it is necessary to replace the glass cover of the petri dish to keep the medium from drying up. It may be removed, however, as often as desired, in order to examine the culture with a microscope, or irradiate it with ultra-violet light. Cultures can be conveniently labeled with india ink directly on the cellophane.

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SPECIAL ARTICLES

THE EFFECTS OF BREED ON GROWTH OF THE EMBRYO IN FOWLS AND RABBITS

T. C. BYERLY[1] has recently made an important study of the weight of chick embryos in two different breeds of domestic fowls and in their reciprocal hybrids. He reaches the conclusion that breed does not affect the size of the embryo except as it affects the size of the egg previous to incubation. This is contrary to the conclusion reached by Painter[2] and by Castle and Gregory[3] in the case of the rabbit, which leads Byerly to question the correctness of the rabbit findings.

In the rabbit studies it had been found that the size of the egg at the time of fertilization is no greater in Flemish Giant rabbits than it is in Polish (a very small breed), but that the average birth weight of a Flemish Giant is nearly double that of a Polish. It is obvious accordingly that Flemish embryos increase in weight faster than Polish embryos prior to birth, as they are well known to do subsequently. Since there is no discoverable difference in cell size between Flemish and Polish rabbit embryos (Painter), it is clear that the former must contain *more* cells, and this means that cell multiplication must proceed more rapidly in the development of Flemish than in that of Polish rabbits. Castle and Gregory have found such a difference in evidence as early as 48 hours after mating. Byerly questions the adequacy of the data submitted in support of this conclusion. To this criticism we offer no objection at this time because we have made additional observations, which will be presented in a paper[4] now in press, showing that the difference in number of blastomeres and in mitoses is clearly present at still earlier stages, *viz.*, 40 and 41 hours after mating.

The case of the chick embryo is more difficult because the size attained by the embryo at the time of hatching, which corresponds roughly with the birth weight of the rabbit, is strictly limited by the weight of the egg prior to incubation. A large chick can not hatch from a small egg. Nevertheless, it is possible to derive from Byerly's observations clear indications as to whether breed (*i.e.*, genetic constitution), does or does not influence embryo size prior to hatching, while there is still an unexhausted supply of nourishment for the embryo to draw upon.

The two breeds studied by Byerly in pure matings and in reciprocal cross matings were White Leghorn and Rhode Island Red, which for brevity we may call the White and the Red breeds, respectively. Red hens average about one third larger than White, or as 100:138 in mean body weight. The mean egg weight of the Red breed was also slightly greater, 60.5 grams as compared with 58.4 grams, the mean egg weight of the Whites. Whether the energy content of the Red egg is greater is unknown, as the relative weight of shell and relative size and composition of the yolk are unknown. Byerly directs his attention chiefly to a comparison of the weight of the embryo when removed from the yolk in White as compared with Red eggs throughout the incubation period. It appears from his observations that the blastoderm of the egg, when removed from the yolk, prior to incubation is heavier in the White breed than in the Red. For the White breed, the mean weight is 0.0030 grams; for Reds, 0.0028 grams. Whether the difference is due to a larger amount of formed cellular material[5] or to a larger amount of adhering yolk is unknown, but whatever its nature, the difference persists throughout the first nine days of incubation, in which the embryos taken from White eggs are slightly heavier than those taken from Red eggs. Subsequently, *i.e.*, from the 10th to the 19th days of incubation, the Red embryos are heavier. This is shown both in Byerly's Table 1 summarizing his more numerous observations and in his Table 3 summarizing the data obtained under specially controlled conditions, "from hens of the same age and receiving the same diet, from eggs of the same weight and incubated in the same incubator at the same time."

Nevertheless the hatching weight of chicks in the two breeds is substantially the same, which points to total egg size as a factor limiting the size of the chick prior to the time that it begins to receive nourishment from other sources.

The more rapid growth of Red embryos, after the initial handicap of a smaller blastoderm had been overcome, and before total egg size had entered as a limiting factor just prior to hatching, is completely

[1] *Jour. Morphol. and Physiol.*, 50, December, 1930.
[2] *Jour. Exp. Zool.*, 50, 1928.
[3] *Jour. Morphol. and Physiol.*, 48, September, 1929.
[4] *Jour. Exp. Zool.*, 59, April, 1931.

[5] Possibly in the White breed cell increase in the blastoderm proceeds farther than in the Red breed before coming to a standstill previous to incubation. If so, we can understand why this initial advantage persists for several days before the more rapid growth rate of the Red breed overtakes it.

in harmony with the observations made on rabbits, in that it shows that the embryo of the larger breed grows faster when other conditions are equal.

Another and even clearer indication that breed (genetic constitution) affects the rate of growth of the embryo throughout the entire period of incubation (even before endocrine organs are established) seems to have been overlooked by Byerly. This is the more rapid growth of crossed as compared with uncrossed embryos. The difference in blastoderm composition in the two breeds prior to incubation, which obviously influences embryo weight up to the ninth day of incubation, may be completely eliminated by confining the comparison to the eggs of one breed at a time, comparing the size of embryos produced in White eggs fertilized by White males with that of embryos produced in White eggs fertilized by Red males, and also comparing the size of embryos produced in Red eggs fertilized by Red males with that of embryos produced in Red eggs fertilized by White males. In both cases Byerly's observations show the cross-bred embryos to be preponderantly heavier, whether the mother was White or Red.

The White eggs opened each day (Table I) range in number from 10 to 75 in each series (pure-bred and cross-bred). The pure-breds average heavier on 4 of the 19 days of incubation, *viz.*, the 2nd, 8th, 16th and 18th. On the 15 remaining days, including both the first and the last, the cross-bred embryos are heavier.

The observations made on Red eggs are less numerous but point to the same conclusion. The cross-bred embryo is in general heavier. The number of cross-bred embryos studied is smaller and does not cover every day of the incubation period, ranging from 4 to 11 embryos per day, but its indications are clear. The period covered is from the 2nd to the 19th days of incubation, omitting the 6th and 7th, and the 13th, 14th and 15th. Cross-bred embryos are heavier on all except two (the 9th and 18th) of the 13 days sampled.

As to the hatching weight, that of the cross-breds is slightly greater in the Red series and slightly less in the White series. Here available nourishment within the egg comes in as a limiting factor. If this were removed, by taking body weights a few weeks subsequent to hatching, cross-breds would undoubtedly be found again heavier, as is well known from other observations.

The specially controlled series of embryos produced by Byerly, from eggs of the same size incubated simultaneously side by side, summarized in his Table 3, confirms the conclusions based on his more general series summarized in Table I. The number of embryos studied is smaller, ranging from 2 to 14 per day in each of the four series, but the conditions under which they were produced make their evidence particularly important. Embryos from the eggs of White hens mated with White males are heavier on 3 of the 12 days sampled; *viz.*, the 2nd, 3d and 12th; cross-bred embryos from the eggs of White hens mated with Red males are heavier on the other nine days (4, 5, 8, 9, 10, 11, 16, 17 and 19). Embryos from the eggs of Red hens mated with Red males are heavier on 4 of the 12 days sampled; *viz.*, 9, 11, 16 and 19; cross-bred embryos from the eggs of Red hens mated with White males are heavier on the other eight days (2, 3, 4, 5, 8, 10, 12 and 17). With the small number of embryos examined, it is evident that random sampling affects the results here more than in Table I, which included larger numbers; nevertheless the general trend of the observations is clear and consistent with the results of Table I. *Other things being equal, a cross-bred embryo grows faster than one not cross-bred.*

There is, we think, no escaping the conclusion based on Byerly's own observations that breed (genetic constitution) does influence growth rate and through it body size. Embryos of the larger breed grow faster as soon as they have attained an even start. Also eggs of the same breed laid by the same flock of hens under identical conditions, if fertilized by males of their own breed, produce smaller embryos than are produced if fertilization is accomplished by males of the other breed. Are the cross-bred embryos heavier because they contain more cells or larger cells? We may take our choice of these alternatives. If they contain more cells, then cell multiplication must occur more rapidly in the larger embryo, exactly as it does in rabbits. If one chooses to assume that the cells are larger rather than more numerous in cross-bred embryos, the burden of proof rests with him, for Painter has not found it so in rabbits, but in any case it is obvious that a cross-bred embryo grows faster than one not cross-bred in birds as well as in rabbits.

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THE EFFECT OF DIET ON HOOKWORM INFESTATION IN DOGS[1]

THE investigations summarized in this brief preliminary report give an experimental demonstration

[1] From the department of helminthology of the School of Hygiene and Public Health of the Johns Hopkins University. This work was made possible by the aid of the International Health Division of the Rockefeller Foundation.