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Autor(en): **Benz, G. / Abivardi, C.**

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Effects of temperature on survival and reproduction of the golden spider beetle, *Niptus hololeucus* FALDERMANN (Col., Ptinidae)

G. BENZ & C. ABIVARDI

Entomologisches Institut der ETH Zürich, ETH-Zentrum, CH-8092 Zürich

Niptus hololeucus survives for a limited period of time at 2-30 °C, but development proceeds only at variable temperatures of 10-25 °C. The highest "constant" temperature allowing uninterrupted development is 20 ± 2 °C. At higher constant temperature the last instar larvae stop development, and newly eclosed adults enter adult diapause. Young beetles surviving 6 months at 2 °C reproduce normally at 20 °C, whereas those surviving 7 months at 10 °C do not reproduce. Unadapted beetles are killed within 50 minutes at minus 18 °C and within 10 minutes or less at 45-50 °C.

INTRODUCTION

The golden spider beetle (*Niptus hololeucus* FALD.) is widely distributed in Europe. It is of some ill-fame as a pest of certain materials and stored products. In Switzerland the beetle is known since 1862, when it caused much damage in a draper's shop in Winterthur (KOHLER, 1930). It became quite famous in 1989, when a mass outbreak in a spinning mill led to judicial actions and much ado in the press (BENZ, 1989).

In connection with a judicial expertise information of the effects of temperature was needed. The literature on such effects, summarized by WEIDNER (1983), is relatively scarce. The lower threshold of development is at 10 °C and 50% rH; optimum development occurs at 20 °C and 70% rH (with approximative duration of adult life of up to 200 days if water is available, and 150 days without). At 25 °C and 75% rH mortality of the larvae is high and the fecundity of the females is low. However, certain effects could not be explained with these facts alone. Therefore, more information was needed.

The following is an account of our temperature experiments conducted with two strains of *N. hololeucus*. Of special interest was the testing of unpublished results of Dr. I. KREHAN (Bayer Plant Protection Center Monheim, Leverkusen, FRG). He found that development from the egg to the egg-laying adult proceeds without interruption at temperatures of 15-20 °C within 4 months and also at 18-23 °C, if the last instar larvae and the young adults (during their maturation period) are kept at 20 °C or lower temperatures; otherwise the larvae and/or immature adults enter diapause and development does not take place or takes a very long time.

MATERIAL AND METHODS

The insects

Two strains of *N. hololeucus* were used. Strain G (Germany) was a laboratory strain of Dr. KREHAN. Strain K (Kollbrunn) was a strain taken from the population in the infested spinning mill at Kollbrunn. Both strains were usually reared on the medium of KREHAN (see below) at 20 °C and 70% rH.

The rearings

The rearing medium was composed of 1 part ground dogs biscuits (Tornow's Hundefeinkost with 30.3% raw protein, 11.9% raw fat, 4.5% raw fiber, 6.5% raw ashes, as well as 12,000 i. u. of vitamin A and 1,500 i. u. of vitamin D_3 per kg), 1 part of bruised wheat, and 1 part of ground rolled oats. The ingredients were mixed and filled 2–3 cm deep into rectangular 20 liter glass containers. On top of the mix cotton rolls were evenly distributed and covered with 2 plates of pressed peat (as a place for pupation). A leaf of cabbage was laid on the plates (as a source of water for the adults). The leaf was replaced by a fresh one twice a week. The glass containers were closed with gauze. Starting with 160 beetles such a rearing unit produces at 20 °C and 70% rH up to 3000 beetles within 5 months.

Low and high temperature experiments

Sub-zero temperature experiments: Samples of 20 beetles of the K strain in small glass tubes were put for different periods of time (15 to 50 min) in a freezer at minus 18 °C. After the freezing period the insects were transferred into larger tubes with semolina of corn and kept at 20 °C. Mortality was noted for up to a week.

High temperature experiments: Beetles of the G and the K strains were treated for different periods of time at 30–50 °C. Mortality was recorded on the following day.

Mortality at 2° C and reproductive capacity

Samples of 10 beetles of the K strain per plastic tube with semolina of corn were kept at 2 °C for 1, 2, 3 or 6 months (50 beetles for each experiment) and mortality was recorded.

30 beetles surviving 6 months at 2 °C were kept at 20 °C on ordinary rearing medium. After one month the beetles were removed. The medium was searched for offspring after 4 months. As a control 30 young beetles of the stock breeding of the K strain were also placed on medium for one month and the medium was searched for offspring after 4 month.

Mortality of the G and K strains at 10° C

Fourteen experiments, each with 50 beetles of the G or the K strain, were conducted at 10 °C. Mortality was checked after 1 to 7 and 12 months.

The reproductive capacity of survivors kept for seven months at 10° C

50 beetles of the G strain surviving 7 months at 10 °C were tested for reproductive capacity in the same manner as the survivors at 2 °C mentioned

above, with the exception that in this case the medium was supplemented with a piece of cabbage leaf (see rearings). The media were searched for offspring after 2 months.

Development and reproductive capacity at 20 to 26°C

Groups of 30 eggs of the G and the K strains were placed on medium and incubated at 20 ± 2 °C or at 26 ± 2 °C and 70% rH. Development of the larvae, pupae, and adults as well as oviposition of the latter was checked.

Groups of 50 freshly eclosed beetles of the G and the K strains were reared for one month on medium supplied with a piece of cabbage leaf at 20 °C and 26 °C. After one month the beetles were removed and the media were observed for 4 months and searched for offspring.

Groups of 20 last instar larvae and young adults were kept for 2 months at room temperature of 23–24 °C or at a constant temperature of 25 °C. After 2 months the larvae and beetles were transferred to 20 °C for another month. Development of the larvae and egg laying of the adults was checked.

RESULTS

Influence of sub-zero and high temperatures

The influence of a temperature of minus 18 °C on unconditioned beetles of the K strain is presented in Fig. 1. A chilling period longer than 15 min causes mortality which increases linearly with the exposure time. Chilling for 50 min or longer leads to 100% mortality. The exposure time for 50% mortality is about 33 min.

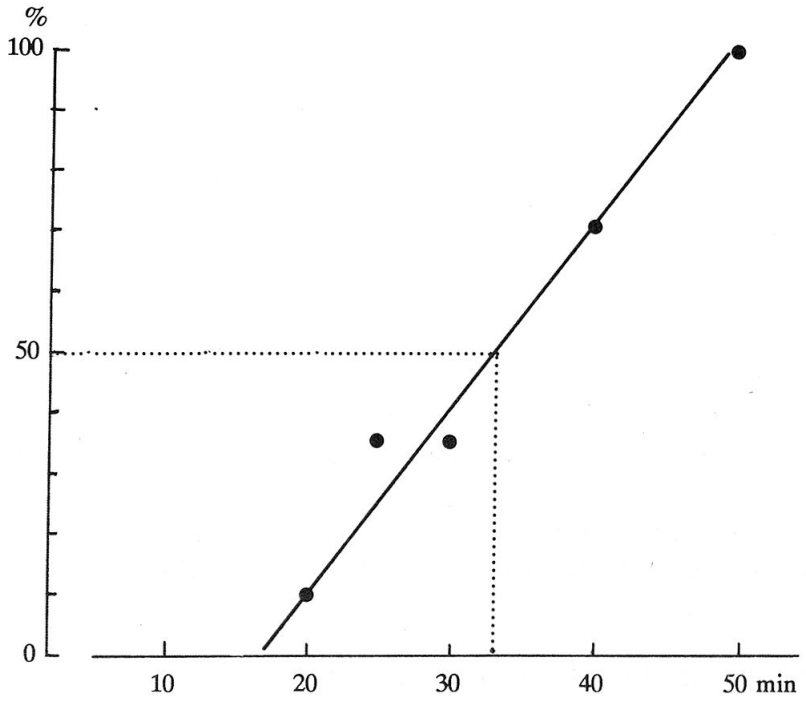

Abb. 1. Mortality (ordinate) of the K strain of *Niptus hololeucus* during and/or after exposure to minus 18 °C for different times (abscissa).

Temperatures of 30 °C and 35 °C cause hyperactivity of the beetles for 2.5 and 1.5 hrs respectively, followed by a slowing down of the movements leading to inactivity after about 3 and 2 hrs respectively. If the beetles in heat-coma are brought to room temperature they revive within 1 hour.

At 40 °C the beetles are hyperactive for about 5 min and fall into heat-coma within 10–20 min. If the beetles are returned to room temperature after 1 h about 30% revive whereas the rest die within 5 h.

At 45 °C and 50 °C the beetles fall into heat-coma within 2–3 min and 1 min and die within 10 min and 2 min respectively.

Mortality at 2 °C and 10 °C

At 2 °C the beetles fall in chill-coma, whereas beetles at 10 °C are still active. The mortalities of the different groups of beetles of the G and K strains stored for 1 to 12 months at relatively low temperatures are computed in Tab. 1.

Tab. 1. Mortality of the G and K strains of *Niptus hololeucus* during storage at low temperatures.

Temp. °C	N	Storage (months)	Mortality (%) G strain	K strain
2	20	2	-	0
	20	3	-	5
	20	6	-	16 (32)[a]
10	50	2	0	0
	50	3	0	0
	50	4	6	-
	50	5	24	-
	50	6	46/52[b]	28
	50	7	36/40[c]	-
	50	12	96	-

[a] 16% dead and 16% paralyzed, 30 survivors tested for reproduction; [b] 2 repetitions; [c] 2 repetitions, 50 survivors tested for reproduction.

Reproductive capacity of beetles stored at 2 °C and 10 °C

The reproductive capacity of the beetles surviving storage for 6 months at 2 °C was not impaired. They produced 88 offspring (22 L, 2 P, 64 I); the corresponding controls produced 82 offspring (28 L, 8 P, 46 I).

In contrast, the survivors of storage for 7 months at 10 °C had no offspring, whereas the corresponding controls produced 345 larvae (checked after 2 months).

Development and reproductive capacity at 20 °C to 26 °C

At 20 °C both strains produced about 400 offspring per 50 parents within one month. Development from egg to egg took 120 to 150 days for both strains.

The average time in days for the different stages was (egg = 15, L_1 23, L_2 25, L_3 36, P 15, maturation of imago in cocoon 16, preoviposition period outside cocoon 12).

Less than 10 larvae per 50 parents were found in the G and K rearings at 26 °C. No development of larvae to pupae was found.

At the room temperature of 23–24 °C as well as at constant 25 °C the last instar larvae did not pupate within 2 months, and the adults laid no eggs. When the larvae and adults were transferred to 20 °C development did not proceed for another month, when the insects were discarded.

DISCUSSION

The results indicate that survival of *N. hololeucus* is possible at the relatively large range of 2 to 30 °C. At least in non-adapted insects sub-zero temperatures of minus 18 °C and temperatures above 30 °C are detrimental. In nature living beetles have been found at minus 4 °C and they survived hibernation at constant minus 8 °C (CYMOREK & KOCH, 1969). Beetles survive storage for 6–7 months at 2 °C and 10 °C, but only the former (in chill-coma) are able to reproduce afterwards, whereas the latter are sterile. The most interesting result is that development proceeds uninterrupted at 20 °C, whereas development ceases at 23–26 °C in the last instar as well as in the immature adult. This confirms Dr. KREHANS observation that temperatures below 23 °C are needed for uninterrupted development from egg to egg. Since development of the last larval instar and the immature adult does not immediately proceed when the insects are brought to 20 °C it is justified to speak of prepupal and adult diapause.

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ZUSAMMENFASSUNG

Die Wirkung der Temperatur auf Überleben und Fortpflanzung des Messingkäfers Niptus hololeucus FALDERMANN *(Col., Ptinidae).* – Der Messingkäfer überlebt Temperaturen von 2–30 °C während einer gewissen Zeit aber nicht dauernd. Temperaturen unter 0 °C und über 30 °C schädigen die Käfer rasch. Sie überleben einen Aufenthalt von 6–7 Monaten bei 2 °C bzw. 10 °C, doch können sich nur die ersteren fortpflanzen, wenn sie bei 20 °C gezüchtet werden, während die letzteren steril sind. Ununterbrochene Entwicklung ist bei 20 °C möglich, während bei 26 °C die Entwicklung im letzten Larvenstadium stillsteht oder die jungen Adulten nicht geschlechtsreif werden.

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