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EFFECTS OF TEMPERATURE AND PHOTOPERIOD ON THE DEVELOPMENT AND SURVIVAL OF THE DOCK LEAF BEETLE (*GASTROIDEA VIRIDULA* DEG.)

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ABSTRACT

The effects of temperature (20°C, 25°C, 30°C) and photoperiod (16D:8N, 12D:12N, 8D:16N) on larval body weight, food consumption, egg production, and survival of *Gastroidea viridula* Deg. (Coleoptera: Chrysomelidae) were determined. Temperatures and photoperiods affected insect development time, larval body weight, and survival. Larvae continued development while 60 days at temperature of 20°C and photoperiod of 8D;16N, but only while 30 days at 30°C, 16D:8N and 12D:12N. Photoperiod not affected the oviposition period and number of eggs produced. Results show that both temperature and photoperiod significantly affects larval body weight and survival.

Key words: *Rumex confertus* Willd., mossy sorrel, *Gastroidea viridula* Deg., dock leaf beetle, development, survival, temperature, photoperiod.

INTRODUCTION

R. confertus occurs in Poland and the world near the rivers, recently [23]. The most important phytophagous insect occurring on mossy sorrel (*R. confertus*) is *G. viridula* (Coleoptera, Chrysomelidae). The dock leaf beetle, especially the larvae, can defoliate whole dock plants if they occur in high densities [7]. Because of its feeding specialization this leaf beetle species is considered a potential biological control agent of dock plants [19].

The rate of growth and development of insects and other organisms depends on the temperature. Temperature can play a critical role in survival of insect species. Also the other factors as photoperiod and relative humidity are important. However, temperature is usually the main element that influences insect's rate of development. Temperature can act as a stressor and often affects the predation potential and reproduction of the insect predators [22, 24].

Knowledge of the temperature-dependent population growth potential is crucial for understanding population dynamics [1, 28]. Also reproductive tactics of some insects are affected by photoperiod because day length is a reliable cue indicating seasonal change in environmental suitability [18]. Knowledge of temperature and photoperiod effects on the dock leaf beetle is fragmentary.

The aim of the study was to determine the temperature and photoperiod effects on feeding, weight of consumed food, larval body weight, development, and survival of *G. viridula* in the laboratory tests.

METHODS OF THE STUDIES

The experiments were conducted in 2003 and 2004 under laboratory conditions. Insects from the natural habitat were captured for the experiments. The material collected this way was used for rearing. *G. viridula* was chosen for that experiment as model species. The chrysomelid beetle (an oligophagous insect), seems to be relevant for biological control of mossy sorrel (*R. confertus*). The experiments with the weight of the consumed food, larval body weight, number of laid eggs, and survival of *G. viridula* were conducted at temperatures of 20°C, 25°C, 30°C, and photoperiods of 16D:8N, 12D:12N, 8D:16N (Day/Night light time). Every experiment was conducted with five replicates on Petri dishes supplied with filter paper. The fresh leaves of *R. confertus* were provided to females or larvae of *G. viridula* every day. Filter paper was also changed daily.

The laboratory observations:

1. The number of laid eggs by the *G. viridula* females was observed in the fecundity experiment. Two females and males were inserted in the Petri dish. Every day number of laid eggs was recorded.
2. The weight of consumed leaves of *R. confertus* by larvae of *G. viridula* was measured on scale. Fresh leaves were provided every day. The observations were continued over the whole larval development. The measurement was done every 5th day. Every Petri dish contained 10 larvae.
3. The *G. viridula* larval body weight was measured every 5th day. The observation was continued over the whole larval development. Every Petri dish contained 10 larvae.
4. Mortality rate of *G. viridula* was noted from the egg throughout the imagines stage. Leaves with a known number of eggs were put into each Petri dish. The hatched larvae were growing up to the adults' emergence.

The results of weight of consumed food, larval body weight, and survival were subjected to an analysis of variance. Mean amounts were separated after analysis of variance using Tukey's test for significant differences at $\alpha = 0.05$.

RESULTS

Both temperatures and photoperiods significantly affected larval body weight (Table 1).

Table 1. *G. viridula* total larval body weight at different temperatures and photoperiods measured every 5th day (mg/larva)

Temperature	Photoperiod			Mean
	16D:8N	12D:8N	8D:16N	
20°C	15.94	16.18	15.72	15.95
25°C	17.28	17.26	17.16	17.23
30°C	17.8	17.76	17.5	17.69
Mean	17.0	17.07	16.79	16.96

Temperature – HSD $_{\text{Tukey}, \alpha=0.05}$ = 0.2
Photoperiod – HSD $_{\text{Tukey}, \alpha=0.05}$ = 0.2
Temperature * Photoperiod – HSD $_{\text{Tukey}, \alpha=0.05}$ = ns

It seemed that for the larval development the most favorable temperature and photoperiod were 30°C and 16D:8N, respectively. At this condition total larval body weight, measured every 5th day, reached 17.8 mg. Consequently, lowering the temperature reduced larval body weight.

Weight of the consumed food significantly increased with increasing temperature (Table 2).

Table 2. Total weight of consumed food by *G. viridula* larvae at different temperatures and photoperiods measured every 5th day (mg/24h/larva)

Temperature	Photoperiod			Mean
	16D:8N	12D:8N	8D:16N	
20°C	242.8	243.0	237.6	241.13
25°C	250.8	251.8	250.2	250.93
30°C	259.2	256.6	261.2	259.0
Mean	250.93	250.47	249.67	250.36

Temperature – HSD $_{\text{Tukey}, \alpha=0.05}$ = 4.39
Photoperiod – HSD $_{\text{Tukey}, \alpha=0.05}$ = ns
Temperature * Photoperiod – HSD $_{\text{Tukey}, \alpha=0.05}$ = ns

At temperature of 20°C larvae ate less provided food as compared to 25°C and 30°C. Probably supplied food was better adopted at 30°C, and the highest effectiveness of consumed food was observed. There was no significance for the photoperiods investigation.

Survival of the larvae was significantly reduced at lower temperature and photoperiod (Table 3).

Table 3. Survival of *G. viridula* at different temperatures and photoperiods (%)

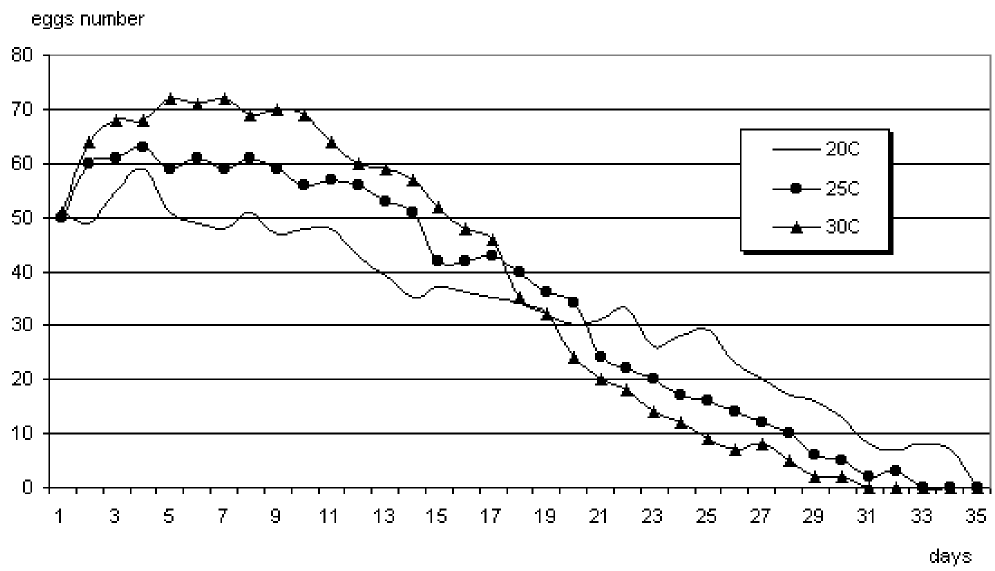
Temperature	Photoperiod			Mean
	16D:8N	12D:8N	8D:16N	
20°C	43.0	43.2	40.0	42.07
25°C	50.6	49.6	44.8	48.33
30°C	64.8	65.0	54.6	61.47
Mean	52.8	52.6	46.47	50.62

Temperature – HSD $_{\text{Tukey}, \alpha=0.05}$ = 0.81
Photoperiod – HSD $_{\text{Tukey}, \alpha=0.05}$ = 0.81
Temperature * Photoperiod – HSD $_{\text{Tukey}, \alpha=0.05}$ = 1.40

The highest mortality of *G. viridula* was observed at temperature of 20°C and photoperiod of 8D:16N, where 60% of all insects form tested population died. The most favorable temperature-photoperiod was 30°C and 16D:8N. In that case 64.8% of all insects successfully completed development.

Increasing temperature increased number of eggs lying, but reduced lifespan of *G. viridula* (Fig. 1).

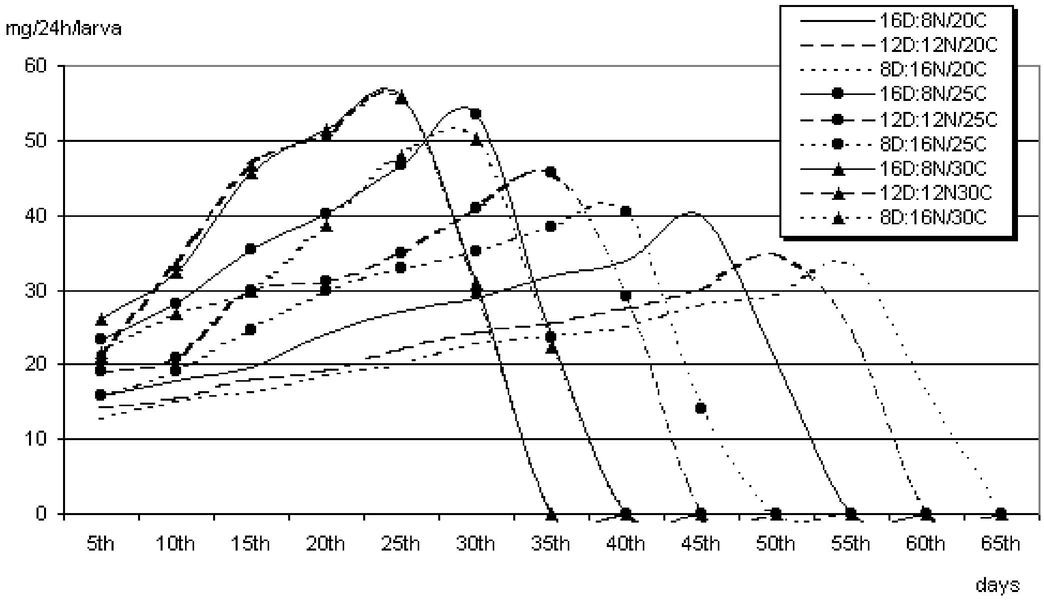
Fig. 1. Daily number of eggs laid by *G. viridula* females at different temperatures



At 20°C females were active while 34 days. The highest amount of daily laid eggs reached 59. At 25°C and 30°C the longevity of eggs lying was reduced. Females laid eggs while 32, and 30 days respectively. Daily fecundity was the highest at 30°C. Females laid over 70 eggs in the 5th, 6th, and 7th day of their activity. For all temperatures the highest number of eggs were laid within the first part of the female lifespan. No significant results in daily number of laid eggs at different photoperiods were recorded.

At 20°C larvae continued development over 50 days. Consequently at 20°C, longer development time was recorded at photoperiods of 12D:12N, and 8D:16N (Fig. 2).

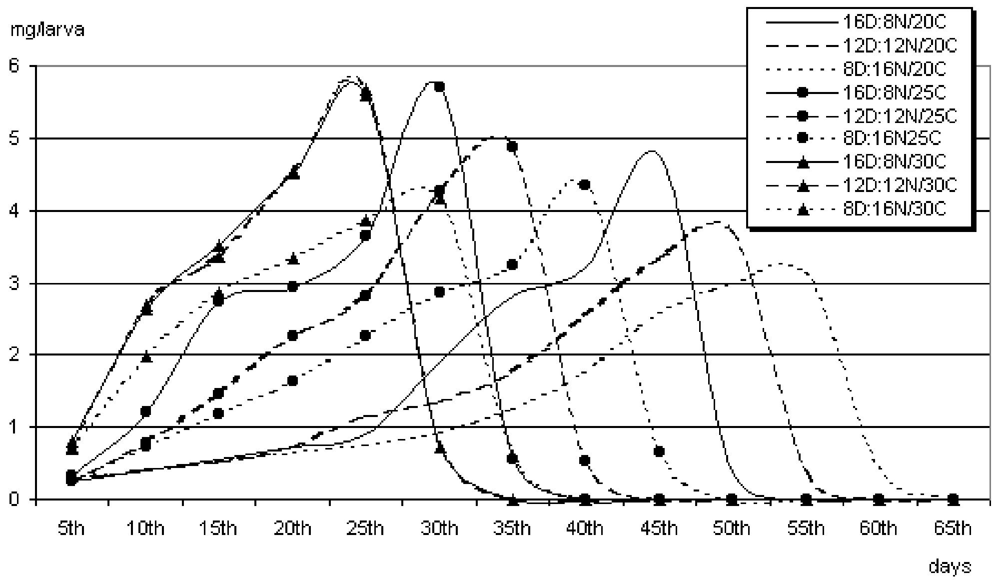
Fig. 2. Daily weight of consumed food by *G. viridula* larvae at different temperatures and photoperiods



The highest amount of consumed food at temperature of 20°C was observed at photoperiod of 16D:8N. In the 45th day, third instar larva, consumed 40mg/24h of *R. confertus* leaves. At 25°C larval development time was reduced, even to 35 days at photoperiod of 16D:8N. At this temperature larvae consumed daily more *R. confertus* leaves in comparison to 20°C. In the 30th day, third instar larva, consumed over 50mg/24h of *R. confertus* leaves (16D:8N). Whole development time of *G. viridula* larvae at photoperiods of 16D:8N and 12D:12N reached 30 days. Similar amount of consumed food was observed for both mentioned photoperiods. At temperature of 30°C the largest amount of daily consumed food was recorded for photoperiods of 16D:8N and 12D:12N in the 25th day of development time (56 and 55.8 mg/24h/larva, respectively). It suggests that temperature range from 25°C to 30°C is the most favorable for the larval development.

Temperatures and photoperiods significantly affected larval body weight (Fig. 3).

Fig. 3. Daily larval body weight of *G. viridula* at different temperatures and photoperiods



At temperature of 20°C third instar larval body weight reached over 4,5mg in the 45th day at photoperiod of 16D:8N. Under 12 hours of daylight the highest weight of single third instar grub was 3.7mg. The most intensive larval body weight reduction was observed for the photoperiod of 8D:16N. The highest weight of grub reached 3.12mg. At temperature of 25°C larger larval weight was observed; even 5.7mg in the 30th day at photoperiod of 16D:8N. Also temperature of 30°C affected larval development. Third instar larval body weight in the 25th day at photoperiods of 16D:8N and 12D:12N was 5.6 and 5.68mg, respectively.

DISCUSSION

The developmental time of *G. viridula* (Coleoptera, Chrysomelidae) was app. 50 days at 20°C and photoperiod of 16D:8N. Engel [4] reported a similar development periods. At 25°C and 30°C the development time was reduced to app. 40, and 35 days respectively. Honek et al. [9] noticed that total development time decreased with increasing temperature. Also Kim and Riedl [14] found that adult longevity decreased with increasing temperature. Similar results of temperature-development time relation was also recorded by Kim et al. [13], Lauzière et al. [16], Liu et al. [17], Sánchez-Ramos and Castañera [25], and Sporleder et al. [28].

Preying of larvae reduced significantly weight of leaves. The weight of consumed leaves increased with increasing temperature. It may suggest that effectiveness of consumed food was higher as compared to lower temperatures. Soares et al. [26] proofed that temperature is a limiting factor to larval and adult relative consumption rate.

G. viridula was extremely fertile. The temperature significantly affected the number of eggs deposited by females. This is in good aggrement with resultes by Nabeta et al. [21]. The highest number of eggs per day was over 70. At the temperature of 20°C females laid eggs for longer time as compared to higher temperatures. Mohite et al. [20] also found fecundity correlated with temperature. The total female fertility ranged form 1143 at 20°C to 1248 eggs at 30°C per lifespan. Engel [4] observed 586 – 1028 eggs per female. Kivan and Kilic [15] found fecundity increased with increasing temperature. Gilles et al. [6] noticed that lifetime fecundity tended to decrease when temperature increased, because of the shortening of the oviposition period. Day longevity not affected the number of eggs laid by females. However, they are insects which reproductive tactics are affected by day longevity [5, 18].

For all larval stages, the developmental time decreased with increasing temperature. This is in good aggrement with results recorded by Herrera et al. [8], Imamura et al. [10], Son and Lewis, [27], as well as by Weston and Diaz [29].

G. viridula was characterised by an average mortality rate. Both temperature and photoperiod affected the insect survival. At 30°C and two photoperiods (16D:8N, 12D:12N) over 60% of insects survived. At temperature of 20°C and photoperiod of 8D:16N 60% of all insects died. It may suggest that lower temperatures resulted in longer developmental periods. Duale [3] recorded optimum conditions for oviposition and development between 25°C and 30°C. Chocorosqui and Panizzi [2] noticed that long day may have result in lower nymph mortality rates of *Dichelops melacanthus*. Jagadish and Jayaramaiah [11] ragarded that the temperatures of 25°C and 30°C were highly favorable for the development of the different life stages of the beetle.

Those results may be of usfulness for biological control methods focusing on the dock leaf beetles and *Rumex* plants. It is well known that under natural site conditions *G. viridula* may significantly reduce the vegetative area of mossy sorrel. Combined effects of *G. viridula* and other biological control agents increase *Rumex* mortality and thus contribute to its natural control [19]. Morover, damage from *G. viridula* and *U. rumicis* may affect the growth and biomass of *R. obtusifolius* [12].

CONCLUSIONS

1. Temperatures and photoperiods affected the *G. viridula* larval body weight. At higher temperature larval body weight was larger.
2. Higher temperature induced larger weight of consumed food by larvae.
3. Investigated temperatures and photoperiods significantly impacted the insects’ development. At higher temperature the insect development was shorter.
4. Females laid larger amount of eggs at 30°C, but the duration of time was reduced.

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