Photoperiodism in *Orthopodomyia signifera*

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Larvae of the tree-hole mosquito, *Orthopodomyia signifera*, were collected from North Carolina and subjected to long- and short-day photoperiods. Long days at 25°C permit rapid molting of fourth instar larvae to pupae. Lower temperature (15°C) modifies developmental rate but does not appear to block photoperiodic response to long days. Short days at 25°C may halt development, may retard development, or may permit rapid development in either the third or fourth larval instar. *O. signifera* is probably polymorphic for both the stage at which diapause may occur and for the depth or firmness with which it is established.

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Des larves du moustique *Orthopodomyia signifera*, récoltées en Caroline du Nord, ont été soumises à des photopériodes longues et courtes. Des jours longs, à 25°C, permettent à la larve de quatrième stade de se métamorphoser rapidement en nymphe. Une température plus basse (15°C) modifie la vitesse de développement, mais ne semble pas enrayer l'effet des jours longs. Des jours courts à 25°C peuvent ou bien enrayer le développement, ou bien le retarder, ou encore permettre un développement rapide de la larve de troisième ou de quatrième stade. Chez *O. signifera*, il y a probablement polymorphisme quant à l'époque du développement où la diapause se produit et aussi quant à l'intensité ou la rigidité de cette diapause. [Traduit par le journal]

Orthopodomyia signifera is a tree-hole mosquito which normally occurs along the eastern seaboard of the United States, westwards to Nebraska and Texas, and as far south as Jamaica and Mexico (Reeves 1941; Jenkins and Carpenter 1946; Stone *et al.* 1959). *O. signifera* is thought to rely upon photoperiodic cues to mediate its seasonal development (Baker 1935). The extant data on this species are, however, derived from two individuals. Baker (1935) caught two larvae of *O. signifera* in October, 1934, and placed one on long-day photoperiod (it developed) and one on short-day photoperiod (it did not develop). I have been able to confirm and add to these data of Baker with larvae of *O. signifera* collected in North Carolina.

Materials and Methods

Second-, third-, and fourth-instar larvae were collected October 1, 1971, near Chapel Hill, N.C. (36° N, 79° W) from several water and detritus-filled, oaken barrels, ca. 100 liters volume. The sole mosquito coinhabitants of these barrels were the larvae of the carnivorous tree-hole mosquito, *Toxorhynchites rutilus*. After collection, the larvae were stored at 0–4°C on an irregular photoperiod for 6 weeks without food. This delay in experimentation was unavoidable but parallels Baker's (1935) storage of *O. signifera* for 3 months at 5°C. The effect of storage remains an unknown variable in both cases.

For experiments, larvae were exposed to their long- (17.5L:6.5D) or short-day (11.5L:12.5D) photoperiod at 25 ± 0.75°C. These experiments were carried out in 0.1 m^3 cabinets (0.4 0.4 0.6 m = HWD) illuminated by a single 4-W cool-white fluorescent lamp placed at a distance of 10–15 cm from the larvae. The lamps were isolated within transparent sections of a light-baffled conduit and cooled by air blowers. Simultaneously, some larvae were exposed to long-day photoperiod (17.5L: 6.5D) at 15 ± 0.5°C. In this case, light was provided by a single 15-W cool-white fluorescent lamp placed 25 cm from the larvae. Experiments at 15°C were carried out in Forma Model 11 refrigerated incubators. Food consisted of a mosquito mixture (Bradshaw and Lounibos 1972) and was provided ad libitum.

Experimental Results

Effect of Photoperiod on Mature Larvae

To test the effect of photoperiod on wild-caught fourth-instar larvae, 17 larvae were exposed to long days and 16 to short days. Within a week, four of the larvae on the longer and three of the larvae on the shorter regimen had died. The rest of the fourth-instar larvae experiencing long-day photoperiod began pupating on day 7; all had completed pupating by the end of day 10 (Fig. 1A). Of the 13 living larvae experiencing short-day photoperiod, the first pupated after 9 days. Pupation continued at erratic intervals thereafter but five larvae remained undeveloped after 75 days. To test whether the latter were capable of development, they were transferred to a long-day regimen on day 78. All of them pupated 9–11 days thereafter (Fig. 1A). Adults emerged 4–5 days after pupation, regardless of photoperiod.

Effect of Short Days on Earlier Instars

To test the ability of photoperiod to elicit a developmental arrest, 14 second-instar larvae were exposed to 11.5 h of light per day at 25°C. All of these larvae molted to the third instar 3–5 days later. The third instar larvae were then maintained on the same short-day regimen. Seven of the 13 larvae molted to the fourth instar 5–7 days after becoming third-instar larvae (Fig. 1B). Five additional larvae molted after spending 15–21 days in the third instar; one more molted after 40 days; the last larva died without any sign of development after spending 69 days in the third instar (Fig. 1B).

The rapid development of seven third-instar larvae (Fig. 1B) suggested that they might not become dormant; they were therefore maintained on the same short-day regimen as fourth-instar larvae. Five of the larvae pupated after 13–41 days (Fig. 1C) while the last two had not pupated after 67 days. These two fourth-instar larvae were then transferred to long-day conditions and pupated 10–11 days thereafter (Fig. 1C). The five individuals spending 15–21 days as third-instar larvae (Fig. 1B) served as a control of the above experiment and were transferred to a long-day regimen immediately upon molting to the fourth instar (Fig. 1D). All five completed the fourth instar and pupated within 8–12 days (Fig. 1D). Again, adults emerged 4–5 days after pupation.

Effect of Temperature on Response to Long Days

To test the effect of temperature on the ability to respond to long-day photoperiod, 15 fourth-instar larvae were exposed to 17.5 h of light per day at 15°C. Two larvae died within the first week. The remaining 13 pupated after 21–31 days (Fig. 1E). Temperature therefore has a modifying effect on developmental rate but

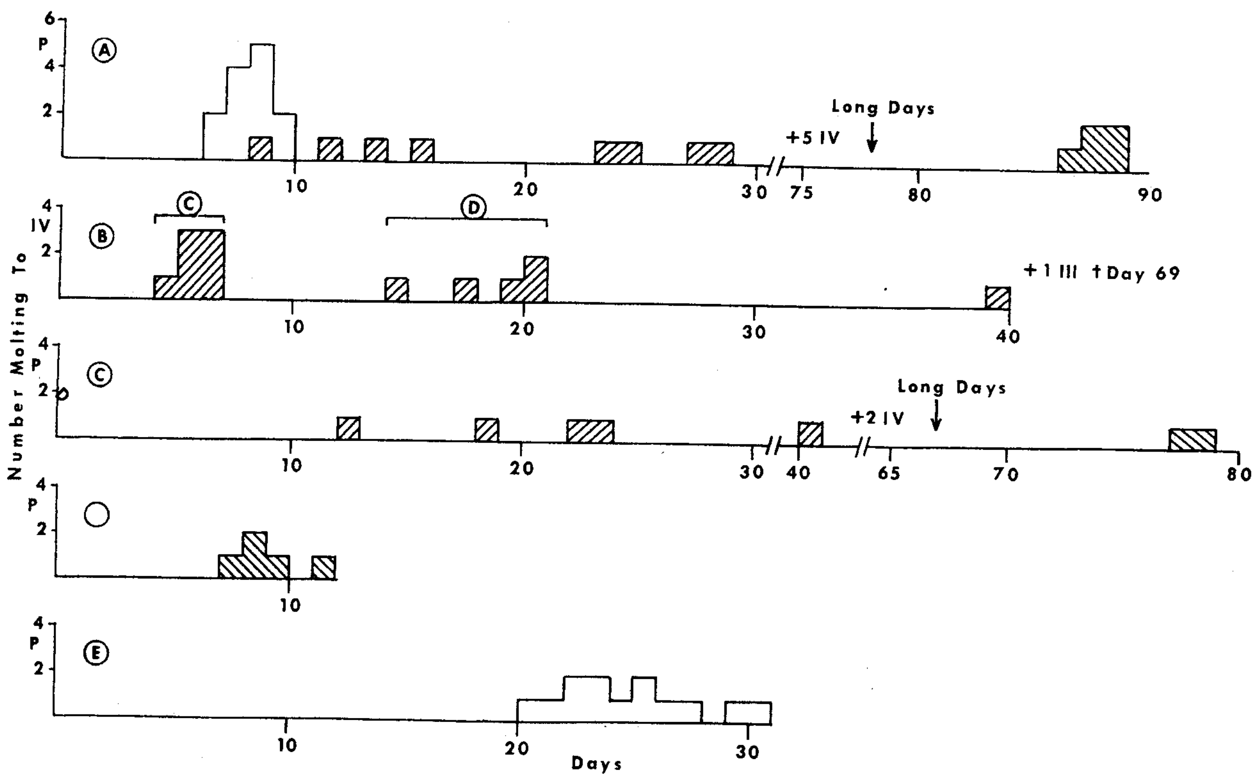

FIG. 1. Photoperiodic and temperature effects on *Orthopodomyia signifera* larvae. A. Number of fourth-instar larvae molting to pupae in response to long (open outline) or short days (screen) at 25°C. Undeveloped larvae were transferred from short to long days on day 78. Abscissa: days on experimental conditions. B. Number of third-instar larvae molting to the fourth instar in response to short days at 25°C. Abscissa: duration of the third instar. C. Number of fourth-instar larvae molting to pupae in response to short days at 25°C; larval sample derived from rapid molting larvae in 1B. Abscissa: duration of the fourth instar. D. Number of fourth-instar larvae molting to pupae in response to long days at 25°C; larval sample derived from retarded molting larvae in 1B. Abscissa: duration of the fourth instar. E. Number of fourth-instar larvae molting to pupae in response to long days at 15°C. Abscissa: days on experimental conditions. Ordinate: IV, fourth-instar larva; P, pupa.

cold temperatures do not block photoperiodic response to long days.

Discussion

Baker (1935) exposed one second-stage larva to long-day photoperiod and one third-stage larva to short-day conditions at an unspecified temperature. The larva experiencing the longer light regimen developed but the other remained as a third-instar larva for 4 weeks. One would conclude from Baker's data that *O. signifera* overwinters as a third-instar larva in a diapause mediated by photoperiod. The information in Fig. 1 presents a much less definitive picture. As seen in Fig. 1A, long days rapidly evoked pupation among fourth-instar larvae but response to short days was mixed. Over half the larvae pupated within 30 days but the remaining 40% had not pupated after 78 days. A similar response is noted among third-instar larvae (Fig. 1B): short days do not seem to affect the rapid development of some larvae but retard development in others. Third-instar larvae which molt rapidly to the fourth instar nonetheless show inhibited development in the fourth instar under short-day conditions (Fig. 1C). Regardless of the duration of exposure to short-day photoperiod, all fourth-instar larvae subsequently responded rapidly to long days and pupated within 8–12 days after transfer to the longer regimen (Fig. 1A, C, D).

It seems reasonable to presume that larvae spending more than 30 days in either the third or the fourth instar are in a state of arrested development, or diapause. Some larvae, even under short-day conditions, spend less than 10 days in either instar; these larvae certainly are not in diapause. The problem then remains about how to describe the physiological or developmental state of those larvae spending an intermediate number of days in the third or fourth instar. Rather than invent a new term on the basis of scant data, I shall refer to these individuals as experiencing retarded development. *O. signifera* larvae then do not diapause when they experience long days, even at 15°C (Fig. 1A, E), but short days may either evoke diapause, retard development, or not affect development in either the third or the fourth instar. These results suggest that *O. signifera* is polymorphic for both the stage at which diapause may occur and for the depth or firmness with which it is established.

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