MANUAL ON THE PREVENTION OF POST-HARVEST GRAIN LOSSES

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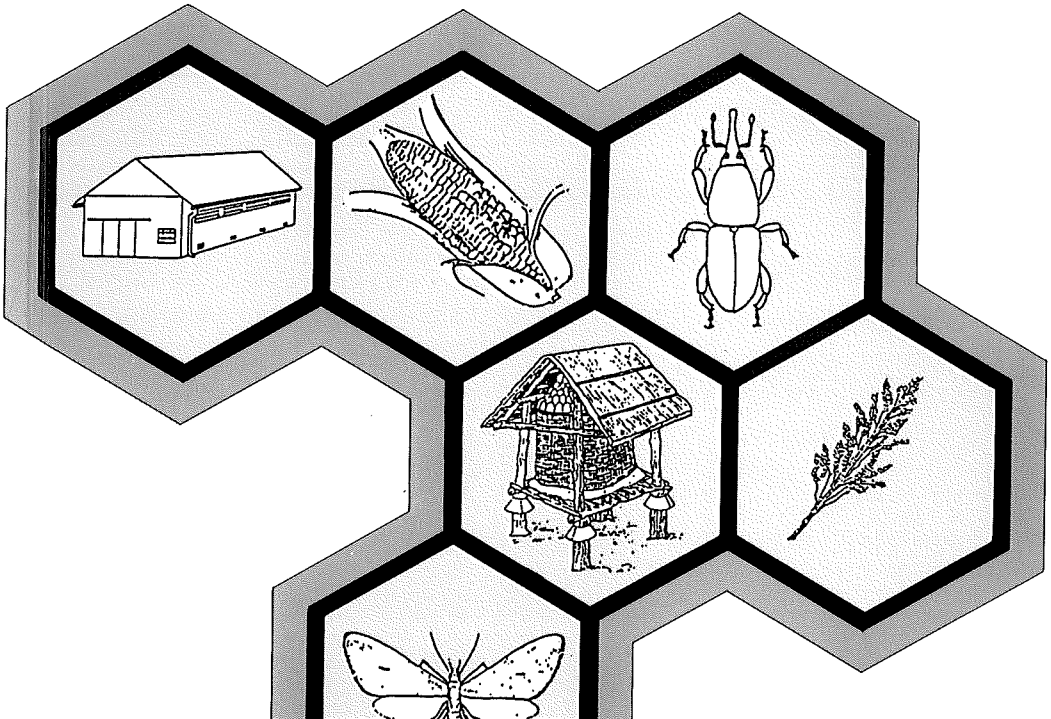

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Multon, J.L. (Ed.) 1982. Conservation et stockage des grains et graines et produits derivés, Paris, volume 1, 576 pp.

Multon, J.L. (Ed.) 1988. Preservation and Storage of Grains, Seeds and their By-Products, Paris, 1095 pp.

7 Important Pests in Storage

The greatest damage to stored produce is generally caused by insects, though this may be exceeded by rodents in some countries.

A high rate of reproduction and a short development period enable them to cause important damage by rapidly developing from a small number of individual insects to a large mass.

The multiplication factor of Tribolium is 70, for example. This means that under optimum conditions one pair of Tribolium will have the following offspring:

after 1 month: 2 x 70 = 140
after 2 months: 140 x 70 = 9,800
after 3 months: 9,800 x 70 = 660,000

7.1 Identification of Pests

Insect species are different from one another in terms of their behaviour, their damage caused and their reaction to control measures. It is essential to identify insects found in the store and to know about their biology in order to be able to answer the following questions:

- Is it a **storage pest**?

  Example:
  Several species of Bruchus are field pests of legumes and may be brought into the store where they cannot develop. In this case, these insects are no storage pests.

- Is it an **important** storage pest?

  Example:
  The Rust-red Flour Beetle (Tribolium castaneum) is for example a very important storage pest of various commodities, especially cereals and cereal products in tropical and subtropical regions, whereas the Depressed Flour Beetle (Palorus subdepressus) generally plays a minor role.

- Is it a insect species which reveals **problems in storage**?

  Example:
  The Black Fungus Beetle (Alphitobius laevigatus) occurs mainly in mouldy stock. If this insect is found, moist storage conditions are most probable.

- What **control measures** should be performed?

  Example:
  Bostrichidae, e.g the Lesser Grain Borer (Rhizopertha dominica) are most effectively controlled by pyrethroids less by organophosphorous compounds.

There are various aids to identifying insects:
- Identification keys, which are not suitable for everyday practical use in stores.
- Illustrations in the form of posters, leaflets, brochures or books.
- Reference collections of storage pests for direct comparison with the ones found.

Every storekeeper should have a hand magnifying glass with eight to twelvefold magnification.

7.2 Classification of Storage Pests

By far the largest group of storage pests are **beetles (Coleoptera)**, followed by **moths (Lepidoptera)**. There are still others including dust lice (**Psocoptera**) which cause little damage to stored produce but may become a hygienic problem if they occur in large numbers.

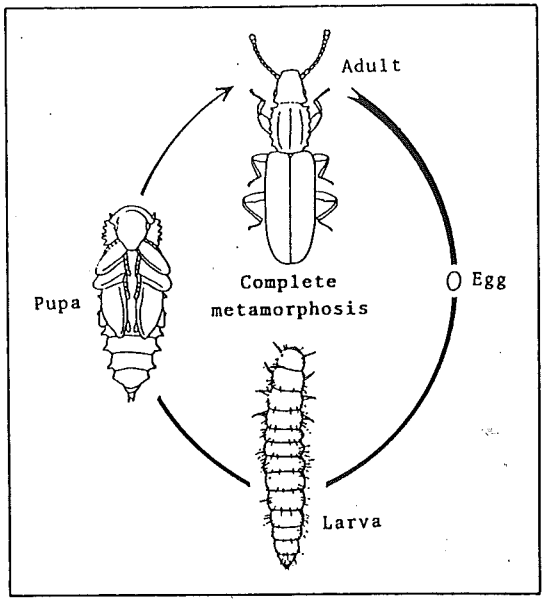
Beside insects mites (**Acarina**) occur as pests in grain and particularly in flour. They belong to the order of **Arachnida**.

7.3 Development of Insects

Beetles and moths pass through several stages of development.

The adult insects lay eggs from which larvae hatch. Larvae cause the most damage as a result of their intensive feeding on the stored produce. Their development passes through a number of growing stages called instars followed by pupation. The adult emerges from the pupa.

This development cycle is referred to as **complete metamorphosis**.



The duration of this cycle varies from species to species and is greatly influenced by external factors (see Section 7.4)

There are often also differences from species to species as to where the eggs are laid (in or on grain), where the larvae develop (inside or outside grain) and where pupation takes place (inside or outside grain).

7.4 The Effect of Changes in Climate on Development

Every species has its optimum temperature and moisture conditions for development (see Section 2.2.5). Individual stages of development of any particular species may also have different preferences.

The **optimum temperatures** lie mainly between 25 and 32°C. At temperatures of below 14°C and above 42°C development generally does not take place. Most storage pests die at temperatures of below 5°C and above 45°C.

The **optimum relative humidity** for most species lies at around 70 %, the minimum being 25 - 40 % and the maximum 80 - 100 %. Very few species are able to survive in etremely dry conditions (Oryzaephilus spp. down to 10 % r.h., Trogoderma granarium and Tribolium spp. down to 3 % r.h.).

Under optimum conditions, the **duration of the development cycle** from egg to adult is around 18 - 25 days for beetles and 28 - 35 days for moths. Under unfavourable conditions, this period may be extended to several months.

Insects are greatly influenced in their activity and fertility by the changes in **light** in the course of a day. Especially moths are most active at dawn and at dusk. Inspections to check for flying insects should therefore be made at these times. This applies also to moth control measures with fogging machines. Artificial light can help to considerably restrict the flying activity and fertility of moths.

7.5 The Use of Various Sources of Food by Pests

Pests have different requirements as to the composition of their food:

- **Primary pests** are able to feed on whole, healthy and well-storable grains.

Examples: weevils, lesser grain borer (Rizopertha dominica), Angoumois grain moth (Sitotroga cerealella)

- **Secondary pests** can only attack broken grain, moist, and thus soft grain, grain damaged by primary pests or processed products, e.g. flour.
  Examples: flour beetles

- **Mould indicating pests** live partially or entirely on fungi and their presence reveals problems with moisture.
  Examples: Black fungus beetle (Alphitobius diaperinus), foreign grain beetle (Ahasverus advena)

- **Scavengers** live largely on dust, the excrement of other insects or dead insects. They do not usually feed on the stored produce itself, but often pose a serious hygienic problem.
  Example: dust lice

- **Predators** live entirely or partially on insects, mostly on larvae (see Section 10.2).
  Example: Wheat beetle (Tenebroides mauritanicus)

  Some storage pests also prey on the larvae of other species. Their use in reducing infestation is, however, far less than the damage they themselves cause by feeding on the stored produce.
  Example: Tribolium castaneum

Whether an insect can make use of stored produce as a source of food depends on a number of factors:

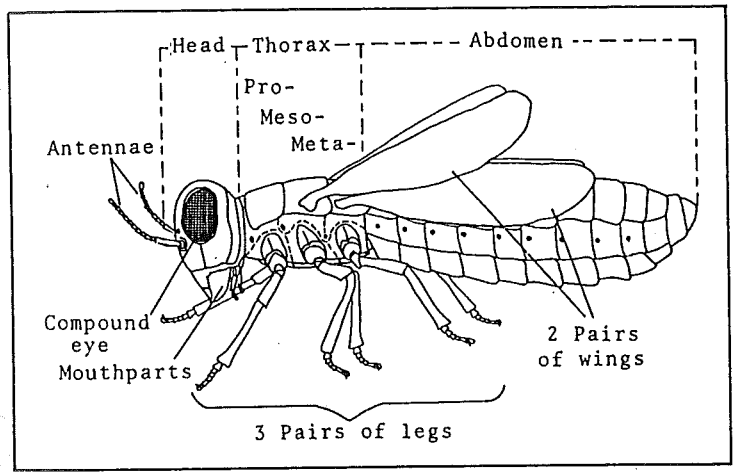
Most storage pests are able to penetrate a stack of bags far more quickly and thoroughly than bulk produce because

of the gaps between the bags. The size, the surface texture and nutrients in the grain influence the ability of the pest to attack the commodity. This applies also for packaging material and the state of the store itself.

7.6 Morphological Features of Insects

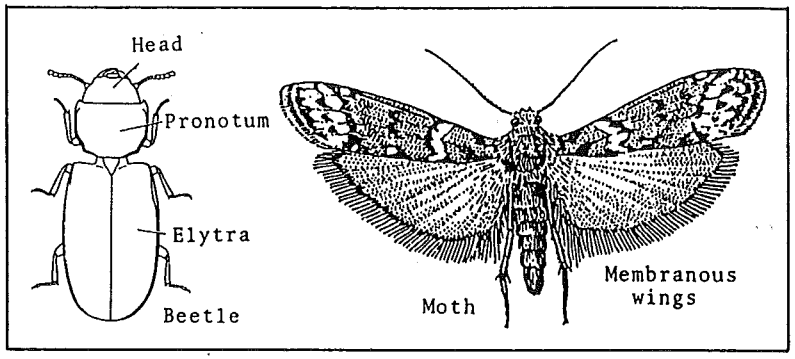
The body of an insect is divided into three parts:

- The **head**, which bears the eyes, the antennae and the mouthparts
- the **thorax**, which consists of three segments (prothorax, mesothorax, metathorax) carries three pairs of legs and the wings or the elytra, respectively
- the **abdomen**, where the reproductive and digestive organs are located

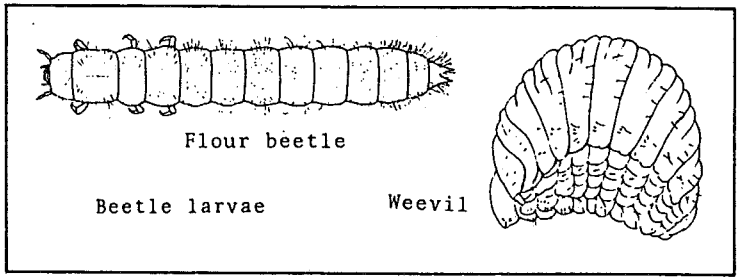


In the case of **beetles**, the forewings (elytra) are thickened and hornlike and protect the abdomen.

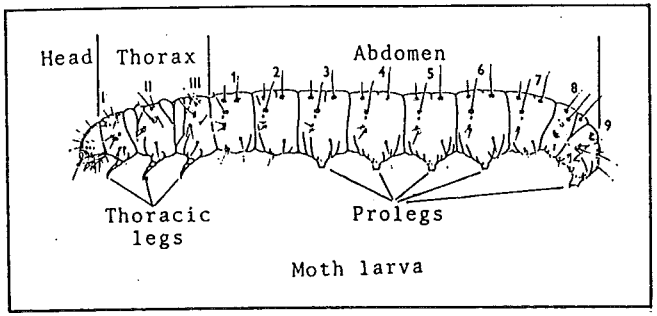
Moths have two pairs of membranous wings densely covered with pigmented scales.



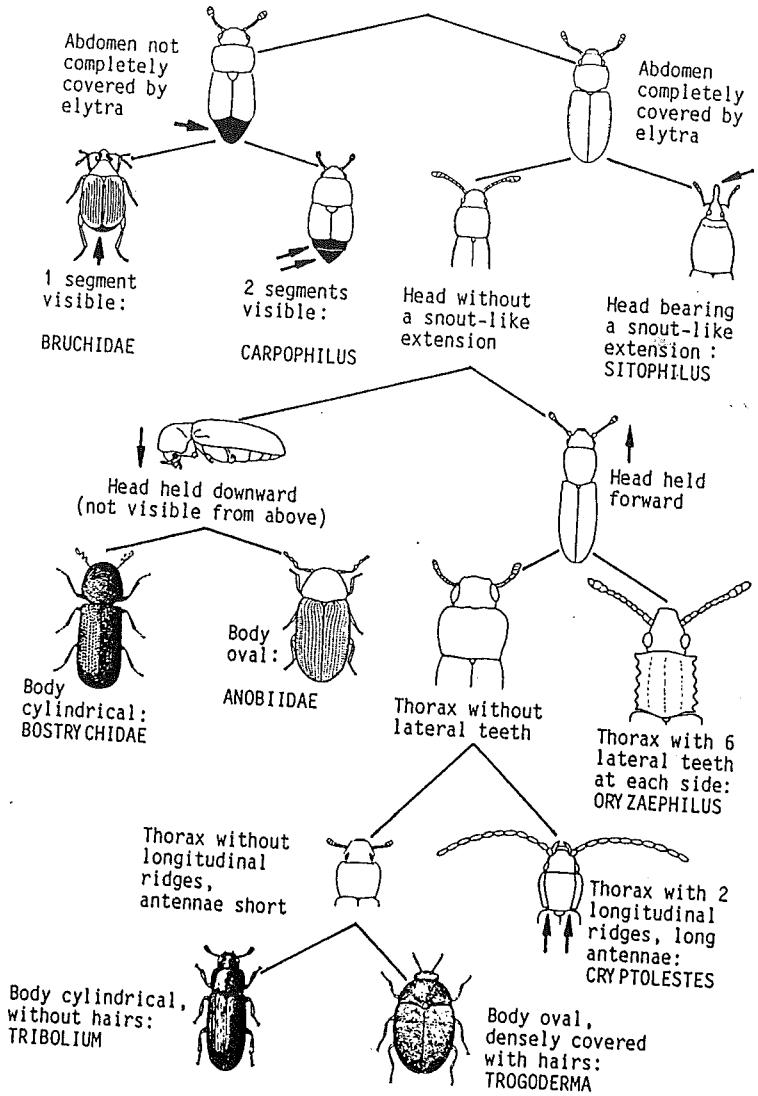
Beetle larvae have three pairs of legs. However, in some species which develop inside the grain (e.g. weevils). they are lacking.



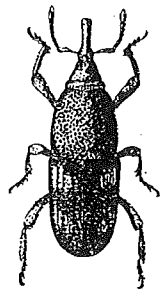
Moth larvae have three pairs of thoracic legs and additionally four pairs of prolegs, located at the 3rd, 4th, 5th and 6th segment of the abdomen. The final segment of the abdomen has a further pair of prolegs.



7.7. Pictorial Key for Identification, Descriptions and Biology of a Number of Important Storage Pests



Sitophilus oryzae



Common name: Rice weevil
Family: Curculionidae

Description

size: 2.5 - 3.5 mm
shape: more or less cylindrical
colour: black-brown with four reddish spots on the elytra
recognition: well defined snout; elbowed and clubbed antennae; circular punctures on the prothorax; can fly

Distribution

Cosmopolitan

Life history

range of temperature: 17 - 34°C
optimal temperature: 28°C
range of rel. humidity: 45 - 100 %
optimal rel. humidity: 70 %
eggs laid: up to 150 separately deposited inside the grain
life cycle: 35 days at optimum
110 days at sub-optimal conditions

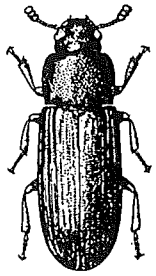
Damage

Adults and legless larvae are primary pests of cereals, rice and dried cassava. Larvae spend their lives inside the grain.

Similar species

S. zeamais (Maize weevil): larger, but almost indistinguishable externally; with similar distribution, biology and behaviour. Good flyer.
S. granarius (Granary weevil): without spots on elytra, punctures on prothorax oval-shaped . A pest of cereals (especially wheat and barley) in temperate regions.

Tribolium castaneum



Common name: Rust red flour beetle
Family: Tenebrionidae

Description

size: 3 - 4 mm
shape: elongate body, more or less parallel sided
colour: red brown - dark brown
recognition: antennae are inserted under the sides of the head (frontal ridge) and form a three-segmented club;
elytra with finely punctured lines

Distribution

throughout the tropics and the subtropics

Life history

range of temperature: 22 - 40°C
optimal temperature: 35°C
range of rel. humidity: 1 - 90 %
optimal rel. humidity: 75 %
eggs laid: up to 500
life cycle: 20 days under optimum conditions

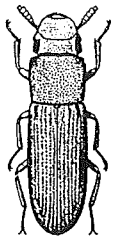
Damage

Larvae and adults are secondary pests and attack cereals and cereal products, groundnuts, nuts, spices, coffee, cocoa, dried fruit and occasionally pulses. Infestation leads to persistent disagreeable odours of the products.

Similar species

T. confusum (segments of antennae gradually broaden towards the tip), cosmopolitan

Latheticus oryzae



Common name: Long headed flour beetle
Family: Tenebrionidae

Description

size: 2.5 - 3 mm
shape: cylindrical; elongate body; more-or-less parallel sided
colour: yellowish brown; bright
recognition: head longer in proportion to body than that of Tribolium;
5-segmented antennal club with smaller terminal segment

Distribution

throughout the tropics

Life history

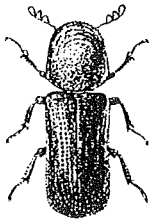
range of temperature: min. 25°C
optimal temperature: 35°C
range of rel. humidity: min. 30 %
optimal rel. humidity: 85 %
life cycle: 22 days at optimum conditions

Damage

Adults and larvae act as secondary pests of cereals, oil seeds and milled products.

Rhizopertha dominica

Common name: Lesser grain borer
Family: Bostrychidae



Description

size: 2 - 3 mm
shape: slim, cylindrical
colour: red-brown to black-brown
recognition: head concealed beneath prothorax (typical for the Bostrychidae); prothorax bears marginal rows of teath; elytra with well defined rows of punctures

Distribution

mainly in tropical and sub-tropical regions

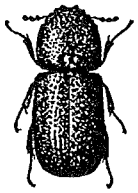
Life history

range of temperature:	18 - 38°C
optimal temperature:	34°C
range of rel. humidity:	25 - 70 %
optimal rel. humidity:	60 - 70 %
eggs laid:	300 - 500
life cycle:	20 - 84 days

Damage

Primary pest of cereal grains, other seeds, cereal products, dried cassava, etc. Damage is done by adults and larvae, which develop within the grain.

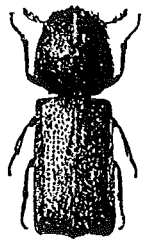
Similar species



Dinoderus spp. bearing two slight depressions at the base of the pronotum. Found on dried cassava and incidentially on other commodities.

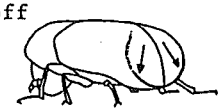
Prostephanus truncatus

Common name: Larger grain borer
Greater grain borer
Family: Bostrychidae



Description

size: 3 - 5 mm
shape: cylindrical
colour: dark brown
recognition: similar to Rhizopertha, but elytra apically flattened, steeply inclined, curved ridges at the sloping part; elytra look like cut off



Distribution

Central America, accidentially introduced to East and West African countries

Life history

range of temperature:	18 - 40°C
optimal temperature:	32°C
range of rel. humidity:	40 - 90 %
optimal rel. humidity:	80 %
eggs laid:	up to 400
life cycle:	27 days at optimum

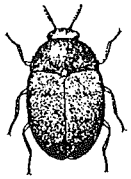
Damage

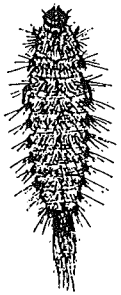
Primary pest

Adults and larvae attack maize as well as dried cassava and yams. Causes severe losses of farm-stored maize in african countries.

Trogoderma granarium

Common name: Khapra beetle
Family: Dermestidae





Description

	adult	larva
size:	2 - 3 mm	5 mm
shape:	oval	spindle-shaped
colour:	dark brown, often with blurred, reddish markings	yellowish brown to golden brown
recognition:	with fine hairs	reddish-brown hairs with two tail-like tufts

Distribution

In hot, dry areas, especially in the near and middle east and Africa.

Life history

range of temperature:	22 - 41°C
optimal temperature:	33 - 37°C
range of rel. humidity:	2 to 50 %
optimal rel. humidity:	25 %
eggs laid:	50 - 80
life cycle:	25 days at 37°C and 25 % r.h. larval diapause up to 4 years

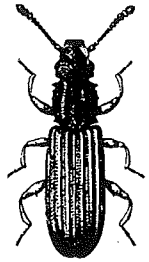
Damage

Primary pest

Damage is done only by larvae on cereal grains and products, oilseed cakes, nuts, pulses, etc.

Oryzaephilus surinamensis

Common name: Saw-toothed grain beetle
Family: Silvanidae



Description:

size:	2.5 - 3.5 mm
shape:	slender
colour:	dark brown
recognition:	six toothlike projections along each side of the prothorax

Distribution

Cosmopolitan

Life history

range of temperature:	18 - 37°C
optimal temperature:	30 - 35°C
range of rel. humidity:	10 - 90 %
optimal rel. humidity:	70 - 90 %
eggs laid:	up to 150
life cycle:	20 - 80 days

Damage

Secondary pest of cereals and cereal products, also on copra, spices, nuts and dried fruit. Damage is done by larvae and adults.

Similar species

O. mercator, in the warmer temperate and tropical regions. Less tolerant to extremes of temperature and humidity than O. surinamensis. More common on oilseeds, also on copra, spices, nuts and dried fruit.

Cryptolestes ferrugineus

Common name: Rust-red grain beetle
Family: Cucujidae

Description

size:	1.5 - 2.5 mm
shape:	tiny, flat and slender, elongate
colour:	reddish brown
recognition:	head and prothorax account for half of the body length; prothorax bearing two longitudinal ridges; antennae without club and half the length up to the length of the body

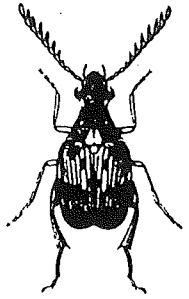
Distribution
Cosmopolitan

Life history

range of temperature:	21 - 43°C
optimal temperature:	33°C
range of rel. humidity:	50 - 90 %
optimal rel. humidity:	70 %
eggs laid:	100 - 400
life cycle:	17 - 100 days at optimum conditions; mean duration of life cycle: 23 days

Damage
Secondary pest on all types of grain and grain products, also on nuts, dried fruit, oilseed cakes, cocoa and cowpeas. Adults and larvae attack stored products and are often causing "hot spots".

Callosobruchus chinensis



Common name: Cowpea weevil
Family: Bruchidae

Description

size:	3 - 4.5 mm
shape:	more or less triangular
colour:	pale brown with blackish patches on the elytra
recognition:	body clothed in short hairs; last abdominal segment visible; antennae slightly serrated; each hind femur bears a tooth; large emarginated eyes

Distribution
Throughout the tropics and subtropics

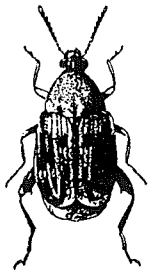
Life history

range of temperature:	18 - 35°C
optimal temperature:	30°C
range of rel. humidity:	25 - 90 %
optimal rel. humidity:	80 %
eggs laid:	up to 100 glued to surface of pod or seed
life cycle:	23 days at optimal conditions

Damage
Larvae, which develop within the seed, feed as primary pests on cowpeas, pigeon peas, lentils and other pulses. Infestation begins in the field.

Similar species
C. maculatus (originated in Africa, now distributed throughout the tropics and subtropics)
Caryedon serratus (Groundnut seed beetle, size 4 - 7mm)

Acanthoscelides obtectus



Common name: Dried bean weevil
Family: Bruchidae

Description

size: 3 - 5 mm
shape: oval
colour: grey and reddish brown with yellowish and dark brown patches of hairs on the elytra
recognition: Hind femur with one large tooth and two small teeth; elytra do not completely cover the abdomen; antennae serrated

Distribution

Cosmopolitan

Life history

range of temperature:	17 - 35°C
optimal temperature:	30°C
range of rel. humidity:	30 - 90 %
optimal rel. humidity:	70 %
eggs laid:	40 - 50 laid on ripening pods or among stored seeds
life cycle:	21 days at optimum conditions

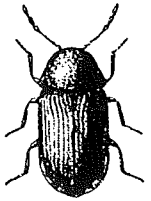
Damage

Larvae are primary pests of common beans. Infestation may begin in the field.

Similar species

There are various other species of Bruchidae attacking pulses, which cannot easily be identified.

Stegobium paniceum



Common name: Drugstore beetle
Family: Anobiidae

Description

size: 1.2 - 4 mm
shape: globular
colour: light-brown - dark brown
recognition: similar to L. serricorne, but last three segments of antennae form a loosely segmented club; elytra striated

Distribution

more or less cosmopolitan

Life history

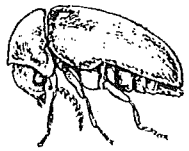
range of temperature:	15 - 34°C
optimal temperature:	30°C
range of rel. humidity:	35 - 100 %
optimal rel. humidity:	60 - 90 %
eggs laid:	up to 75
life cycle:	40 days at optimum conditions at 20°C 90 to over 200 days

Damage

Larvae are primary pests of processed goods like chocolate, confectionary, biscuits and so on. Also on dried herbs and spices.

Lasioderma serricorne

Common name: Cigarette beetle
or Tobacco beetle
Family: Anobiidae



Description

size: 2 - 4 mm
shape: globular
colour: light brown to reddish brown
recognition: large prothorax more or less covering the deflexed head
body covered with fine hairs

Distribution

cosmopolitan; most abundant in the tropics

Life history

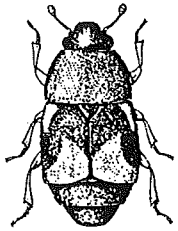
range of temperature:	18 - 37°C
optimal temperature:	30 - 35°C
range of rel. humidity:	25 - 100 %
optimal rel. humidity:	70 %
eggs laid:	20 - 100
life cycle:	about 25 days at optimum conditions
	up to 120 days at 20°C

Damage

Primary pest
Only larvae feed on tobacco products, cereals and cereal products, oilcakes, oilseeds, pulses, spices, dried fruit and many other commodities.

Carpophilus hemipterus

Common name: Dried fruit beetle
Family: Nitidulidae



Description

size: 3 mm
shape: flattened ovate to oblong
colour: black-brown with a yellow transverse band on the elytra
recognition: elytra leaving two segments of the abdomen exposed;
last two segments of the antennae form a club

Distribution

Cosmopolitan

Life history

range of temperature:	19 - 42°C
optimal temperature:	28 - 34°C
range of rel. humidity:	50 - 90 %
optimal rel. humidity:	80 %
eggs laid:	up to 1000
life cycle:	13 - 28 days at optimal conditions

Damage

Secondary pest, indicator of damp, mouldy conditions.
Adult beetles and larvae cause damages on poorly dried cereal grains, cocoa, copra, oilseeds, dried fruit, vegetables, herbs and mouldy produces.

Ephestia cautella

Common name: Tropical warehouse moth

Family: Pyralidae

Description

	adult	larva
size:	15 - 20 mm (wing span)	15 - 20 mm
colour:	grey; fore wing greyish-brown with an indistinct pattern	white, sometimes pinkish or greyish
recognition:		setae (hairs) arising from dark brown pigmented spots

Distribution

Throughout the tropics; less common in arid areas

Life history

range of temperature:	10 - 33°C
optimal temperature:	30°C
range of rel. humidity:	min. near 0 %
optimal rel. humidity:	40 - 75 %
eggs laid:	200 - 500
life cycle:	30 days at optimum conditions

Damage

Larvae are found as primary pests in a wide range of commodities, especially cereal flours and other milled products, but also in whole grains, mainly feeding on the germ. Webbing and frass produced in infested products are nuisance factors.

Similar species

E. kuehniella (15 - 25 mm wing span, mainly in countries with temperate climate)

Plodia interpunctella

Common name: Indian-meal moth

Family: Pyralidae

Description

	adult	larva
size:	14 - 20 mm (wing span)	up to 17 mm
colour:	basal third of the fore wing cream coloured, rest of the wing copper with dark grey markings	yellowish-white, sometimes reddish or greenish
recognition:		base of setae without pigmented spots

Distribution

Cosmopolitan

Life history

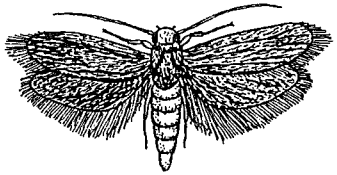
range of temperature:	16 - 36°C
optimal temperature:	28 - 32°C
range of rel. humidity:	30 - 90 %
optimal rel. humidity:	75 %
eggs laid:	60 - 400
life cycle:	27 days at 30°C and 70 % r.h. 52 days at 20°C and 70 % r.h.

Damage

Larvae are primary pests of cereal grain and flour, groundnuts and dried fruit. Webbing and frass produced in the infested commodities are nuisance factors.

Corcyra cephalonica

Common name: Rice moth
Family: Pyralidae



Description

	adult	larva
size:	15 - 25 mm (wing span)	15 mm
colour:	fore wings mid- brown uniformly coloured	pale
recognition:		spiracles thickened on their posterior rims:

Distribution
Throughout the humid tropics

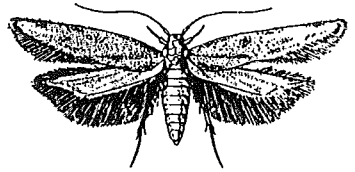
Life history

range of temperature:	min. 18°C
optimal temperature:	30 - 32.5°C
range of rel. humidity:	min. 20 %
optimal rel. humidity:	70 %
life cycle:	26 - 27 days at optimum conditions

Damage
Larvae are primary pests of cereal grain and flour, nuts, groundnuts, dried fruit, cocoa, copra and many other commodities. The dense white cocoons of the pupae, which are very tough are often seen attached to the bag surfaces. Infestation is characterized by aggreations of kernels, frass, cocoons and dirt caused by webbing.

Sitotroga cerealella

Common name: Angoumois grain moth
Family: Gelechiidae



Description

size:	10 - 18 mm (wing span)
colour:	fore wings buff, often with a small black spot in the distal half hind wings greyish
recognition:	hind wings with a long fringe of hairs, sharply pointed at the tip

Distribution
Cosmopolitan

Life history

range of temperature:	16 - 35°C
optimal temperature:	26 - 30°C
range of rel. humidity:	20 - 80 %
optimal rel. humidity:	75 %
eggs laid:	up to 200
life cycle:	28 days at 30°C and 80 % r.h.

Damage
Larvae are primary pests of whole cereal grains as paddy, sorghum, maize and wheat. Larval development takes place inside the grain. Damage is very similar to that caused by weevils.

7.8 Further Literature

Anonymous 1970. Food Storage Manual, FAO/WFP, TDRI, Rome, Part I, 304 pp.

Dobie, P., C.P. Haines, R.J. Hodges & P.F. Prevett. Insects and Arachnids of Tropical Stored Products Their Biology and Identification, TDRI, Slough, 273 pp.

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Scotti, G. 1978. Les insectes et les acariens des céréales stockées, AFNOR/ITCF, Paris, 238 pp.

Weidner, H. & G. Rack. 1984. Tables de détermination des principaux ravageurs des denrées entreposées dans les pays chauds, GTZ, Eschborn, 148 pp.

8 Pest Control Using Insecticides

In pest control there are two kinds of treatment which complement each other: preventive and curative measures.

The preventive measures, which consist above all in suitable storage buildings and the careful observance of all hygiene measures, form the basis of all pest control. Without these, any other measures are bound to be of no effect and uneconomic. Preventive pest control is described in detail in Section 5.2; Section 3.3 also contains relevant information.

The most important curative measure in stored-product pest control is the use of chemicals. A distinction is made between insecticides and fumigants (see Chapter 9).

The parts of this chapter concerned with the application of insecticides apply only to central storage. Section 4.4.3 deals with the application of insecticides in small farm storage. The remaining parts of this chapter are equally relevant for both types of storage.

8.1 Insecticides

8.1.1 General Principles

- Insecticides are always used as a supplement to hygiene measures and can never substitute them.

- A high level of infestation makes control with insecticides more difficult. Care should therefore be taken to perform control of any pest infestation in time.