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JOURNAL OF PLANT PROTECTION RESEARCH Vol. 49, No. 3 (2009)

DOI: 10.2478/v10045-009-0040-2

AN INFLUENCE OF LOWERED TEMPERATURE ON THE MIGRATION ACTIVITY OF THE POPULATION OF *RHIZOPERTHA DOMINICA* F. (*COLEOPTERA, BOSTRICHIDAE*)

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Received: October 30, 2008
Accepted: June 6, 2009

Abstract: The subject of the study was the lesser grain borer *Rhizopertha dominica* F. – a dangerous pest of stored grain. The study was carried out in the laboratory at a temperature of 31°C, the optimal temperature for this species, and also in the temperature lowered to 22°C and 60±5% relative humidity. The main aim of the research was to investigate the migration activity of *R. dominica* in lowered temperature. In addition the population dynamics, mortality and sexual ratio in a population of *R. dominica* were also analyzed.

It was shown that lowering the temperature to 22°C caused an increase in the migration activity of *R. dominica* in the initial phase of infesting a new habitat. A larger migration and mortality of females were observed. In addition, the population growth was slow and prolonged in time at the temperature of 22°C as compared to the optimal temperature. Lowering the temperature did not influence the mortality of the *R. dominica* population.

Key words: *Rhizopertha dominica*, lower temperature, migration activity, population dynamics, mortality, sex ratio

INTRODUCTION

Trade exchange and quick transfer of a large amount of goods in bulk in intercontinental transport contribute to the spread of storage pests (Nawrot 2002). Moreover, populations of grain beetles exhibit a large migration activity, which leads to attacking and infesting grains gathered in storehouses and granaries (Ciesielska 1992; Ciesielska and Kłyś 2002). This is a serious problem of a worldwide scale, causing huge economic losses as a result of food destruction by the beetles.

The subject of the study was the lesser grain borer, *Rhizopertha dominica* F., a dangerous pest of stored grain and food products. The main aim of the presented paper based on the laboratory experiments was to investigate the migration activity of the lesser grain borer in lowered temperature conditions. In addition, the population dynamics, mortality and sexual structure in of the population were also analyzed.

MATERIALS AND METHODS

The experiment was conducted to investigate the lesser grain borer migration. A set of two culture vessels constructed by Kłyś (1997) was used. This enabled the *R. dominica* adults to leave the initial population without a possibility to return (Ciesielska and Kłyś 2002; Kłyś 2007). Both vessels contained 40 g of wheat. The initial population numbered 40 adults of the same age which were placed in the external vessel from which they could migrate through 1.5 mm diameter holes to the internal vessel. They were made according to the method worked out by Ciesielska (1971). Based on this method, a monthly check was done and at the same time the substrate was supplemented to keep the constant amount of 40 g. This enabled the experiment to be carried out over a long time. The experiment was conducted in the thermostat keeping the temperature of 31°C, the optimal temperature for this species and at 60±5% relative humidity. The results of these studies were used as a control with respect to the results obtained at the temperature lowered to 22°C. The experiment was repeated six times. The insects used in the experiments were supported from general laboratory cultures kept in the thermostat at the temperature of 31°C and at 60±5% relative humidity in which they were kept for 15 days. The assessment of the migration activity was based on analysis of the population size as well as on the following indicators: migration, mortality rate and sex ratio. The statistical analysis was worked out on the basis the chi – squared test from the Statistica 8.0 program.

RESULTS

The results obtained during the one-directional migration of *R. dominica* at the optimal temperature for development indicate that the migration activity of this species during the whole experiment was maintained

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at a high level and fluctuated between 67 and 98%. Two distinct periods of intense migration could be identified. The first one took place during the initial infestation of wheat, that was after 30 and 60 days, when the migration rate reached 87 and 88%. The second came between 180th and 210th day when the migration rate reaches the maximum value of 87–98%. Lowering the temperature to 22°C caused a rise in the migration at the initial stage of infesting a new habitat, i.e. after 30 days, when 100% of insects migrated from the original population. The above higher rate of migration in comparison to that at 31°C continued up to the 120th day of culture (Fig. 1).

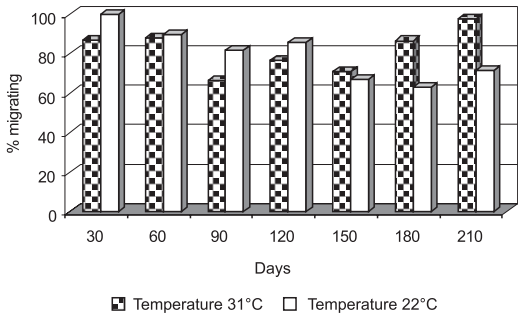

Fig. 1. Migration activity of the population of *R. dominica*

The number of the migrants was considerably higher compared to the size of the initial population at each time interval in both temperatures, that proved a high migration activity of the insect species. However, at the temperature of 22°C, the number of the migrants was much lower in comparison to the number of the migrants at the temperature of 31°C during the whole experiments, except for the 210th day (Fig. 2). The analysis of the chi-squared test showed that the difference between the size of the initial population at the temperature of 31°C and the size of the initial population at 22°C is statistically significant. The differences in numbers of the migrant groups at the applied temperatures were also statistically significant.

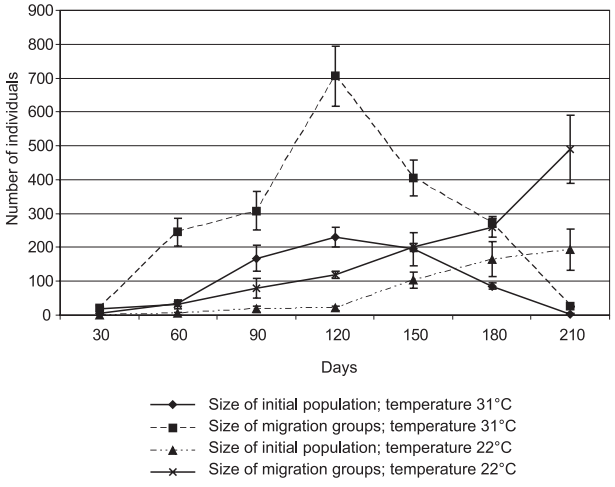

Fig. 2. Population dynamics of *R. dominica* in migration condition

The highest mortality was observed among the migrants at the temperature of 31°C which was confirmed by a mortality rate ranging from 8.5 to 94%, but at 22°C, mortality was very low, from 0 to 15% in both initial population and among migrating insects (Fig. 3).

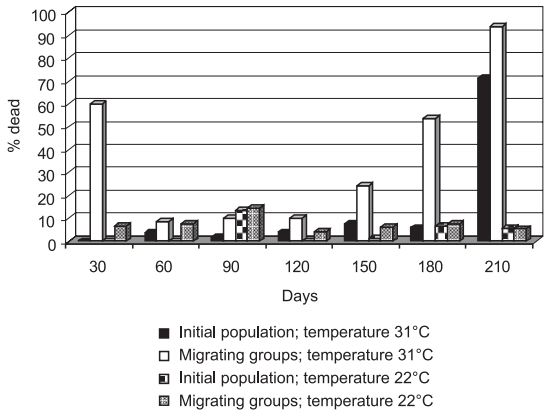

Fig. 3. Per cent of dead individuals in population of *R. dominica* in migration condition

At 31°C in the initial population during the whole experiment, the sex ratio equal led or was higher than 1. Nevertheless, among the migrants, the sex ratio was lower than 1 up to the120th day of the experiment. Starting from the 150th day, when the substrate was used and the population was aging, an increase in the number of males in the emigration groups was observed. The sex ratio values among the dead emigrating individuals were < 1, which proved higher mortality of females among the migrants.

At the temperature of 22°C the sex ratio in the initial population of *R. dominica* in the majority of time intervals was lower than 1. However, among the migrants, females exhibited a higher migration activity from the beginning of the experiment up to the 150th day. Then there was a balance in the activity of both sexes. Hence, among the dying insects at the temperature of 22°C, in both initial population and among the migrants higher mortality of the females was observed (Table 1 and 2).

Table 1. Sex ratio in *R. dominica* in conditions of migration (live individuals)

Days	Temperature 31°C		Temperature 22°C	
	initial population	migration groups	initial population	migration groups
30	1	0.5	0	0.7
60	1.4	0.6	0.8	0.8
90	1.5	0.8	0.7	0.9
120	1.1	0.8	0.7	0.7
150	1.1	1.1	0.8	0.8
180	1.2	1.1	1	1
210	1.3	1.7	1	1

Table 2. Sex ratio in *R. dominica* in conditions of migration (dead individuals)

Days	Temperature 31°C		Temperature 22°C	
	initial population	migration groups	initial population	migration groups
30	0	0.5	0	0.3
60	0.9	0.9	0	0.6
90	1	0.7	0.9	0.6
120	0.4	0.9	0	0.9
150	0.5	0.5	0.9	0.9
180	1	0.7	0.3	0.9
210	0.7	0.8	0.5	0.7

DISCUSSION

Generally, it is considered that the spread of insects – storage pests is caused mainly by carriage, that it is more often passive than active. Nevertheless, results of the research conducted in storehouses, silos and laboratory on species such as *Oryzaephilus surinamensis* L., *Sitophilus granarius* L., *S. oryzae* L. or *Laemophleus minutus* L. indicated that the insects quickly infested piles of grain. They continually attacked and contaminated the new batches of grain (Surtees 1965; Ciesielska 1992, 1994; Sinha 1973). Also *R. dominica,* a species which did not appear to be very mobile moved very skilfully in stored grain (Kłyś 1991). This species also had a definite tendency to actively infest grain piles moving from the outside of a pile to the inside (Surtees 1965; Gołębiowska *et. al.* 1976).

It is known that the most important factors which have a direct effect on the development and activity of pest populations are: temperature, relative humidity of air and grain as well a nutrient (Yinon and Shulov 1970; White 1988; Samson *et al.* 1989). These environmental conditions could either increase or decrease migration of these insects.

The experiment was performed to investigate the influence of lowered temperature on the migration activity of a population of *R. dominica*. It was shown that lowering the temperature to 22°C increased the migration process during the first four months of study. A particularly high migration (100%) was observed at the initial stage of invading a new habitat. During this period the insects migrated intensively outside the initial population despite excess of a nutrient. On the other hand, at the temperature of 31°C, two periods of intensive migration were noted. The first one was during the infestation of a new nutrient and the second during the last phase of the study, i.e. after 210 days. The studies on migration processes of *R. dominica* performed by Ciesielska and Kłyś (2002), at the temperature of 28°C and 60% of relative humidity gave similar results. The studies performed by Ciesielska (1992, 1994) on the *S. oryzae*, *S. granarius* and *O. surinamensis* populations at the temperature of 27°C and 70% relative humidity also showed a high migration activity of these species.

The effect of the population densification, temperature and humidity on cluster formations and dispersion of different beetle species was studied by Surtees (1964, 1965). The author demonstrated that at the air temperature of 15°C beetles of the lesser grain borer gather at the centre of a pile, where generally, the temperature was higher. In higher temperatures of the habitat, dispersion was higher even with a tendency to occupy dry portions of grains.

In turn Beckett *et al.* (1998) studied *R. dominica* and *S. oryzae* mortality at moderate temperatures. Obtained data indicated that all life cycle stages survived longer at a given temperature as grain humidity increased and the effect of humidity on the survival increased as the temperature decreased.

The results of the studies showed that lowering the temperature to 22°C did not influence mortality of the population. It was maintained at a low level in the initial population and among migration groups. However, a higher migration of females than males was observed, especially in the initial phase of the study, whereas a higher mortality of females was observed during the whole experiment. Moreover, it has been demonstrated that the population development of *R. dominica* at the temperature of 31°C was quick and sudden, whereas at 22°C was slow and prolonged. In the temperatures of both 31°C and the lower temperature of 22°C, *R. dominica* exhibited a high emigration tendency. This is particularly important at the time when this species invades new habitats and attacks subsequent batches of grain or grains products. Better understanding of the migration activity of this pest in different temperatures enables us to search more effective methods of limiting their spread and in turn, prevent infestation of new habitats, hence reducing the damage.

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POLISH SUMMARY

WPŁYW OBNIŻONEJ TEMPERATURY NA AKTYWNOŚĆ MIGRACYJNĄ POPULACJI KAPTURNIKA ZBOŻOWCA *RHIZOPERTHA DOMINICA* F. (*COLEOPTERA*, *BOSTRICHIDAE*)

Obiektem badań był kapturnik zbożowiec *Rhizopertha dominica* F. – groźny szkodnik magazynowanego ziarna zbóż. Badania prowadzono w laboratorium w temperaturze 31°C optymalnej dla tego gatunku owada i w obniżonej do 22°C, oraz w wilgotności względnej 60±5%. Główny problem badawczy dotyczył aktywności migracyjnej kapturnika zbożowca w warunkach obniżonej temperatury. Analizowano także dynamikę liczebności, śmiertelność i strukturę płciową populacji kapturnika.

Stwierdzono, że obniżenie temperatury do 22°C powoduje wzrost aktywności migracyjnej *R. dominica*, w początkowym okresie opanowywania nowego siedliska. Zaobserwowano również większą migrację samic i zwiększoną ich śmiertelność. Ponadto rozwój populacji w temperaturze 22°C jest powolny i wydłużony w czasie, w porównaniu z temperaturą optymalną. Obniżenie temperatury nie wywiera wpływu na śmiertelność populacji kapturnika zbożowca.