litter. From yellow × non-yellow matings, 325 litters have been obtained, including 1,812 young, an average of 5.57 young to a litter. These averages are considerably higher than Cuénot's, indicating either a healthier stock of animals or better experimental conditions. Qualitatively, however, the results obtained in the two cases are completely in accord. The yellow × non-yellow matings produced larger litters than the yellow × yellow matings, but not so much larger as we should expect if homozygous yellow zygotes simply perished without otherwise affecting the character of the litter. For, in that case, the two categories of litters should be to each other in average size as 3:4, but we find that they were really as 3.38:4. The litters of yellow × yellow parents, instead of being 25 per cent. smaller, are only 15.5 per cent. smaller than those of yellow × non-yellow parents. In other words, when 100 pure yellow zygotes perish, they cause 38 other zygotes to develop in their stead. How can this be brought about? Cuénot supposes that some of the potential pure yellow combinations really become heterozygous yellow combinations and so swell the size of the litter. But in that case the total percentage of yellows should exceed 66.66 per cent., which it does not in our experience. We are forced, therefore, to conclude that the perishing of a pure yellow zygote makes possible the development of a certain number of *other* fertilized eggs.

Two ways may be suggested in which this might come about. First, more eggs may normally be liberated at an ovulation than there are young born subsequently. In that case, failure of some eggs to become attached to the uterus may make the chances greater that the remainder will become attached, or the perishing of some may make the chances greater that the rest will successfully complete their development. Or secondly, the production of a relatively small number of young at one birth may lead indirectly to more free ovulation subsequently, and so to the production of a larger litter at a second birth. It should be possible to test the validity of both these hypotheses experimentally.

The result here described for yellow mice, in common with that of Baur in the case of *Antirrhinum*, would seem to show that a Mendelian class may be formed and afterwards be lost by failure to develop. In other words, a physiological inability to develop may permanently modify a Mendelian ratio, causing the loss of an entire class.

As regards the matter of selective fertilization of the egg discussed by Wilson and Morgan in connection with this case, it is evident that nothing of the sort here occurs.

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FURTHER DATA REGARDING THE SEX-LIMITED INHERITANCE OF THE BARRED COLOR PATTERN IN POULTRY[1]

In two previous papers[2] the writers have de-

[1] Papers from the Biological Laboratory of the Maine Agricultural Experiment Station, No. 22.

[2] Pearl, R., and Surface, F. M., "On the Inheritance of the Barred Color Pattern in Poultry," *Arch. f. Entwicklungsmech.*, Bd. XXX., pp. 45–61, 1910 (Roux Festschrift). "Studies on Hybrid Poultry," Ann. Rept. Me. Agr. Expt. Stat., 1910, pp. 84–116.

scribed the results in the F_1 generation of crossing reciprocally Barred Plymouth Rock and Cornish Indian Game fowls. In these papers it was shown that the type of barred pattern seen in Barred Plymouth Rocks appeared to be inherited in a sex-limited manner, the females of the breed mentioned being heterozygous in respect to the factors determining both sex and the barred pattern. These experiments have been continued and it is our purpose in this paper to present the evidence obtained in the F_2 generation, which is in complete accord with the hypothesis of sex-limited inheritance adduced to account for the F_1 results. In this paper the inheritance of the barred pattern in these crosses will be alone discussed. In a later paper other characters, including fecundity, shank color, etc., will be considered.

At the outstart it should be recalled that in the F_1 generation of this cross, but one type of non-barred birds appeared. These were the females resulting from the cross C.I.G. ♂ × B.P.R. ♀. These were solid black birds. In the F_2 generation *three* main types of *non-barred* birds appeared. These were: (*a*) solid black birds, like those in F_1, (*b*) solid white birds, and (*c*) birds showing the game pattern and type of coloration. In the present discussion all of these birds will be considered *together*, as non-barred, *i. e.*, lacking the barred pattern. While they are different among themselves they are alike in this point: they lack the barred pattern. The analysis of these different types of non-barred birds will be considered in detail in a later paper.

Confining our attention here then to the two main categories of birds *with*, and birds *without*, the barred pattern, we have the results set forth below. It will be noted that all possible matings of the F_1 crosses *inter se* and with the parent birds, were made in the experiments.

Using the following symbols,

B = presence of the barred pattern,
b = absence of the barred pattern,
F = presence of the ♀ sex,
f = presence of the ♂ sex,

we have the following constitutions of the birds used, the assumption being made that both B and F can not exist together in the same gamete:

Pure Barred Rock ♂ = $Bf \cdot Bf$,
Pure Barred Rock ♀ = $Bf \cdot bF$,
Pure Cornish Indian ♂ = $bf \cdot bf$,
Pure Cornish Indian ♀ = $bf \cdot bF$.

This leads to the following expectation in the

F_1 Generation:

Mating: *B.P.R.* ♂ × *C.I.G.* ♀.
Expectation:
$Bf \cdot Bf \times bf \cdot bF = Bf \cdot bf$ = Barred ♂♂,
$+ Bf \cdot bF$ = Barred ♀♀.

Mating: *C.I.G.* ♂ × *B.P.R.* ♀.
Expectation:
$bf \cdot bf \times Bf \cdot bF = bf \cdot Bf$ = Barred ♂♂,
$+ bf \cdot bF$ = Non-barred ♀♀.

It was shown in the papers already referred to that these expectations were realized experimentally in the F_1 generation.

We come now to the

F_2 Generation.

I. Mating: *Pure B.P.R.* ♂ × *F_1 Barred Cross-bred*[3] ♀.

Expectation:
$Bf \cdot Bf \times bf \cdot bF = Bf \cdot bf$ = Barred ♂♂,
$+ Bf \cdot bF$ = Barred ♀♀.

[3] After careful consideration it has seemed to the writers advisable to use the term "cross-bred" to designate the offspring from crosses of different *breeds* of poultry, instead of the term "hybrid," reserving the latter to designate the progeny of species crosses. This was the usual connotation of the word "hybrid" before the rediscovery of Mendel's laws. While "hybrid" has the sanction of "good biological usage" at the present time as applied to all sorts of crosses, it seems desirable in the interests of precision of diction in scientific work to use different terms for the progeny from crosses of closely related and more distantly related forms. "Cross-bred" is a term of unmistakable meaning and has long been employed by breeders of domestic animals with the sense in which it is here used. It is unfortunate that we do not have in English in a single word a polite equivalent of the German "*Bastard*" for use in such cases.

The expectation here is that all the offspring, both ♂ and ♀, will be barred.

Experimental Result.—There were 9 matings of this kind made. From these matings were produced 62 ♂ and 61 ♀ chickens.[4] All were barred.

II. Mating: *Pure B.P.R.* ♂ × *Non-barred* F_1 *Cross-bred* ♀.

Expectation:

$Bf \cdot Bf \times bf \cdot bF = Bf \cdot bf =$ Barred ♂♂,
$+ Bf \cdot bF =$ Barred ♀♀.

The expectation here is that all the progeny, both ♂ and ♀, will be barred.

Experimental Result.—There were 9 matings of this kind made. From these matings were produced 27 ♂ and 37 ♀ chickens. All were barred.

III. Mating: *Pure C.I.G.* ♂ × *Barred* F_1 *Cross-bred* ♀.

Expectation:

$bf \cdot bf \times Bf \cdot bF = bf \cdot Bf =$ Barred ♂♂,
$+ bf \cdot bF =$ Non-barred ♀♀.

The expectation here is that all the ♂ progeny will be barred and all the ♀ non-barred.

Experimental Result.—There were 4 matings of this kind made. From these matings were produced 53 ♂ chickens—all barred—and 56 ♀ chickens—all non-barred.

IV. Mating: *Pure C.I.G.* ♂ × *Non-barred* F_1 *Cross-bred* ♀.

Expectation:

$bf \cdot bf \times bf \cdot bF = bf \cdot bf =$ Non-barred ♂♂,
$+ bf \cdot bF =$ Non-barred ♀♀.

The expectation here is that all the progeny, both ♂ and ♀, will be non-barred.

Experimental Result.—There were 4 matings of this kind made. From these matings were produced 19 ♂ and 16 ♀ chickens, all non-barred.

V. Mating: F_1 *Cross-bred* ♂ × *Pure B.P.R.* ♀.

Expectation:

$Bf \cdot bf \times Bf \cdot bF = Bf \cdot Bf =$ Barred ♂♂,
$+ bf \cdot Bf =$ Barred ♂♂,
$+ bf \cdot bF =$ Non-barred ♀♀,
$+ Bf \cdot bF =$ Barred ♀♀.

The expectation here is that all the ♂ progeny will be barred, and that of the ♀ progeny one half will be barred and one half non-barred.

Experimental Result.—There were 6 matings of this kind made. From these matings there were produced 38 ♂ and 32 ♀ chickens. All the ♂♂ were barred, and of the ♀♀ 13 were barred and 19 were non-barred.

VI. Mating: F_1 *Cross-bred* ♂ × *Pure C.I.G.* ♀.

Expectation:

$Bf \cdot bf \times bf \cdot bF = Bf \cdot bf =$ Barred ♂♂,
$+ bf \cdot bf =$ Non-barred ♂♂,
$+ Bf \cdot bF =$ Barred ♀♀,
$+ bf \cdot bF =$ Non-barred ♀♀.

The expectation here is that barred and non-barred birds will appear in equal numbers in both ♂ and ♀ progeny.

Experimental Result.—There were 6 matings of this kind. From these matings were produced 14 ♂ chickens, of which 9 were barred and 5 non-barred, and 23 ♀ chickens, of which 4 were barred and 19 non-barred.[5]

VII. Mating: F_1 *Cross-bred* ♂ × *Barred* F_1 *Cross-bred* ♀.

Expectation:

[4] In this and all of the following cases the numbers of offspring given denote the number which survived until such time as they bore *adult* plumage. It is impossible to make use of chicks in the down plumage in the study of inheritance of barring, because the barred pattern does not appear in the down feathers at all but only in the adult plumage. A full discussion of this point will be found in our first paper on the subject (*loc. cit.*). In general the use of chicks in the down plumage for the study of the inheritance of pattern and color characters in poultry is open to very serious criticism. The reason for this is that in many cases there is no *definite* or *fixed* relation between the color of the chick in the down and in the adult plumage. A chick which is pure white in the down may be black as an adult: a chick which shows the down characters of a Barred Rock may have the adult pattern of a Game and so on. A full discussion of this point, with definite statistical data will be presented in a later paper.

[5] For the probable explanation of this and other deviations from the expected *ratio* in the case of the ♀♀, see below.

$Bf \cdot bf \times Bf \cdot bF = Bf \cdot Bf =$ Barred ♂♂,
$+ bf \cdot Bf =$ Barred ♂♂,
$+ Bf \cdot bF =$ Barred ♀♀,
$+ bf \cdot bF =$ Non-barred ♀♀.

The expectation here is that all the ♂ progeny will be barred and of the ♀ progeny one half will be barred and one half non-barred.

Experimental Result.—There were 9 matings of this kind made. From these matings were produced 69 ♂ chickens—all barred —and 66 ♀ chickens, of which 29 were barred and 37 non-barred.

VIII. Mating: F_1 *Cross-bred* ♂ × *Non-barred* F_1 *Cross-bred* ♀.

Expectation:

$Bf \cdot bf \times bf \cdot bF = Bf \cdot bf =$ Barred ♂♂,
$+ bf \cdot bf =$ Non-barred ♂♂,
$+ Bf \cdot bF =$ Barred ♀♀,
$+ bf \cdot bF =$ Non-barred ♀♀.

The expectation here is that barred and non-barred birds will appear in equal numbers in both ♂ and ♀ progeny.

Experimental Result.—There were 8 matings of this kind made. From these matings were produced 58 ♂ chickens, of which 27 were barred and 31 were non-barred, and 39 ♀ chickens, of which 13 were barred and 26 were non-barred.

This completes the total number of possible matings. The experiments include all told 670 adult recorded F_2 chickens.

Discussion of Results.—From the results above set forth it is apparent that *as regards the appearance of the different types of birds in the different matings, theory and fact are in close accord in all cases.* More precise and clear-cut results than have been obtained in this experiment would be difficult to find. The precision and definiteness of the results is emphasized by the fact that *in every case an objective description of the bird was made and recorded without any knowledge on the part of the describer of its pedigree or the characters which it would theoretically be expected to bear.* No attempt was made even to work out in the laboratory the theoretical F_2 expectations until after all the data (description of birds) were collected. In fact these F_2 expectations which appear above were never set down on paper by any one in this laboratory until late this present fall, after all the experimental results were collected and tabled. The objectivity of the work could not have been more thoroughly safeguarded. All the original descriptions of the birds were made by the same person, R. P.

There is one point in regard to which it might at first be thought that there was serious disagreement between theory and fact. It will be noted that in matings V., VI., VII. and VIII., there is in each case a more or less marked discrepancy between the expected and the actual numbers of barred female progeny. In matings V. and VII. the discrepancies are small, and may easily be explained as purely chance deviations. In the cases of more serious discrepancy, as well as in these two, the number of barred females actually found is in each case smaller than the expected number. The explanation of this is probably *not* that we have here an exception to Mendelian expectation. On the contrary we have every reason to believe that the explanation is much simpler and consists mainly in the fact that barred females were systematically stolen from the plant during the summer. As has been said it is necessary in working with the barred pattern to wait until the birds are in adult plumage before they can be recorded. Now it happens that, fortunately or unfortunately, the Maine Stations Barred Rock stock is locally held in high esteem for its economic qualities. The location of the houses upon the range this year, and other circumstances as well, made it impossible to control thieving, and a large number of birds were lost in this way. The majority of the barred F_2 cross-bred females were indistinguishable from pure Barred Rock females to a casual observer. Many of them were undoubtedly stolen on the supposition that they were pure Rocks. A careful and thorough study of the evidence has left no doubt in our minds that the above is an important factor in the explanation of the discrepant ratios. Every experimentalist will appreciate our feelings when the discovery of these depredations was made. The whole case illustrates very well the condition which one working in a state agricultural institution is liable at any time to be confronted with, because of the fact that, owing to public opinion, he can not enforce stringent and drastic measures to guard against the stealing of such things as chickens and eggs.

One further fact to which we wish to call attention here has to do with the character of the barring exhibited by certain of the F_2 birds. In the paper describing the F_1 birds special stress was laid on the fact that the barring in these birds was not of such fine quality from the fancier's standpoint as in pure Barred Rocks. No one familiar with good specimens of that breed could ever mistake a barred F_1 bird for a pure Rock. In certain of the F_2 birds this is not the case. Certain of the F_2 matings produced birds which had a much finer, sharper and cleaner cut barred pattern, or, to adopt a technical expression, a "snappier" barring than any pure Barred Rock in the Station stock. In other words, it appears that though the heterozygous nature of the F_1 birds was apparent in their external characters, the segregation of barred pattern in the F_2 generation was not merely perfect, but, to speak paradoxically, was more than perfect, *i. e.*, produced something better than existed in the parent stock. It may be said, in passing, that the same thing is true with reference to comb types. In the F_1 generation there were very few *perfect* pea combs, from the fancier's standpoint. In the F_2 generation where pea combs segregated out relatively many of them were of fine showroom quality, and relatively few were badly defective or intermediate between pea and single. The relation of the individuality of the birds bred to the quality of the segregation products furnishes an exceedingly interesting and important problem.

One further point needs mentioning. In the F_1 generation the male birds produced by the cross of B.P.R. ♂ × C.I.G. ♀ and its reciprocal were all alike in gametic formula and external appearance. The F_2 results indicate that the same results were obtained with F_1 males from the cross B.P.R. ♂ × C.I.G. ♀ as with those obtained from the cross C.I.G. ♂ × B.P.R. ♀. These two kinds of males were, in other words, equivalent in fact as well as in theory.

In later papers the details of the results here briefly reported will be presented, and a discussion of the different types of non-barred birds and the laws of their appearance entered upon.

By way of summary it may be said that experiments involving 670 adult birds in the F_2 generation, arising from all possible matings of F_1 birds *inter se* and with the parent pure breeds (Barred Plymouth Rock and Cornish Indian Game) give results in regard to the inheritance of the barred color pattern which are in accord with a Mendelian hypothesis of sex-limited inheritance of this character, developed along lines originally suggested by Spillman.

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THE ASTRONOMICAL AND ASTROPHYSICAL SOCIETY OF AMERICA

THE eleventh annual meeting of the Astronomical and Astrophysical Society of America was held at Harvard College Observatory, Cambridge, Mass., on August 17, 18 and 19. The society was welcomed to Cambridge by Professor E. C. Pickering, both in his capacity as president and as director of the observatory. Among those present were more than a score of foreign astronomers and physicists, who had come to this country for the purpose of attending this meeting and later that of the International Union for Cooperation in Solar Research at Mount Wilson in California. The complete list of those in attendance is as follows: Miss Allen, Miss Breslin, Miss Cannon, Miss Carpenter, Miss Cushman, Mrs. Fleming, Miss Harwood, Miss Hayes, Miss Leavitt, Miss Leland, Miss O'Reilly, Miss Walker, Miss Waterbury, Mrs. Whitin, Miss Whiting, Messrs. Apple, Archer, Backlund, Bailey, Barton, Bell, Belopolsky, L. Brown, L. Campbell, Cirera, Coit, Comstock, Cortie, Cotton, Dinwiddie, C. L. Doolittle, Douglass, Dugan, Duncan, Dyson, Edwards, Eichelberger, Fabry, Fisher, Fowler, Gimenez, Hepperger, Hills, Humphreys, Hunt, Hussey, E. S. King, Larmor, C. Lundin, C. A. R. Lundin, Man-