J. Ent. Acarol. Res.
Ser. II, 43 (2): 157-168

30 September 2011

M. SCHÖLLER, S. PROZELL

Biological control of cultural heritage pest Coleoptera and Lepidoptera with the help of parasitoid Hymenoptera

Abstract - Natural enemies are known from many cultural heritage pests, but their potential for biological control has been marginally exploited only. In this publication, examples of practical and commercial application of parasitoids of beetles and moths are compiled as well as laboratory research that contributes to the development of guidelines for parasitoid releases. One the one hand there are parasitoids found to occur simultaneously with the pests in buildings, on the other hand there are parasitoids that were never found to be associated with the respective pests but accept them if brought into the cultural heritage environments. An example for the latter is the egg parasitoid *Trichogramma evanescens euproctidis*, a parasitoid of moth eggs including those of the cloth moth *Tineola bisselliella*. In semi-field trials it was shown that inundative releases of the egg parasitoids are necessary and that effectiveness is reduced on thick cloth with long strand. *Trichogramma* release units have to be placed directly on the cloth to be protected. A naturally occuring parasitoid of Anobiid beetles is the pteromalid larval parasitoid *Lariophagus distinguendus*. This parasitoid was applied against the drugstore beetle *Stegobium paniceum* in historic libraries and against spider beetles (Ptininae) in historic buildings. A simulation model for the population-dynamics of *L. distinguendus* and the golden spider beetle *Niptus hololeucus* is presented. Finally, monitoring of the Braconid larval parasitoid *Spathius exarator* used for indirect monitoring of the common furniture beetle *Anobium punctatum* is described. The future potential of parasitoids to control cultural heritage pests is discussed.

Key words: museum pests, Ptininae, natural enemies, monitoring, parasitoids.

INTRODUCTION

Biological control in a strict sense is the application of living organisms for the control of pest organisms. A further subdivision into micro-biological control applying smaller organisms like e.g. fungi or bacteria, and macro-biological control applying larger organisms like nematodes or insects is useful and relevant in the context of registration of biological control agents (Franz & Krieg, 1982). Other biologically based controls, like bio-technological methods (e.g. Bt-toxins), pheromones and other semiochemicals, insect growth regulators and phytochemicals (botanical insecticides) are not included here. This review focuses on commercially available parasitoids for

the control of beetles and moths attacking cultural heritage. Adult parasitoids search for hosts (i.e. pests) for oviposition, and the progeny of parasitoids typically need only one host individual to complete development (Franz & Krieg, 1982). Consequently one advantage of parasitoids is the active search for pest individuals in hidden places and their ability to locate hosts also at low host-densities. Parasitoids feed exclusively on host insects, frequently the adults do not need to feed at all and they do not damage artefacts.

The target pests are synanthropic insects attacking wood or other materials used for museum items, or the buildings themselves. While a number of species can be found almost exclusively associated with these materials, there is another group of species that attack additionally stored products for human consumption. These stored-product pests may destroy materials as well, either by feeding on the materials or on their way to pupation sites. While little information is available on natural enemies of the more specific cultural heritage pests, and almost none on biological control, a lot of information is available on natural enemies and biological control of stored-product pests (Schöller *et al.*, 2006). Looking at the parasitoids studied in this context, on the one hand there are species that are associated with human-based habitats and their stored-product insect hosts. On the other hand, there are parasitoid species that accept stored-product insects as hosts, but were transferred from agricultural ecosystems to indoor habitats.

Biological control of the cloth moth *Tineola bisselliella*

Egg parasitoids in the genus *Trichogramma* are applied for biological control of various pest Lepidoptera in field crops like corn or apple. They are polyphagous and accept eggs of many Lepidoptera (Wajnberg & Hassan, 1994). Immature *Trichogramma* sp. are glued on cardboard release units, the adults emerge continuously for several weeks. Nowadays, release units are available that provide activity of *T. evanescens euproctidis* (Girault, 1911) for three or even 4 weeks. Several species of *Trichogramma* have been shown to accept eggs of *Tineola bisselliella* (Hummel, 1823) including *T. evanescens euproctidis*, the species applied against stored-product moths in Central Europe (Zimmermann *et al.*, 2003). For *Trichogramma* spp., the surface structure of textiles and carpests is comparable with hairy leaf surfaces. Hairy leaf surfaces were shown to reduce the foraging activity of *Trichogramma* sp., e.g. on tomato leaves (Wührer, 1994). In order to test if a large surface will reduce the effectiveness of released parasitoids on cloth, Zimmermann (2005) placed cloth (25 cm x 45 cm) in cages (100 cm x 50 cm x 65 cm) previously used for semi-field trials with *Trichogramma* spp. on green plants. He compared 3 types of cloth: (1) Finely woven cloth 1.5 mm in thickness without long distant strand (fibres) (2) medium-finely woven cloth ca. 3.0 mm in thickness with long distant strand (fibres) and (3) tanned sheepskin rug ca. 2.5 cm in thickness. Five batches of eggs with 120 *T. bisselliella* eggs each were placed 10 cm, 20 cm, 30 cm and 40 cm from the release point as baits. Fresh *T. bisselliella*-host eggs were provided on day 2, 3 and 5 after release of *Trichogramma* individuals. The number of *Trichogramma* individuals on the egg baits were recorded as well as parasitism by counting black host eggs. The number of female *T. evanescens* active on the cloth was increasing with an increasing number of parasitoids released (Fig. 1). The number of

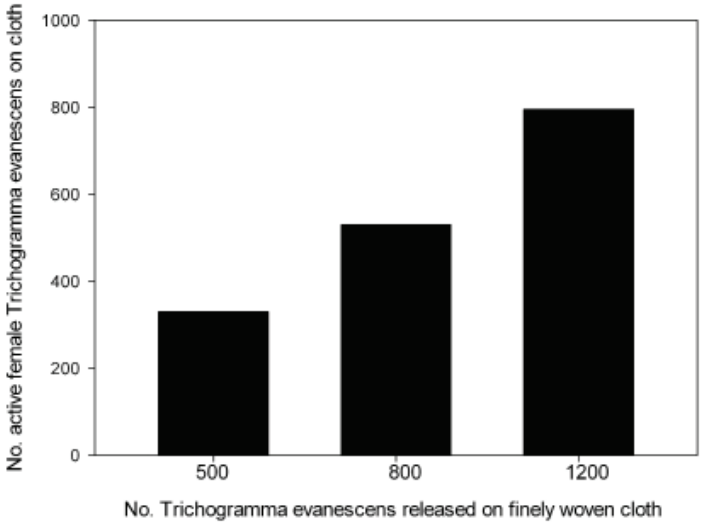

Fig. 1 - Number of active female *Trichogramma evanescens* on finely woven cloth depending on the number of parasitoids released. After data in Zimmermann (2005).

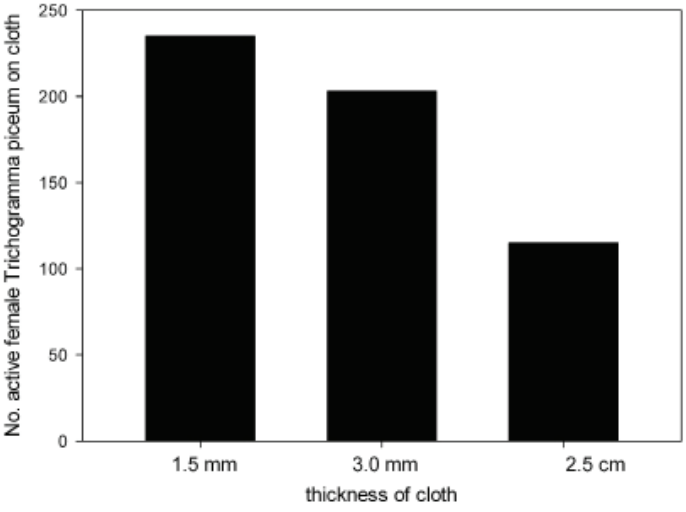

Fig. 2 - Number of active female *Trichogramma piceum* on cloth depending on the thickness of the cloth. After data in Zimmermann (2005).

Trichogramma-females active on the cloth was decreasing with increasing thickness of the cloth (Fig. 2). Trials with egg-baits on stuffed animals pointed in the same direction (Prozell & Schöller, unpubl.). The conclusions drawn for the release recommendations were: *Trichogramma* spp. have to be applied inundatively, in most cases all year round, and the release units have to be placed directly on the cloth or shelf to be protected. Currently 1000 *T. evanescens* per m^2 and week are recommended.

First applications of *T. evanescens euproctidis* were performed in a depot of an ethnographical museum in South-West Germany, and in the Jewish Museum in Berlin. In depots, the identification of infested items might be very time consuming, but the parasitoids actively search for moth eggs. In the Jewish Museum, the parasitoids helped to suppress a residual cloth moth population feeding on fluff balls formed by wear debris of the visitor's wool clothes in cracks and crevices and was integrated with an improved cleaning procedure. For more recent releases in museum collections see Biebl & Querner (this volume). One of the problems associated with the release of *Trichogramma* spp. for control of the cloth moth is the exclusive acceptance of the egg stage of the moth. The disruption of the developmental cycle is expected to be slow due to the slow developmental speed of the cloth moth. Consequently the integration with larvicidal strategies is a future challenge. However, as a preventive control strategy at low densities of the cloth moth *T. evanescens* is already a valuable tool.

Considerable work has also been done to study the braconid wasp *Apanteles carpatus* (Say, 1836), however, this parasitoid is not commercially available yet. *Apanteles carpatus* is a solitary koinobiont endoparasitoid of *T. bisselliella* and *Tinea pellionella* L., 1758 larvae, i.e. one wasp develops per moth host larva and the moth larva is carrying the parasitoid larva for some time before being killed by the latter. *A. carpatus* is capable of complete development in all larval stages of *T. bisselliella* (Plarre *et al.*, 2000). For a field study in a heavily infested rug store, Plarre *et al.* (1999) released laboratory reared *A. carpatus* monthly. The release of *A. carpatus* alone had no suppression effect on the cloth moth population, only the combination of *A. carpatus*-release with a sanitation program significantly reduced the pest. A number of other predators, parasitoids and pathogens of *T. bisselliella* are known (Zacher, 1933; Wudtke, 2002; Zimmermann, 2005), but none of them was evaluated for biological control so far.

Biological control of the drugstore beetle *Stegobium paniceum*

Stored-product pests may destroy materials as well, either on their way to pupation sites or because the materials contain ingredients suitable for development. In Halle / Saale, Saxony-Anhalt, Germany, a historic library became infested by the drugstore beetle *Stegobium paniceum* (L., 1758). The beetles were thriving both below the floorboard on wheat straw used as insulation, and in book covers. The books originated from the 16th to 18th century, when the book covers were filled with pulp made from linen scraps. *Stegobium paniceum* developed in the pulp, produced the characteristic exit holes and therewith destroyed irreplaceable cultural heritage. The books were moved to a fumigation-chamber and treated with nitrogen. However, some re-infestation was detected after the books were moved back to the library, presumably originating from

the floorboard. The parasitoid *Lariophagus distinguendus* (Förster, 1841) was released on the shelves, 2000 in October and 2000 in June. The release was evaluated to have successfully suppressed the re-infestation of the library (Schöller, 2010). Another trial on host-finding in boxes containing books was carried out in an Israeli library, where *L. distinguendus* was shown to find host larvae both between and inside infested books (Wilamowski *et al.*, 2008). A bibliography of the natural enemies of *Stegobium paniceum* and the tobacco beetle *Lasioderma serricorne (*F., 1792), a species with similar biology, is given in Schöller (1998).

temperature [°C]	number of eggs / female / day
14	0.0090
17	0.0556
20	0.0486
23	0.0625
26	0.0069
30	0.0000

Tab.1 - Oviposition of *Niptus hololeucus* at different temperatures, data from Howe & Burges (1952) used for simulation with SITOPHEX.

month	temperature [°C]	relative humidity
July	25	60
August	25	55
September	25	60
October	20	65
November	15	70
December	10	70
January	10	70
February	8	70
March	15	65
April	20	65
May	20	65
June	25	60

Tab.2 - Temperature and relative humidity conditions used in the model of biological control of *Niptus hololeucus* by *Lariophagus distinguendus* with SITOPHEX software.

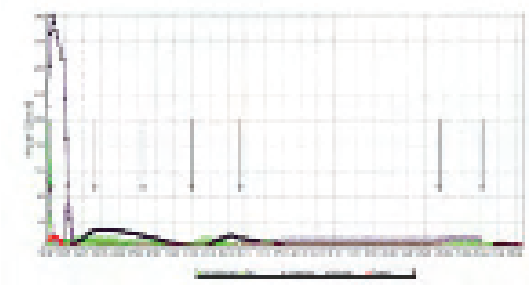

Fig. 3 - Simulation of biological control of *Niptus hololeucus* by releases of *Lariophagus distinguendus* with SITOPHEX. Arrows indicate 7 releases of 400 *L. distinguendus* each, black triangles = young *N. hololeucus* larvae, white triangles = old *N. hololeucus* larvae, other stages below 20 individuals.

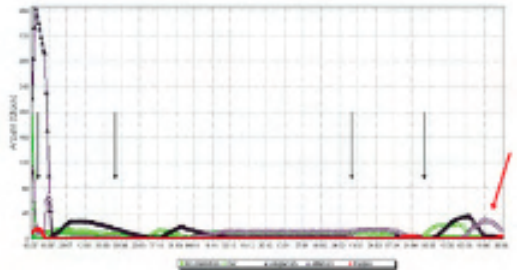

Fig. 4 - Simulation of biological control of *Niptus hololeucus* by releases of *Lariophagus distinguendus* with SITOPHEX. Arrows indicate 4 releases of 400 *L. distinguendus* each, black triangles = young *N. hololeucus* larvae, white triangles = old *N. hololeucus* larvae, other stages below 20 individuals, oblique arrow (right) indicates increase in young larvae.

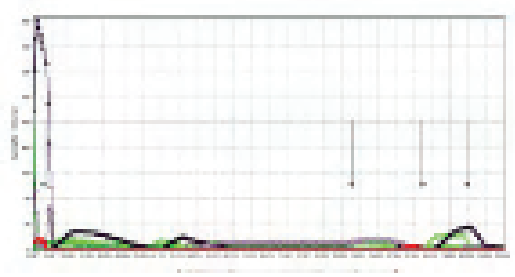

Fig. 5 - Simulation of biological control of *Niptus hololeucus* by releases of *Lariophagus distinguendus* with SITOPHEX. Arrows indicate 4 releases of 400 *L. distinguendus* each, black triangles = young *N. hololeucus larvae*, white triangles = old *N. hololeucus* larvae, other stages below 20 individuals.

Biological control of spider beetles (Anobiidae, Ptininae)

Spider beetles are mainly scavengers feeding equally on plant or animal materials. Beside their natural habitats, a number of species infest historic houses feeding on organic insulation materials and become a nuisance in residences (Howe, 1959). Moreover, spider beetles were found to infest historic books and herbaria (Gamalie, 2006). A number of spider beetle species were found to be suitable hosts for *L. distinguendus,* such as *Ptinus fur* L., 1758 (Herold, 1933; Hüsing, 1935), *Ptinus tectus* Boieldieu, 1856 (Kaschef, 1955), *Gibbium psylloides* (Czenpinski, 1778) (Kaschef, 1961) and *Niptus hololeucus* (Faldermann, 1835) (Schöller, unpubl.). Spider beetles are difficult to control in houses because the larvae develop hidden within walls and in dead floors, and no monitoring devices are available. In recent years, *L. distinguendus* was released against the hump beetle *G. psylloides* and the golden spider beetle *N. hololeucus* in Germany by pest control companies and became a regularly applied control technique (Kassel, 2008). However, due to the lack of appropriate monitoring techniques, the optimal timing of the parasitoid releases has still to be determined. In this case, modelling the pest and parasitoid's population dynamics might be useful. As a first step, we used the modelling software "SITOPHEX" (Rossberg *et al*., 2004) originally programmed for the system *Sitophilus granarius – Lariophagus distinguendus*. We replaced biological data of the granary weevil *S. granarius* (L., 1758) by those of the golden spider beetle *N. hololeucus*. One of the major differences in biology of the granary weevil compared to the golden spider beetle is the low reproduction of the latter at temperatures higher than 25°C (Tab. 1). The temperature and relative humidity conditions used in the model are given in Tab. 2.

Fig. 3 shows a simulation of the current release strategy by pest control companies, i.e. monthly releases when temperature conditions are favourable. The susceptible old larval stages and the pupae are controlled within one month and the population is suppressed in a way that few or no adults enter the living rooms. If the number of releases is reduced to four, one in beginning of July, September, March and May, respectively, an increase in young larvae is predicted in June (Fig. 4). However, if the timing of the four releases is changed to beginning of July, March, May and June, this increase in young larvae can be suppressed (Fig. 5). This effect can be explained by the poor development of *N. hololeucus* during high temperatures in September, indicating the importance of population suppression early in spring in temperate climates. Even though these models cannot be validated at present due to the lack of monitoring devices, simulation models are thought to give some decision-support for parasitoid releases.

Monitoring of parasitoids of *Anobium punctatum*

The study of natural enemies of cultural heritage pests might be useful not only for biological control, but also for monitoring. Early detection of material destroying pests is essential to prevent damage, especially when irreplaceable objects of cultural heritage are concerned. However, monitoring of these pest species is often difficult. For example, pheromone traps for detection of *Anobium punctatum* (DeGeer, 1774) resulted in very poor trap catches in field trials in Germany. During the course of study

of natural enemies, it turned out that some natural enemies are more easily detectable and give indirect evidence of the presence of the pest. Paul *et al*. (2007) studied *A. punctatum* and its natural enemies in a church closed for restoration in Erfurt, Germany.

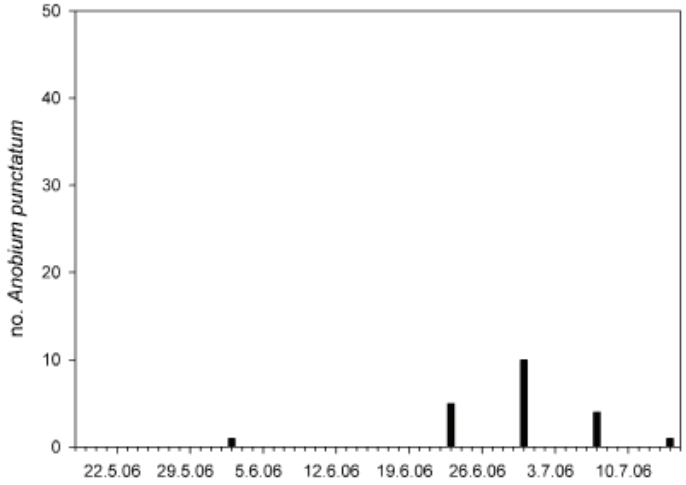

Fig. 6 - Number of *Anobium punctatum* caught in yellow dish traps in a church in Erfurt, Germany. After data in Paul *et al*. (2007).

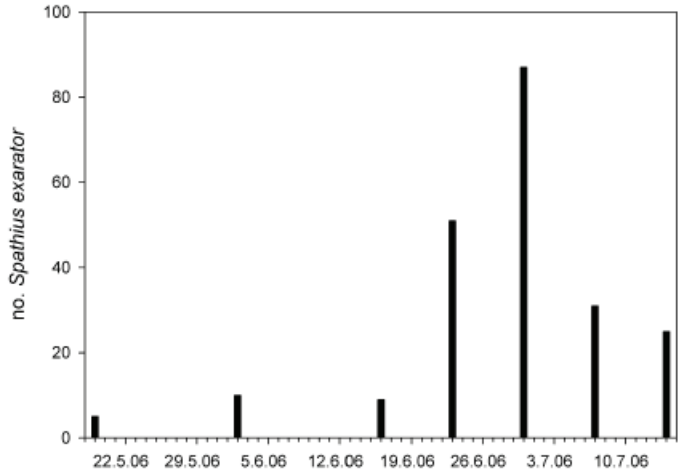

Fig. 7 - Number of *Spathius exarator* caught in yellow dish traps in a church in Erfurt, Germany. After data in Paul *et al*. (2007).

Yellow dish traps, a monitoring technique used in outdoor ecological field studies was used here in the context of protection of museum artefacts and wood. Yellow dishes are filled with water and a bit of detergents in order to attract flower-visiting insects. These traps are especially attractive for parasitoids that do no host-feeding and rely on nectar for adult nutrition. Other arthropods are trapped by chance, the number caught in the trap is affected by the number of insects present and temperature.

Fig. 6 shows the number of *A. punctatum* and Fig. 7 the number of the braconid parasitoid *Spathius exarator* (L., 1758) trapped in yellow dish traps. Few *A. punctatum* were trapped, mostly between mid of June and mid of July. *S. exarator* was trapped throughout the trapping season from mid of May to mid of July in relatively large numbers, the peak coinciding with that of *A. punctatum*. The presence of *A. punctatum* could therefore be proven before adult beetles became active.

Such relationships have to be worked out for each parasitoid-host combination, e.g. the death watch beetle *Xestobium rufovillosum* DeGeer, 1774 was trapped on white sticky traps, but only small numbers of its predator *Korynetes caeruleus* (DeGeer, 1775) and no parasitoids (Belmain *et al*., 1999).

CONCLUSIONS AND OUTLOOK

The speculations about the potential of biological control of cultural heritage pests by Pinniger (2001) did not fulfil 10 years later. Pinniger (2001) reported one of the questions most frequently asked to him as a pest manager in museums, archives and historic houses was ‘can we use biological control for pests in museums?’ and his answer for all practical purposes was ‘no’. This view was based on the widespread assumption that a biological equilibrium is needed as a prerequisite for biological control. The result of a biological control would be again a biological equilibrium including the presence of a low level of pests to ensure the continuity of the system resulting in a failure to meet the requirement for zero tolerance of pests in museum environments. However, the inundative release strategy was developed already in the 1960’s to resolve this problem by the release of large numbers of laboratory-reared natural enemies in order to artificially augmenting the number of parasitoids compared to the hosts, i.e. the pests (DeBach & Hagen, 1964). Each parasitoid female is adapted to increase its own fitness, i.e. to produce as much offspring as possible, and this may lead even to a local extinction of the host in such an artificial system. No pests have to be released in collection areas in order to maintain the equilibrium as suggested by Pinniger (2001) when the inundative control strategy is applied. It was the inundative release strategy that was applied both in stored-product protection and in the commercial applications of biological control in museums so far. The second assumption of Pinniger (2001) was high cost of natural enemies. In the cases of *T. evanescens euproctidis* (3000 wasps cost 2 EUROS) and *L. distinguendus* (40 wasps cost 10 EUROS) this seems not to limit the application, however, this might be an issue for more specialised natural enemies or those that are difficult to mass-rear.

Biological control of cultural heritage pests is in its very beginnings. Several species of natural enemies were recorded to occur spontaneously in houses, but even the host-parasitoid or predator-prey relationships are not clarified yet for all cases (Becker, 1954). Their potential for biological control is far from been exploited. Social insects like termites and ants developed multiple defence strategies possibly limiting biological control efforts in this area. The examples of practical application described here show that both the control strategies and the potential control success heavily depend on the artefacts to be protected and the biology of the pest species, i.e. every application has to be worked out in detail. For example, the population dynamics of *L. distinguendus* with *Niptus hololeucus* as host will not apply for *Gibbium psylloides* as host. In many field studies parasitoids have been shown to be effective at low pest numbers, and typically heavy infestations cannot be controlled by natural enemies.

Biological control of stored product pests is nowadays widely known by farmers and industry and is applied by pest control companies in Central Europe against moths and beetles. Those parasitoids that attack both stored-product and cultural heritage pests will be commercially available for future field trials. The development of a commercial application of other species of natural enemies migth require 5 to 10 years, consequently a lot of work remains to be done for the commerzialisation of natural enemies of cultural heritage pests.

REFERENCES

Belmain S.R., Simmonds M.S.J., Blaney W.M., 1999 - Death watch beetle, *Xestobium rufovillosum*, in historical buildings: monitoring the pest and its predators. Entomologia experimentalis et applicata, 93: 97-104.

DeBach P., Hagen K.S., 1964 - Manipulation of entomophagous species. In: DeBach P., Biological Control of Insect Pests and Weeds. Chapman and Hall, London: 429-455.

Becker G., 1954 - Räuber und Parasiten holzzerstörender Insekten in Gebäuden. Verhandlungen der Deutschen Gesellschaft für angewandte Entomologie, 1954: 76-86.

Franz J.M., Krieg A., 1982 - Biologische Schädlingsbekämpfung. Parey, Berlin, 3. Auflage, 252 pp.

Gamalie G., 2006 - Old books damaging ptinids (Insecta, Coleoptera, Ptinidae) in Romania. Analele Stiintifice ale Universitatii "Al. I. Cuza" din Iasi Sectiunea Biologie Animala, 52: 137-146.

Howe R.W., Burges H.D., 1952 - Studies on beetles of the family Ptinidae. VII. The biology of five Ptinid species found in stored products. Bulletin of entomological research, 48 (1): 153-186.

Howe R.W., 1953 - Studies on beetles of the family Ptinidae. VIII. The intrinsic rate of increase of some Ptinid beetles. Annals of applied biology, 40 (1): 121-133.

Paul F., Prozell S., Schöller M., 2008 - Monitoring natürlicher Feinde des Gemeinen Nagekäfers *Anobium punctatum* (DeGeer, 1774) (Coleoptera: Anobiidae). Mitteilungen der Deutschen Gesellschaft für Allgemeine und Angewandte Entomologie, 16: 323-326.

Herold W., 1933 - Über einige Wohnungsschädlinge (*Glyciphagus, Lathridius*, *Ptinus*, *Tenebrio*, und *Lariophagus*). Mitteilungen der Gesellschaft für Vorratsschutz, 9: 51-56.

Hüsing J., 1935 - Über einen Parasiten, *Lariophagus distinguendus* Först. (Hym., Chalc.), an *Ptinus fur* L. (Col., Ptin.). Zoologischer Anzeiger, 110: 324-326.

Kassel A., 2008 - Im Würgegriff. Biologische Schädlingsbekämpfung bei Messingkäfer- und Kugelkäfer-Befall. B+B Bauen im Bestand, 31: 42-43.

Kaschef A.H., 1955 - Étude biologique du *Stegobium paniceum* L. (Col. Anobiidae) et de son parasite *Lariophagus distinguendus* Först. (Hym. Pteromalidae). Annales de la Societé Entomologique de France, 124: 1-88.

Kaschef A.H., 1961 - *Gibbium psylloides* Czemp. (Col., Ptinidae) new host of *Lariophagus distinguendus* Först. (Hym., Pteromalidae). Zeitschrift für Parasitenkunde, 21: 65-70.

Pinniger D., 2001 - Pest management in museums, archives and historic houses. Archetype publications, London: 115 pp.

Plarre R., Lieber K., Burkholder W., Phillips J., 1999 - Host and host instar preference of *Apanteles carpatus* (Say) (Hymenoptera: Braconidae) a possible parasitoid for biological control of clothes moths (Lepidoptera: Tineidae). Journal of Stored Products Research, 35: 197-213.

Plarre R., Lieber K., Burkholder W., 2000 - Host instar preference of *Apanteles carpatus* (Say) (Hymenoptera: Braconidae) a parasitoid of *Tineola bisselliella* (Hummel) (Lepidoptera: Tineidae). Mitteilungen der Deutschen Gesellschaft für Allgemeine und Angewandte Entomologie, 12: 499-504.

Rossberg D., Prozell S., Steidle J.L.M., Schöller M., Neukampf R., 2004 - Modeling software Sitophex / Kornkäfer. Julius Kühn-Institut, Berlin, Germany.

Schöller M., 1998 - Biologische Bekämpfung vorratsschädlicher Arthropoden mit Räubern und Parasitoiden. Sammelbericht und Bibliographie. In: Reichmuth Ch., 100 Jahre Pflanzenschutzforschung. Wichtige Arbeitsschwerpunkte im Vorratsschutz. Mitteilungen aus der Biologischen Bundesanstalt für Land- und Forstwirtschaft, Parey, Berlin, Heft 342: 85-189.

Schöller M., Flinn P.W., Grieshop M.J., Zdarkova E., 2006 - Biological control of stored product pests. In: Heaps J.W., Insect management for food storage and processing. Second edition. AACC International, St. Paul, Minnesota: 67-87.

Schöller M., 2010 - Biological control of stored-product insects in commodities, food processing facilities and museums. Julius-Kühn-Archiv, 425: 599-609.

Wajnberg E., Hassan S.A., 1994 - Biological control with egg parasitoids. Wallingford, UK: CAB International on behalf of the International Organization for Biological Control of Noxious Animals and Plants: xiv + 286 pp.

Wilamowski A., Kessler I., Rabin I., Prozell S., Navarro S., 2008 - Biological control of *Anobium punctatum* in infested books, using the parasitoid *Lariophagus distinguendus.* Ninth International Conference on NDT of Art, Jerusalem Israel, 25-30 May 2008, http://www.ndt.net/article/art2008/papers/232Wilamowski.pdf

Wudtke A., 2002 - Möglichkeiten des Methodentransfers vom Vorratsschutz zum Materialschutz. Bekämpfung von Museumsschädlingen am Beispiel der Kleidermotte *Tineola bisselliella* (Hum. 1823), Lepidoptera: Tineidae - Mensch und Buch Verlag, Berlin, at the same time Dissertation Humboldt-Universität zu Berlin: 130 pp.

Wührer B., 1994 - Auswahl wirksamer *Trichogramma*-Stämme zur Bekämpfung von Schadlepidopteren im tropischen Gemüsebau. Dissertation, University Darmstadt: 156 pp.

Zacher F., 1933 - Haltung und Züchtung von Vorratsschädlingen. Handbuch der biologischen Arbeitsmethoden. Parey Verlag, Hamburg: 92 pp.

Zimmermann O., Schöller M., Prozell S., 2003 - The use of *Apanteles carpatus* (Hym.: Braconidae) and *Trichogramma* spp. (Hym.: Trichogrammatidae) for biological control of tineid moths (Lepidoptera). In: Credland P.F., Armitage D.M., Bell C.H., Cogan P.M., Highley E., Advances in Stored Product Protection. Proceedings of the 8th International Working Conference on Stored Product Protection, 22-26 July 2002 York, United Kingdom: 319-321.

Zimmermann O., 2005 - Untersuchungen zur biologischen Bekämpfung der Kleidermotte *Tineola bisselliella* (Hummel 1823) und anderer tineider Textilschädlinge (Lepidoptera: Tineidae) mit parasitoiden Hymenopteren. Dissertation Johannes-Gutenberg-Universität zu Mainz: 202 pp.

Matthias Schöller, Sabine Prozell, Biologische Beratung Ltd., Storkower Str. 55, 10409 Berlin, Germany.
E-mail: bip@biologische-beratung.de