Capsule formation: Organisms in the mucoid phase form definite capsules. Such capsules can be readily demonstrated by Muir's stain in peritoneal exudates and with somewhat greater difficulty on organisms grown on solid media.

Lack of type-specificity: Preliminary agglutination studies have failed to yield any evidence of type-specificity for organisms in the mucoid phase.

Soluble substance: Filtered saline suspensions of organisms in the mucoid phase give a definite precipitate with serum prepared against organisms in that phase. This precipitable substance appears to be different from any previously isolated constituent of *Streptococcus hemolyticus*. The indications are that this substance is common to the mucoid phase of the several strains examined. The chemical nature of this soluble substance is being further investigated.

SUMMARY

(1) The occurrence and distribution of the mucoid phase of *Streptococcus hemolyticus* is indicated.

(2) Severe and acute infections usually yield organisms in the mucoid phase: mild and chronic infections usually yield smooth organisms.

(3) Organisms which are highly virulent for mice produce mucoid colonies; but all mucoid cultures are not necessarily virulent.

(4) Organisms in the mucoid phase produce a soluble precipitable substance which is common to the several strains examined.

MARTIN H. DAWSON
MIRIAM OLMSTEAD
COLLEGE OF PHYSICIANS AND SURGEONS
COLUMBIA UNIVERSITY AND THE
PRESBYTERIAN HOSPITAL

AN EXPERIMENTAL ANALYSIS OF THE CAUSE OF POPULATION FLUCTUATIONS

IT has previously been shown that populations of the confused flour beetle (*Tribolium confusum* Duval) which are confined in beakers of whole wheat flour come to a "steady state" or "quasi-equilibrium," especially with respect to the adult populations.[1, 2, 3] Under such conditions the egg populations show certain interesting and periodic fluctuations. It has been the object of the experiments under consideration to determine the causes of these fluctuations.

When an experiment is initiated with a number of adult beetles that is well below the "saturation point," the number of eggs present in the environment increases until it approaches the "potential number"[4] and then drops off to rise again when the daughters of the original population begin to lay eggs. Theoretically, the number of eggs present in the environment should remain at the "potential number" unless the females cease to lay their daily quota of eggs or some factor within the environment causes the eggs to disappear. The basis for this statement is the fact that the daily quota of eggs will accumulate each day during the period between oviposition and hatching. On the day that the first daily quota of eggs hatches an equal number of eggs will be laid and the number of eggs present in the environment should remain constant. If there is a change in the number of eggs present it must mean either that the oviposition rate has not remained constant or that some factor in the environment has interfered with the eggs. Good[5] and others have shown that under ordinary conditions the females continue to lay eggs for over a year; hence it seems that some factor in the environment may be involved.

It has been shown repeatedly that the number of eggs rises to the potential number and then falls to a low level as the number of larvae in the environment increases.[6] Park[7] and Maclagan[8] have called attention to the fact that the net number of eggs present in such environments, expressed as eggs per female per day, decreases as the population increases. The attention of these authors has been devoted primarily to the matter of adult populations and they have concluded that the reduction in the number of eggs and larvae has been due to a decrease in the rate of oviposition. It is difficult to prove that oviposition is the variable factor, because the coefficient of variability of the rate of oviposition of individual females has been determined to be as high as 62 per cent.[9]

In the experiments now being reported upon, "oviposition" was maintained constant in order to mea-

[1] Royal N. Chapman, "Quantitative Analysis of Environmental Factors," *Ecology*, 9: 111–122, 1928.

[2] F. G. Holdaway, "An Experimental Study of the Growth of Populations of the Flour Beetle *Tribolium confusum* Duval, as Affected by Atmospheric Moisture," *Ecol. Monographs*, 2: 261–304, 1932.

[3] John Stanley, "A Mathematical Theory of the Growth of Populations of the Flour Beetle, *Tribolium confusum* Duval," *Canadian Jour. Res.*, 6: 632–671 and 7: 426–550, 1932.

[4] The "potential number" is the product of the average number of eggs laid per female per day, the number of days required for the eggs to hatch and the number of females present.

[5] Newell E. Good, "Biology of the Flour Beetles, *Tribolium confusum* Duv. and *T. ferrugineum* Fab.," *Jour. Agr. Res.*, 46: 327–334, 1933.

[6] Royal N. Chapman, "Animal Ecology," McGraw-Hill Book Co., pp. 212–214, 1931.

[7] Thomas Park, "Studies in Population Physiology: The Relation of Numbers to Initial Population Growth in the Flour Beetle, *Tribolium confusum* Duval," *Ecology*, 13: 172–181, 1932.

[8] D. S. Maclagan, "The Effect of Population Density upon Rate of Reproduction with Special Reference to Insects," *Proc. Roy. Soc.*, B. 111: 437–454, 1932.

[9] Royal N. Chapman and Lillian Baird, "The Biotic Constants of *Tribolium confusum* Duv.," *Jour. Exp. Zool.* In press.

sure the factors in the environment which act in reducing the number of eggs present at various times during the period when the population is rising to the quasi-equilibrium. In order to do this four beakers were set up, each containing 32 grams of whole wheat flour which had been reduced to a fineness which would permit it to pass through a number four standard silk bolting cloth. In one of these beakers eight pairs of flour beetles were introduced as a check population. Sixteen adult male beetles were placed in each of the other three beakers to be compared with the check population; and each day eggs were added at the rate that they would have been laid at the prevailing temperature, if half of the number of adults had been females. Thus the number of eggs added became a known quantity. Inasmuch as Park[10] has shown that males eat eggs at the same rate as females, the egg eating in these populations should be comparable with the check population. If nothing in the environment interfered with the eggs they should have increased in number until they reached the "potential number" and remained constant.

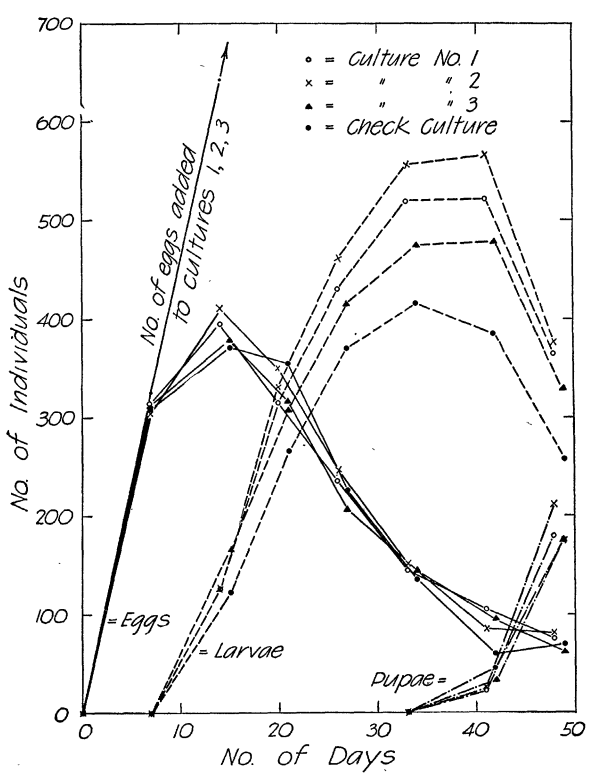

FIG. 1. A comparison of the egg populations in a check culture of 8 pairs of beetles in 32 grams of wheat flour with three cultures of 16 males each to which eggs were added at the same rate as would have obtained had half of the beetles been females.

[10] Thomas Park, "Studies in Population Physiology: II. Factors Regulating the Initial Growth of *Tribolium confusum* Populations," *Jour. Exp. Zool.*, 65: 17–42.

The accompanying graph (Fig. 1) shows that the number did not remain constant and that all four egg populations followed approximately the same course. On the 33rd and 34th days after 1,455 eggs had been added to the three synthetic populations the numbers of eggs were 142, 150 and 141. The check environment with eight females contained 135 eggs. The drop in the number of eggs present is coincident with the rise in the number of larvae. Since the larvae are known to eat eggs[4] and seem to represent the only change in the environment, it seems probable that they were the major factor concerned with the decrease in the number of eggs.

Park[11] and Maclagan[12] compared the number of eggs and larvae "per female per day" based upon counts of cultures on the 11th and 25th days and concluded that the smaller numbers at higher population densities demonstrated that population density decreased the oviposition rates. In the "synthetic populations" in the present experiment there were only 3.2, 3.4 and 2.87 eggs and larvae "per female per day" on the 26th day, although 4.6 had actually been added.

It is to be noted, however, that the numbers of larvae appearing in the three "synthetic populations" are greater than in the normal population which served as the check. The difference between the numbers of larvae in the three "synthetic populations" is comparable to that between the lowest "synthetic population" and the check. Comparison with other data[13] shows that there is a considerable fluctuation in the number of larvae present at the peak of the larval curves and as yet there seems to be no adequate explanation other than to ascribe the differences to experimental errors.

From the present experiment it seems evident that population systems of flour beetles produce a resistance to their own potential rate of increase, in spite of a constant rate of oviposition, and that this resistance is responsible for the decrease in the egg population which occurs in the early history of a population of flour beetles.

ROYAL N. CHAPMAN
W. Y. WHANG

UNIVERSITY OF HAWAII

[11] *Op. cit.*
[12] *Op. cit.*
[13] See footnotes 2 and 6.

BOOKS RECEIVED

BAKER, F. S. *The Theory and Practice of Silviculture.* Pp. xiv + 502. 87 figures. McGraw-Hill. $5.00.

CHIAO, CHI-MING. *A Study of the Chinese Population.* Pp. iv + 56. Milbank Memorial Fund, New York. $0.25.

ELDRIDGE, JOHN A. *The Physical Basis of Things.* Pp. xiv + 407. Illustrated. McGraw-Hill. $3.75.

JUNK, W., Editor. *Tabulae Biologicae Periodicae.* Band III, No. 4: P. 321–436. Band IV, No. 1: Pp. 160. Editor, Berlin.