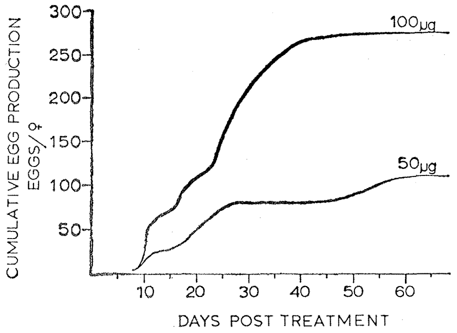

Fig. 1. Cumulative egg production of adult alfalfa weevils treated topically with 50 or 100 μg of *trans-trans*-10,11-epoxyfarnesenic acid methyl ester.

males and 12 females; all were held in 4-liter jars containing bouquets of cut stems of alfalfa.

In the groups receiving 50 or 100 μg of the epoxide, activity and feeding began within 3 days and increased from none to a very active "normal" rate within 6 to 7 days; oviposition began on the 8th day after treatment. Although there was some activity and slight feeding by the groups that had received the lower doses (0.1 to 10.0 μg), and a few mating pairs were observed in the 10-μg group, no oviposition occurred, and all returned to a diapause condition 2 to 3 weeks after treatment. Acetone-treated and untreated controls remained in diapause and demonstrated no feeding, mating, or oviposition during the 7-week period of observation.

Oviposition was the most readily measured phenomenon, being quantified over the 7-week period. Although the groups treated with 50 or 100 μg of epoxide produced significant numbers of eggs (Fig. 1), a definite dose-response relation existed: duration of oviposition and number of eggs produced were greater after the higher dosage. Additional experiments have demonstrated the reproducibility of these results.

Since an exogenous supply of synthetic hormone breaks diapause, it seems that one may justifiably conclude that diapause in the alfalfa weevil is essentially the result of an endocrine-deficiency syndrome of the corpora allata. However, the synthetic hormone seems not to simply overcome some kind of metabolic inertia and trigger or push the insect out of diapause; in that event the host's own corpora allata should take over, and the great disparity between groups of insects in response to oviposition would be eliminated. In view of the dose dependency of the ovipositional response, the corpora allata of these insects may have remained inactive. We believe that our results, taken together with the inability of de Wilde and de Boer (*1*) to break normal diapause in *Leptinotarsa* by implantation of corpora allata, argue in favor of the existence of an inhibition that suppresses corpora-allata activity and is therefore primarily responsible for the onset and maintenance of diapause.

The ability to terminate diapause with a synthetic hormone may have several practical uses: (i) continuous rearing in the laboratory of insects that normally diapause; (ii) immediate laboratory use of insects collected in a diapausing condition [the fact that parasites (*microctonus* sp.) have emerged from treated weevils indicates that development of the parasites was governed by the physiologic condition of the host; the parasites would normally have been recovered 3 to 4 months after the onset of diapause in the host]; (iii) potential control of insects, since termination or prevention of diapause in an insect exposes it to the consequences of a hostile environment which it normally avoids by entering diapause; thus the insect will be in a physiologic state to feed (in the possible absence of a host plant, as in winter) and to mate and reproduce during a period of environmental stress.

W. S. Bowers
C. C. Blickenstaff
Insect Physiology Laboratory and
Grain and Forage Insects Research
Branch, U.S. Agricultural Research
Service, Beltsville, Maryland 20705

References

1. J. de Wilde and J. A. de Boer, *J. Insect Physiol.* **6**, 152 (1961).
2. D. Stegwee, *ibid.* **10**, 97 (1964).
3. K. Slama, *ibid.*, p. 283.
4. W. S. Bowers, M. J. Thompson, E. C. Debel, *Life Sci.* **4**, 2323 (1965).
5. C. C. Blickenstaff, *Ann. Entomol. Soc. Amer.* **58**, 523 (1965).

31 October 1966

■

Background Selections of Geometrid and Noctuid Moths

Abstract. *Several common moths, collected at night and placed in an experimental box, showed daytime selections of backgrounds which tended to match the reflectance of their forewings. In one case, two distinct forms of a species showed different background selections.*

Many moths habitually rest upon natural backgrounds which match their wings (*1*). However, the extent to which moths can actively select appropriate backgrounds is uncertain. The only prior experimental study is that of Kettlewell (*2*), who demonstrated that light and dark forms of *Biston betularia* prefer white and black paper backgrounds, respectively. I now summarize evidence for reflectance matching in an experimental box by eight common geometrid and noctuid species collected during the summer of 1966 in Pelham, Massachusetts. In one of these species, the selections of a melanic form differed from those of the prevailing paler form.

The moths were trapped either at a 100-watt bulb or at trees baited with a mixture of brown sugar and beer. After collection, the moths were placed in an experimental box (38.1 cm square by 88.9 cm high) made of plywood 1.3 cm thick. The inner sides of the box were painted four shades of gray. A 1.9-cm^2 piece of stripping was glued into each corner of the box and painted on two sides with the two adjacent shades to make corner selections unambiguous. The top of the box was covered with a pane of frosted glass over a pane of clear window glass. The bottom was a sheet of aluminum foil. The box was placed in a wooded area where a thick canopy excluded direct sunlight.

Each morning, between 0600 and 0800 Eastern Standard Time, the background selections of the moths collected the previous evening were noted, and samples were taken for later identification and reflectance determination. Very few *Catocala spp.* were taken, as these moths were being color-marked and released in another study. All moths were identified with Forbes' keys (*3*).

The percent reflectance values for the sides of the box and the moths' forewings were obtained from a General Electric recording spectrophotometer equipped with a Davidson & Hemmengdinger tri-stimulus integrator. All measurements were made with daylight illumination and with pressed $BaSO_4$ as the white standard. For each moth species or form, the forewings of 12 moths (4 moths in the case of *Catocala spp.*) were glued as a montage onto black construction paper, and percent reflectance was measured over a

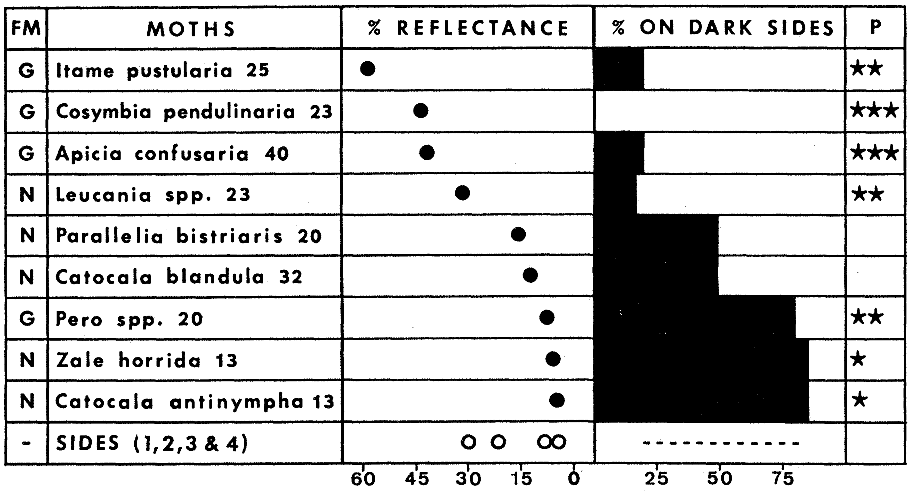

Fig. 1. Reflectances and background selections of nine common moths, with reflectances of the sides of the experimental box. The number of individuals tested is given after each species name. FM, Family; G, Geometridae, N, Noctuidae. Significant deviations from chance selections of the light and dark sides are indicated by stars for probabilities (*P*) of less than 0.05 (one), 0.01 (two), and 0.001 (three).

circle 2.85 cm in diameter within this montage. The reflectance of the construction paper was 7.33 percent.

The reflectances and background selections of the lightest and darkest species, of which 12 or more specimens were collected, are shown in Fig. 1. In addition, two species of intermediate reflectances are included. (*Pero spp.* are considered dark moths, as the basal two-thirds of the forewings were darker than side 3 of the box.)

In chi-square analyses, the moths of each species were divided into two groups: those selecting the two lighter sides and those selecting the two darker sides of the box. This procedure was used because of the small numbers of some species and the relatively close reflectance values of the sides being combined. All of the light and dark species exhibited significant deviations from a chance distribution on the lighter and darker sides of the box (Fig. 1). In addition, the summed distribution of the light moths differed from that of the dark moths, and both of these distributions differed from that of the intermediate moths (all $P < .001$).

These results indicate that some species of moths are able to select backgrounds which tend to match the reflectance of their forewings. However, Kettlewell's earlier results with *Biston betularia* (*2*) indicated that distinct phenotypes of one species might also select appropriate backgrounds. A similar finding was obtained during the present study with two forms of *Catocala ultronia.* The most common moth in the study area was the form *lucinda,* characterized by relatively pale median areas on each forewing. A number of the melanic form *nigrescens,* characterized by nearly uniform brown-black forewings, were also collected. The percent reflectance value of *lucinda* was between the values for sides 2 and 3 of the experimental box, and the value of *nigrescens* was less than that for side 4. Of 85 *lucinda* tested, 57 selected sides 2 and 3, and 22 selected side 4; of 12 *nigrescens* tested, 2 selected sides 2 and 3, and 10 selected side 4. The difference between these distributions is significant ($P<.001$). Similar differences in background selections by different forms of a single species have been suggested from field observations of *Oenosandra boisduvalii* and *Ectropis consonaria* (*4*). These results suggest that background matching in some species may be a phenotype or individual, rather than a species, attribute.

T. D. SARGENT

Department of Zoology, University of Massachusetts, Amherst 01002

References and Notes

1. G. H. Thayer, *Concealing Coloration in the Animal Kingdom* (Macmillan, New York, 1909), pp. 232–240; H. B. Cott, *Adaptive Coloration in Animals* (Methuen, London, 1940), pp. 5–102.
2. H. B. D. Kettlewell, *Nature* **175**, 943 (1955).
3. W. T. M. Forbes, *Cornell Univ. Agr. Exp. Sta. Mem.* **274** (1948); *ibid.* **329** (1954).
4. H. B. D. Kettlewell, *Entomologist* **91**, 214 (1958).
5. I thank Dr. F. J. Francis and R. R. Keiper for assistance.

11 October 1966

Immunologic Maturation in utero: Kinetics of the Primary Antibody Response in the Fetal Lamb

Abstract. *The kinetics of the primary antibody response to bacteriophage* ϕ*X174 have been studied in the fetal lamb* in utero *after permanent indwelling catheterization of the fetal blood vessels. The initial antibody response by the developing fetus to this form of antigenic stimulus is comparable to that found in adult animals and shows none of the characteristics of the immature immunologic response that have generally been ascribed to fetal and neonatal animals.*

The manner in which developing animals achieve immunologic competence and the timing of this development have attracted much interest for theoretical as well as practical reasons. Whereas it was believed that immunologic maturation occurs only at or after birth among mammalian species (true of many small laboratory rodents), recent evidence (*1*) indicates that a variety of immunologic functions may be manifested by the fetuses of many species (human, rhesus-monkey, ovine, bovine, and others). Moreover, the fetus becomes immunologically competent to respond to each antigen at a particular gestational age. Competence for some antigens appears extremely early in gestation, for other antigens later, and for some antigens only after birth. Thus, one cannot speak of an overall state of immunologic competence or incompetence in the developing animal.

At the time of the young animal's transition from immunologic nonreactivity to ability to respond to a given antigenic stimulus, it has generally been supposed that the initial attempts at response are somewhat hesitant and weak (*2*). The term "immunologic immaturity" generally connotes such a transition period of initial feeble response by the young animal. We have reported (*3*) that when the fetal lamb develops the capacity (shortly after midgestation) to reject orthotopic skin homografts, there is apparently no hesitancy or immaturity on the part of the fetus in its first re-