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EMIGRATION ACTIVITY OF THE SAW-TOOTHED GRAIN BEETLE *ORYZAEPHILUS SURINAMENSIS* L. (COLEOPTERA: SILVANIDAE) IN VARIOUS ENVIRONMENTAL TEMPERATURES

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Abstract: The study pertained to the saw-toothed grain beetle *Oryzaephilus surinamensis* L., a dangerous pest of stored food products. The studies were carried out in the laboratory. Thermostats were set at a temperature of 31°C; an optimum temperature for this insect species, and in temperatures lowered to 28 and 22°C. The relative air humidity was kept at 60 ±5% relative humidity (RH). The main topic of the study was to examine the effect of lower temperatures in the environment, on the emigration activity of *O. surinamensis*. In these conditions, the population dynamics and the sex structure in *O. surinamensis* populations were also studied. The saw-toothed grain beetle was found to display very high emigration activity at 31 and 28°C. Lowering the temperature to 22°C caused a decrease in emigration activity and total inhibition of emigration activity until the 120th day of the experiment. A higher emigration levels among females rather than males, was also observed.

Key words: emigration activity, *Oryzaephilus surianamensis*, population dynamics, sex ratio

INTRODUCTION

For many years, different measures have been taken to contain or reduce the number of pests attacking cultivated plants and stored cereal grain. These measures can generally be divided into biological, chemical, and ecological categories associated with prophylactic and natural methods of pest control.

In storehouses and granaries, the ecological factors directly affecting the increase in the population numbers of insects, play a major role. These factors include temperature and humidity, whose effects vary according to the developmental stages of insects (Cielsielska 1966; Nawrot 2002). Temperature is one of the major physical factors conditioning the implementation of an organism's life processes. In the case of storage insect pests, more knowledge concerning the effects of temperature on the population dynamics as well as emigration activity, could prove useful in developing the prophylactic measures needed to battle the spread of these pests.

The results of this study present the effects of decreasing environmental temperature upon the development and emigration activity of the saw-toothed grain beetle *Oryzaephilus surinamensis* L. population. The saw-toothed grain beetle is one of the polyphagous species of storage pests. This beetle is difficult to control because of its high fertility, the short time needed for complete development, and its significant emigration potential. Moreover, because of its small body size and great mobility it can effectively hide in many places of the granaries. For this reason, it is difficult for insecticides to be applied effectively. The beetle has developed a strong resistance to several insecticides (Heather and Wilson 1983; Wallbank and Collins 2003). The saw-toothed grain beetle occurs worldwide and it is one of the commonest pests of cereal grains and other grain products occurring in Poland. It was once classified as a secondary pest because of its inability to damage whole cereal grains. Nowadays, however, it also feeds on whole wheat grains (Nawrot 2002; Laszczak-Dawid *et al*. 2008).

MATERIALS AND METHODS

The studies were carried out in controlled temperatures in the laboratory. The experiments used sets of two different sized plastic containers. The smaller container with a 28 cm^2 floor area was placed in a larger container which had a floor area of 50 cm^2. The floor area of the larger vessel was covered with a layer of glycerine which constituted a 'trap' for migrating insects. The smaller vessel was filled with 40 g of semolina, and 40 even-aged saw-toothed grain beetles obtained from general cultures. The insects used were alive for 15 days prior to the experiments. An external container was covered by a perforated lid allowing air access. The internal container was open allowing for free movement of insects to the exter-

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nal container. The glycerine trap in the external container prevented the insects' return to the internal container.

The cultures carried out at 31°C were treated as the control experiment, as 31°C is the optimum temperature for this insect species. The remaining cultures were maintained at 28 and 22°C. All cultures were maintained under a relative humidity (RH) of 60 ±5%. In each temperature, cultures were run simultaneously in six repetitions.

The experimented lasted 240 days. The status of the population was checked every 30 days. Individuals were counted, dead or alive, and their sex was established. The population numbers, sex structure, and emigration activity were determined for each population of *O. surinamensis*. The sex ratio (♂/♀), representing the sex structure as the ratio between the number of males and females, was also determined (Andrzejewski and Falińska 1986). The data were analysed by statistical methods. The Chi-square test of the Statisticaâ software package was used.

RESULTS

The obtained data indicate that in optimum temperatures, the numbers of emigrating individuals of *O. surinamensis* was high up until the 120th day of the study; markedly exceeding the initial population. The lowering of the temperature by 3°C from the optimum temperature for this species, caused a drop in the numbers of emigrating individuals of *O. surinamensis* for a long period *i.e.* from the start of the experiment up until the 210th day. The lowering of the temperature by 9°C, resulted in reduced numbers of migrants in the following periods analysed up to the 150th day. Only after 210 days of the experiment, did the numbers of emigrants increase to reach 30 individuals (Fig. 1). The analysis of the chi-squared test showed that differences between the size of emigrants at 31°C and the size of the emigrants at 22°C is statistically significant from the start of the experiment up until the 150th day and after 210th days. In all cases, $p = 0.000001$ (respectively $\chi^2 = 90.94$; $\chi^2 = 384.0$; $\chi^2 = 111.0$; $\chi^2 = 446.0$; $\chi^2 = 209.29$; and $\chi^2 = 2027.50$).

At the optimum temperature *O. surinamensis* showed high emigration activity, particularly throughout the initial four months of the studies. The emigration index was then more than 70%. The highest level of emigration was noted after 30 days and it amounted to 84%. When the temperature was lowered to 22°C, there was a decrease in emigration activity of *O. surinamensis*, reaching ca. 30% after 30 days. In the period between the 60th and 120th day of the study, the emigration stopped completely with no emigrating individuals detected. The increase in emigration activity occurred only after 180 days and lasted, with a certain decreasing tendency, until the end of the studies. At a temperature of 28°C there was also a decrease in the emigration activity of the saw-toothed grain beetles compared with the control population. Only near the end of the experiment; namely after 210 and 240 days, did the emigration of beetles increase (Fig. 2).

In most of the time periods studied, the analysis of the sex ratio showed that lowering the temperature caused an increase in the proportion of females among migrating individuals. Generally, in all temperatures used, the females showed higher emigration activity as confirmed by the values of the sex ratio below 1 (Table 1).

The comparison of the results obtained at both temperatures, indicate the limiting effect of both temperatures on the population development and emigration activity in *O. surinamensis*. A temperature of 22°C, however, was shown to have more impact in terms of limiting the population development and emigration activity. The exception was in the final stage of the experiment, where, with very low population numbers, the emigration activity increases.

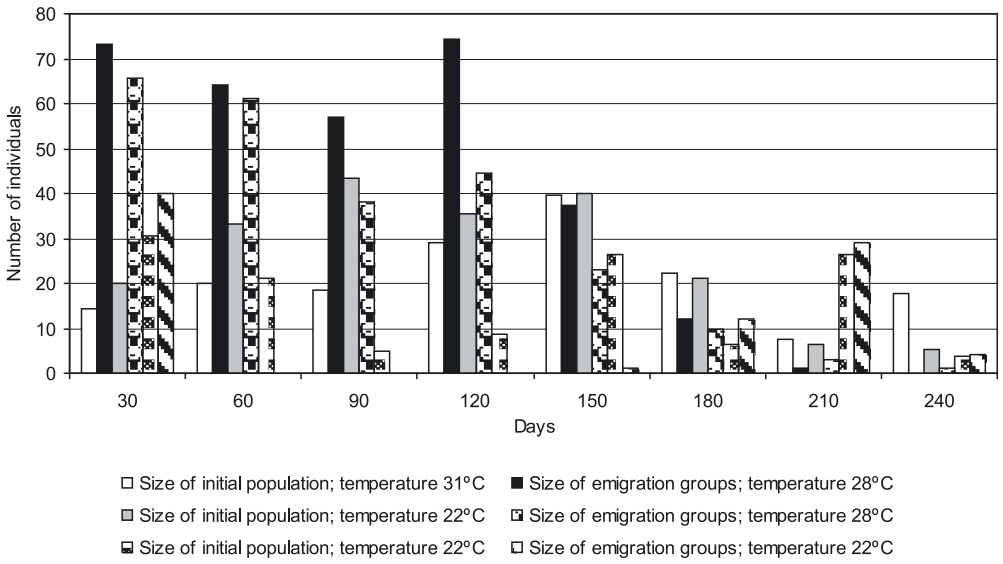

Fig. 1. Population dynamics of *O. surinamensis* in emigration condition

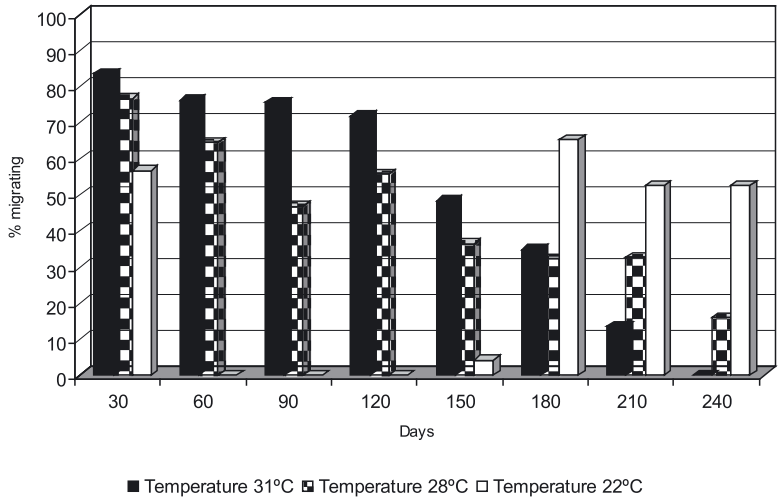

Fig. 2. Emigration activity of the *O. surinamensis* population

Table 1. Sex ratio in *O. surinamensis* in emigration conditions

Days	Temperature 31°C		Temperature 28°C		Temperature 22°C	
	initial	emigration	initial	emigration	initial	emigration
	population	groups	population	groups	population	groups
30	1	0.7	1.3	0.6	0.3	1
60	1	0.8	1.2	0.6	0.2	0
90	1.1	0.7	1.5	0.6	♀♀	0
120	1	0.4	1.5	0.6	1	0
150	1	0.9	1.3	0.4	1.2	♀♀
180	1.2	0.5	2.5	0.5	♂♂	0.5
210	1.2	♀♀	2	♀♀	1.2	0.3
240	0	0	1.5	♀♀	♂♂	0.7

♀♀ – only females were in the samples
♂♂ – only males were in the samples

DISCUSSION

Insects are susceptible to changes in the temperature of their surroundings. Each species has its own characteristic ecological tolerance resulting from its adaptation capacities. The development of storage insect pests can occur from 15 to 34°C. As a rule, eggs are the most susceptible to the changes in temperature whereas adults are the least susceptible. Donahaye *et al*. (1995) studied the effects of exposure to low temperatures; namely: 0, –5, –10, and –18°C in all the developmental stages of three insect pest species that feed on stored products: *Tribolium castaneum* (Herbst), *O. surinamenisis,* and *Ephestia cautella* (Walker). In *O. surinamensis,* the least susceptible stage at 0°C was its larva. At temperatures of –5 and –18°C, the least susceptible were the adult insects, and at –10°C the pupa.

In laboratory conditions, Evans (1983) studied the effect of humidity (45 and 70%) and thermal acclimation upon the survival of *Cryptolestes ferrugineus*, *O. surinamensis*, *Rhyzopertha dominica*, *Sitophilus granarius*, *Sitophilus oryzae* and *T. castaneum* in wheat or flour cooled to 9 and 13.5°C. The survival time in low temperatures often markedly differed among the species. Generally, *T. castaneum* had the lowest survival time and *S. granarius* had the longest. There was a statistically significant relationship between the effect of temperature and humidity, whereas he noted a shorter survival time in 45% RH rather than in 70% RH. The chill-coma temperature and acclimation temperature were linearly related in all species at each humidity level. There was generally an inverse relationship between survival and the chill-coma temperature.

In another study, Longstaff (1988) described the effect on the survival of adult insects of cooling grain applied together with an insecticide. He found the toxicity of the insecticides and the rate of their decomposition depends on the temperature.

The laboratory studies on the effects of insect population density as well as the temperature and humidity of grain on the formation of groupings and on the dispersion of various species of storage beetles, were carried out by Surtees (1963). One of the species studied was the saw-toothed grain beetle. This author demonstrated that in the range of temperatures used in the experiment (15–35°C), from between 1–10% of individuals came to the surface of the grain. Lowering of the humidity of the grain to 9% increased the number of individuals appearing on the sur-

face of the grain in all temperatures tested. At 25°C and with 14% humidity, 3–4% of beetles came to the surface. The insects were moving horizontally and transversely, and were more active in the evening than in the morning.

Kłyś (2009) also studied the effect of lower temperatures on emigration activity in the *R. dominica* population. She found that lowering the temperature to 22°C intensified the emigration process of this pest, but only in the initial stage of colonising a new habitat.

Kłyś (2011) also studied the emigration activity of another stored product pest, the granary weevil *S. oryzae*. She found that this species displayed a very high level of emigration activity at both 31, and 22°C. Lowering the temperature to 22°C resulted in a decrease in emigration activity to 40%, albeit only in two time intervals, *i.e.* after 60 and 120 days of maintaining the culture. She also observed greater emigration activity by females rather than males.

The results obtained in the presented study indicate that the population of *O. surinamensis* is biologically very resilient, which is supported by the high emigration activity of these insects at temperatures of 31 and 28°C, as well as by the predominance of females over males among the migrating individuals, at all studied temperatures. It confirms the major danger presented by this very active pest. The lowering of the temperature to 22°C resulted in the reduction of the emigration activity in the initial stage of the studies, and in its complete elimination up to the 120th day of the studies. In the case of storage pests, learning more about the conditions which govern their migratory activities increases the chances for more effective control of the pest. Applying suitable factors, such as temperature, limits the pests' dispersal.

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