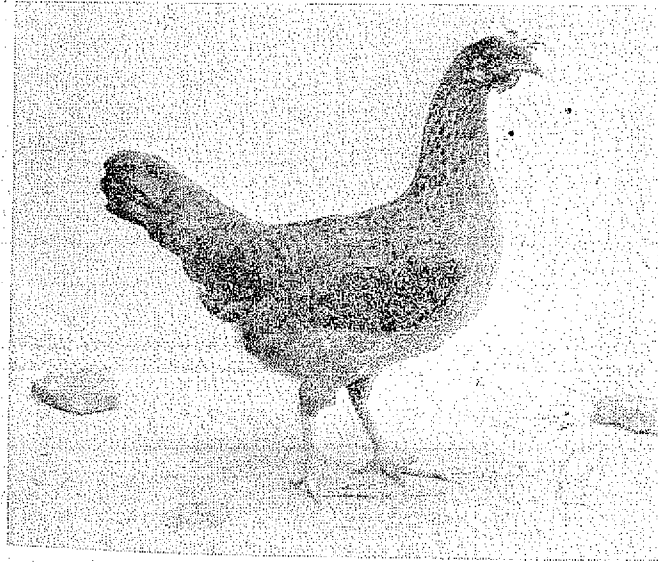
30 silver greys, and 40 browns where expectation is 2:1:1. Both barred and unbarred birds appeared in each class. From them were selected four barred birds of the brown class (viz. a cock and three hens) which approached most nearly to the Brown Leghorn type in colour and general habit; and in 1937 these were mated together in order to obtain the homozygous barred cocks. The majority of these were easily recognized in the down through their pale colour (cf. Pl. 1, fig. 2). They were also characterized by a marked light head patch and by a blurring of the light dorsal rump striping. Some homozygous **BB** ♂♂ were however in general depth of colour not far removed from a normal brown striped down (cf. Pl. 1, figs. 1 and 5). But further experience showed that the homozygous males could be distinguished from brown-stripes heterozygous for barring (cf. Pl. 1, fig. 4) by the marked light head patch, and especially by the blurring of the light striping on the rump. In **Bb** chicks of either sex there may be indications of a light head patch, but in this material it was never very marked, and might be absent. But in all **Bb** chicks the rump striping is sharply marked, whether the tone of the brown be very dark, as in the Danish strain, or lighter, as in most of the strains in this country (cf. Pl. 1, figs. 3 and 4).

Breeders of Brown Leghorns are aware that the tone of the down colour shows a considerable range of variation, probably due, as will appear later, to definite genetical factors. On the lighter type of Brown Leghorn down the barring factor in a homozygous condition produces its most marked effect, such as is shown in fig. 2 of Pl. 1. On the darker type its effect is to produce a down of which the general tone is not far

removed from that of the lighter type where the barring factor is in a heterozygous condition (cf. Pl. 1, figs. 1 and 5). Possible confusion is, however, eliminated when it is recognized that the darker **BB** type always shows blurring of the light rump stripes as well as a light head patch, whereas in the lighter **Bb** the head patch is small or absent and the light rump stripes are sharply defined. Although the Legbar, the name we give to this new breed, exhibits, like the Brown Leghorn, some variation in the intensity of pigment in the down of the chicks, there is nevertheless a perfectly clear distinction between the **BB** male chicks and the **Bb** females.

THE ADULT PLUMAGE

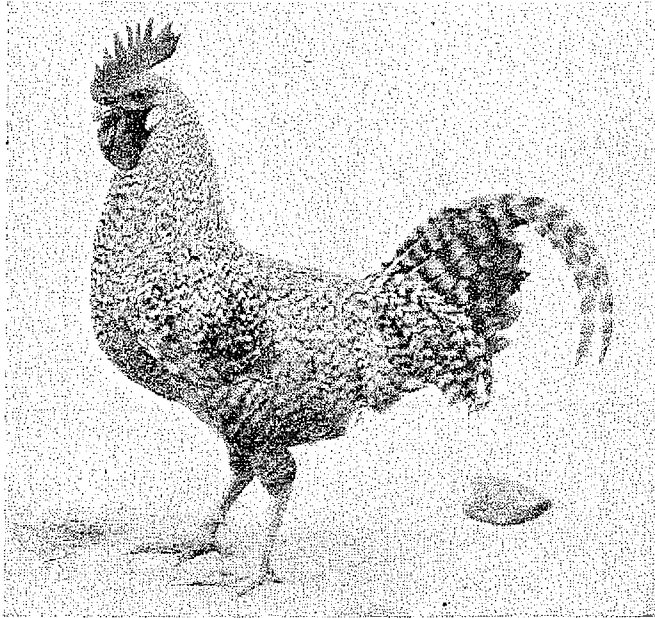
As might be expected from a breed founded on the Brown Leghorn, the Legbar shows a marked sexual dimorphism in the plumage. The hen, as shown in Text-fig. 1, is not unlike a Brown Leghorn in general



Text-fig. 1. Legbar pullet.

appearance, though the gold of the hackle and the salmon of the breast are rather less intense. It has, however, a dingier look owing to the blurred barring in the body feathers and tail. The cock on the other hand is a strikingly handsome bird. As Text-fig. 2 shows, he is barred all over, though the general effect is definitely lighter and softer than in a barred

breed such as the Plymouth Rock. At the same time the pale gold of the hackles and the bright chestnut of the wing coverts lead to his presenting an appearance at once brilliant and quite unlike that of the male of any recognized breed.



Text-fig. 2. Legbar cockerel.

THE RELATION BETWEEN DARKER AND LIGHTER DOWNS

In 1939 some further experiments were made with a view to discovering the relation between the darker and lighter types of down that had been encountered, and the following four pens were mated up.

Pen 11, ♂ 184/38 × ♀ 441/38, both of which had downs of the darker type. The resulting twenty-two chicks were classified as follows:

	Darker	Lighter
♂♂	8	1
♀♀	10	3
Total	18	4

The proportions in which the two types appeared are consistent with the view that the darker type is dominant, and that the parents were both heterozygous.

Pen 12, ♂ 497/38 × ♀ 503/38. Here the ♂ approximated to the darker

type and was presumably heterozygous, while the ♀ was of the lighter type. The twenty-two chicks hatched were as follows:

	Darker	Lighter
♂♂	4	8
♀♀	5	5
Total	9	13

On the assumption that ♂ 497 was heterozygous, expectation for the two types is equality.

Pen 13, ♂ 496/38 × ♀ 112/38. Here again the ♂ approximated to the darker type while the ♀ was of the lighter type. The twelve chicks were distributed as follows:

	Darker	Lighter
♂♂	6	2
♀♀	3	1
Total	9	3

Pen 14, ♂ 451/38 × ♀ 164/38. The ♂ was here of the lighter type while the ♀ was a dark brown stripe though not quite so dark as some that were bred. The seventeen chicks were as follows:

	Darker	Lighter
♂♂	3	5
♀♀	3	6
Total	6	11

Expectation here again is equality.

Taking Pens 12, 13, and 14 together, where equality is expected the totals are 24 of the darker and 27 of the lighter type.

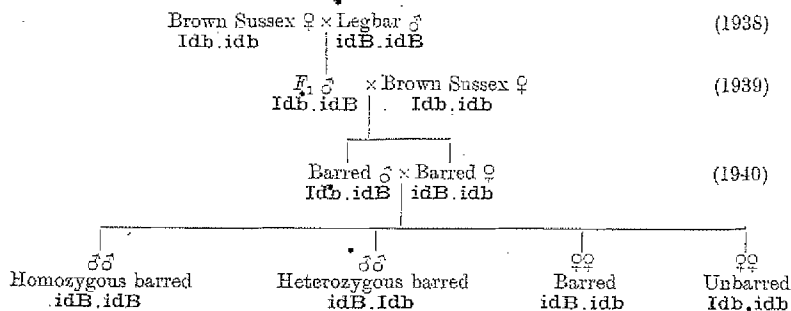
In 1940 a further test was made by mating ♂ 137/39 (a bird with the darker type of down derived from Pen 11/39) with three lighter type ♀♀ all from Pen 12/39. Of the twenty-six male chicks eleven were of the lighter and fifteen of the darker type; of the eighteen female chicks eight were of the lighter and ten of the darker type. Taken altogether the figures are consistent with the view that there is a definite factor leading to darkening of the down, which was doubtless brought in by the dark downed Danish strain, and that this factor reacts as a dominant to the ordinary lighter brown-striped type. Though in the great majority of cases there is no difficulty in referring a down, whether ♂ or ♀, to the darker or lighter class, there are occasional cases which give rise to hesitation, and I incline to think that there may be minor factors involved which push, as it were, the heterozygous bird in the one direction or the other. Nevertheless the general dominance of the darker over the lighter type is unmistakable.

SHANK COLOUR

When hatched the shanks of Legbar chicks show a definite slaty or willow tinge, and this at first seemed puzzling in a breed based upon the Brown Leghorn which contains the dominant *Id* factor for light shank. The point proved an interesting one, and light has been thrown upon it through some further experiments upon the influence of the barring factor on brown downs. In 1938 a mating was made between a Legbar cock and a Brown Sussex hen, a breed which is also brown-striped in the down. In 1939 two F_1 ♂♂ were each mated back to several Brown Sussex hens, producing of course barred and unbarred birds of both sexes. About 100 birds were reared and from the barred ones were selected two pens from those birds which most closely approached the Brown Sussex in general type. For one of the objects of the experiment was to produce an auto-sexing breed of table poultry. At the time these chicks were hatched the point in connexion with the tingeing of the shanks had not arisen, and no particular attention was paid to this feature as the chicks emerged. Incidentally, however, the tingeing of the shanks was recorded in a certain number of cases. When it was noticed, on going over the records at the end of the season, that all such cases were confined to the female sex it was realized that a point of interest had arisen, and the shank colour on hatching was carefully noted in 1940, in which year two pens were mated up from among the barred birds bred in 1939. It should be stated that this phenomenon of tinged shanks is a transient one, and in no case did a bird which hatched with tinged shanks fail to develop a light shank colour, whether white or yellow, on approaching maturity.

Before considering the 1940 data we may briefly outline what appears to be the explanation of this phenomenon of shank tingeing. In the Legbar \times Brown Sussex cross we are dealing with two factors inhibiting mesodermal shank pigmentation, viz. the shank inhibitor, *Id*, and the barring factor, *B*. As I pointed out in a recent paper (1940), these two factors act upon the shank pigmentation in a different manner. *Id* chicks, from hatching onwards, always show a light shank except for an occasional "shot-mark", i.e. the inhibitory action of *Id* on the mesodermal pigmentation occurs at a relatively early stage. On the other hand, *B* does not completely suppress the development of the mesodermal shank pigment until a later stage. *B* chicks, in the absence of *Id*, show some mesodermal pigmentation in the earlier stages though the barring factor gradually leads to its suppression before the bird reaches maturity.

For no adult barred bird is ever dark shanked. Further, **Id** and **B** are closely linked in the sex-chromosome (cf. Punnett, 1940). On this view we may now examine the data gathered in 1940. And it will perhaps help to clarify the argument if I give a brief scheme of the Brown Sussex \times Legbar crosses accompanied by what I consider to be the genetical interpretation involved. For the sake of simplicity I have in this scheme assumed that **Id** and **B** are so closely linked that cross-overs may be neglected. Actually, as will appear later, a few cross-overs do occur.



The 1940 mating between barred male and barred female should on this scheme give rise to four classes of birds, viz. homozygous and heterozygous barred ♂♂, barred (heterozygous) ♀♀ and unbarred ♀♀, and these four classes should be produced in approximately equal numbers. Such was the case. But in so far as shank tingeing is concerned these four classes should show definite distinctions. For since **BB** ♂♂ lack **Id** they should show tinged shanks, while the **Bb** ♂♂ should hatch with light shanks.¹ Again, the barred ♀♀, lacking **Id**, should hatch with tinged shanks, and the unbarred ♀♀, containing **Id**, should hatch with light shanks. The actual data obtained are as follows:

	BB ♂♂	Bb ♂♂	♀♀
Light shank: barred	—	18	3*
unbarred	—	—	16
Tinged shank: barred	13	1*	18
unbarred	—	—	—

* Cross-overs.

These data are in full accordance with the explanation offered on the assumption that about 6% of cross-overs occur. Elsewhere (Punnett, 1940) I have argued for a cross-over value of about 10% between **Id** and **B**. The data are at present too scanty to fix this value with any precision.

A few further data may be given in support of the hypothesis ad-

¹ The distinction between **BB** and **Bb** ♂♂ is similar to that described for the Legbars, so that these two classes can be distinguished in the down.

vanced. In 1940 another barred ♂, constitutionally **Idb. idb** was mated with several Brown Sussex hens (**Idb. idb**). Apart from rare cross-overs expectation is here equal numbers of barred and unbarred ♂♂ all with light shanks, together with equal numbers of unbarred ♀♀ with light shanks and barred ♀♀ with tinged shanks. The actual figures were as follows:

		♂♂	♀♀
Light shank:	barred	10	1*
	unbarred	12	5
Tinged shank:	barred	—	9
	unbarred	—	—

* Cross-over.

Here again the experimental data are evidently in close accord with the hypothesis outlined.

These experiments enable us to see how it is that the Legbar hatchlings with tinged shanks. For in selecting for barring we have at the same time selected against the inhibitory shank pigmentation factor owing to the "repulsion" that exists between **B** and **Id**. We have unconsciously produced a breed in which the **Id** factor of the Leghorn has been eliminated through selecting for barring. The Legbar is really a breed with mesodermal shank pigment derived from the Plymouth Rock, but, as in all barred breeds, the expression of the pigmentation factor is inhibited by that for barring as the bird grows to maturity.

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EXPLANATION OF PLATE 1

- Fig. 1. [♂]Darker ♂ (**BB**) type. Fig. 3. Darker ♀ (**Bb**) type.
 Fig. 2. Lighter ♂ (**BB**) type. Fig. 4. Lighter ♀ (**Bb**) type.
 Fig. 5. Darker ♂ (**BB**) type.

