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INFLUENCE OF THE TEMPERATURE AND HUMIDITY ON THE DEVELOPMENT TIME OF EGGS AND IMMATURE STAGES OF *LYGUS PRATENSIS* (LINNAEUS, 1758) (HETEROPTERA: MIRIDAE) IN PRIMORSKY KRAI

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Summary. The data on influence of temperature on the duration of egg development and nymphal ages of the field bug *Lygus pratensis* (Linnaeus, 1758), which is a potato virus vector, are provided. The development of eggs and nymphs of *L. pratensis* was studied under various combinations of relative humidity and temperature with a constant photoperiod of 16 hours. The thermal constant for the development of bug larvae was found to be 389.1 °C, 394.2 °C, and 445.9 °C, with an average of 410 °C. The optimal temperature range for the field bug is 20–25 °C, with 65% humidity. Within these limits, there was minimal mortality and the most successful ontogenesis.

Key words: Miridae, field bug, life history, temperature, humidity, Russian Far East.

Н. В. Мацишина, О. А. Собко, А. С. Дидора, Н. Г. Богинская, М. А. Корнеева, П. В. Фисенко. Влияние температуры и влажности на продолжительность развития яиц и нимфальных возрастов *Lygus pratensis* (Linnaeus, 1758) (Heteroptera: Miridae) в Приморском крае // Дальневосточный энтомолог. 2020. N 413. С. 15-19.

Резюме. Приводятся сведения по влиянию температуры на продолжительность развития яиц и нимфальных возрастов лугового клопа *Lygus pratensis* (Linnaeus, 1758), являющегося вектором переноса вирусов картофеля. Развитие яиц и нимф *L. pratensis* изучали при различных сочетаниях относительной влажности и температуры при постоянном фотопериоде 16 ч. Тепловая константа для развития личинок клопа оказалась равной 389,1 °С, 394,2 °С и 445,9 °С, а в среднем – 410 °С. Оптимальным для лугового клопа оказался интервал температур в 20–25 °С при влажности 65%. В данных пределах наблюдалась минимальная смертность и наиболее успешное прохождение онтогенеза.

INTRODUCTION

The object of our study is the field bug *Lygus pratensis* (Linnaeus, 1758), belonging to the family Miridae. It is a broad polyphage. Nymphs and imago feed on the vegetative and

reproductive plants organs, causing growth retardation. In the absence of control, the field bug causes losses of 10% of the herbs and herbaceous crops yield, as well as indirectly harm potato, carrying viruses. Methods of its management in an insectarium have not been worked out, which determined one of this study tasks.

One of the most important food crops in the world, potato (*Solanum tuberosum*) is infected with many viruses, nine of which are of significant economic importance, causing significant crop losses and a marked decrease in product quality. The leading role among them is played by viral (including viroid) and mycoplasmal diseases. There are more than 30 types of viruses, 1 viroid and 4 phytoplasmas that affect potato. Almost all of them are transmitted by aphids (Hemiptera: Aphidoidea) and other phytophagous insects. In order to minimize the consequences of viral infections in countries with a high level of agricultural development, sanitary measures are maintained and improved, including continuous monitoring of the spread of viruses and certification of planting material based on the diagnosis and improvement of potato varieties, as well as control of potato viruses insect vectors. The interaction of viruses and host insects at the population level is very diverse. New variants of viruses and vector biotypes which differ in their properties appear and their ratio in populations changes. There is an active formation of new pathological connections in vectors and viruses with new hosts (Mitchell, 2004). These issues are not sufficiently studied on potato. Insects from various families are known as vectors of viral infection, but the key pests are bugs.

MATERIALS AND METHODS

The field bug *Lygus pratensis* was introduced to the insectarium culture on 22 May 2020 (culture number LP-AR-20). Collections were carried out in the plantings of horseradish (*Armoracia rusticana*), Atlant variety. Insects were kept in the laboratory at a temperature of 25 °C and humidity of 65±5%, the photoperiod was 16 hours. The colony was kept in plastic breeding containers (20 × 10 × 6 cm) and was supported on asparagus beans (*Phaseolus vulgaris* L.) and 10% sucrose solution (Lu *et al*., 2008). Green bean pods also served as a substrate for oviposition and were replaced every day. Containing eggs green bean pods were subsequently moved to breeding containers lined with filter paper. They were placed on racks at 26 ± 1 °C, relative humidity 65 ± 5% and 16 h. light day till the 1st age nymphs appearance. The nymphs were moved to similar containers covered with a nylon mesh that provided air circulation, and the feed was changed every two days until imago appeared. Each cage contained approximately 60 imago or 100 nymphs.

The used methods were similar to those given in Bommireddy *et al*. (2004) and Lu *et al*. (2009, 2010). The development of *L. pratensis* was studied at six constant temperatures (10, 15, 20, 25, 30 and 35 °C) at a relative humidity of 65% and a photoperiod of 16 hours. Asparagus bean pods were placed in growing cages as described above. After 8 hours, the bean pods containing eggs were removed from the containers. Egg rafts were counted using МБС-10 binocular, and then placed in breeding cages. Each cage contained 30–50 eggs, and each temperature variant had 4 repetitions. Egg hatching was recorded daily for 30 days, and newly hatched nymphs were removed. They were placed in a glass cage with a volume of 1 l, covered with calico. Each cage was equipped with beans as food, which was replaced with fresh ones every day, and a strip of filter paper to increase the space for nymph activity.

The nymph development was recorded daily until the molt and death of the imago.

The *L. pratensis* eggs and nymphs development was studied at various combinations of relative humidity (45, 65 and 75% relative humidity) and temperature (25 and 35 °C) with a constant photoperiod of 16 hours according to the above mentioned method. Mathematical processing of the experiment results was performed using SAS 9.2 software with a 95% con-

fidence interval (SAS Institute, Cary, NC). The average development duration of each developmental stage between different thermopreferences was compared using nonparametric analysis (Kruskal-Wallis test) (PROC NPAR1WAY). The influence of different temperatures and relative humidity levels (RH) on the duration of the eggs and nymphs development was analyzed using the Student-Newman-Keuls' method (SNK).

RESULTS AND DISCUSSION

It was found that at 10 °C the normal passage of embryogenesis and nymphs development is impossible. There was a significant difference in the *L. pratensis* eggs and nymphs development duration between different thermopreferences at all development stages (humidity 65%): egg ($\chi2$ = 219,39, df = 4, P< 0,001), nymph of the 1st age ($\chi2$ = 126,05, df = 4, Pb< 0,001), nymph of the 2nd age ($\chi2$ = 128,44, df = 4, Pb< 0,001), nymph of the 3rd age ($\chi2$ = 134,18, df = 4, Pb < 0,001), and the nymph of the 4th age ($\chi2$ = 141,99, df = 4, Pb < 0,001), nymph of the 5th age ($\chi2$ = 137,10, df = 4, Pb < 0,001). The duration of each development stage significantly reduces when the temperature increases from 15 to 30 °C (Table 1). At temperatures from 30 °C to 35 °C the duration of egg development still decreased and the duration of the nymph stage increased significantly.

Table 1. Span of *Lygus pratensis* eggs and nymphal ages development at different temperature levels and constant relative humidity of 65%

Development stage, nymph instars	The development duration, days				
	15,0	20,0	25,0	30,0	35,0
Egg	29,8 ± 0,25	18,5 ± 0,23	11,0 ± 0,13	7,5 ± 0,13	6,8 ± 0,07
Nymph 1st	8,5 ± 0,54	5,5 ± 0,22	3,5 ± 0,16	2,5 ± 0,04	3,0 ± 0,00
Nymph 2nd	12,0 ± 0,28	5,5 ± 0,10	3,0 ± 0,09	2,3 ± 0,06	2,0 ± 0,29
Nymph 3rd	10,1 ± 0,36	6,2 ± 0,15	3,1 ± 0,07	2,3 ± 0,06	2,0 ± 0,48
Nymph 4th	12,1 ± 0,32	7,0 ± 0,12	4,0 ± 0,08	2,5 ± 0,05	2,8 ± 0,29
Nymph 5th	18,5 ± 0,40	10,5 ± 0,17	6,0 ± 0,10	3,8 ± 0,07	5,2 ± 0,48

Different humidity (45 and 65%) and temperature (25 and 35 °C) levels significantly affected the eggs and nymphs (egg: $F_{2,281}$ = 21,3, P< 0,001; nymph: $F_{2,212}$ = 8,89, P < 0,002) development. The egg development duration was significantly longer at 45 and 65% relative humidity, compared to 75% at 25 °C ($F_{2,11}$ = 62,95, P < 0,001), but there were no significant differences between the three relative humidity levels at 35 °C ($F_{2,9}$ = 1,33, P < 0,324).

The lower eggs development threshold (T_{min}) was estimated using the Briere model (Briere & Pracros, 1998; Briere *et al*., 1999), and was 10,68, 10,12, and 5,0 °C, respectively. The first two thermopreference indicators correspond to the Zhang's results (1964). Our experiment showed that at a temperature below 10°C, bug eggs do not hatch. The egg T_{max} (35.0 °C) was higher than that of the nymph. At 35 °C, a clear development inhibition was found for the nymph, but not for the egg. This difference can be caused by the limit of the temperature range (10–35 °C), during which there was no slowdown in development. It was found that temperature had a significant impact on the *L. pratensis* eggs and nymphs development. The egg development duration decreases when the temperature rises from 15 to 35 °C,

with an average development duration of 30,1 days at 15 °C and 6,4 days at 35 °C. The nymphs developed for 58,2 and 11,5 days, respectively, but when the temperature increased, it was observed inhibition of development, especially for ages 4 and 5.

The thermal constant for the bug larvae development was found to be 389,1 °C, 394,2 °C, and 445,9 °C, with an average of 410 °C. The thermal constant, that was derived from the larvae development at several temperatures, makes it possible to determine the timing of the of field bug development at other temperatures.

As the results of research and laboratory observations have shown, temperature has a very significant effect on the duration of larval development. The highest percentage of survival was observed at the temperature optimum, along with a reduction in the development period (Table 2). As it moves away from the optimal temperature, the percentage of larval survival decreases. Along with an increase in the percentage of larval mortality within relatively low temperatures, the duration of the development period is lengthened.

Table 2. Temperature influence on the larval development duration of *Lygus pratensis* and their mortality in laboratory conditions

Temperature, °C	The development duration, twenty-four hours	Mortality, %
10,0	-	100
15,0	91± 0,32	90,5
20,0	53,2±0,23	45,5
25,0	30,6± 0,08	21,5
30,0	23,2± 0,07	23,4
35,0	21,8± 0,29	42,3

Analyzing the dynamics of larval extinction at different temperatures, it was found that a large percentage of larval mortality falls on the younger ages share (I and II). This is obviously due to the age-related resistance of older larvae to adverse temperature conditions. At a constant temperature, the shortest period of time was needed for the first-instar nymphs and the longest one for the fifth-instar, which is probably due to the different heat requirements of older larvae: the amount of required for the fifth-instar heat (189–195 °C) was three times higher than the amount of effective temperature required for the development of the first-instar larvae (66–75 °C).

Of note is that in each of the four samples of field bugs collected in natural, plant viruses were detected by PCR. RNA extraction was carried out according to standard methods (Bekesiova, 1999). For experiment using commercial kits Syntol "FITTOSCREEN" for the detection of viruses and viroids by PCR in real time. Y, L, M and S viruses of potatoes were detected.

Similar temperature and humidity limits were identified by A.H. Saulich for the predatory bug *Podisus maculiventris* (Say). She noted that the *P. maculiventris* larvae development rate in the temperature range from 17 to 28 °C can be quite satisfactorily described by the regression equation 100/Y = –3,56+0,35t (Saulich & Musolin, 2011). It is easy to notice that in the temperature range of 17–19 °C, the growth rate points are located slightly below the calculated line, at 24 °C – on the contrary, slightly higher, and at 27–28 °C the rate of development again decreases, which indicates that this dependence differs from the linear one. In the average range of used temperatures, the velocity and the sigmoid lines are close, and only at 27–28 °C the linear relationship is broken and the development inhibition increases, which emphasizes the nonoptimality for such temperatures type. In this regard, the temperature of 28 °C, that is sometimes recommended for the laboratory *Podisus maintenance*, hardly can be

considered as optimal. This is slightly lower than the calculated threshold value given in the literature by some authors (Shagov & Shutova, 1977; Legaspi & Legaspi, 2005), but closely coincides with the data of others (De Clercq & Degheele, 1993).

It can be concluded that the optimal thermopreference for the field bug is a temperature range of 20–25 °C with a humidity of 65%. There was the minimal mortality and successful ontogenesis within these limits.

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REFERENCES

Bekesiova, I., Nap, J.-P. & Mlynarova, L. 1999. Isolation of high quality DNA and RNA fron leaves of the Carnivorous plant *Drosera rotundifolia*. *Plant Molecular Biology Reporter*, 17: 269–277.

Bommireddy, P.L., Parajulee, M.N. & Porter, D.O. 2004. Influence of constant temperatures on life history on immature *Lygus elisus* (Hemiptera: Miridae). *Environmental Entomology,* 33, 1549–1553.

Briere, J.F. & Pracros, P. 1998. Comparison of temperature-dependent growth models with the development of *Lobesia botran*a (Lepidoptera: Tortricidae). *Environmental Entomology*, 27: 94–101.

Briere, J.F., Pracros, P., Roux, A.Y., Roux, L. & Pierre, J.S. 1999. A novel rate model of temperaturedependent development for arthropods. *Environmental Entomology*, 28, 22–29.

De Clercq, P. & Degheele, D. 1993. Quality assessment of the predatory bugs *Podisus maculiventris* (Say) and *Podisus sagitta* (Fabricius) (Heteroptera, Pentatomidae) after prolonged rearing on a meat-based artificial diet. *Biocontrol Science Technology*, 3: 133–139.

Legaspi, J.C. & Legaspi, B.C., Jr. 2005. Life table analysis for *Podisus maculiventris* immatures and female adult under four constant temperatures. *Environmental Entomology*, 34(5): 990–998.

Lu, Y.H., Wu, K.M., Wyckhuys, K.A. & Guo, Y.Y. 2009. Comparative study of temperature-dependent life histories of three economically important *Adelphocoris spp*. *Physiology Entomology*, 34: 18–324.

Lu, Y.H., Wu, K.M., Wyckhuys, K.A. & Guo, Y.Y. 2010. Temperature-dependent life history of the green plant bug, *Apolygus lucorum* (Meyer-Dür) (Hemiptera: Miridae). *Applied Entomology and Zoology*, 45: 387–393.

Mitchell, P.L. 2004. Heteroptera as vectors of plant pathogens. *Neotropical Entomology*, 33(5): 519–545.

Saulich, A.H. & Musolin, D.L. 2011. *Biology and ecology of the predatory bug Podisus maculiventris (Say) (Heteroptera, Pentatomidae) and the possibility of its use against the Colorado potato beetle Leptinotarsa decemlineata Say (Coleoptera, Chrysomelidae). Educational and methodological guide to the course "Seasonal cycles of insects" for master's students at the Department of entomology*. St. Petersburg. 84 p. [In Russian]

Shagov, E.M., & Shutova, N.N. 1977. *Podisus* development under constant temperatures. *Plant protection*, 4: 48–49. [In Russian]