Discussion

Although the developmental parameters for Latridiid beetles have not been elucidated, Hinton (1941) described the life histories of several species on cultures of *Penicillium glaucum* and *Mucor mucedo* on bread and cheese. The durations of the time the egg was laid to adult emergence were 27–32 d (egg to the second instar larval stage was at 15.6 °C and the third instar to pupal stage was at 20 °C) for *Cartodere nodifer* (Westwood), 36 d at 23.9 °C for *Dienerella filum* (Aubé), 51–52 d (egg at 17.2 °C and larva to pupa at 19.4 °C) for *D. filiformis* (Gyllenhal), and 40 d at 18.3 °C for *Corticaria fulva* (Comolli) (Hinton 1941). The period from egg to adult observed for *D. argus* in the present study was longer than the periods observed for *Cartodere nodifer* and *Corticaria fulva*, and was the same as the periods observed for the two *Dienerella* species at comparable temperatures. Based on the systematic review by Kiritani (2012), the average T_0 and K values from egg to adult for 31 coleopteran species are 10.9 ± 2.5 °C and 415 ± 239 DD (mean ± SD), respectively. The T_0 and K values for *D. argus* were 10.5 °C and 526 DD on *C. cladosporioides*, 9.0 °C and 500 DD on *P. citrinum*, and 10.9 °C and 370 DD on *P. decumbens*, all of which are average values for coleopterans.

The daily mean temperatures of the garret of the laboratory, the original location of the test insects, fluctuated within the range of 12–17 °C in the winter, constantly surpassing T_0 (= 9.0–10. 9 °C) (Fig. 1). This result strongly suggests that *D. argus* had bred there year-round. In fact, the adult beetles were caught irrespective of the season. Because the female adults require at least one week before starting oviposition at 25–30 °C, the thermal constant K for one generation on *P. decumbens* was assumed to be 470–500 DD (370 DD for egg to adult emergence + 100–130 DD for the pre-oviposition period). The accumulated daily mean temperature above 10.9 °C was calculated at 3974 DD in the garret of laboratory, and the number of generations per year was estimated at eight.

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Comparison of mandible morphology of two stored product bostrichid beetles, *Rhyzopertha dominica* and *Prostephanus truncatus*

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Abstract

Insect mandibles are most frequently encountered fragments in processed foods. Thanks to their sclerotised and darkly pigmented nature, they usually remain intact in foods and are relatively easily detectable. Moreover, because of their complexity and variety of shapes, stored product beetle mandibles may be useful in species determination. The present work deals with a comparative morphology of two stored product bostrichid beetles, *Rhyzopertha dominica* and *Prostephanus truncatus*. The mandibles were studied using by light and scanning electron microscopy and their morphological details, overall appearance and size are provided.

Keywords: mandibles, stored product pests, Bostrichidae, *Rhyzopertha dominica*, *Prostephanus truncatus*

1. Introduction

Beetle mandibles serve as effective tools for both intake and processing of food. From the stored product perspective, they are used for overcoming barriers imposed by a manufacturer thus enabling to infest a commodity (Stejskal et al., 2017). For this reason, external morphology of mandibles can provide information about mechanism of feeding and infesting potential of the particular insect species. Lesser grain borer *Rhyzopertha dominica* and larger grain borer *Prostephanus truncatus* are serious pests of stored grain in many regions worldwide (Stejskal et al., 2015). As both species are internal grain feeders with relatively inconspicuous adult way of life (Edde, 2012), early detection of the infestation is problematic. Nevertheless, thanks to their microscopic size and highly sclerotised nature, mandibles are most numerous fragments in the processed foods (Trematerra et al., 2011) and may thus serve as an indicator of level of a product contamination and for species identification.

2. Materials and Methods

Both species were reared at 27 °C and 75% relative humidity on wheat (*R. dominica*) or maize grains (*P. truncatus*). Only newly emerged, 1 – 7 days old individuals were used. The mandible measurements were taken using stereomicroscope Olympus SZX10 equipped with a Canon 1300D digital camera and analysed by QuickPHOTO INDUSTRIAL 3.1 software. Before examining with the JEOL 6380 scanning electron microscope, the mandibles were cleaned in 20% lactic acid for 24 hours, dried with critical point drying and mounted on aluminium plates.

3. Results

For both species, interspecific differences in size, shape, as well as morphological details were indentified. The mandibles of *P. truncatus* were described for the first time. The morphological characteristics and the most important differences are summarized below:

3.1 Rhyzopertha dominica (Fig. 1A)

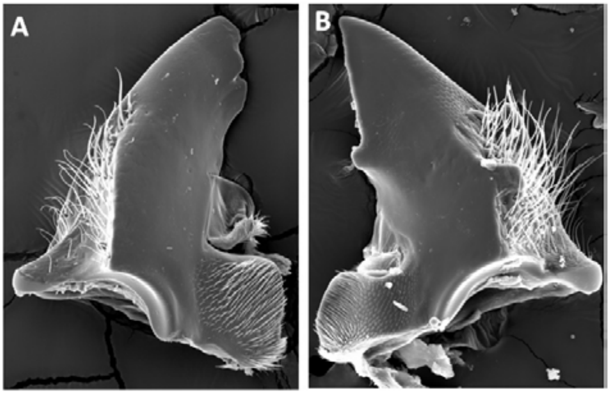
Mandible length 270 - 310 µm. Shape of incisive part: incisor lobe relatively short and blunt. A setal tuft relatively small, containing only 10 – 20 long branched setae. Mola quadrate from the dorsal aspect, smooth, without any apparent structure, only with shallow groove approximately in the middle. Setae along the molar area in dorsal part uniform. Lateral margin without any lateral protuberance.

3.2 Prostephanus truncatus (Fig. 1B)

Mandible length 390 - 440 µm. Incisor long, with blunt mesal protuberance in proximal part, primary incisor pointed. Wide setal brush containing > 100 short setae. Mola rounded, chewing area concave with coarse surface. Setae along the molar area of two types. Lateral margin with two large protuberances on lateroventral and laterodorsal aspect.

Fig.1 SEM photographs of mandibles of (A) *Rhyzopertha dominica* and (B) *Prostephanus truncatus*.

4. Discussion



Despite great variability of insect mandibles, there exist generalities in their morphology according to feeding habits of the species (e.g. Samways et al., 1997; Smith and Capinera, 2005). For example, pointed bifid or unidentate apex of mandibles serves as a piercer and is mainly present in predatory species. Similarly, highly developed mola is used for trituration of a dense material and is thus present in species feeding on hard material. The relative size and shape of mola and molar surface are different in both studied species and probably reflect their slightly different food source. Nevertheless, the well developed mola in both species is probably linked with presence of a dust in the infested commodities by these species (Kumar, 2002). Also, the incisors are adapted for scraping and play a role in removal of a food as well as in penetration of a hard material (e.g. wood, seed surface, or, secondary, food packages). Thus, the length and robustness of the incisive part may be a reason of a great penetration ability of the studied species (Stejskal et al., 2017).

In this work, we described mandible morphology in two stored product bostrichid beetles, *R. dominica* and *P. truncatus*. The mandibles of *P. truncatus* are described for the first time. We identified differences between the two species in size, shape as well as morphological details. We conclude that the two species can be easily identified based on their mandibles and that the species determination is possible at low magnifications by light microscopy.

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Behavioural responses of Callosobruchus maculatus to volatiles organic compounds found in the headspace of dried green pea seeds

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There is growing evidence that insects rely on chemical cues to locate food, hosts, predators, and potential mates. The pulse beetle Callosobruchus maculatus has been recognised for decades as the major post-harvest insect pest of legume seeds. In a previous study, we identified five volatile compounds in the headspace of dried green pea seeds as electroantennographically active in C. maculatus antennae: 1-pentanol, 1-octen-3-ol, (*E*)-2-octenal, nonanal and 3-carene. Volatile compounds are generally perceived by insects as blends, we hypothesized that *C. maculatus* might particularly show attraction to different mixtures of the aforementioned compounds. To test this we examined the behavioural response of *C. maculatus* towards volatile mixtures in a dual choice Y-tube olfactometer. The results showed that females were attracted to five mixtures while males were attracted only to two binary mixtures consisting exclusively of aldehydes. The other mixtures caused *C. maculatus* to move away. Further investigations with the attractive mixtures should be done in real storage conditions with the aim of developing a trap for the pulse beetle, *C. maculatus.*

Investigation on the Species and Distribution of Stored Grain Insects in Northwest China

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Abstract

To understand the diversity of stored grain insects in northwest China, we have fulfilled insect collection in 56 grain storage enterprises, 60 grain, oil and feed processing plants and 65 farmers situated in 26 cities of five provinces (Shaanxi, Gansu, Qinghai, Ningxia and Xinjiang) in northwest China from 2016 to 2017. After systematical identification, totally 83 species of stored grain insects have been found in this investigation, belonging to five orders, namely Class Insecta Order Zygentoma, Order Coleoptera, Order Lepidoptera and Order Hymenoptera, as well as Class Arachnida Order Chelonethida, in which Order Coleoptera owns 74 species in 22 families, Order Lepidoptera owns six species in four families, Order Zygentoma and Order Hymenoptera own one species in one family respectively, and Class Arachnida Order Chelonethida has one species in one family. After the statistics of four insect investigations in northwest China during 1955-2017, this paper has analyzed the results of four insect investigations and the representative stored grain insects in northwest China.

Key Words: northwest China, stored grain insects, species, distribution, investigation

1. Introduction

Located in the hinterland of the Eurasian continent, the northwest region covers the first (high-cold and dry stored grain region), second (low temperature and dry stored grain region) and fourth