

**Effect of Photoperiod on the Life History of the Predatory Bug,
Macrolophus Caliginosus Wagner [Hemiptera:Miridae]**

تأثير مدة فترة الإضاءة على تاريخ حياة حشرة البق المفترس

Macrolophus caliginosus Wagner

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Received: (14/1/2006), Accepted: (5/9/2006)

Abstract

Laboratory experiments were carried out to study the effect of photoperiod on the life history of the predator *Macrolophus caliginosus* Wagner [Hemiptera: Miridae] fed on eggs of the greenhouse whitefly, *Trialeurodes vaporariorum* (Westwood) [Homoptera: Aleyrodidae]. Day-length had no significant effect on either nymphal mortality, development time or adult longevity of *M. caliginosus*. The absence of light had no negative effect on the consumption rate of *M. caliginosus*. However, the number of *T. vaporariorum* eggs consumed by the predator increased with decreasing photoperiod. Light was of significance for the development of the predator embryos during incubation period as no hatching occurred under continuous darkness, but hatching was reduced at 8L:16D in comparison to hatching at 16L:8D.

Key words: Photoperiod, Life history, *Macrolophus caliginosus*, *Trialeurodes vaporariorum*, laboratory experiments.

ملخص

تم إجراء أبحاث مخبرية لدراسة تأثير مدة فترة الاضاءة على دورة حياة البق المقترس *Macrolophus caliginosus* Wagner عند تغذيته على بيوض ذبابة البيوت الزجاجية البيضاء *Trialeurodes vaporariorum* (Westwood) لقد وُجِدَ أن فترة الاضاءة ليس لها تأثيرات معنوية على أي من معدلات وفيات حوريات البق أو فترة التطور أو مدة حياة الحشرات الكاملة. بالإضافة الى ذلك، لم يلاحظ وجود تأثيرات سلبية لانعدام الاضاءة على معدلات الافتراس لحشرات البق على بيوض ذبابة البيوت الزجاجية البيضاء. كما وجد أن معدلات الاستهلاك لبيوض الذباب الأبيض قد ازدادت مع انخفاض فترات الاضاءة وأظهرت الدراسة أن الإضاءة كانت ضرورية لحدوث التطور في الأجنة في بيوض البق ولم يحدث فقس في أي من هذه البيوض التي حفظت تحت ظروف الظلام المستمر (0L:24D)، واما تحت ظروف الإضاءة القصيرة (8L:16D)، فان معدلات الفقس كانت منخفضة وذلك بالمقارنة مع الإضاءة الطويلة (16:8D).

Introduction

Environmental factors such as light, temperature, humidity, rainfall, food, natural enemies, and competitors show characteristic seasonal patterns of change. Photoperiod offers the most reliable cues to approaching seasonal changes⁽³⁾. Except the equator, each altitude shows a regular seasonal pattern of changes in day-length and, as one moves farther from the equator, these changes become more pronounced⁽³⁾. Insects have commonly evolved adaptations that take advantage of this reliability and, thus, photoperiod is the primary regulator of diapause induction. Insects have exploited extensively the geographical patterns of photoperiod in their evolution of ecological, physiological, morphological and behavioural adaptation⁽³⁾.

Insect responses to photoperiod changes fall into four categories: (i) for some species it is not important whether day-lengths are changing. The only significant factor for such species is the duration of day-length in relation to the critical photoperiod⁽⁸⁾; (ii) other species do respond to

changes in day-length across a critical photoperiod by inducing or maintaining diapause. Neither constant long days nor constant short days in themselves are sufficient to induce a high incidence of diapause and, if reared strictly under constant photoperiod, these insects show a very low incidence of diapause; (iii) there are insect species that respond to a change in day-length across a critical photoperiod by terminating their diapause. If these species are reared under constant photoperiods, the response curve consists of an approximately straight line at 100% diapause. However, if the sensitive stage experiences an increase in day-length from a short day (below the critical photoperiod) to a longer one (above it), diapause is avoided or is terminated. This response is termed the short-day-long-day response⁽⁷⁾; and (iv) species that respond to changes in day-length without a critical photoperiod. The question remains whether the actual changes in day-length alone can induce or terminate diapause independently of a critical photoperiod⁽¹⁰⁻¹¹⁾.

Daily patterns of behaviour are apparent in the activity of most insect species. According to their behavioural response to photoperiod, insect species were classified into three groups including diurnal, nocturnal, and crepuscular species. These differences in activity patterns were attributed to daily cycles of temperature, humidity and light intensity⁽³⁾. It has been reported that the nocturnal insects are active only at night due to their motor activity that is inhibited by daylight, and if they kept in a continuous darkness, their activity would be expected to continue⁽³⁾.

Host searching and habitat finding is one of the fascinating and challenging subjects in the biology of any beneficial insect. Temperature is the primary factor influencing insect behaviour, but light could have a considerable effect on the activity and searching potential of a predatory insect⁽⁶⁾. For example, chrysopids are more efficient in the dark, while, adult of aphid predatory midge, *Aphidoletes aphidomyza* (Rond.) [Diptera: Cecidomyiidae], is active only at dusk or in darkness⁽⁵⁾.

Objectives

The objectives of the present research are to study the effect of photoperiod regime on egg incubation period, development time and mortality of nymph as well as adult longevity and fertility of *Macrolophus caliginosus* fed on eggs of the greenhouse whitefly (GHWF), *Trialeurodes vaporariorum*. In addition, the consumption rate for the eggs of the greenhouse whitefly by this predator was determined.

Materials and Methods

Three photoperiod treatments, 16:8., 8:16 and 0:24 (L:D) were used to study the effect of photoperiod regimes on the life cycle of *M. caliginosus* reared on GHWF eggs offered on tobacco leaf-disks for two generations in incubators at 25°C and 75% r.h.

Newly emerged nymphs obtained from eggs of *M. caliginosus* that reared on GHWF eggs on tobacco leaf-disks at 25°C, 75% r.h. and 16:8 L:D were used for starting the research.

Two experimental sets were conducted, in the first set, 57, 52, and 18 predator nymphs were kept at 16:8, 8:16, and 0:24 (L:D) were used.

In each treatment, each nymphal instar was provided a heavy infestation of GHWF eggs on tobacco leaf-discs placed in a 2.4 cm diameter Perspex-sandwich cage⁽⁴⁾.

Each Perspex-sandwich cage was made from a 2.4 cm diameter hole done centrally in a Perspex sheet, 75L x 38W x 8T mm. This sheet was sandwiched between a 75L x 38W mm glass slide placed below the underside of the cage and a 75L x 38Wx3T mm Perspex sheet with a 10 mm hole done centrally and covered with a 50 mesh cloth and placed above the upper side of the cage, all held together by rubber bands.

Each predator was provided with the prey eggs on tobacco leaf-discs placed underside upwards on a 2 mm thick agar media to maintain the leaf-disc in fresh condition.

When the predator reached the adulthood, each female was coupled with a male and caged in 5 cm diameter Petri-dish cage under its

standardized experimental conditions and provided by tobacco leaf-discs heavily infested with GHWF eggs.

In addition, a *Pelargonium* leaf, free from GHWF infestation was included in the cage as an alternative oviposition site for the predator ⁽⁴⁾.

Adults of the predator were transferred to freshly prepared cages every other day, and the tobacco leaf-discs and the *Pelargonium* leaves occupied by *M. caliginosus* eggs were kept under its relevant standardized experimental conditions as those used for nymphal development. Then hatching rate was recorded at 24 hours interval.

In the second experimental set, 18 predator nymphs that had emerged from 16L:8D and 17 from 8L:16D were reared for a second generation under the same conditions. Since no nymphs were emerged from eggs maintained under 0L:24D, 25 predator nymphs obtained from the 16L:8D treatment were used the full darkness treatment in the second treatment set.

In addition, to investigate if the full darkness affected rate of hatching of eggs of the predator, leaf-discs with the predator eggs that laid under full darkness treatment of the second experimental set were transferred to an incubator with 16L:8D and observed for nymphal emergence.

Data collection and statistical analysis:

The consumption rate of the predator from GHWF eggs under each photoperiod regime was determined by counting the daily number of GHWF eggshells remained on each leaf-disk as the predator was observed sucking the fluid of GHWF eggs and leaving the eggshells behind.

The fertility of the predator under each treatment was calculated by counting daily the number of nymphs which emerged from leaf-discs that the adult predators were reared on.

Statistical analysis for the comparison between the three photoperiod regimes was done using one way ANOVA, Tukey's family error rate, meanwhile comparison between the two generations was calculated by using t-test analysis.

Standard Error for the % mortality was calculated from the equation:

s.e. = $100 \sqrt{p q/n}$, where p = proportion of mortality, $q = 1 - p$ and n = number of replications.

P value for percentage mortality was calculated using χ^2 analysis

Results

1. Effect of photoperiod on nymphal development time and female longevity of *M. caliginosus*:

Over the two generations, neither nymphal development nor adult longevity were significantly affected by photoperiod (Table 1). However, at 8L:16D, the duration of nymphal development was significantly shorter in the second generation than in the first generation ($P = 0.037$).

Table (1): Duration Means (Days \pm S.E.) of nymphal development and adult longevity Means (Days \pm S.E.) of *M. caliginosus* under different photoperiods.

| Parameters | Generation | 16L:8D | 8L:16D | 0L:24D | P value |
|------------------------|----------------------------|-----------------|---------------------|------------------|-----------|
| Nymphal Development | 1 st generation | 18.9 \pm 0.24 | 19.2 \pm 0.31 | 18.0 \pm 0.52 | 0.094 NS |
| | 2 nd generation | 18.7 \pm 0.43 | 17.7 \pm 0.68 | 17.9 \pm 0.67* | 0.583 NS |
| | P value | 0.68 NS | 0.037* | 0.94 NS | |
| Adult Female Longevity | 1 st generation | 9.9 \pm 0.88 | 9.7 \pm 1.8 (12) | 13.6 \pm 2.3 | 0.151 NS |
| | 2 nd generation | 11.6 \pm 2.6 | 13.8 \pm 4.55 (4) | 10.6 \pm 0.88 | 0.684 NS |
| | P value | 0.56 NS | 0.45 NS | 0.27 NS | |

* The nymphs used for starting the treatment were obtained from 16L:8D treatment.

2. Effect of photoperiod on nymphal mortality of *M. caliginosus* fed on greenhouse whitefly eggs:

There were no significant differences in the mortality of *M. caliginosus* nymphs in three examined photoperiods within each generation (Table 2). However, mortality was higher at 8L:16D than in the other two treatments, but the difference was not significant. Nor did rearing the predator under these programmes for a second generation results in any significant difference in the mortality from that in the first generation under a similar photoperiod.

Table (2): Percent mortality of *M. caliginosus* nymphs recorded under different photoperiods (% Mortality \pm s.e. (d/n)*)

| Photoperiod program | 1 st generation | 2 nd generation | P value |
|---------------------|----------------------------|----------------------------|------------|
| 16L:8D | 28.1 \pm 5.95(16/57) | 33.3 \pm 11.11(6/18) | 0.669 NS** |
| 8L:16D | 46.2 \pm 6.91(24/52) | 58.8 \pm 11.93(10/17) | 0.365 NS |
| 0L:24D | 38.9 \pm 11.49(7/18) | 33.3 \pm 9.62(8/24) | 0.710 NS |
| P value | 0.147 NS | 0.197 NS | |

*: (d/n) = number of nymphs that died/ number of nymphs which started the experiment.

** : NS = Not significant at P value \leq 0.05.

Also, results in Table 2 showed that no significant differences in the nymphal mortality of the predator were recorded for each photoperiod regime between two generations.

3. Effect of Photoperiod on consumption of *M. caliginosus* fed on greenhouse whitefly eggs:

The mean number of GHWF eggs consumed daily by a single *M. caliginosus* nymph during its development was significantly greater under

the continuous darkness (0L:24D) than under 8:16 or 16:8 (L:D) whereas the consumption rate of nymphs did not differ significantly among 8L:16D and 16L:8D treatment (Table 3). Moreover, the total greenhouse whitefly eggs consumed during the whole development time of *M. caliginosus* nymph as well as the daily consumption of adult tended to increase with decreasing photoperiod, but these were not significantly different.

Table (3): Mean number of greenhouse whitefly eggs consumed by *M. caliginosus* under different photoperiods (Means \pm s.e.)

| Photoperiod | Total consumption during development | Daily consumption by nymphs | Daily consumption by adults |
|-----------------|--------------------------------------|------------------------------|-----------------------------|
| 16L:8D | 663.2 \pm 21.1 | 35.7 ^b \pm 1.43 | 65.6 \pm 9.43 |
| 8L:16D | 703.4 \pm 38.86 | 36.6 ^b \pm 2.28 | 69.8 \pm 20.39 |
| 0L:24D | 763.7 \pm 44.65 | 42.7 ^a \pm 2.24 | 98.3 \pm 10.2 |
| <i>P. value</i> | 0.095 NS | 0.022* | 0.141 NS |

*: Means within a column with different letters differ significantly at $P \leq 0.05$

3. Effect of photoperiod on fertility of *M. caliginosus* fed on greenhouse whitefly eggs:

There was no significant effect of the photoperiod neither on the proportion of females that developed to adulthood nor on the proportion of the fertile females that laid eggs (Table 4).

The mean numbers of offspring produced per female in both generations did not differ significantly ($P \leq 0.05$). However, in the first generation, nymphs emerged only from the 16:8 and 8:16 (L:D) treatments, while in the second generation, nymphs emerge only from the 16L:8D treatment.

There was no significant difference in the incubation period when eggs were incubated at either 16:8 or 8:16 (L:D) photoperiod (Table 4).

However, eggs were laid by females reared at 0L:24D but those eggs did not hatch when kept under the same photoperiod (0l:24D) in the first generation, whilst when the 0L:24D treatment was repeated for the second generation and their leaf-discs were incubated under 16L:8D photoperiod, nymphs had emerged in an incubation period similar to that taken by eggs laid by females reared at 16L:8D and incubated also at that photoperiod

Table (4): Fertility of *M. caliginous* under different photoperiods (Means \pm s.e.).

| Parameter | Generation | Photoperiod | | | |
|-------------------------------|----------------------------|-------------------|--------------------|-------------------|-------------|
| | | 16L:8D | 8L:16D | 0L:24D | P value |
| Proportion of females | 1 st generation | 0.54 \pm 0.08 | 0.50 \pm 0.09 | 0.64 \pm 0.14 | 0.883 NS |
| | 2 nd generation | 0.67 \pm 0.14 | 0.57 \pm 0.19 | 0.62 \pm 0.12 | |
| Proportion of fertile females | 1 st generation | 0.67 \pm 0.11 | 0.45 \pm 0.16 | 0.86 \pm 0.13 | 0.081 NS |
| | 2 nd generation | 0.47 \pm 0.18 | 0.5 \pm 0.25 | 0.20 \pm 0.13 | |
| Total offspring*/ female | 1 st generation | 7.2(N) \pm 1.52 | 4.6(N) \pm 0.3 | 6.7(E) \pm 2.16 | 0.670 NS |
| | 2 nd generation | 3.9(N) \pm 2.7 | 2.0 (E) \pm 1.15 | 2.5(N) \pm 1.86 | 0.852 NS |
| | P value | 0.31 NS | 0.42 NS | 0.16 NS | |
| Total nymphs/ fertile female | 1 st generation | 10.8 \pm 1.36 | 10.2 \pm 5.70 | Non emerged | 0.895 NS |
| | 2 nd generation | 10.3 \pm 5.84 | Non emerged | 12.5 \pm 5.49** | 0.817 NS |
| | P value | 0.914 NS | -- | -- | |
| Incubation period (days) | 1 st gener. | 11.9 \pm 0.21 | 12.0 \pm 0.35 | Non emerged | 0.88 NS |
| | 2 nd gener. | 11.7 \pm 0.3 | No emerged | 11.0 \pm 0.39** | 0.16 NS |
| | P value | 0.67 NS | -- | -- | |

*: (N) = nymphs, (E)= eggs which did not hatch.

** : Eggs laid under 0:24 L:D and incubated under 16:8 L:D.

Discussion

Photoperiod can have a profound influence on the regulation of insect populations, diapause and dispersal ^(9,3). Also, because day-length is a predictable indicator of climatic change in the temperate zones, the photoperiodic response is considered as an adaptation for the synchronization of insect life histories with favourable seasons ⁽¹²⁻¹³⁾.

Results of the present research showed that there was no significant effect of day-length on either the duration of development or adult longevity of *M. caliginosus* fed on greenhouse whitefly eggs at 25°C. However, an important effect was observed on the fertility of the predator. At 16L:8D female predator produced a viable offspring in two successive generations, but at 8L:16D, only the first generation produced a viable offspring and in the absence of light (0L:24D), no nymphs emerged, even from the first generation.

However, the results also showed that adult had successfully mated and eggs were laid even under continuous darkness, but when those eggs were kept for the incubation period under continuous darkness, non hatched and no nymphs emerged. Moreover, when in the second generation, when similar eggs were incubated at 16L:8D, they were able to develop and nymphs emerged with an incubation period similar to that of eggs laid by females reared in the 16L:8D photoperiod regime.

In conclusion, short day conditions, or continuous dark tended to cease embryonic development of *M. caliginosus*, whereas, long day conditions such as 16L:8 with long day conditions such as 16:8 L:D, stimulate egg hatching. Long photoperiods reported to induce reproduction by *Chrysoperla carnea* (Neuroptera: Chrysopidae) ⁽¹⁰⁻¹¹⁾, which is to some extent in agreement with our findings.

Furthermore, results of the present research showed that *M. caliginosus* were able to consume greenhouse whitefly eggs under continuous darkness with a daily consumption rate significantly higher than that under either short day (8L:16D) or long day (16L:8D) regimes. These results are in general agreement with rate of consumption of the predatory bug, *Orius tristicolor* [Hemiptera: Anthocoridae] fed on *Tetranychus pacificus* McGregor ⁽¹⁾. In addition, same author reported that *O. tristicolor* consumed sufficient mites in the absence of light to develop in a period similar to other photoperiod treatments ⁽¹⁾. It is therefore suggested that *M. caliginosus* might had nocturnal tendency in feeding as its daily consumption all over its life-time tended to increase with decreasing hours of light.

Conclusions

1. Day-length had no significant effect on either nymphal mortality, duration of development or adult longevity of *M. caliginosus*.
2. The absence of light had no negative effect on the rate of consumption of *M. caliginosus* when fed on GHWF eggs. Indeed, the number of GHWF eggs consumed increased with decreasing photoperiod.
3. Long day regime (16L:8D) was found to be necessary for the development of the embryos during egg incubation as no hatching occurred under continuous dark, and hatching ceased in the second generation under short day regime (8L:16D).

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