Data Sheets on Quarantine Pests

Trogoderma granarium

IDENTITY

Name: *Trogoderma granarium* Everts
Synonyms: *Trogoderma affrum* Priesner
Taxonomic position: Insecta: Coleoptera: Dermestidae
Common names: Khapra beetle (English)
Trogoderme (dermeste) du grain (French)
Khaprakäfer (German)
Escarabajo khapra (Spanish)
Bayer computer code: TROGGA
EPPO A2 list: No. 121

HOSTS

T. granarium is a general storage pest which occurs mainly on cereals and cereal products, oilseeds (especially groundnuts and oilcakes), pulses and pulse products, as well as on compound animal feeding stuffs. The occurrence on other products, as on empty sacks and gums, etc., is probably accidental by cross infestation.

GEOGRAPHICAL DISTRIBUTION

It is very important to distinguish between records which relate to introductions and those of established infestations. *T. granarium* is established within an area broadly limited north by the 35° parallel, south by the Equator, west by West Africa and east by Myanmar; i.e. the warm dry regions along the Suez route from the Indian subcontinent to Europe. *T. granarium* has been introduced into areas of similar climatic conditions elsewhere, especially the alternative route between India and Europe around Africa. Initially, these introductions caused severe damage but outbreaks have been local and have, in most cases, been eradicated. In general, *T. granarium* is only successful in competition with other major stored product pests in conditions of low humidity.

T. granarium has also established in some areas of unfavourable climate, in protected environments only, for example in Western Europe and Japan.

EPPO region: Established in Algeria, Austria, Cyprus, Egypt, Germany (found in the past in protected environments, but not established), Israel, Lebanon, Libya, Morocco, Spain, Switzerland, Syria, Tunisia, Turkey (south-eastern), UK (protected environments only). Found in the past but not established in Belgium, Denmark, Ireland, Luxembourg, Netherlands, Russia. Intercepted only in Hungary and Italy.

Asia: Afghanistan, Bangladesh, India, Indonesia (found but not established), Iran, Iraq, Israel, Japan (restricted distribution), Korea Republic, Lebanon, Myanmar, Pakistan, Saudi Arabia, Sri Lanka, Syria, Taiwan, Turkey, Yemen.

Africa: Algeria, Burkina Faso, Egypt, Kenya (found but not established), Libya, Mali, Mauritania, Morocco, Niger, Nigeria (mainly in north), Senegal, Sierra Leone (intercepted

only), Somalia, South Africa (found but not established), Sudan, Tanzania (found but not established), Tunisia, Zambia, Zimbabwe.
North America: Mexico (found in the past but not established), USA (found in the past but eradicated in Arizona, California, New Mexico, Texas).
South America: Venezuela.
Oceania: Intercepted only in Australia (Beal, 1956; Bailey, 1958) and New Zealand.
EU: Present.

For more information, see Howe & Lindgren (1957), Howe (1958; 1963), Faber (1971), Aitken (1975), Banks (1977), Viljoen (1990).

BIOLOGY

The adults are short-lived, mated females living 4-7 days, unmated females 20-30 days and males 7-12 days; they do not fly and feed very little, if at all. Mating occurs about 5 days after emergence. The beetle can lay a full complement of eggs following a single mating, but a second mating greatly increases the total number of eggs produced: once-mated females laid 66 eggs, whereas twice-mated individuals laid about 58 and then 509 eggs after the respective matings. Delay in mating of 15-20 days results in up to 25% reduction in fecundity. The preoviposition period, which is not affected by humidity, is negligible at 40°C, 1 day at 35°C, 2 days at 30°C, 2-3 days at 25°C, and, at 20°C, no eggs are produced. Under optimum conditions, the female lays an average of about 50-90 eggs loosely in the host material. The eggs hatch in 3-14 days.

Complete development takes place within the range 21 to over 40°C. The life cycle from egg to adult takes an average of 220 days at 21°C, 39-45 days at 30°C and 75% RH and 26 days at 35°C, the optimum. Development can take place at a relative humidity as low as 2%, at which the life cycle is prolonged.

The rate of increase of populations at 33-37°C is about 12.5 times per month: this compares with 20 times at 32-35°C (minimum RH 30%) for *Rhyzopertha dominica* and 25 times at 27-31°C (minimum RH 50%) for *Sitophilus oryzae*, the principal competitors of *T. granarium* as pests of whole grain.

In the zone where *T. granarium* is indigenous, where mean temperatures are consistently above 25°C, the larvae develop rapidly into the pupal stage, e.g. in 15 days at 35°C. If the temperature falls below 25°C for any period of time and, sometimes, if the larvae are very crowded, they may enter diapause and development ceases. The larvae are cold-hardy, surviving temperatures below -8°C. Diapause often occurs at constant temperature, below 30°C. In diapause, the larva can moult but is relatively inactive and rarely feeds. It tends to seek out crevices in the fabric of buildings. A larva can remain in this state for several years, but the provision of a new consignment of food, especially in warm conditions, may stimulate renewed development and pupation.

Young larvae are unable to feed on whole grains and depend on damaged grains or grain products for food (they readily attack softer foods such as nuts). Such damaged grains are always present in practice in lots of stored grain. Older larvae can feed on whole grains. The amount and condition of the food present affects the speed of development, but larvae can survive long periods (at least 13 months) without food. These starving larvae pupate within a week on the return of favourable conditions such as high temperature and availability of food. Starvation of dormant larvae for 3 months, followed by a brief period of feeding, results in the production of 41% of the normal number of eggs. However, this percentage is ample for the survival of the pest. One to 3 months of starvation does not affect the pupation rate of dormant larvae.

For more information, see Hinton (1945), Howe (1952), Hadaway (1956), Burges (1959; 1963), Faber (1971), Karnavar (1972), Nair & Desai (1972).

DETECTION AND IDENTIFICATION

Morphology

Eggs

Initially milky-white, later pale-yellowish; typically cylindrical, 0.7 mm long and 0.25 mm broad; one end rounded, the other more pointed and bearing a number of spine-like projections, broader at the base and tapering distally.

Larva

Total length of the first-instar larva is 1.6-1.8 mm, a little more than half of which consists of a long tail, made up of a number of hairs borne on the last abdominal segment. Body width is 0.25-0.3 mm, and colour uniformly yellowish-white, except for the head and body hairs which are brown. The head bears a short antenna of three segments. A characteristic feature of the larva is the presence of two kinds of body hairs: simple hairs, in which the shaft bears many small, stiff, upwardly directed processes; and barbed hairs, in which the shaft is constricted at regular intervals, and in which the apex consists of a barbed head. This head is as long as the combined lengths of four of the preceding segments. Simple hairs are scattered over the dorsal surface of the head and body segments. The tail consists of two groups of long simple hairs, borne on the 9th abdominal segment. Barbed hairs are found in pairs of tufts, borne on certain abdominal tergites. As the larva increases in size, the colour changes progressively from the pale yellowish-white of the first-instar larva to a golden or reddish-brown. The density of the body hairs increases but these hairsand the tail become much shorter in proportion to the length and breadth of the larval body, and in the 4th instar the hairs give the appearance of four dark transverse bands. The mature larva is approximately 6 mm in length and 1.5 mm in breadth. A conspicuous feature of a khapra beetle infestation is masses of these hairy larvae and their cast skins.

Morphologically, the mature larva of *T. granarium* can be separated from that of *T. versicolor* by the absence of a dark pretergal line on the 7th and 8th abdominal segments, such a line being faint or absent on the 7th segment and never present on the 8th segment in *T. granarium*.

Pupa

At the last ecdysis, the larval skin splits, but the pupa remains within this skin for the whole of its life. The pupa is of the exarate type; male smaller than female, average lengths being 3.5 mm and 5 mm, respectively.

Adult

Oblong-oval beetle; about 1.6-3.0 mm long by 0.9-1.7 mm wide; males brown to black, with indistinct reddish-brown markings on the wing covers; females are slightly larger than males, and lighter in colour; antennae are 11-segmented; head is small and usually deflexed.

Several other species also occur in grain and other stored products, sometimes in large numbers, and they may be confused with *T. granarium*. It is important that any field identification should be checked in the laboratory. For more information, see Hinton (1945), Beal (1956; 1960), Faber (1971).

Detection and inspection methods

The most likely stage to be seen during inspection is the larva and the most usual evidence is cast larval skins. Special attention should be given to any produce from the areas where the pest is indigenous, especially oilseeds and oilseed products, pulses, cereals and gums, as well as used and new sacks and hessian from these areas. Examine malt from temperate areas carefully. In warehouses which are suspect, examine cracks and crevices and look behind any panelling against walls. In ships, look also under rust scale, under timber coverings of tanks, on ledges, etc. In dry cargo containers, look between floor boards and

behind linings. Larvae are most likely to be seen during the hour before dusk since they tend to be more active at such periods.

Trapping is another way to monitor the presence of *T. granarium* in warehouses and other storage facilities. In Russia, traps with maize or wheat have been used (Saplina, 1984) and gave better records than visual observations. A trap has been recently developed for USDA/PPQ which combines a feeding attractant for larvae and a pheromone for adult males (Barak, 1989).

MEANS OF MOVEMENT AND DISPERSAL

The natural spread of this pest can be considered as limited. International spread is mainly by larvae in commodities, empty sacks and in the structure of ships and dry cargo containers.

According to information from the UK where, for many years, extensive monitoring of imports for infestation has taken place, most interceptions of *T. granarium* during the five years 1970-1975 were in produce from India, Myanmar, Nigeria, Senegal and Sudan. By far the most commonly infested commodity was groundnut expeller oilcake, followed by cottonseed oilcake, gum arabic and gum verek, rice bran and rice, pulses and senna pods. Second-hand bags are also a means of spread.

PEST SIGNIFICANCE

Economic impact

The khapra beetle is principally a serious pest of stored products under hot dry conditions; complete destruction of grain and pulses may take place in a short time. In humid climates, the rates of increase of its competitors are so much greater that it has difficulty in establishing itself. However, in such areas, it lives at the inner edge of the expanding hot zone of stacks or bulks, in which heating has been induced by the activity of other species. In the EPPO region in the 1970s, *T. granarium* was rated as of considerable economic importance in Cyprus, Tunisia and Turkey.

Howe & Lindgren (1957) and Howe (1958; 1963) reported what would now be called PRAs (pest risk analyses) of the potential of *T. granarium* in North America.

Control

The larva of *T. granarium* is somewhat more resistant to fumigants than most stored product beetles. However, methyl bromide fumigation gives good control for a wide range of commodities. Effective control in the structure of buildings and ships requires high concentrations maintained over the fumigation period to enable the gas to penetrate into cracks and crevices. A list of dosage schedules may be found in EPPO quarantine procedure No. 12 (OEPP/EPPO, 1982). Various investigations on the effectiveness of methyl bromide fumigation have been reported by Bogs (1976), Wohlgemuth *et al.* (1976), El-Lakwah (1977a; 1977b), Bell *et al.* (1985). Phosphine can also be used against *T. granarium*; dosage schedules are given by OEPP/EPPO (1984).

In India, the use of deoiled neem (*Azadirachta indica*) seed powder mixed into wheat seemed to be an effective and cheap method to control the pest in stored wheat (Singh & Kataria, 1986). The use of carbon dioxide was also reported to be effective in India (Srivastava, 1985). However, Swedish scientists reported the CO_2 treatment (in concentrations up to 60% C CO_2 content) as insufficient to control *T. granarium* (Morner *et al.*, 1987). As an alternative to the fumigation of cereals with methyl bromide or other pesticides, the use of a heat treatment has been reported to be very effective against the khapra beetle (Fleurat-Lessard, 1985). An exposure to 60°C for 30 min resulted in 100% mortality of all stages of *T. granarium* (Ismail *et al.*, 1988).

Phytosanitary risk

T. granarium is an A2 quarantine organism for EPPO (OEPP/EPPO, 1981), and is also of quarantine concern for CPPC, COSAVE, JUNAC, NAPPO and OIRSA. The continued occurrence of *T. granarium* on produce imported from countries where it is indigenous, and the potential for spread due to increasing use of dry cargo containers and roll-on roll-off road transport, make it a continued threat to EPPO countries. This not only applies to the risk of establishment in heated buildings in areas of unfavourable climate, but also to parts of Greece, Italy, Spain and Russia on the fringes of the natural range, where it is not known to be established. A minimum period of 4 months with an average temperature of 20°C is considered necessary for *T. granarium* to be a pest. Although EPPO does not in general consider pests of stored products to be quarantine pests, because of the ease with which they are spread around the world and their ability to survive in protected storage environments, an exception is made in the case of *T. granarium*. In addition, it should be recalled that other continents take severe measures against *T. granarium*; the presence of the pest in an EPPO country would be a significant additional constraint to its exports.

PHYTOSANITARY MEASURES

EPPO recommends (OEPP/EPPO, 1990) that it is preferable not to require a phytosanitary certificate for stored products, but rather to inspect consignments on import and take appropriate post-entry action, for example treatment following EPPO Quarantine Procedures Nos 12 or 18 (OEPP/EPPO, 1982; 1984).

BIBLIOGRAPHY

Aitken, A.D. (1975) Insect travellers. 1. Coleoptera. *Ministry of Agriculture, Fisheries and Food, Technichal Bulletin* **31**, 82-86.

Bailey, S.W. (1958) The position of khapra beetle in Australia. *FAO Plant Protection Bulletin* **6**, 1-2.

Banks, H.J. (1977) Distribution and establishment of *Trogoderma granarium* Everts (Coleoptera: Dermestidae): climatic and ohter influences. *Journal of Stored Products Research* **13**, 183-202.

Barak, A.V. (1989) Development of a new trap to detect and monitor khapra beetle (Coleoptera: Dermestidae). *Journal of Economic Entomology* **82**, 1470-1477.

Beal, R.S. (1956) Synopsis of the economic species of *Trogoderma* occurring in the United States with description of a new species (Coleoptera, Dermestidae). *Annals of the Entomological Society of America* **49**, 559-566.

Beal, R.S. (1960) Descriptions, biology and notes on the identification of some *Trogoderma* larvae (Coleoptera: Dermestidae). *Technical Bulletin, United States Department of Agriculture* No. 1228, 26 pp.

Bell, C.H.; Hole, B.D.; Wilson, S.M. (1985) Fumigant doses for the control of *Trogoderma granarium*. *Bulletin OEPP/EPPO Bulletin* **15**, 9-14.

Bogs, D. (1976) [Effectiveness of methyl bromide against storage pests at low temperatures]. *Nachrichtenblatt für den Pflanzenschutz in der DDR* **30**, 221-222.

Burges, H.D. (1959) Studies on the dermestid beetle, *Trogoderma granarium*. III. Ecology in malt stores. *Annals of Applied Biology* **47**, 445-462.

Burges, H.D. (1963) Studies on the dermestid beetle, *Trogoderma granarium*. VI. Factors inducing diapause. *Bulletin of Entomological Research* **54**, 571-587.

El-Lakwah, F. (1977a) [Studies on the action of methyl bromide against *Trogoderma granarium* larvae especially at low temperatures]. *Anzeiger für Schädlingskunde, Pflanzenschutz* **50**, 68-73.

El-Lakwah, F. (1977b) [Effect of relative humidity on the action of methyl bromide against *Trogoderma granarium* larvae]. *Anzeiger für Schädlingskunde, Pflanzenschutz* **50**, 81-83.

Faber, W. (1971) [Khapra beetle, a dangerous citizen of the world]. *Pflanzenarzt* **24**, 65-68.

Fleurat-Lessard, F. (1985) Les traitements thermiques de désinfestation des céréales et des produits céréaliers: possibilité d'utilisation pratique et domaine d'application. *Bulletin OEPP/EPPO* **15**, 109-118.

Hadaway, A.B. (1956) The biology of the dermestid beetles, *Trogoderma granarium* and *T. versicolor*. *Bulletin of Entomological Research* **46**, 781-796.

Hinton, H.E. (1945) *A monograph of the beetles associated with stored products*. Vol. 1. British Museum (Natural History), London, UK.

Howe, R.W. (1952) Entomological problems of food storage in northern Nigeria. *Bulletin of Entomological Research* **43**, 111-144.

Howe, R.W. (1958) A theoretical evaluation of the potential range and importance of *Trogoderma granarium* Everts in North America. *Proceedings of the 10th International Congress of Entomology, Montreal, 1956* **4**, 23-28.

Howe, R.W. (1963) The prediction of the status of a pest by means of laboratory experiments. *World Review of Pest Control* **2**, 30-40.

Howe, R.W.; Lindgren, D.L. (1957) How much can the khapra beetle spread in the USA? *Journal of Economic Entomology* **50**, 374-375.

Ismail, A.Y.; Abid, S.H.; Mawlood, N.A. (1988) Effect of high temperature on the mortality of the red flour beetle *Tribolium confusum* and khapra beetle *Trogoderma granarium*. *Zanco* **1**, 35-42.

Karnavar, G.K. (1972) Mating behaviour and fecundity in *Trogoderma granarium* (Coleoptera: Dermestidae). *Journal of Stored Product Research* **8**, 65-69.

Morner, J.; Hyvonen, A.; Simonsson, M. (1987) Experiments with carbon dioxide against stored product pests. *Vaxtskyddsnotiser* **51**, 87-92.

Nair, K.S.S.; Desai, A.K. (1972) Some new findings on factors inducing diapause in *Trogoderma granarium* Everts (Coleoptera: Dermestidae). *Journal of Stored Product Research* **8**, 27-54.

OEPP/EPPO (1981) Data sheets on quarantine organisms No. 121, *Trogoderma granarium*. *Bulletin OEPP/EPPO Bulletin* **11** (1).

OEPP/EPPO (1982) Quarantine procedures No. 12. Methyl bromide fumigation of stored products. *Bulletin OEPP/EPPO Bulletin* **12**, Special Issue (EPPO recommendations on fumigation standards), 30-31.

OEPP/EPPO (1984) Quarantine procedures No. 18. Phosphine fumigation of stored products. *Bulletin OEPP/EPPO Bulletin* **14**, 598-599.

OEPP/EPPO (1990) Specific quarantine requirements. *EPPO Technical Documents* No. 1008.

Saplina, G.S. (1984) [Inspection of storage premises using traps]. *Zashchita Rastenii* No. 9, p. 38.

Singh, R.P.; Kataria, P.K. (1986) Deoiled neem kernel powder as protectant of wheat seeds against *Trogoderma granarium* Everts. *Indian Journal of Entomology* **48**, 119-120.

Srivastava, J.L. (1985) Use of controlled atmosphere for the control of stored product insects. In: *Behavioural and physiological approaches in pest management* (Ed. by Regupathy, A.; Jayaraj, S.), pp. 202-207. Coimbatore, Tamil Nadu, India.

Viljoen, J.H. (1990) The occurrence of *Trogoderma* (Coleoptera: Dermestidae) and related species in southern Africa with special reference to *T. granarium* and its potential to become established. *Journal of Stored Products Research* **26**, 43-51.

Wohlgemuth, R.; Drosihin, J.; El-Lakwah, F. (1976) [Investigations on the fumigation in quarantine of bulk-laden oilcake in barges against the khapra beetle]. *Mitteilungen der Biologischen Bundesanstalt für Land- und Forstwirtschaft, Berlin-Dahlem* No. 173, 29 pp.