REPRODUCTIVE DIAPAUSE IN *NYSIUS HUTTONI* WHITE (HETEROPTERA: LYGAEIDAE)

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ABSTRACT

The induction of reproductive diapause of *Nysius huttoni* was studied in the laboratory at $20 \pm 1^\circ\text{C}$ and $60 \pm 10\%$ RH under a series of photoperiod regimes: 16:8 h, 14:10 h, 12:12 h and 10:14 h light:dark. Reproductive diapause was considered to have occurred if females failed to lay eggs for 50 days after emergence. The sensitivity of different life stages to diapause-inducing photoperiods varied. When newly emerged females whose immature stages had been reared at 16:8 h were transferred to 10:14 h and 12:12 h, 46.7% and 79.3% of them entered reproductive diapause, respectively. However, when fifth instar nymphs were transferred from 16:8 h to 10:14 h and 12:12 h, 100% of adult females entered reproductive diapause. If the entire life cycle was maintained at 10:14 h and 12:12 h, 66.7% and 40.0% of females entered reproductive diapause, respectively. The critical photoperiod for reproductive diapause was estimated to lie between 13:11 h and 13.5:10.5 h.

Keywords: *Nysius huttoni*, Lygaeidae, reproductive diapause, photoperiod.

INTRODUCTION

The New Zealand wheat bug, *Nysius huttoni* White (Heteroptera: Lygaeidae), is endemic to New Zealand and occurs throughout the country (Gurr 1957; Eyles & Ashlock 1969). It is an important pest of wheat (Gurr 1952, 1957) and brassica crops (Ferguson 1994).

This bug usually overwinters as an adult (Gurr 1952) and undergoes reproductive diapause, which is induced by shortening day lengths during late summer (Farrell & Stufkens 1993). However, the critical photoperiod for inducing reproductive diapause and response of different life stages to photoperiods have not been reported, making it difficult to model its population dynamics. The aim of the present study was to determine the effect of photoperiod on the reproductive diapause of *N. huttoni*, thus providing information for the development of a pest management strategy.

MATERIALS AND METHODS

Breeding colony

A *N. huttoni* breeding colony was maintained at $20 \pm 1^\circ\text{C}$, $60 \pm 10\%$ RH and a photoperiod of 16:8 h light:dark, and housed in a clear, cylindrical plastic container (10 cm high x 8.5 cm diameter), with a 4.5 cm diameter gauze covered hole in the lid for ventilation. A medical cottonwool bud (6.5 cm long x 0.5 cm diameter) was provided as an oviposition site. Food, which consisted of sunflower seeds and twin cress stems, *Coronopus didymus* (L.) Sm., was replaced daily. All experiments were conducted under the above conditions except for alterations in photoperiods.

Effect of photoperiod on reproductive diapause

To detect the reproductive diapause of *N. huttoni* females, Farrell & Stufkens (1993) transferred the third and fourth instar nymphs collected in the field in later summer to

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12:12 h in the laboratory. This method was modified and improved by using a series of photoperiods, 16:8 h, 14:10 h, 12:12 h and 10:14 h, in this study. Adults were sexed according to Elyes (1963). The three experiments conducted are outlined below.

In Experiment A, four hundred newly laid eggs (<24 h old) were transferred from the breeding colony to each of the four test photoperiods and maintained until adult emergence. Nymphs were mass-reared in the plastic containers described above. Fifteen pairs of newly emerged adults from each photoperiod were transferred to separate glass vials (8.0 cm high x 2.5 cm diameter) with a 1.2 cm diameter gauze covered hole in the lid. The four sets of adults were maintained in the same photoperiod used for rearing their immature stages.

In Experiment B, two hundred newly moulted fifth instar nymphs from the breeding colony were transferred to plastic containers and maintained under each photoperiod. From these, 20 pairs of newly emerged adults from each photoperiod were individually transferred to glass vials and maintained in the same photoperiod under which they had moulted.

In Experiment C, adults were directly transferred from the breeding colony to the test photoperiods, with 30 pairs set up for each photoperiod as described above.

For all experiments, a cottonwool bud was provided as an oviposition site for each glass vial. The number of females that failed to lay eggs within 30 and 50 days was recorded for all experiments. The critical photoperiod was estimated to have occurred when 50% of females failed to oviposit (Beck 1980).

Statistical analysis

To assess the effect of photoperiod on reproductive diapause, the Marascuilo procedure of nonparametric analysis (Marascuilo 1966) was used. In two treatments in Experiment B 100% of females failed to oviposit. In these cases, this number (n) was adjusted slightly to $n + 0.01$ to avoid having the proportion of females that did not enter diapause as zero. This adjustment did not affect the statistical analysis. The rejection level for the test statistic U_o' was the 5% critical value for chi-square (5.99 for $df = 2$; 7.82 for $df = 3$).

RESULTS

The percentages of females that failed to oviposit within 30 and 50 days under the four photoperiods are shown in Table 1. For females that were held at the same photoperiod as their immature stages (Experiment A), diapause incidence tended to increase as photoperiod decreased, but there was no significant difference between photoperiods for 30 days ($U_o' = 4.53$; $df = 3$). In this experiment, more than 50% of females failed to oviposit within 30 days at 10:14 h and 12:12 h and within 50 days at 10:14 h. However, for females exposed to the same photoperiod as their fifth instars (Experiment B), when photoperiod was decreased to 12:12 h, almost 100% of females entered diapause for at least 50 days, which was significantly higher than the diapause incidence under longer photoperiods ($U_o' = 129.17$ and 291.62 for 30 and 50 days, respectively; $df = 3$). In Experiment C, where adults were transferred immediately after their emergence from a long photoperiod of 16:8 h to one of the test photoperiods, the highest proportion of females (79.4%) entered diapause at 12:12 h ($U_o' = 106.74$ and 92.96 for 30 and 50 days, respectively; $df = 3$).

TABLE 1: Percentage (%) of females that failed to lay eggs for 30 and 50 days after emergence under different photoperiod conditions¹.

Photoperiod (light:dark)	30 days			50 days		
	A	B	C	A	B	C
16:08 h	40.00a α	15.00c α	3.57c α	20.00b α	15.00b α	3.57c α
14:10 h	46.67a α	55.00b α	57.14b α	33.33ab α	10.00b α	25.00bc α
12:12 h	60.00a β	99.95a α	79.31a β	40.00ab β	99.95a α	79.31a β
10:14 h	73.33a β	99.95a α	46.67b β	66.67a β	99.95a α	46.67ab β

¹Numbers followed by the same English letters in each column and the same Greek letters within rows of 30-day or 50-day columns were not significantly different at $P < 0.05$.

Under 16:8 h and 14:10 h, the photoperiod experienced during immature development had no effect on female diapause behaviour ($U_0 = 4.33$ and 3.53 for 30 and 50 days at 16:8 h, respectively, and $U_0' = 0.43$ and 4.13 for 30 and 50 days at 14:10 h, respectively; $df = 2$ in all cases) (Table 1). However, when fifth instar nymphs were transferred from 16:8 h to 10:14 h and 12:12 h (Experiment B), significantly more females entered diapause than when all life stages were maintained under short photoperiods or when adults were transferred directly from 16:8 h to the short photoperiods ($U_0' = 17.41$ and 29.86 for 30 and 50 days at 12:12 h, respectively, and $U_0' = 39.48$ and 97.81 for 30 and 50 days at 10:14 h, respectively; $df = 2$).

If diapause is defined as the absence of oviposition for either 30 or 50 days after emergence, then critical photoperiod fell either between 14:10 h and 14.5:9.5 h, or between 13:11 h and 13.5:10.5 h.

DISCUSSION

In many insect species, diapause incidence increases with the number of prediapauses stages exposed to diapause-inducing conditions (e.g. Rock et al. 1983). However, this is not the case with *N. huttoni* since fifth instar nymphs appeared more sensitive to shortened photoperiods than earlier stages. In some other insects the adult is the most sensitive stage to photoperiod (Tauber & Tauber 1970; Tauber et al. 1986; Nunata & Hidaka 1983; Nechols 1988), but *N. huttoni* adults appeared less sensitive to shortened photoperiods than fifth instar nymphs.

The exposure of the entire life cycle of *N. huttoni* to 10:14 h and 12:12 h resulted in relatively low percentages of females entering diapause. Whether constant photoperiods cause a loss of sensitivity to changes in photoperiod is unknown. In the green lacewing, *Chrysopa* (= *Chrysoperla*) *carnea* (Stephens), adults underwent a much less intense diapause when the entire life cycle was maintained in a constant photoperiod of 12:12 h than when they were maintained at 16:8 h before being placed in a diapause-inducing photoperiod (Tauber & Tauber 1970).

Nysius huttoni is a Type I (Beck 1980) species in which long photoperiods promote continuous development while short photoperiods induce diapause. Farrell & Stufkens (1993) reported that reproductive diapause was considered to have occurred if females failed to lay eggs for 30 days after emergence at 12:12 h, but they did not calculate the critical photoperiod for induction of diapause. If failure to oviposit for 30 days after emergence was used to define the critical photoperiod for *N. huttoni* reproductive diapause, then the critical photoperiod for reproductive diapause induction would be between 14:10 h to 14.5:9.5 h in our study. However, this occurs in January in New Zealand (Anon. 1995-1999), which coincides with a period of rapid development and growth for *N. huttoni*. If diapause is defined as the absence of oviposition for 50 days after emergence, then the critical photoperiod falls to between 13:11 h and 13.5:10.5 h which is the photoperiod in late February and early March (Anon. 1995-1999). Farrell & Stufkens (1993) reported that a high proportion of females did not develop eggs during February and March of 1991 and 1992. Therefore, *N. huttoni* reproductive diapause ought to be defined as failure to oviposit for 50 days after emergence, with a critical photoperiod of between 13:11 h and 13.5:10.5 h. This information could be useful for monitoring populations of *N. huttoni*, and for making management decisions such as when to apply pesticides.

Our estimation of critical photoperiod is based on constant photoperiods and does not take into account any effect of the changes in temperature and/or humidity to which *N. huttoni* may also respond under natural conditions. Temperature has been found to play a modifying role in the photoperiodic response of a number of insects (Stevenson & Boivin 1990; Christiansen-Weniger & Hardie 1999). Therefore, further investigation may be needed under the different combinations of various environmental conditions.

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REFERENCES

- Anon. 1995-1999. New Zealand climate digest. National Institute of Water and Atmospheric Research Limited, Environmental Data Division, Wellington, New Zealand.
- Beck, S.D. 1980: Insect photoperiodism. Academic Press, New York. 387 p.
- Christiansen-Weniger, P.; Hardie, J. 1999: Environmental and physiological factors for diapause induction and termination in the aphid parasitoid, *Aphidius ervi* (Hymenoptera: Aphidiidae). *J. Insect Physiol.* 45: 357-364.
- Eyles, A.C. 1963: Incubation period and nymphal development in *Nysius huttoni* White (Heteroptera: Lygaeidae: Orsillinae). *N.Z. J. Sci.* 6: 446-461.
- Eyles, A.C.; Ashlock, P.D. 1969: The genus *Nysius* in New Zealand (Heteroptera: Lygaeidae). *N.Z. J. Sci.* 12: 713-727.
- Farrell, J.A.; Stufkens, M.W. 1993: Phenology, diapause, and overwintering of the wheat bug, *Nysius huttoni* (Hemiptera: Lygaeidae), in Canterbury, New Zealand. *N.Z. J. Crop Hort. Sci.* 21:123-131.
- Ferguson, C.M. 1994: *Nysius huttoni* White (Heteroptera: Lygaeidae) a pest of direct drilled Brassicas. *Proc. 47th N.Z. Plant Prot. Conf.*: 196-197.
- Gurr, L. 1952: Notes on *Nysius huttoni* F. B. White, a pest of wheat In New Zealand. *N.Z. Sci. Rev.* 10: 108-109.
- Gurr, L. 1957: Observation on the distribution, life history, and economic importance of *Nysius huttoni* (Hemiptera: Lygaeidae). *N.Z. J. Sci. Tech.* 38A: 710-714.
- Marascuilo, L.A. 1966: Large-sample multiple comparisons. *Psychol. Bull.* 65: 280-290.
- Nechols, J. 1988: Photoperiodic responses of the square bug (Heteroptera: Coreidae): diapause induction and maintenance. *Environ. Entomol.* 17: 427-431.
- Nunata, H.; Hidaka, T. 1983: Photoperiodic control of adult diapause in the bean bug *Riptortus clavatus* Thunberg (Heteroptera: Coreidae). II. Termination of diapause induced under different photoperiods. *Appl. Entomol. Zool.* 18: 439-441.
- Rock, G.C.; Shaffer P.L.; Shaltout A.D. 1983: Tufted apple budmoth (Lepidoptera: Tortricidae): Photoperiodic induction of larval diapause and stages sensitive to induction. *Environ. Entomol.* 12: 66-70.
- Stevenson, A.B.; Boivin, G. 1990: Interaction of temperature and photoperiod in control of reproductive diapause in the carrot weevil (Coleoptera: Curculionidae). *Environ. Entomol.* 19: 836-841.
- Tauber, M.J.; Tauber, C.A. 1970: Adult diapause in *Chrysopa carnea*: stages sensitive to photoperiodic induction. *J. Insect Physiol.* 16: 2075-2080.
- Tauber, M.J.; Tauber, C.A.; Masaki, S. 1986: Seasonal adaptations of insects. Oxford University Press, New York. 411 p.