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by

T. SENGUPTA, P. MUKHOPADHYAY AND
(MRS.) R. SENGUPTA

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INTRODUCTION

In recent years in India many individuals with little entomological training, specially pest control operators, veterinary physicians, sanitarians, experimental biologists and pepole connected with grain and seed trade become interested in insect infesting stored foods. Insects attack the food we eat constantly, from the field crops and throughout the storage period in warehouse, grain and seed mills, in farm bins, grain elevator, in bakeries, in stores and in our kitchen. A fact which is not quite realised by common folks, apart from visible damage, pests may also cause a series of biochemical changes inside the seed and grain kernel attacking the nutritive value and quality of food staff. Damage in general become heaviest where there is long summer with high temperature and humidity, which allow development of many generations during the year. In colder and dry climatic zones pests are fewer and less troublesome. Among stored products pests, beetles are one of the major group of insects, which cause enormous damage to stored products. Stored product beetle pests pass through egg, larval and pupal stages before they finally become adults. Number of eggs varies from a few to several thousands. Beetles comprise the largest order 'Coleoptera' of animal kingdom these include around 25,0000 described species and over 600 species have been associated with stored food products (Hinton and Corbett, 1963), of which, some make direct damage to grains and seeds and some only feed refuse or fungi. Grains become infested in number of ways, infestation may start in the field or during harvesting. It is general practice to store grains and seeds year after year in same container or bins or bags. If there is crack in container or crevices in godown, insect can be concealed in these places, from where infestation may take place. Temporary storage often adds to the danger of infestation. Many beetles live in dust and waste grains and seeds that accumulate in cracks and crevices.

Insects which damage the stored grain and their products belong mainly to two groups : (1) Coleoptera : beetles and (2) Lepidoptera : chiefly moths. Beetles are more harmful than moths, as they could feed and bore both in adult and larval stages, whereas moths are harmful only in larval stages. Conditions of the grains is greatly influenced by the factor like temperature, humidity, moisture content, carbon-dioxide, insects and microbial activities. Change of above factors become the starting point for destruction. With the increase of moisture content (9%) of the grain results in the increased insect

activities. Attack of insects in grains and grain products result in the loss of physical, chemical and nutritive value and finally attacks the market value. Physical loss mainly in weight, appearance and colour is entailed. The grains increase in acidity, reducing sugars, uric acid due to insect attack. Insects often devour the germ portion or embryo which is more nutritive. In India loss due to insect infestation to grains is about 15%. Infested grains may as well cause health hazards (Mazumder 1969), *Sitophilus granarius* and *Tenebrio molitor* may cause Plague bacilli from dead rat, *Tenebrio molitor* may also cause Rikettsia and streptococci, *Tribolium confusum* and *Sitophilus oryzae* are intermediate hosts of tapeworm and acanthocephaloid respectively, whereas *Necrobia rufipes* and dermestid larvae cause dermatitis. In India, due to climatic factors, incidence of agricultural stored product pests are chronic and severe. It is estimated that in India about 25% of all crops are lost during growing and harvesting in the field due to insect pests and diseases, and another 15% lose in storage by the attack of insects, fungi etc. (Mazumder, 1969). Like raw food grains and their products, processed food materials are also susceptible to insect infestation. Processed foods are also preferred by the same species which infest raw food grains.

Information about identification, biology, ecology and distributon of beetles pests of stored products have been published from time to time, but scattered and is not always quickly or easily obtainable. Moreover during recent times we have received many queries from different organizations such as Agricultural Universities and Research Institutes, Govt. Plant Quarantine and fumigation department and general Universities from all over India regarding identification and other informations of various stored product beetles. The maximum queries recived are on *Tribolium castaneum*, *Alphitobius laevigatus*, *Sitophilus oryzae*, *Lasioderma serricorne*, *Callosobruchus chinensis*, *Rhizopertha dominica*, *Necrobia rufipes* and *Oryzaephilus surinamensis* whereas queries on other species dealt in this paper are comparatively less. An attempt has been made here to provide an easy key [along with pictorial one (page)] to the species of Indian common beetles associated with stored products for identification and also their host, associate insects, life history, diagnostic characters, and illustration of each species are given.

Distribution : Almost all the species dealt here associated with stored products and have widespread geographical distribution. The

vast international trade of food stuffs carries them to all parts of the world, probably no other insect group can also readily or easily transported and widely travelled as beetles. The tropical species of Dermestidae, *Trogoderma granarium* easily survive and breed in cold climatic zone by their unique characters of moulting of larval skin. Detail about distribution and host have been dealt in material studied and text of each species.

CONTROL OF STORED PRODUCTS BEETLES :

Effective control measures mean the working together of good husbandry and chemical control. This includes adequate preparation and maintenance of clean building structures coupled with well planned chemical treatment of uninfested and infested grains.

1. *Building structures* : Prior to bringing in of fresh, uninfested grains in storage, the building, silos, bins etc. should be thoroughly cleaned. Any remains on which insects might feed and breed or pervent them from a contact with insecticides should be removed. After the cleaning operations are completed the building structures should be treated with insecticides. In western countries the two recommended compounds are fenitrothion and primiphos methyl, both of which are organophosphates. On porous surfaces wettable powder formulations are suitable as they give a good deposit. For metal surfaces e.g. grain bins, emulsifiable concentrates are recommended. In places where sprays do not gain access insecticide smokes are suggested e.g. y—HCH or lindane (old abbreviation r—BHC). Chemical treatment shold be coupled with careful inspection of all material when brought in for storage. Some additional helpful steps include constructing the building such as to keep stored products dry, constructions should also be sufficiently tight to aid efficient fumigation.

2. *Infested grains* : In general the insecticides (fumigants) that are used to control stored grain pests have a non-specific mode of action. Thus most of them do not combine with specific targets at the molecular lebel yet achieve high activity with a relatively low concentration. As such compounds used against the grain weevil can also be used to control other beetles.

In western countries the most commonly used fumigant mixture is ethylene dichloride + carbon tetrachloride either in 3 : 1 combination or 1 : 1 combination. Ethylene chloride is mixed with carbon

tetrachloride to reduce fire hazard, however, ethylene chloride is toxic to warm blooded animals and should be handled with care. Operators should not inhale the vapour, should keep the liquid off skin and clothes, and should not use naked lights or smoke, as on exposure to heat the gas produce the highly toxic phosgine In our country the fumigants widely used are phospine, ethylene dibromide and methyl bromide. Phosphine is easily available and easy to handle. It is normally generated from tablets of aluminium phosphate and ammonium carbamate which in presence of moisture produces phosphine. Recommended dose under atmospheric pressure is 45 tablets or 165 pellets per 30 m^3 (=1000 ft^3 approx.). Fumigation should be carried out for 5 days at 12 to 15°C, 4 days at 16 to 20°C and 3 days at 21°C or above. It is very toxic to higher animals and thus a controlled release is recommended. Ethylene dibromide is an important fumigant and has a comparatively longer effect than methyl bromide or phosphine. It is however very toxic to higher animals and must be handled with care. Methyl bromide has proved of great value in fumigation of stored products. For preventing reinfestation or cross infestation grain bag stacks are treated with dust or wettable powder formulations of DDT and HCH. Other insecticides used include aldrin, dieldrin and endrin.

3. *Uninfested grains* : A very useful protective measure particularly in buildings with previous history of infestation, is to treat the grains with a mixture of malathion plus lindane. The insecticide mixture can be either mixed into the grains as a dust, or sprayed as an emulsion. The recommended dose is a mixture not exceeding 500 gm/tonne (20% malathion + 0.5% lindane). When spray is used malathion should not exceed 1 litre/tonne (1.2% emulsion). The choice of correct applications also has profound influence on the efficiency of the chemical control measures.

In recent years resistance to insecticides in stored product pests has created an additional problem in the way of effective control measures. Cross resistance and multiple resistance together with the limited choice of alternative chemicals creates further complications. It is therefore valuable to know the mechanism of resistance. This information can be used to try either alternative insecticides or synergists. The practical importance of resistance detected in the laboratory differs with the residual life of a chemical. Thus in case of

compounds like malathion or fenitrothion resistance will mean that only the effective life of treatment will be reduced. With fumigants no residual life is involved and thus the practical consequences of resistance will be felt immediately.

Material examined: *Sitophilus oryzae* (Linnaeus)—A large number of enqueries regarding this species are received in the section throughout the year from various parts of India ; specimens were examined from Kalyani, Calcutta, Kharagpur and Burdwan (West Bengal), Chaibasa (Bihar), Udaipur (Rajasthan) and Poonch (Jammu & Kashmir).

Sitophilus zeamais (Motschulsky)—So far we have not examined any specimen of this species collected from India, though Aitken (1975) mentioned that it has been recorded from oriental region. The specimens examined during this study was received from D. G. H. Halstead, Pest Infestation Laboratory, Slough.

Sitophilus granarius (Linnaeus)—Only 4 examples of this species collected from Calcutta in wheat in the month of May (1907) has been examined. In recent time we have not received any report of this species from India.

Sitophilus linearis (Herbst)—One of us (T Sengupta) has collected several specimens of this species from stored *Tamarindus indica* at Chaibasa (Bihar). Similarly the specimens collected from Kharagpur (West Bengal) and Sambalpur (Orissa) are also examined.

Carpophilus dimidiatus (Fabricius)—This species is collected from Kharagpur (West Bengal), Ranchi & Pusa (Bihar), Nilgiri Hills (Tamil Nadu) has been examined and one of us (T Sengupta) collected a large number of specimens from Bajra Crop at Coimbatore (Tamil Nadu).

Carpophilus hemipterus (Linnaeus)—Specimens examined are from Calcutta (West Bengal), Ranchi (Bihar), Musulipapal (Tamil Nadu) and Poona (Maharashtra).

Urophorus humeralis (Fabricius)—Specimens examined are collected from Calcutta (West Bengal).

Carpophilus obsoletus Erichson—Specimens examined are collected from Calcutta (West Bengal), Ranchi (Bihar), Rotung (Arunachal

Pradesh), Bombay (Maharashtra) and Port Blair (Andaman Islands), recently one of us (T Sengupta) has collected a few example from dried plum from Chaibasa (Bihar).

Necrobia rufipes (Degeer)—This spceies has been collected several time from various dry food shops at Calcutta during the month of June-August and T Sengupta has collected this species from Cashewnut factory at Jhargram (West Bengal). Other examples examined are from Kurseong (West Bengal), Shillong (Meghalaya), Ahemedabad (Gujrat), Srinagar (Kashmir) and Coconada (Tamil Nadu).

Oryzaephilus surinamensis (Linnaeus)—This species has been collected several times from Calcutta in dried walnuts, date food, shipment of biscuits and rice ; from seed of *Shorea robusta* from Bankura (West Bengal) ; in rice from Chaibasa and Ranchi (Bihar) and also studied a few examples from Dehra Dun (Uttar Pradesh) and one example from Tamil Nadu collected from sorgum food.

Oryzaephilus mercator (Fauvel)—One of us (T Sengupta) has collected this species several times from Calcutta (West Bengal) in wheat, cornflex, cashewnuts and groundnuts and specimens from Chaibasa (Bihar), Ajmir (Rajasthan) and Bombay (Maharshtra) are also examined.

Ahasverus advena (Waltl)—A large number of materials collected from Chaibasa from dried plums, from seed of *Shorea robusta* at Bankura (West Bengal), Copra consignment at Calcutta and stored rice from Kerala and also material borrowed from a exculture maintained at P. I. C. L. Slough, England are examined.

Cryptolestes pusillus (Schönherr)—A large number of specimens of this species has been collected by us chiefly from under bark from various parts of North Bengal (West Bengal), Assam, Meghalaya, Bhutan, Gorakhpur (Uttar Pradesh), Bannarghata (Karnataka). Only record of this species from rice is from Santinekatan (West Bengal) during the month of June and in flour and biscuits from Calcutta during the month of March.

Cryptolestes ferrugineus (Stephens)—One of us (T Sengupta) has collected this species several times from Calcutta in rice and wheat during post monsoon months and also from Dhupguri : Jalpaiguri district (West Bengal) from leaf litter and many examples of this species

borrowed from P. I. C. L. Slough, England which areexa mined for present study.

Rhizopertha dominica (Fabricius)—Several examples are received quite a few times from Department of Zoology, Kalyani University and also studied the examples collected from Calcutta (West Bengal), Ranchi (Bihar), Waltair (Andhra Pradesh) and Kashmir.

Callosobruchus maculatus (Fabricius)—A few examples collected from Kalyani & Calcutta (West Bengal), Ajmir (Rajasthan) and Gujrat have been examined.

Callosobruchus chinensis (Linnaeus)—During recent years we received several enquaries regarding this species and specimens examined are from Calcutta (West Bengal), Hoshiarpur (Punjab), Ajmir Rajasthan) and some examples from Rangoon (Burma).

Callosobruchus analis (Fabricius)—Several examples collected from Calcutta (West Bengal), Hoshiarpur (Punjab), Ajmir (Rajasthan) and also material from Rangoon (Burma) have been examined.

Caryedon serratus (Olivier)—Many examples collected by one of us (T Sengupta), from Chabiasa (Bihar) in *Tamarindus indica*, and other examples from Calcutta, Pandua (West Bengal), Benaras (Uttar Pradesh) and Coimbatore (Tamil Nadu) have been examined.

Bruchus pisorum (Linnaeus)—A few examples of this species collected from Gauhati (Assam), Ajmir (Rajasthan) have examined.

Lasioderma serricorne (Fabricius)—A large number of examples collected by T Sengupta from his kitchen at Calcutta in various spices. The same has been collected several times from dried fish at Calcutta (West Bengal) and many examples has been studied which are from Samastipur (Bihar), Bombay (Maharashtra), Madras (Tamil Nadu) and Tuticorin (Kerala).

Stegobium paniceum (Linnaeus)—Several examples of this species collected from Calcutta (West Bengal), Chaibasa (Bihar), Vellayani (Kerala) and Poona (Maharashtra) has been examined.

Trogoderma granarium Everts—A number of examples collected several times from Calcutta (West Bengal) and Delhi have been examined.

Tenebroides mauritanicus (Linnaeus)—Only a few examples of this species received from Coimbator (Tamil Nadu) in wheat bran have been examined.

Tribolium castaneum (Herbst)—This is a commonest species of all stored product pests and maximum number enquaries received in the section from all most all over India throughout the year.

Latheticus oryzae (Waterhouse)—So far, we have seen a few example of this species collected from Izatnagar (Uttar Pradesh) and recorded from wheat bran from Coimbatore (Tamil Nadu).

Alphitobius laevigatus (Fabricius)—Many examples of this species has been examined, which are collected from Calcutta & Kalyani (West Bengal), Patna (Bihar), Missamari (Assam), Mathura & Rajpur (Uttar Pradesh), Jodhpur (Rajasthan), Poonch (Jammu & Kashmir), Hebbal (Karnataka), Hyderabad (Andhra Pradesh) and Andaman Islands.

Palorus ratzeburgii (Wissmann)—Fairly large number of specimens received for identification from Prof. A. Choudhury, Department of Zoology, Calcutta University who noted that this specimens has been collected in the month of March from rice and broken grains and the species is kindly be identified by Dr. D. G. H. Halsted, Pest Infestation Laboratory, Slough.

1. Family CURCULIONIDAE

Curculionidae is one of the largest families of the order Coleoptera and includes true weevils. They may be found in a variety of habitats. The larvae are legless and bore or mine in vegetable tissue. Some species are pests of field crops, some fruits, and others are wood borers of dead or seasoned timber. Among weevil pests, the genus *Sitophilus* Schönherr includes most notorious pests of stored grains, of which, the species *Sitophilus oryzae* (L.) (Rice weevil), and *S. zeamais* Motschulsky (maize weevil), *S. granarius* (L.) (Granary weevil) are most important. The former two species are very serious and primary pests of stored grain throughout the warmer parts of the world. In temperate climate these species are replaced by *S. granarius* (L.). In India, the species *S. oryzae* and *S. zeamais* are found throughout the country and *S. granarius* is recorded from West Bengal. The genus *Sitophilus* can be easily recognized by its small, elongate, rather slender body, beak cylindrical, straight and usually shorter than

pronotum, antennal club not compressed, third segment of tarsi either narrow or expanded and rather glabrous or pilose at the sides, pronotum feebly longer than wide, narrowed apically, elytra deeply striated.

Taxonomy, nomenclature and identification of *Sitophilus oryzae* (L.) and *Sitophilus zeamais* Motschulsky has been confused for a long time, Linnaeus (1763) described the species *oryzae*, latter Motschulsky (1855) described the large form as *zeamais*. The two species are closely related and found in the same habitat especially in stored rice, wheat and maize. Kuschel (1961) finally sorted out its nomenclature and referred the small bodied species as *oryzae* and large ones as *zeamais*. Appearance of these two species is similar and in a mixed population it is rather difficult to separate them by their external morphological characters. Birch (1944) and Richards (1944) showed that the two species differ in their physiology and as well in their size, *S. oryzae* is in an average smaller than *S. zeamais*. Kuschel (1961) and Halstead (1964) showed that they differ in their genital structure. Moreover, *S. oryzae* are predominately found in wheat whereas, *S. zeamais* dominate in rice and maize, Aitken (1975) showed that appoximately 10% mixed population was found in wheat, about 14% in maize and 21% in rice. Another closely related species is *Sitophilus granarius* (L.) commonly known as granarry weevil, which also attack wheat, maize and rice but fortunately are less serious pest in India. The species *S. granarius* can be easily separated by its pronotum, being sparsely punctate and puncturation are elongate, elytra devoid of reddish spots, less shiny, deeply impressed and feebly punctate, intervals smooth and alternately wider and elevated, which are more distinct near base. The fourth species of *Sitophilus*, known to be a pest in India is *S. linearis* (Herbst), a common pest of *Tamarindus indica*. It occurs all over India where tarmarind is grown. Infestation often starts in the field and usually breed in stored seeds.

1. **Sitophilus oryzae** (L.) (Figs. 1-4)

(=*Calandra oryzae* L., *Calandra sasakii*, Takahashi)

This is a serious pest of cereals and their products. As it is was first found in rice it is commonly known as rice weevil, although it attacks mostly wheat, less so in maize, rather rare in rice products, millet and other grains and also found under bark and on leaves. Both adult and larvae cause serious damage on stored wheat. The

larvae generally feed the endosperm which reduce the weight and food value. The damaged wheat in turn attacked by mould and bacteria and other insects. Larvae also produce a large quantity of whitish powdery excreta which makes the grain more dusty and unpleasant smell. The adult produces extra heat by their body cavities, which increases heat with bins and bags, in turn, promotes faster breeding. Female makes a cavity on grain and lays translucent eggs beneath seed cost and then plugs the whole with gelatinous secretions. Single female can lay 150-300 eggs in 3-6 days. These eggs hatch into tiny grub which are very active and feed inside the grain and are responsible for most of the damage. The mature larvae about 4 mm. long, whitish, fleshy, legless and curved in appearance. Larval stage last for 3-4 weeks. Pupation takes place inside the grain. The pupa is white, later becomes dark brown. Pupal period lasts for 3-6 days. The adult beetle come out through the circular hole in its outer layer, made by themselves. Adult lives for 3-5 month. Grains having moisture lees than 10% is generally not attacked. Hill (1975) mentioned that the life cycle takes 26 days at 30°C and 70% RH. The optimum climatic conditions for development range from 27°C to 31°C and development ceases below 17°C. Life cycle usually complete within 4 to 6 weeks.

Chief differences between *Sitophilus oryzae* and *Sitophilus zeamais* :

Sitophilus oryzae (L.)	*Sitophilus zeamais* Motschulsky
1. Eyes small	1. Eyes large
2. Male genitalia as figured (Fig. 3, 4)	2. Male genitalia different (Fig. 5, 6)
3. Mostly prefers and associated with wheat	3. Mostly prefers and associated with rice and maize.
4. Female lays more eggs in wheat than rice	4. Female lays more eggs in rice than in wheat
5. Life cycle slightly quicker and shorter in optimum temperature.	5. Life cycle slightly longer in optimum temperature
6. Less abundant in Eastern and Southern India.	6. Most abundant in Eastern and Southern India.

2. **Sitophilns zeamais** Motschulsky (Figs. 5, 6)

They are commonly known as 'maize weevil' and are closely

related to *Sitophilus oryzae* (L.) and is very difficult to distinguish from them. Their biology and type of damage are very much similar and can be separated from the *Sitophilus granarius* (L.) by their more or less clearly defined reddish spot on elytra and less shiny in appearance.

3. **Sitophilus granarius** (L.) (Fig. 7)

This is popularly known as 'grain weevil' or 'true weevil' and important pest of stored grains and their products, generally attack all kinds of whole grain. In India this species are found to be associated with wheat. Durning infestation larvae feeds & hollows out endosperm of the grains, due to which food value and weight of the grain reduces and not damaging germ. Beside this larvae produce whitish, powdery excreta which is of no food value and makes the grain more dusty.

Life cycle studied by Richards (1947) and Howe and Hole (1968). Female makes a cavity within the grain and lay eggs and seals with mucilaginous saliva. Each female can lay about 190 eggs and the rate of egg laying varies with temperature and humidity. These eggs hatch into an apodous larva and moults 4-times as it grows. Then it transforms into pupa and finally into adult within a few days. Adults live for 6-9 months. It is recorded that adults can survive 100 days at 4.5°C and 40 days at 2°C and are inactive below 10°C, while immature stages survived for 70 days at 4.5°C. Length of life cycle depends on the temperature and humidity, ranging 182 days at 15°C & 50% RH to 26 days at 30°C & 70% RH.

2. Family NITIDULIDAE

The members of the family are commonly known as 'sap feeding beetle' Most of them feed on sap of trees and juice of fruits, especially when fermented. Many live on flowers, fungi and carrion, whereas a few are predacious and some of them are leaf miners. Grouvelle (1913) in Junk's coleopterous catalogue listed 23 species under the genus *Carpophilus* Stephens from India. Hinton & Corbet (1963) mentioned that 16 species recorded to attack stored food products in Store houses and granaries. Of these, three species, namely, *Carpophilus dimidiatus* (F.), *C. hemipterus* (L.) and *Urophorus humeralis* (F.) are commonly found in India.

The genus *Carpophilus* and *Urophorus* can easily be recognised by its broad head which is distinctly narrower than pronotum, clypeus

slightly indistinct and porrect, margined by a depression at each side, eyes usually large, antennae little longer than head, scape enlarged, pedicel and joint 3 cylindrical and about equal in length, club compact, flattened, rounded or oval in out line, labrum bilobed, pronotum nearly as broad as elytra, scutellum usually broadly rounded posteriorly, elytra short exposing two or three apical segments and tarsi 5 segmented.

5. **Carpophilus dimidiatus** (Fabricius) (Fig. 8)

The is commonly known as 'corn sap beetle.' This species is closely related to *C. hemipterus* but can be easily separated by its elytra being unicolourous or with sutural region slightly darkar than rest of the elytra instead of two pale redeish spots on each blackish elytron. They are commonly found to be associated with stored products and are usually a pest of grain and grain products, oil seeds, illipenuts and sago flour and a few recorded from rice products. It is quite common and abundantly occur in India and recorded from West Bengal, Bihar, Tamil Nadu, Maharashtra (Poona).

Biology has been studied by Balzer (1942), Lindgren and Vincent (1953) and Lefkovitch (1966). They stated that development is possible within the range of 17.5°C to 32.5°C and relative humidities over 50% and life cycle was found to range from 49 days at 18.5°C to 15 days at 32°C.

6. **Carpophilus hemipterus** (L.) (Fig. 9)

This species is popularly known as 'dried fruit beetle' It is cosmopolitan in distribution and occurring throughout all temperate and warm regions of the world. In India this species is quite common and so far, recorded from West Bengal & Bihar. They generally infest dried fruits, sometimes on other stored products such as cereals, oil seeds and their products,

Hinton (1945) observed that this species can feed on the flesh of the fruit itself, but the fruit is rendered more attractive to them by being contamineted with fungus or yeasts. Normally, they cannot enter the fruit unless the surface is broken or damaged. Lindgren & Vincent (1953) studied its life cycle and found that development ranged from 42 days at 18.5°C to 12 days at 32°C.

7. **Urophorus humeralis** (F.)

The species *humeralis* (F.) was previously placed under the genus *Carpophilus*. Later, Gillogly (1962) described this species under the genus *Urophorus*. This species is closely related to the species *Carpophilus dimidiatus* (F.) in form as well as in habits but is slightly larger, uniformly, shiny and dark brown in colour. This species usually found on decaying fruits feeding on fermenting juice of fruits. It is also recorded from beans, oilcake, copra, coconuts, dried onion, barley, sago flour etc. from differnt parts of the world. Wallace (1966) recognized it as a pest of maize in Sarawak. Illingworth (1929) noted that it is an abundant and troublesome pest of pineapple in Hawaii. Connell (1956) mentioned that life cycle is completed in 82 days at 68°—80°F. Lindgren & Vincent (1953) mentioned that their developmental period ranges from 17 days at 32°C to 34 days at 21°C.

8. **Carpophilus obsoletus** Erichson

This species is widely distributed throughout the tropics and subtropics. In India this species is recorded from West Bengal, Bihar, Arunachal Pradesh, Maharastra and Andaman Islands. Sengupta collected the species from dried plum.

3. Family CLERIDAE

The cleridae or checkered beetles is a fairly large family, includes 3366 describeds pecies from the world and mainly predacious in nature and usually found in forest, specially in woody plants and both adult and larvae prey on other insects, some lives on flower and feed pollen. Some species of *Necrobia* Olivier are only associated with stored products, of which, *Necrobia rufipes* (Degeer) and *Necrobia ruficollis* (F.) are most common. In India *N. rufipes* (Degeer) is recorded as serious pest of cashew nuts. The clerid beetles are usually brightly coloured and covered with errect setae, species elongated, size varies from 3—24 mm, antenna 11-segmented usually with a distinct club, eyes usually emarginate, tarsal formula 5-5-5, abdomen with 5 or 6 visible sternites which are completely covered with elytra.

9. **Necrobia rufipes** (Degeer) (Fig. 10)

This is commonly known as 'copra beetle' or' 'Red-legged ham beetle' and can easily be recognised from other *Necrobia* species by its dorsal surface being entirely blue, legs red, antennal club dark

brown or black and apical segment of antenna is slightly broader than its length. They are quite common and distributed throughout the tropics and serious pests copra, palm kernels and also animal products and rarely found in grain and grain products. In India we have seen them causing serious damage to stored cashew nuts at Calcutta and cashew nut factory at Jhargram : West Bengal. This species has been recorded from Calcutta, Kurseong and Darjeeling : West Bengal, Shillong : Meghalaya, Srinagar : Kashmir and Coconada : Tamil Nadu. It has been observed in Jhargram cashewnut factory that these beetles are associated with *Oryzaephilus mercator* (Fauvel), *Carpophilus* sp., *Tribolium castaneum* (Herbst), *Alphitobius laevigatus* (F.) and they are very active and fly readily during summer. da Costa (1955) studied its biology and noted that lowest temperature needed for full development at 20.6°C and high humidities are favourable for their growth and larval survival.

4. Family SILVANIDAE

The members of the family are small, flat beetles, formerly included under the family Cucujidae. Crowson (1955) treated them under a separate family Silvanidae. They usually live under bark and vegetable debries and feed on fungus. So far known, three species which are associated with stored products *Oryzaephilus surinamensis* (L.), *Oryzaephilus mercator* (Fauvel) and *Ahasverus advena* (Waltl), former two species are more serious pests of various stored products. The genus *Oryzaephilus* can easily be recognised from other genera of Silvanidae by its 6 acute teeth on each side of prothorax, pronotum with a median and a pair of lateral longitudinal carinae, dorsomedian part of pronotum with an elongated, flattened discal area demarcated by lateral carinae, elytra with nine rows of serial punctures and prominent interstices, and antenna 11-jointed with there jointed club. The species *Oryzaephilus surinamensis* (L.) is closely related to *Oryzaephilus mercator* (Fauvel) and easily be confused. They can be separated by following characters :-

Oryzaephilus surinamensis (L.)

1 Temple of head as long as 3-4 eye facets.
2. Temple longer and eyes usually shorter than twice the length of temple.

Oryzaephilus mercator (Fauvel)

1. Temple of head as long as 2-2.5 eye facets.
2. Temple short, and eyes about 3.4-4 times the length of temple.

3. Prefers and mostly associated with starchy food specially grains products.	3. Prefers and mostly associated with oil seeds and their products.

10. **Oryzaephilus surinamensis** (L.) (fig. 11)

This species is commonly known as 'saw toothed grain beetle' Both adult and larvae attack all kinds of food of vegetable origin, associated chiefly with starchy foods than oilseed and their derivatives. They have been recorded from grain products, rice, flours meals, cornflex stock and poultry feeds, nuts, candies and dried fruits. Because of their small size they can easily hide in small crevices and easily transported in sacks and containers. They are often associated with *Tribolium castaneum*, *Sitophilus oryzae* and also found to be associated with *Necrobia rufipes*, *Cryptolestes pusillus* and *Oryzaephilus mercator*. Normally they dose not attack the whole grain but cause roughening of grain surface and off odour in grain.

We have collected this species from Gorakhpur (U. P.), Chaibasa (Bihar) and Delhi attacking unboiled rice and wheat, they have been recorded from dried walnuts, biscuits and cornflex at Calcutta, sorghum seeds at Madras and *Prosopis juliflora* pods in Dehra Dun (U. P.).

Life history of the *O. surinamensis* was studied by Howe (1956). Female deposit their eggs in crevices of the grain and dropped loosely in flours etc. The eggs are small, slender, cylindrical and whitish. The larvae are elongated and make cocoons of a gelatinous substance to which the food particles are adhered. Under favourable condition they complete their life cycle from egg to adult stage as early as 24 days, while in spring they took about 6—10 weeks time. It has been recorded that the life cycle extended even beyond 5 years in cold countries. It has been observed in Calcutta during June-July the life cycle took about 21—28 days. Howe (1956) pointed out that development is possible within temperature range 20° to 37.5°C with the optimum at 30°C to 35°C and 70% to 90% relative humidity, at which life cycle takes about 20 days.

11. **Oryzaephilus mercator** (Fauvel) (fig. 12-14)

This species is commonly known as 'marchent grain beetle' Likewise *Oryzaephilus surinamensis*, this species is quite common throughout warm climatic zone of the world and recorded as a serious

pest of oilseeds in India. Unlike *surinamensis* they are fond of oilseeds and their products than starchy food. In India they are severe pest of cashewnuts, oilcake and copra, has been recorded also from wheat, cornflex, unboiled rice and ground nuts. They are often associated with *Necrobia rufipes, Cryptolestes pusillus, Tribolium castaneum, Sitophilus oryzae* and *Oryzaephilus surinamensis.*

Life history of *Oryzaephilus mercator* was studied by Howe (1956) and mentioned that under favourable conditions, development takes place within a range of temperature from 17.5°C to 37.5°C, with optimum at 30°—32.5°C and 75% relative humidity, under favourable condition they required to complete their life cycle from egg to adult about 25 days.

Ahasverus Gozis is a small genus, closely related to *Cathartus* Reiche but can easily be separated by its antennal joint 9 being distinctly narrower than joint 10, prothorax transverse, lateral margin curved outwardly, anterior angles produced and callosity like, sterno-pleural sutures terminate in anterior angles, elytra ovoid, femoral lines on ventrite 1 opened.

12. **Ahasverus advena** (Walte) (Fig. 15, 16)

This species is commonly known as 'Foriegn grain beetle' So far, this species was recognized as pest of secondary importance. Recently, one of us (T Sengupta) observed them causing severe damage to store dried plums (bair) at Chaibasa : Bihar. In unpublished data T K. Pal of Zoological Survey of India recorded it from seeds of *Shorea robusta,* and also recorded from copra consignment. So far, this species is recorded from Madhya Pradesh, Maharashtra, Tamil Nadu, Kereala, Bihar and West Bengal. Aitken (1975) noted that high percentage of this species from Oriental and Ethiopian cargoes specially in illipenuts, also in copra, sagu flour and grains. Hill (1965) studied the life cycle on mouldy Copra at unspecified temperature and relative humidity and mentioned egg stage last for 4 days, larval stage 11—14 days, pupal stage 4—7 days and total developmental period from egg to adult require 20—23 days, and he also pointed out eggs on copra without moulds hatched in 4 days but none reached maturity. The minimum time required for their complete development, from egg to adult in favourable condition at 80% RH and 30°C varies from 18—25 days.

5. Family CUCUJIDAE

The representative of the family Cucujidae are commonly known as 'flat bark beetles', majority of them live under bark and others in decaying plant materials. The primitive species are predacious and of little economic importance but some species of the genus *Cryptolestes* Ganglbauer are serious, wide spread pest of grains.

Cryptolestes is a cosmopolitan genus, closely related to the genus *Laemphloeus* Dejean and *Microlaemus* Lefkovitch, differs from the former in having front coxal cavities close behind, intercoxal process of ventrite 1 broad and its apical margin slightly rounded, fronto-clypeal suture absent and apical margin of clypeus never with five emarginations. Unlike *Microlaemus*, the head of *Cryptolestes* is devoid of fronto-clypeal suture, front coxae globular and its cavities close behind. There are six species of *Cryptolestes*, namely *ferrugineus* (Stephens), *pusillus* (Schönherr), *turcicus* (Grouvelle), *pusilloides* (Steel & Howe), *ugandae* Steel and Howe and *capensis* (Waltl) recorded as pest of stored products from the world. They generally infest husked rice, wheat and wheat products, sorghum, maize, barley and occasionally on oil seeds. Though the close external similarity of the members of this genus often lead to confusion, considerable differences do exist in the range of geographical distribution, habitat and in the sclerites associated with male and female genitalia. Of the six known pest species of *Cryptolestes*, the species *turcicus* (Grouvelle), *pusilloides* (Steel & Howe), *ugandae* Steel & Howe and *capensis* (Waltl) do not occur in India. The most important pest species of this genus are *pusillus* (Schönherr) and *ferrugineus* (Stephens) which are quite common in India and serious pest of stored grain and their products. Of the two pest species of *Cryptolestes* in India, *pusillus* is more common and causes serious damage to unboiled rice, suji and flour. Prior to 1939 *C. pusillus* was considered to be a secondary pest, but during the second world war it was recorded as a serious wide spread pest of rice. *Cryptolestes turcicus* (Grouvelle) is more or less confined to the temperate regions of the world and infest wheat, grain residues, maize, dried fruits etc., *C. pusilloides* (Steel & Howe) is distributed mainly in Southern hemisphere and recorded from wheat and wheat products, sorghum, rice, barley, and occasionally from oil seeds ; *C. ugandae* Steel & Howe is known from Central Africa and associated with stored food ; whereas *C. capensis*

(Waltl) has been recorded from Europe, North and South Africa from flour mills.

13. **Cryptolestes pusillus** (Schönherr) (Figs. 17, 18, 18a)

The species is elongated, flattened, parallel-sided, reddish brown, densely and finely pubescent and popularly known as 'flat grain beetle' and common in humid tropical areas, less so in cooler drier climates and unable to survive in temparate regions. They are scavenging by nature, infesting grains which are out of condition and generally follows up the attack of *Sitophilus oryzae* (L.) and *Tribolium castaneum* (Herbst). In India, Sengupta, Mukhopadhyay & Sengupta (Mrs.) (1978) have recorded the species infesting biscuits (Calcutta, March), flour (Calcutta, March), unboiled rice (Chaibasa : Bihar, June), Suji (Calcutta, August). Besides this, it is also recorded from under bark of *Lagerstroemia perviflora* (Lythraceae) : Hasimara : West Bengal, *Stereospermum chelonoides* (Bignoniaceae), Dainadubi : Meghalaya, *Bombax malabaricum* (Bombacaceae) : Kaziranga : Assam, *Quercus dilatata* (Fagaceae) : Dehra Dun : Uttar Pradesh. This species can easily be recognized by its head being transverse, median line on vertex present, vertex finely, densely and closely punctured and pubescent, antennae 11-jointed and longer in male than female. External surface of mandible simple and rounded, hind angle of pronotum projected and less acute, sclerites associated with male and female genitalia are as figured (Figs. 18, 18a). Males can be easily distinguishable from females, especially in antennal character. The antenna of male is as long as the body, with joints 9-11 forming indistiaguishable club. In the females the antennae never exceeds two thirds of its body length and joints 9-11 form rather distinct club.

Adults are apparently unable to attack healthy grains but the larvae particularly are fond of germ portion of the grains. The adult female usually lays 100-140 eggs, the larvae are very active, flat, moderately elongated, slightly narrowed in front and behind with heavily chitinized urogomphi. The larval stage lasts for 2-4 weeks. Pupation takes place within the cocoon formed by fine silky materials. Under favourable condition species complete its development from egg to adult stage in about 6-9 weeks. Aitken (1975) noted that the lowest temperature limit for development is somewhat between 15°C and 17°C and lowest relative humidity is 50% and shortest life cycle recorded, is 21 days at 37°C and 80% humidity.

14. **Cryptolestes ferrugineus** (Stephens) (Figs. 19, 20, 20a)

This species is commonly known as 'rusty grain beetle' They generally feed on whole and processed grains and oilseeds and causes serious infestation in stored grains in absence of any other pest species and is usually found in flour mills and also recorded from infesting copra, oilcake, cocoa, beans and dried fruits. Sengupta, Mukhopadhyay & Sengupta (Mrs.) (1978) recorded this species from Calcutta : West Bengal infesting rice and wheat during the month of September and November respectively. This species generally favours dry conditions, coarse food and has low larval density and can be easily recognized by its general appearance being elongated, flattened, dorsal surface ferrugineus, median line on vertex distinct, vertex with moderately large, closely arranged punctures and pubescent, length of antenna never exceeding more than half of its body length in both sexes, outer margin of mandible of male with a distinct tooth-like structure near base, hind angle of pronotum projected and distinctly acute, sclerites associated with male and female genitalia as figured (Figs. 20, 20a). Unlike *C. pusillus.* in this species the sexual dimorphism is confined to the nature of mandible, outer margin of which in males with distinct tooth like structure near base, whereas in the female the outer margin is simply rounded.

Life cycle of this species has been studied by Rilett (1949). Young larvae enter into the seed coat through hole made by them. Unlike *C. turcicus* (Grouv.) this species is generally unable to produce a tough silken cocoon containing very little silk. At 75% relative humidity, the life cycle varies from 69-103 days at 21°C to 17-26 days at 38°C. Above 70% relative humidity has no effect on the length of life cycle, but below this level, development is retarded.

14. Family BOSTRYCHIDAE

The family Bostrychidae is one of the most important group of the order Coleoptera which are primarily wood borers, rarely found in stored products and predominate in tropics. There are 455 species known from the world. Many of them are serious pest of timber and forest trees. The only species *R dominica* (F.) is a grain borer and serious pest of stored grains in India. Adult bostrichid beetles can easily be recognised from closely resembling Scolytidae by their tuberculate pronotum, straight antennae, three or four-jointed club,

shape cylindrical, compact with head small, deflexed and usually inserted under prothorax.

15. **Rhizopertha dominica** (Fabricius) (Figs. 21—25)

This is commonly known as 'lesser grain borer' or 'hooded grain borer' This species is native to tropics and spread through commerce to all parts of the world. In India it has been recorded from West Bengal, Bihar, Tamil Nadu and Kashmir. This is a pest of stored grains of all kinds, specially from wheat, barley, rice, maize, millets, sorgum, flour etc. It is also recorded from starchy food substances like dried potatoes, water nuts, biscuits, processed flattened rice (Chira) etc. Both adult and larvae are voracious feeder and cause serious damge. Adult are not capable of field infestation and larvae are free living. They multiply relatively slow and become adundant when grains remain in stores for a long time undisturbed, They are often associated with *Sitophilus oryzae* and *Triboluim castaneum*. It has been reported that this species is also found from the caged logs of *Abies webbiana*, *Alnus nitida*, *Artocarpus hirsuta*, *Bauhinia variegata*, *Buchanania latifolia*, *Dalbergia sissoo*, *Dendrocalamus strictus*, *Garuga pinnata*, *Heritiera fornes*, *Mallotus philippinensis*, *Shorea robusta*, *Sterculia campanulata*, *Terminalia tomentosa*, *Thespesia populnea*, bamboo and pith.

This species can readily distinguished from other grain beetles by its body being cylindrical, head deflexed downwards to such an extent that it is almost hidden under pronotum, colour ranges from brown to black, shiny, antenna 10-jointed, club short, distinct and its joints triangular, pronotum nearly as long as wide and with lateral carina, covered with short, sparse, recumbent in conspicuous hairs, anteriorly with transversely arcuated rows of obtusely rounded teeth, those near the anterior margin forming a strongly elevated crenuate ridge, posteriorly with large flattened granules, puncturation on elytra arranged in 11 definite rows.

Primary larva is scarabaeform and 0.3 mm long and mature larva is recurved and incapable of locomotion. Larvae are white, slightly yellowish towards, head, four ocelli arranged in triangle mouth parts brownish, antennae vary short, abdominal segments bear ventrally a number of long hairs and also on the dorsal segments

of 7 and 8. Last abdominal segment with a curved yellow horn directed backward.

Life-history studied by Potter (1935). Adult female lays 300—500 eggs amongest the grain and hatching starts after 4—6 days. Larvae are initially external feeder and larval period often last for 35—45 days. Pupation takes place on the surface of the grain and last for 7 or 8 days. Life cycle is completed in 6—8 weeks in optimum condition, which range from 32°—36°C with above 50—60% relative humidity. In drier condition life cycle generally takes longer period.

7. Family BRUCHIDAE

Bruchidae are commonly known as 'Pea and bean beetles' and also known as 'Pulse beetle' Members of this family is near to Chrysomelidae but head produced downward into very short snout as weevils. They have been reported to destroy seeds of leguminous plants, but now they have been recorded from various wild and vegetable flowers and leaves of various plant families. They may be easily recognised by their characteristic shape (Fig. 30), head small with a short snout-like prolongation, dull coloured, oval, chunky, body covered with fine hairs, which often ornamented with spots, antenna clavate, eyes often with a deep emargination which extend backwards from the base of antennae, legs stout with hind femora markedly developed, tarsi pseudotetramerous, species usually less than 1/4 of an inch long.

Majority members of Bruchidae live on the seeds of Leguminosae and known pest of pulse. Pests generally falls under two catagories, first ones are field pest and second catagories are those species which attack on stored seeds. The field pests are usually unable to infest dried seeds in store. Bruchid species which attack dried stored seeds are few in number, yet all of them are serious stored grain pests and cause enormous damage to stored seeds in India. The representatives of the genera *Callosobruchus* Pic, *Bruchus* L. and *Caryedon* Schönherr are among the most common and destructive pests, majority of them have been spread all over the world by commerce. Because of variation in colour pattern of some species overlaps those of others and identification is often difficult.

The genus *Callosobruchus* can be distinguished by their lack of tooth on lateral margin of prothorax, a paired spurs present at

apex of hind tibiae, hind femur channelled below and with an angular tooth on outer and inner ventral margin and species multivoltine. Male can be recognised from female by its antenna more serrate and last segment of abdomen emarginate to receive the apex of the pygidium, whereas in female it is almost straight when seen from ventral surface. Species attack stored seeds.

The genus *Bruchus* can be recognised by its prothorax being broad and emarginate on lateral margin near middle, presence of minute tooth on lateral margin of prothorax, usually hind femora with lateral tooth on ventral margin; species usually blackish. Male can be distinguished by presence of an apical tooth or plate in middle tibiae, antennae not serrate and posterior margin of last abdominal sternite deeply emerginate. Species univoltine. The species *B. pisorum* L. and *B. lentis* Froelich are common pest of peas and lentils which attack growing lentils and cultivated peas but unable to infest the dried seeds after harvest. The adult may emarge from the seed in store but unable to re-infest the dired seeds.

The members of the species of *Caryedon* Schönherr can be recognised by their eyes being shallowly eamrginate, head constricted behind eyes, hind femora with a ventral comb like row of strong spnies, elytra with distinct punctate striae reaching upto the apex, species larger and over 5 mm long. The only species *C. serratus* (Olivier) known as pest of Imli or Tetul (*Tamarindus indica*).

Larvae of Bruchidae usually more or less C-shaped sometimes globular and soft-bodied and dull white to light brown with sclerotized head being retracted into the prothorax. Larvae usually live and pupate inside the seed and ultimately emarge as adult. Larvae of *Callosobruchus* and *Bruchus* are globular, soft-bodied, antenna without secondary Setae, maxillary palpi 1-jointed, labial palpi not distinguishable and legs with 3 or 4 segments. Larve of *Callosobruchus* can be easily separated from the larvae of *Bruchus* in having a pair of ocelli on head and in latter genus ocelli absent. *Caryedon* larvae usually larger (4—6 mm. in length), elongated and brown, C-shaphd and covered with minute setae and can be easily separated from larvae of *Callosobruchus* and *Bruchus* by the presence of three ocelli on either side of head and maxillary palpi 3-jointed.

16. **Callosobruchus maculutus** (Fabricius) (Fig. 26)

This species is commonly known as 'Pulse beetle' and serious pest of peas, beans and lentil. In India it has been found destroying chola or Chana (*Civer arietinum*), pea or motor (*Pisum sativum*), Arhor (*Cajanus cajan*) and Mung (*Phaseolus aureus*). The species *C. maculatus* is very similar and often confused with *C. analis* (Fabricius) but can be separated by its antennae being more serrate and longer in male, inner tooth of hind femur equal to outer tooth, lateral black spots on elytra bounded by white setae internally, anteriorly and posteriorly. From *C. chinensis* (L.) it differs by its dorsal margin of abdominal segments devoid of any white patches, eyes moderately bulging and antennae serrate in male. Species 3.0 to 3.5 mm long, red to reddish black, antennae dark brown or black, serrate in both sexes, legs reddish, elytral colour variable and depending on the maturity and its markings range from reddish to reddish black.

In India they are important pest of pulses in stores. Its larvae yellowish white in colour, somewhat C-shaped, about 4.5 mm. in length. It can be separated from the larvae of *C. analis* by its clypeus devoid of any pits and frons with 4 pairs of setae. The larvae bore into seed and eat up the grain karnel and make a cavity, larvae spent their entire life within the seed which takes about 20 days. Pupation takes place in a chamber just under the tests of seed, pupation takes about 7 days to complete, and adults are harmless. Aitken (1975) noted that optimum condition for rapid development is near to 33°C and 90% relative humidity. They can breed from 20°C to 35°C. It has been recorded that there are two types of adult forms live in a population, one is active which are called as 'flight form' and other is normal or 'flight less form' They differ mainly on pygidial and elytral markings. The 'flight form' live a little longer than 'normal forms' and can fly for upto about half a mile.

17. **Callosobruchus chinensis** (L.) (Figs. 27, 28)

This is originally an Oriental species and spread all over the world through trades but generally do not survive in cold climatic zones. The species *C. chinensis* can be recognised by its body being reddish black to black, legs red except the basal portion of hind femur, eyes bulbous, strongly emarginate, antenna dark brown, joints 3-11 serrate in female and pectinate in male, pronotum subconical and dark brown to black, scutellum prominent and swollen with shiny coating, posterior

half of elytra darker than anterior one-third covered with yellowish and white hairs. Species 2-3.5 mm in length. Males can easily separated from the female in having longer and pectinate antennae in male, whereas antennae short and subserrate in female, elytral tubercles absent in female but present at the bases of 3rd and 4th striae in male. The differences between *chinensis* (L.) and *maculatus* (F.) are discussed earlier. In India this species has been spread all over the country where the pulse crops are cultivated. This is a severe pest of lentils, and also causes damage to peas, grams, soyabeans etc. In India, they have been found destroying Chana or Chhola (*Civer arietinum*), masure (*Lens esculentus*), mung (*Phaseolus aureus*), arhor (*Cajanus cajan*) and pea (*Pisum sativum*).

Larvae yellowish white, somewhat bean shaped, length about 3.5 - 4 mm, glabrous with somewhat sclerotized head which are more prominent on lateral side. Larvae of *C. chinensis* can be separated from the larvae of *C. maculatus* by its labrum being subconical and presence of sensory pit on clypeus. It differs from *C. analis* by its labrum being subconical and premental sclerite rounded posteriorly. Howe and Currie (1964) noted that optimum condition for rapid development is 32°C and 90% RH, and can breed a little above 35°C and the lower limit is 17°C. The higher temperature often make adverse effect in their oviposition and larval maturity.

18. **Callosobruchus analis** (F.) (Fig. 29)

This species is very similar to *C. maculatus* and less so like *C. chinensis* in their appearance, habits and life cycle. This chief differences of their external characters has been discussed under *C. maculatus* and *C. chinensis*. Body yellowish to dark red, covered with grey and dark brown hairs, head small and dark brown, antennal joints 1-4 and joint 11 yellowish and 5-10 joints darker, antenna serrate in both sexes, eyes emarginate and slightly larger in male, lateral black spot on each elytron separated by a band of white setae and pygidial median band white and distinct. Species 2 to 3.8 mm in length. Male can be separated from the female by its antenna being slightly thickened, the elytral spots separated by a patch of dull white setae in male whereas in female spots are separated by patch of shining white setae.

This is a true storage species and capable to infest several times to produce successive generations in dried stored pulses and attaek all

kinds of pulses like *C. maculatus* and recorded from sorgum, ground nut, soyabeans, oilcake and coffee. Larvae C-shaped, about 3.5—4 mm in length, yellowish white, head laterally and posteriorly more sclerotized, frons with 3 pairs of setae and associated with a pair of pits. clypeus having a pair of lateral setae and with sensory pit at the base. Howe and Currie (1964) noted that optimum conditions for rapid development varies from 30°C—35°C. This is a predominently oriental species.

19. **Caryedon serratus** (Olivier) (Figs. 30—32)

This is a pest of imli or tetul *(Tamarindus indica)* in India where tamerind is cultivated, specially in Chotonagpur district of Bihar. This species probably originated in India and spread over many tropical and subtropical parts of the world. They are also known from several other wild legumes but probably *T indica* L. is their primary host. In India they have been recorded from *Cassia fistula*, *Acacia arabica*, *Acacia farnesiana*, *Albizzia lebbek*, *Albizzia pennata*, *Bauhinia malabarica* and *Bauhinia recemosa*.

The systematic position of this species is confused for many years and has been referred to under the names of *Caryedon fuscus* (Goeze), *Caryedon gonagra* (F.). This species can easily be recognized by their large size (7—7.5 mm in length), greyish or yellowish brown in colour and clothed with pale yellowish setae, head constricted behind the eyes, hind femora with a strong tooth below the middle and followed by 10—12 smaller tooth, pronotum coarsely punctate and covered with pale yellow setae, elytra elongate and covering the base of pygidium in both sexes, front and middle legs testaceus and hind leg dark brown, tibiae strongly curved and its inner apical angle produced into a long process. The male can be separated from the female by its antennae being comparatively deeply serrated and last visible sternite of abdomen narrower. This species has been recorded for several times from Chaibasa (Bihar), Calcutta (West Bengal), Jammu & Kashmir, Delhi, Chandigarh (Haryana), Bombay (Maharashtra), Madras (Tamil Nadu). This species is also attacked nuts, cocoa, beans, cotton seed cake in Africa.

They generally infest just before harvesting. Larvae brown, covered with minute setae, about 3.5—6 mm in length, head with 3 pairs of ocelli, highly sclerotized, labrum with 3 pairs of median marginal

setae and frons with three sensory pits but without setae. The larva on hatching out burrows into the pod and live in one of the seed. The larvae eat out the interior of the seed and leaving intact external thin brown skin. Pupation take place in a papere cocoon outside the pods and sometimes protruded through exit hole near the base of the seed skin. On maturing beetle bores through the skin and the pod-covering and escapes. It has been mentioned by Aitken (1975) that breeding can be achieved within a temperature range of 23°C—35°C and life cycle is completed within 42 days at 30°C with 70% RH.

20. **Bruchus pisorum** L. (Figs. 33, 34)

This is popularly known as 'pea beetle' and widely spread in plains and hills of India like West Bengal, Punjab, Uttar Pradesh, Himachal Pradesh, Jammu & Kashmir, Rajasthan etc. Sexes of this species can be separated by its middle tibia of male having a spur near its distal end and hind femur with a short dent on the inner carina, but in female middle tibia without a spur and dent on the inner margin of hind femur absent. This species can be characterised by its head being black, frons and clypeus covered with dirty white setae, not carinated, elytra black, elongate and rounded at apex, eyes emarginate, antennae serrated, pronotum black, lateral margin emarginate and with a short spine before emargination and covered with white plae setae with a pateh in the middle, humeral callosities of elytra well developed, middle leg in male with an apical black spur, last abdominol segment with two blackish spots on its dorsal side. Larvae of this species are been shaped about 4—5 mm in length, whitish with oval and glabrous head, frons with 3-prominent setae and a sensory pit on either side, antennae 2-jointed with basal joint membranous and apical joint long and sclerotised and legs three segmented. The common host plants of this species are *Pisum sativum* L. and *Lathyrus odoratus* etc.

8. Family ANOBIIDAE

Representatives of this family are commonly known as 'Death watch beetles' and are well known for the destruction they cause to wood, several of them are serious pests of timber and furniture. Species are usually small 2—6 mm in length, shape subcylindrical or oval, colour brown or piceous, head deflexd and often covered by pronotum, antennae serrate or pectinate, legs contractile, tarsi

5-5-5 and its segments 1 usually long. This family includes two species which are associated with stored products, *Lasioderma serricorne* (F.) and *Stegobium paniceum* (L.)

21. **Lasioderma serricorne** (F.) (Figs. 35—37)

This is commonly known as 'Cigarette beetle', and is a serious pest of tobacco and its products, spices, oilcake and also attack sagu flour and stored cereals. Recently, it has been recorded by us that they are causing severe damage to dried fish and stored Dhania at Calcutta during the month of June, 1977. Both adults and larvae can be build up high population very quickly and cause considerable damage.

The species can be easily recognised by its small size (2—4 mm), oval, reddish yellow to brownish, head bent down at right angle to the body, antennal joints 4—10 serrate, tarsi simple and its formula 5-5-5, and elytra not striate. This species is wide spread throughout the tropics and subtropics. In India it causes considerable damage to oilcakes and spices and observed, it has varied tests in food and attack both plant and animal material. This species can be confused with *Stegobium paniceum*, which are somewhat similar in appearance and size, but can be separated by following characters :

Lasioderma serricorne (F.)	*Stegobium paniceum* (L.)
1. Antennal joints 9—11 not enlarged and 4—10 serrate	1. Antennal joints 9—11 forming a distinct club
2. Species small and broader	2. Species slightly longer and narrower
3. Elytra not striate	3. Elytra striate
4. Prefers tobacco, spices and oilcake	4. Prefers mainly drugs and spices
5. Development usually uot possible below 19°C and life cycle complete with 26 days.	5. Development possible even in 15°C and life cycles complete about 40 days.

Detailed biology has been worked out by Howe (1957). Females are capable to lay eggs soon after emergence of a week or so and about 100 eggs. The newly hatched larvae are very active, negatively

phototactic and capable of penetrating tiny holes and can attack undamaged cereals, grains and pulse seeds. Older larvae are scarabaeiform and less active. The 4th larval instars stop feeding and builds a cell on some firm foundation in which pupation takes place. Larval development takes 17—30 days but may be longer, in cooler conditions. Pupation takes 3 – 10 days. The total developmental period from egg to adult is quite variable but unber favourable condition it takes from 6—8 weeks. This beetls breeds anywhere at temperatures above 19°C and above RH of 20—30% but 30—35°C and 60—80% RH are optimum and no development takes place below 18C°

22. **Stegobium paniceum** (L.) (Figs. 38 – 39)

The genus *Stegobium* Mostchulsky includes only one species *S. paniceum* (=*Sitodrepa panica*) which is one of the most serious pest of species, confectionary, drugs and variety of dry foodstuff, vegetable matter and cereal products. This species is commonly known as 'spice beetle' of the orient, 'bread beetle' in United Kingdom and 'drug store beetle' in America.

This species can easily be recognised by its form being almost cylindrical, about 2.5 mm in length, rust-red colour and witn fine sticky pubescence, antennae with a large, loose three-jointed club, prothorax with its basal middle part not humped but forms a hood covering the head when viewed from above, and elytra striated. The adult spice beetle can be mistaken for the common 'furniture beetle' (*Anobium punctatum*) but latter can be easily distinguishable by its darker colour (brown), a distinct hump seen on hood like prothorax when viewed from side and unlike *Stegobium paniceum* which attacks wood. It is known to be a general feeder, attacking a great variety of stored foods, seeds and other materials. It is frequently found in store houses and granaries in all parts of the world. Both the adults and larvae are destructive. This species is recorded in India from West Bengal, Kerala and Maharastra.

The first sign of an infestation is always the appearance of number of the adult beetles, usually wandering near food staff. Adult beetles do not feed or live about 8 weeks. The eggs are laid by female as many as 100—125 on almost any dry organic materials. It requires 4—8 days for hatching under favourable condition. The small, white

or srightly yellowish larvae emarge from the egg and make tunnel on food substances. Larvae are 0.5 mm in length, slightly curved and covered with fine golden hairs. Larvae are very active and crawls about in search of food. They moult their skin several times and when fully grown they become about 5 mm in length, finally they constructs a cell around itself from foodstuff mixed with saliva and transform into pupal stage. Larval period lasts for about 3—5 weeks and pupal period takes only 6 to 10 days, then adult emarges and restarts the life cycle. The entire life cycle may be passed in less than two months and generally ranges from 6—10 weeks. In cool climates there are one generation in a year but in warmer climates there can be as many as four generations in a year. They are active between 10°C and 35°C and very resistant to dryness.

9. Family DERMESTIDAE

Representatives of this family are commonly known as 'Skin beetles', mostly scavangers, feeding on animal and plant material of high protein content. They are usually oval and compact in shape, covered with hairs or scales, size 1 to 12 mm, colour variable, head small and deflexed, antenna clubed and lie on antennal cavities in respose and hind coxae excavated. The genera *Trogoderma* Latreille, *Anthranus* Fabricius, *Attagenus* Latreille and *Dermestes* L. include most of the injurious species of Dermestidae. So far, the species *Anthranus flavipes* Leconte (from crushed bone), *Attagenus cyphonoides* Reitter (from oil cake), *A. fasciatus* (Thunberg) (from myrabolans) *A. megatoma* (F.) (from rice bran, oil cake and species), *A. pellio* (from rice bran) and *Trogoderma granarium* Everts (from oil cake) are recorded from India. Of these last mentioned species *Trogoderma granarium* is most iujurious and widely distributed in India. This species can feed both animal and plant material.

23. *Trogoderma granarium* Everts (Figs. 40, 41)

It is commonly known as 'Khapra beetle', which feeds exclusively on vegetable matter and attack a wide range of cereals, oilseeds and their derivatives. This species has previously been recorded under several names by various authors, namely, *Attagenus undulatus*, *Aethriostoma undulata*, *Trogoderma khapra* etc. *Trogoderma granarium* can be recognised by its size being small (ranging from 1.5—3 mm in length), convex and oval in shape, colour varies from pale brown to black, antennae

somewhat robust, subserrate, with pedicel small, antennal club four-segmented, eyes evenly rounded, elytra more or less unicolourous or have indistinct red brown marking. Sexual dimorphism is well marked, males are smaller in size, often females are about twice in size than males.

Being a primary pest, they damage the grain starting with germ portions and genearlly prefer dried vegetable matter but serious pest of broken pulses, oilseeds and their cakes etc. Damage mostly done by larvae which reduce grain into frass and adults are short-lived and harmless. Excessive moulting of the species creat public discrimination, less of market appeal due to insanitation caused by cast skins frass and hairs. Crowding of larvae also lead to unhygienic condition in warehouse. Aitken (1975) noted that *T granarium* is thought to have originated in India and has been extensively spread all over the world through trade.

Detailed biology and life-history has been studied by Atwal and Bains (1969—1974) in India. They noted that *T. granarium* passes 4 to 5 generations from April to October and November to March, life-history has been studied in broken wheat grain at constant temperature of 35°C. Adult female lays 80—125 eggs. Larvae are active, move and feed freely, they are yellowish brown in colour and clothed with long hairs, Integument between the segments and ventral side of the body is pale yellowish. The larvae are highly resistant to starvation and may live for months or even years without food. Hiding habit in cracks and crevices are most distinctive. As such it is very difficult to be killed with contact insecticides. Pupation takes place on the surface of the grain in bulk and overlapping edges of bags. Pupal period lasts for 5—8 days. Adults are short lived, for about 14 days and harmless. Life cycle is completed in 25 days under optimum conditions (35°C) with about 12 generations per year. Under favourable condition they breed so rapidly, that the larvae often appear in enormous profusion in the surface layer of the grain. As these beetles have poor power of locomotion, they are usually spread through trade.

10. Family TROGOSITIDAE

The representatives of the family Trogositidae (=Ostomatidae) is difficult to recognize except by its general appearance (Fig. 42) ;

shape elongate or oval and depressed, size 6—10 mm, head prognathus or slightly deflexed and dorsal surface smooth or rugosely punctate, tarsi slender, 1st tarsal segment extremely short, so that tarsi appears to be 4-4-4, elytra entire, colour brown, piceous, blue or green, rarely with errect hairs, abdomen with 5-visible sternites, legs with trochantin of the fore and middle legs exposed. Larvae are carnivorous on wood boring insects. Some feed on stored products or broken grain.

24. **Tenebroides mauritanicus** (L.) (Fig. 42)

This species is commonly known as 'cadelle beetle', sometimes it is also called as 'bolting cloth beetle' for its habit of cutting the silk cloths of bolting reels. This species is originated in Africa and gradually widespread throughout the temperate, tropical and subtropical regions of the world and is frequently found in mills, granaries and store houses where it infests flour meal and grain. They generally infest oilseeds and oil cakes, grain products, cocoa beans, rice and rice products, nuts and occasionally on spices and illipenuts. Both the larvae and adults have the destructive habit and destroy the germ portion of grain and usually attack infesting broken grain. This species can be easily recognized by its colour being black, elongated, oblong, flattened, shiny, glabrous, antennae shorter than head and pronotum together, last 4—5 joints of antennae abruptly enlarged and clubbed ; prothorax strongly constricted at base and distinctly separated from the base of elytra, elytra without longitudinal ridges, pygidium not exposed, species 8—10 mm long.

Female oviposit during greater part of their lives and usually lays about 1,000 eggs by each female under favourable conditions. The eggs are white and are laid in clusters in the food material. In summer incubation period last for 7—10 days. Larvae about 3/4'' long, fleshy, dirty or chalky white and terminating posteriorly into two dark points which are black ; head and thoracic shield also black in colour. Larvae complete their growth within 2—14 months and then transformed into pupa. Both larvae and adults can live for considerable periods without food and frequently remains hidden in the wood work of bins for long time, even after removing the grains also. Girish & Pingale (1968) mentioned that adults & larvae, both are very resistant to cold and can survive for several weeks at temperature as low as 8.9°C and can withstand one hour at 17.8°C.

11. Family TENEBRIONIDAE

Tenebrionidae is a very versatile family, representatives of this family are found in almost all habitats. Some are severe pest of stored products, many species inhabit forest, in litter of forest floor, under bark of logs and stones, decayed trees, in tree fungi, some found in ants and termite nests and many species adapted to arid conditions of desert. They are usually scavangers, feeding on decaying vegetation, animal waste products, humas of soil, roots and stems of plants, cereals, fungi and some are agricultural pests. Among the large number of species only a few of them are serious pests of stored products, nevertheless, they include maximum number important pests of stored products. The representatives of Tenebrionidae not always easily to recognize but can be distinguishable by following characters : body hard, antennal insertion hidden under frons, elytra usually completely covering the abdomen, abdomen with five visible sternites and first three segments connate, front coxal cavities closed behind, heteromerous tarsi, tarsal segments and claws simple. The genera *Tribolium* Macleay, *Palorus* Mulsant, *Latheticus* Waterhouse, *Tenebrio* Linnaeus and *Alphitobius* Stephens include most of the major and serious pest of stored products. Among known tenebrionid pest of stored products, following species have been recorded from India : *Tribolium castaneum* (Herbst), *Latheticus oryzae* Waterhouse, *Alphitobius laevigatus* (F.), *A. diaperinus* (Panzer), *Gnathocerus maxillosus* (F.), *Gonocephalum bilineatum* (Walker), *Himatismum villosus* (Haag-Rutenberg), *Palorus ratzeburgii* (Wissmann), *Palorus ficicola* (Wallaston), *Palorus subdepressus* (Wallaston), *Polycoelogastridion tenuipes* Kaszab, of these first mentioned three species are recorded in India as serious pests of various stored products, others are recorded from illipenut, nutmegs, broken rice, tea, ground nut, rice, and products and oil cake respectively.

The genus *Tribolium* can be recognised by its antenna being longer than head and with 3-jointed compact club or loose 4-jointed club, elytra with at least lateral intervals finely but distinctly carinate, male devoid of tubercle on head, first segment of hind tarsi as long as segments 2 and 3 together, species 3—6 mm long. There are three chief species namely *Tribolium castaneum* (Herbst), *T confusum* Jacq. du Val and *T madens* (Charpentier), last two mentioned species are not recorded as pest from India. *T madens* can be easily recognized by its colour being black and larger in size. The species

Tribolium castaneum and *T confusum* are very similar in appearance and their chief differences are as follows :

T castaneum (Fig. 43)	*T confusum*
1. Antennal club distinctly 3-jointed	1. Antennal joints gradually enlarged to form club.
2. Head not expanded on each side in front of eye	2. Head expanded on each side in front of eye
3. Eyes not margined above	3. Eyes margined above
4. Eyes separated by about width of each eye when seen from below	4. Eyes separated by more than width of each eye when seen from below
5. Species usually smaller, 3—4 mm long	5. Species usually larger, 4—6 mm long

25. **Tribolium castaneum** (Herbst) (Figs. 43, 44)

Tribolium castaneum (Herbst) is commonly known as 'rust red flour beetle' and by far the most abundant and destructive among known pests of stored grains and other products. Though cosmopolitan in distribution, they are particularly predominant in India and other warmer parts of the world. They attack almost every edible thing, we can think of. Man with all his modern methods of control has failed to control these minute beetles. The species *T castaneum* was first described by Herbst (1797) as *Colydium castaneum*, thereafter, it has been recorded under various synonyms. Macleay (1825) has placed it under the genus *Tribolium*. One of us (Mrs. Sengupta, 1965) noted that *T castaneum* show maximum attraction for 'Suji' flour and their other favourable foods are sagu flour, wheat flour, gram flour and can easily make flour unsuitable for human consumption and also severe pests of oilcake, copra, oilseeds and illepenats. The eggs are laid singly, delicate, white in colour and oval in shape. The outer surface of shell is more or less smooth and coated with mucilagenous material which may be act lubricant for egg laying. Incubation period lasts for 4—5 days, when the embryonic development is completed, the larva comes out through the opening made by them. The entire hatching takes 16—20 minutes. The newly hatched larva is an extremely delicate, transluscent white, small, slender and wormiform and gradually become creemish in colour. Its length varies from 6—8 mm. Full grown larva is cylindrical in form and passes through a series of instars. Total larval period varies from

22—30 days with an average of 25.3 days having temperature range 22.5°C– 34.5°C and RH 70%. Pupal stage lasts for 1—2 days. The prepupa changes into pupa which is naked and exhibit violent abdominal movements. At first pupa is white, covered with bristles and gradually changes to light brown colour just before the emergence of adult. Mortality is maximum at a temperature of 45°C and optimum RH beyond which they hardly survive. *Triboluim castaneum* is negatively geotropic and preferred more suji amongst wheat flour, gram flour and suji [Dr. (Mrs) Sengupta, 1965 unpublished Ph. D. thesis]. Larva of *Tribolium* elongate, cylindrical whitish with yellowish tinge in colour. Head and targa of all segments covered with tactile yellow hairs and more numerous on 9th abdominal segment. Ocelli represented by two transverse group of pigmented spots. Antennal joints in the ratio of 1 : 2 : 1 Clypeus bearing two setae near each side margin. Mandibles apically bifid and bearing three setae on dorsal side. Hypopharyngeal sclerome absent. Prothoracic legs slightly larger than meso and meta thoracic pairs. Spiracles annular. Urogomphi directed upward and backward.

26. **Latheticus oryzae** Waterhouse (Fig. 45)

Latheticus oryzae Waterhouse is a fairly common pest of stored products and popularly known as 'long headed flour beetle' This species can easily be recognised by its narrow, subcylidrical body, light brown eyes always partly divided by backwardly produced side margin of head, length of antennae shorter than head and with distinct 5-jointed compact club, hind tarsi with basal segment not as long as the combined length of the two following. This species may confused with the species of *Tribolium* and can be easily separated by its length of antennae distinctly shorter than head and 5-jointed club. Both the larvae and adults attack milled products. They generally preferred cereals flours (wheat, corn, barley, rye), packaged food rice and rice products. This species is now distributed throughout the world infesting grain and grain products causing the same type damage as done the confused flour beetle (*Tribolium confusum*) and common in rice and flour mills.

Female lays 400 white, smooth cylindrical eggs at random in grains. Incubation period lasts for 7—12 days. Under favourable conditions egg hatches out into small, white, active larva which feeds voraciously. Larva period last for 15—80 days depending upon the

temperature. Pupa is naked. Pupal period lasts for 5—10 days. Adults are less resistant to cold temperature. Life history studied by Hafeez and Chapman (1966), life cycle is completed in 25 days at 35°C and 95% RH. and practically no development at 25°C.

27. **Alphitobius laevigatus** (Fabricius) (Fig. 46)

This species is popularly known as 'black fungus beetle' and usually prefer damp and mould grains and unable to infest sound & healthy grains. They are usually a serious pest of illipenuts and less so to grain and grain products and oil seeds. It is quite common, widely distributed and abundantly occur in India and recorded several times from West Bengal, Assam, Uttar Pradesh, Rajasthan and Andaman Islands. This species is somewhat similar to *Tenebrio* species but can be separated by its size being small (6 mm in length), lateral margin of prothorax curved, pronotum densely and coarsely punctured, eyes almost completely divided by backwardly preduced side margins of head. From *Tribolium* sp. it differs by its lateral margin of elytra and prothorax broader and not distinctly curved. Very little is known about the life history of this species. Howe and Burges (1952) observed that 70% RH was necessary for long adult life and successful oviposition. Egg stage is not susceptible to low humidities but young larvae require moist conditions. Larval period lasts for a month at 35°C.

28. **Palorus ratzeburgii** (Wissmann)

This species is popularly known as 'Small eyed flour beetle' and recorded more frequently and common in stored products than any other species of *Palorus*. It is cosmopolitan in distribution and infests grain and grain products, particularly on material containing wheat germ, but less on barley, rice and maize products and commonly found in granaries, warehouses and flourmills etc. Cotterell (1952) recorded this species from stored ground nuts, maize and cassava meal in South Nigeria. This species is rather less common in India and so far recorded from Calcutta in stored grains (Broken rice) in the month of March and it occurs in association with primary pests (*Sitophilus* oryzae). The members of the genus are usually live under bark in association with Scolytidae and Bostrychidae. This species is small (2.5–3 mm), somewhat flattened, slightly oblong, shiny, reddish brown, anterior margin of head moderately explante and slightly inflexed upward ; antennal insertion hidden by the expansion

of frons, antennae short and joints progressively widened towards apex, joint 3 slightly longer than joint 4 and without distinct club ; eyes rather small, round and not projected, ridge above eyes feeble and indistinct ; prothorax slightly narrowed posteriorly, head and pronotum uniformly and distinctly punctate. Puncturation on elytra arranged in distinct rows and interstices are finely and sparsely punctate. Biology of this species has been studied by Butler (1949) and Halstead (1967). The life cycle from egg to adult require 6—10 weeks. Van Emden (1948) and Butler (1949) described the egg and larval stages of this species. Larva can easily be separated from other species like *P. laesicollis* (Fairmaire), *genalis* (Blair), *P. cerylonoides* (Parcoe), *ficicola* (Wollaston) and *P. subdepressus* (Wollaston) by its minute urogomphi and the pupa by its short indistinct setae papillae at the pronotal apex and absence of pronotal fovae. The period require for egg+larval development at 70% RH ranging fron 20—78 days at 35°C and 20°C respectively. Larval developmental period decreased with increased humidity upto 70% RH but above 70% RH the period was increased. Favourable condition for completing its life cycle in Laboratory is 70% RH and temperature between 20°C—37.5°C. The optimum temperature for development at 70% RH is 32.5°C.

Key to the species of Major Beetle Pests of Stored Food Products in India

1. Head strongly produced in front forming a distinct beak or proboscis (Fig.1) ; antennae geniculate (Fig. 1) and clubbed, its scape inserted in scrobe ; gular suture confluent Larva (Fig. 2) fleshy bulky and somewhat C-shapped, head retracted, antennae reduced, legs absent, abdominal targa with 3 to 4 transverse folds ... 2
— Head without distinct beak or proboscis ... 5

2. Rostrum narrow and slender, puncturation on pronotum usually round, coarse and dense ; if sparse, puncturation will be elongate ... 3
— Rostrum distinctly short, broad and parallel-sided, puncturation on pronotum small, round and distinctly separated from one another. Species infests tamarind (*Tamarindus indica*) ... *Sitophilus linearis* (Herbst)

PICTORIAL KEY TO CO

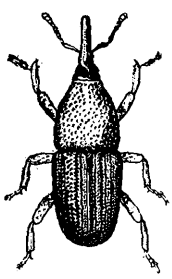
CEREALS

RICE & ITS PRODUCTS

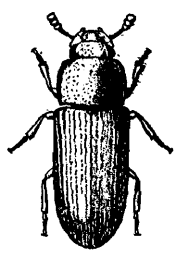
WHEAT & ITS PRODU

RICE

RICE PRODUCTS



SITOPHILUS ORYZAE



TRIBOLIUN CASTANEUN

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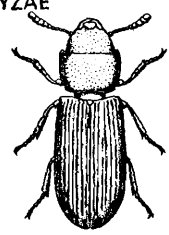
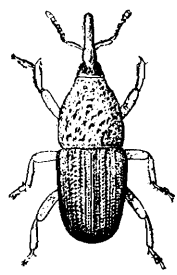


TENEBROIDES MAURITANICUS



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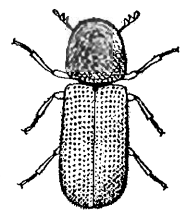
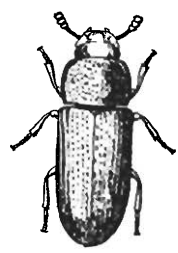
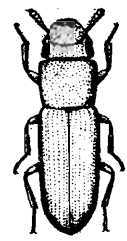


RHIZOPERTHA DOMINICA

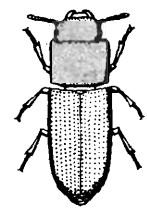
ORYZAEPHII US SURINAMENSIS



TRIBOLIUM CASTANEUM

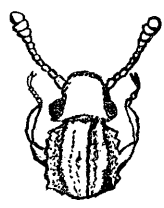


LATHETICUS ORYZAE

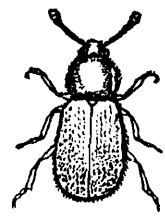


PALORUS RATZEBURGII

CASHEW NUT



ORYZAEPHILUS MERCATOR

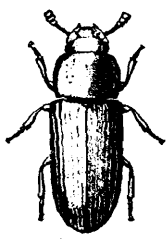


NECROBIA RUFIPES

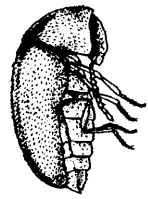
POULTRY FEED

DRY FISH & ANIMAL PRODUCTS

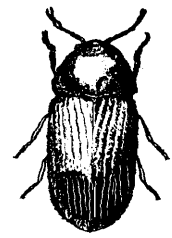
DRUGS



TRIBOLIUM CASTANEUM



LASIODERMA SERRICORNE



STEGOBIUM PANICEUM

3. Puncturation on sides of pronotum round, rather coarse, deep and very dense. Elytra with more or less contiguous double rows of coarse deep punctures and rows are separated by a narrow punctate intervals, generally infest whole grains e.g. rice, wheat etc. ... 4

— Puncturation on pronotum sparse and elongate, elytra with deeply impressed and feebly punctate striae, intervals smooth, alternately wider and more elevated which are more distinct near base ; infests whole grains e.g. wheat, maize etc ... *Sitophilus granarius* (L.)

4. Microsculpture of prothorax and elytra more alutaceous, dorsal surface comparatively duller, aedeagus convex at its upper surface *Sitophilus oryzae* (L.)

— Microsculpture of prothorax and elytra less alutaceous, dorsal surface shiny, aedeagus flattened at its upper surface with two distinct longitudinal impressions ... *Sitophilus zeamais* Motschulsky

5. Elytra truncated exposing at least two abdominal segments, antenna with a distinct characteristic large, compact three segmented club (Fig. 8) ; outer edge of front tibiae dentate. Larva (Fig. 9) elongated, dorsal surface covered with small transverse rows of setae, urogomphi as figured (Fig. 9), spiracle bicameral ... 6

— Elytra usually complete, if short exposing a part of last abdominal segment or pygidium, and antenna devoid of such distinct and compact club, tibiae normal ... 9

6. Elytra short, exposing three abdominal segments. Species infests bean, oilcake, copra, coconuts, dried onion, barley, sago flour etc. *Urophorus humeralis* (F.)

— Elytra longer, exposing two abdominal segments ... 7

7. Elytra dark brown and each elytron with a large and distinct pale yellowish spot at apex and similar smaller spot at base. Species generally infests dried fruits ... *Carpophilus hemipterus* (L.)

— Elytra unicolourous and devoid of spots, sometimes its sutural region darker than the rest ... 8

8. Median longitudinal carina on mesosternum absent, an oblique line cutting off the anterior angles of metasternum forming axillary space, which is extending at least one third of the episternal suture ; species infests whole grain and grain products, sagu flour, rice and rice products, dried fruit etc .. *Carpophilus dimidiatus* (F.)

— Median longitudinal carina present at the middle of mesosternum, pronotum feebly convex and distinctly emarginate. Species infests grain and grain products, nuts, illipe-nuts, dried plum etc. ... *Carpophilus obsoletus* Erichson

9. Dorsal surface shiny blue and covered with distinct errect setae (Fig. 10), legs red, antenna clubbed ; ventral surface of abdomen dark blue, species soft bodied. Head of larva without median epicranial suture, mouth parts strongly protracted. Species infests cashew nut, palm kernels, meats & cheeses etc. ... *Necrobia rufipes* (Degeer)

— Dorsal surface never blue and without errect setae ... 10

10. Prothorax with six lateral distinct teeth (Fig. 11). or front angle of prothorax with a callosity like structure. Larva (Fig. 14) narrow elongate, depressed ; urogomphi absent, antennal segment markedly long ... 11

— Prothrax without such teeth and callosity-like structure on front angle of prothorax absent ... 13

11. Prothortx with six (Fig. 11) or more teeth on each side ... 12

— Lateral margin of prothorax (Fig. 15) without teeth, front angle prominent, produced and its tip broadly rounded, lateral margin uniformly arched and very finely serrated ; antennae slender, rather shorter than head and pronotum together ; lateral margin of elytra explanate. Larva (Fig. 16) elongated, narrow, parellel sided, somewhat depressed, antennal segments 2.5 : 9 : 1, pro and mesothorax shorter than metathorax, abdominal segments 6-8 progressively narrower, all spiracles annular ... *Ahasverus advena* (Waltl)

12. Length of temple of head about as long as 3 to 4 eye facets and length of eye usually less than twice the length of temple, infests all kinds of food of vegetable origin ... *Oryzaephilus surinamensis* (*L.*)

— Length of temple of head about as long as 2 to 2.5 eye facets and length of eye about 3.5 to 4 times the length of temple, serious pest of oil seeds. Larva (Fig. 14) with antennal segments 3 ; 7 : 1, pro & meso-thorax shorter than metathorax, all spiracles annular ... *Oryzaephilus mercator* (Fauvel)

13. Species minute (1.2 mm to 2.8 mm), flat, antennaee longated, first tarsal joint smallest, prothorax with a pair of lateral lines (Fig 17). Larva flat, 8th abdominal segment markedly long, urogomphi short and heavily chitinized, antennal segment 1 : 2 ; 2, ocelli 4 on each side, hypostomal rod parallet-sided, abdominal spiracles annular and thoracic ones bicameral ... 14

— Species larger (Fig. 12), never so flattened, prothorax without lateral lines ... 15

14. Antenna of male nearly as long as or longer than body and distinctly longer than those of female, outer margin of mandible in male evenly rounded at base ; infests broken grain and their preducts ... *Cryptolestes pusillus* (Schönherr)

— The length of antennae never exceeding two-thirds of its body length in both sexes, outer margin of mandible in male toothed at its base, attacks broken rice and its pro-ducts ... *Cryptolestes ferrugineus* (Stephens)

15. Species cylindrical, head deflexed, prothorax hood-shaped (Fig. 21) and its anterior part densely tuberculated, antennal club loose, three jointed and characteristic (Fig. 21). Larva (Fig. 22) C-shaped and fringed with a very few fine short setae, head retracted and yellowish, antenna minute, labial palpi one segment and urogomphi absent. Species generally infests whole grain e.g. wheat, rice, maize, millets, sorgum and also flour, barley etc. ... *Rhizopertha dominica* (F.)

— Species not cylindrical, prothorax normal and not hood shaped and without tubercles, antennal club different ... 16

16. Eyes markedly large and usually with a broad and deep emergination extending backwards from the base of antenna (Fig. 30) or hind fermora markedly enlarged (Fig. 30), last segment of abdomen exposed and prothorax rather characteristic (Fig. 30). Larva (Fig. 31) curved, soft, head minute, deeply retracted into prothorax, legs reduced, labial palpi either rudimentary and 1-jointed or absent ... 17

— Eyes normal and without such emargination, hind femora normal and prothorax different ... 21

17. Each eye with a broad and deep emargination extending backwards from the base of the antenna, hind tibiae straight or slightly curved ... 18

— Eyes without such emerginations, antennae serrated, hind femur with strong tooth below the middle, followed by 10-14 smaller teeth, hind tibiae strongly arched, each produced into a sharp tooth at apex, anterior region of pygiduum covered with golden and black setae ; infests (imli or tetul) *Tamarindus indica* ... *Caryedon serratus* (Olivier)

18. Hind femur with a preapical tooth on its outer lower margin, middle tibiae of male with a tooth or plate anteriorly, antennae not serrated, elytra with white setae forming two spots on second interstriae and a transverse band on it ; infests pea ... *Bruchus pisorum* L.

— Hind femur without such tooth, if present, accompanied by a similar tooth at its inner margin, antennae serrated or pectinate ... 19

19. Inner tooth of hind femur distinctly smaller than outer tooth and occasionally absent, prothorax uniformly red, antennae similar in both sexes ; usually attack pulses ... *Callosobruchus analis* (F.)

— Inner and outer tooth of femur equal, prothorax usually with spots or lines of hairs ... 20

20. Antennae dark and in male pectinate, pygidium with predominent grey hairs, eyes strongly bulgings, elytra with a pair of tubercles at the bases of 3rd and 4th striae in the male ; major pest of lentils and also attack pea, grams etc ... *Callosobruchus chinensis* (L.)

— Antennae darker and in male serrated, pygidium with yellowish hairs, eyes moderately bulging, elytra with or without tubercles in both sexes ; infests pulses ... *Callosobruchus maculatus* (*F.*)

21 Head deflexes, prothorax hood shaped (without tubercles) species usually oval. Larva (Figs. 37,39) C—shaped with protracted head and mandible dentate and body hairy or not ... 22

— Head not deflexed, prothorax not hood-shaped, species if oval, head with a medium ocellus and antenna markedly short ... 23

22. Antennae with segment 4-10 serrated, and elytra not striated ; larva distinctly and densely hairy. Species serious pest of tobaco, its product, dry fish and spices and general feeder on stored foods like sagu flour, oilcake etc ... *Lasioderma serricorne* (F.)

— Antennae normal, not serrated and segments 9-11 forming a large, leose three segmented club and elytra distinctly striated. Larva about 1 mm long, covered with fine, golden hairs and with minute brown spine across back. Species feed on biscuits, confectionary drugs, spices and variety of dry food staff ... *Stegobium paniceum* (L.)

23. Species oval, head with a distinct median dorsal ocellus, dosal surface covered with dense hairs (Fig. 40), joint 1 of tarsi as long as or longer than joint 2, eyes evenly rounded, elytra unicolourous or nearly so. Larva (Fig. 41) wider at middle and gradually narrowed anteroposteriorly and densely covered with hairs, urogomphi absent, last segment of abdomen covered with comparatively long hairs, general feeder on stored foods and fabrices ... *Trogoderma granarium* Everts

— Species elongate, head without ocelli, dorsal surface without such dense hairs ... 24

24. Tarsi 5-5-5 with joint 1 minute and not easily visible, prothorax (Fig. 42) narrowed prosteriorly, slightly constricted and distinctly soparated from the base of elytra, dorsal surface deep reddish brown to black and glabrous, apical margin of clypeus trisi-

nuated. Prothorax of larvae with well separated prosternal plates and with a well defined lanceolate median sternal plates ; generally infest broken grain ... *Tenebroides marutanicus* (L.)

— Tarsi 5-5-4 with segment 1 not smallest and easily visible, prothorax not so narrowed and constricted posteriorly closely applied to base of elytra. Larvae elongate, cylindrical, whitish with yellowish tinge in colour, ocelli represented by two transverse group of pigmented spots, spiracles annular, prothoracic legs, slightly larger than meso and metathoracic legs, anal pseudopod distinct 25

25. Head with distinct, curved, frontoclypeal suture ; antennae shorter than the length of head, apical segment of antenna (Fig. 45) distinctly narrowor than segment 10 and blunt at apex. Species parallel sided and infests broken grain and preferred particularly wheat bran ... *Latheticus oryzae* Waterhouse

— Head without frontoclypeal suture, apical segment of antenna normal (Figs. 44, 46) ... 26

26. Antennae with distinct three segmented club, lateral margin of prothorax evenly narrowed in front and behind. Species 3.0—3.9 mm in length, somewhat parallel sided and infests broken grain like wheat, rice and also flour, sagu etc. ... *Tribolium castaneum* Herbst

— Antenna progressively enlarged towards apex, prothorax either narrowed in front or more distinctly narrowed posteriorly ... 27

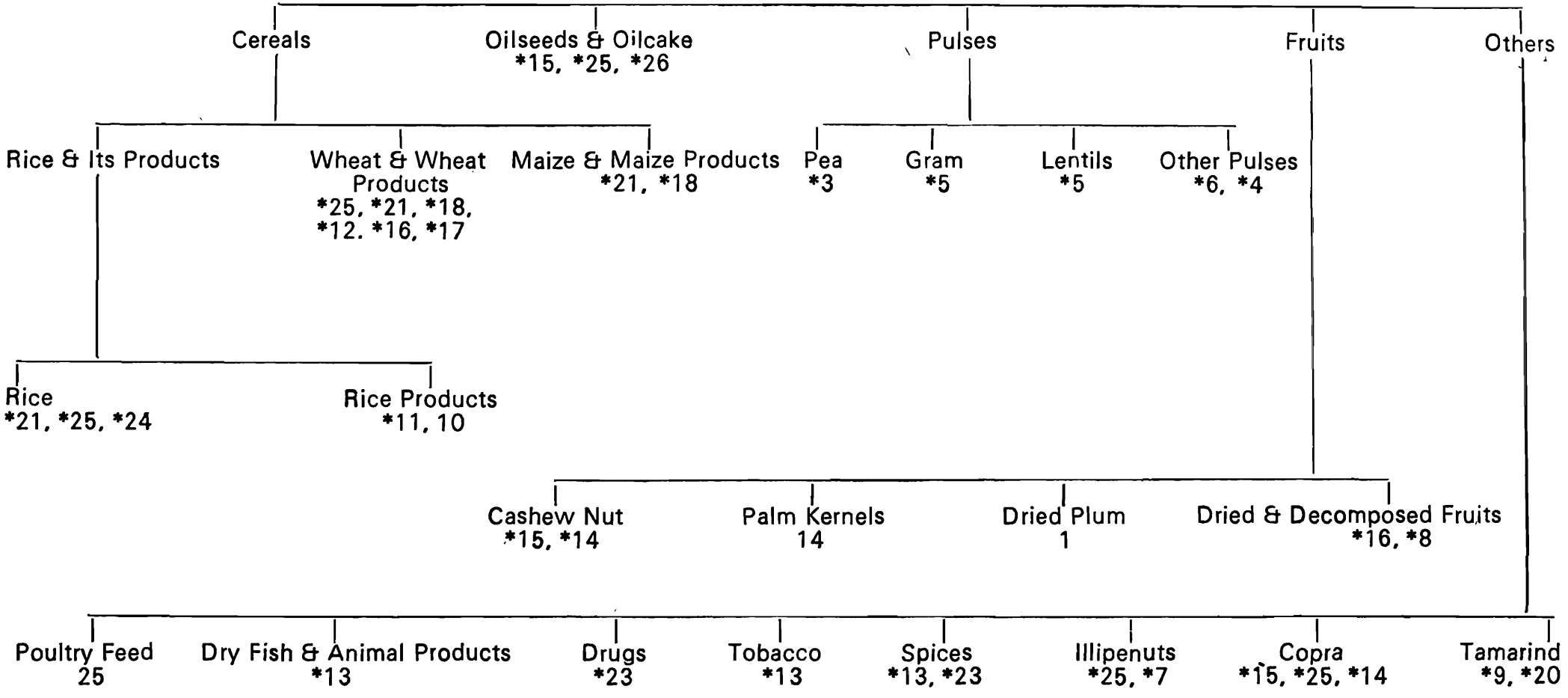
27. Species large, 4.5 mm—10 mm long or longer (Fig.46), dark brown-black in colour, elytra broadened towards apex and prothorax narrowed in front and strongly transverse, elytral striae not distinct, pests of illepenuts, wheat, oilseeds & oilcak etc. ... *Alphitobius laevigatus* (F.)

— Species small, 2.5—3 mm in length (Fig. 47), shiny, reddish brown aud somewhat parallelsided, prothorax slightly narrowed posteriorly, elytral striae distinct and attack on wheat, rice and maize products. .. *Palorus ratzeburgii* (Wissmann)

Major beetle pests of Stored food products in India

1. *Ahasverus advena* (Waltl)
2. *Alphitobius laevigatus* (F.)
3. *Bruchus pisorum* L.
4. *Callosobruchus analis* (F.)
5. *Callosobruchus chinensis* (L.)
6. *Callosobruchus maculatus* (F.)
7. *Carpophilus dimidiatus* (F.)
8. *Carpophilus hemipterus* (L.)
9. *Carpophilus obsoletus* Erichson
10. *Caryedon serratus* (Olivier)
11. *Cryptolestes ferrugineus* (Steph.)
12. *Cryptolestes pusillus* (Schonherr)
13. *Latheticus oryzae* Waterhouse
14. *Lasioderma serricorne* (F.)
15. *Necrobia rufipes* (Degeer)
16. *Oryzaephilus mercator* (Fauvel)
17. *Oryzaephilus surinamensis* (L.)
18. *Palorus ratzeburgii* (Wissmann)
19. *Rhizopertha dominica* (F.)
20. *Sitophilus granarius* (L.)
21. *Sitophilus linearis* (Herbst)
22. *Sitophilus oryzae* (L.)
23. *Sitophilus zeamais* Motschulsky
24. *Stegobium paniceum* (L.)
25. *Tenebroides mauritanicus* (L.)
26. *Tribolium castaneum* (Herbst)
27. *Trogoderma granarium* Everts
28. *Urophorus humeralis* (F.)

MAJOR BEETLE PESTS OF STORED FOOD PRODUCTS IN INDIA



Note : Those are marked with asterisk cause serious damage

SUMMARY

The present paper deals with diagnostic characters, biology, ecology, damage and their control etc. of 28 species belonging to 11 families of the Order Coleoptera viz. Curculionidae, Nitidulidae, Cleridae, Silvanidae, Cucujidae, Bostrychidae, Bruchidae, Anobiidae, Dermestidae, Trogositidae and Tenebrionidae. The keys to the species with adult and larval characters have been included. A pictorial key in respect to host of the common pest species of stored grains & their products is also given. Distribution of each species with their associates and hosts have been dealt with and 47 illustrations are incorporated.

ACKNOWLEDGEMENTS

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FIGURES

FIG. 1

Fam. 1. Curculionidae
Fig. 1. Dorsal view of *Sitophilus oryzae* (L.) 2. Larva of *Sitophilus oryzae* (L.) 3. Aedeagus of *Sitophilus oryzae* (L.) 4. Section through aedeagus of *S. oryzae* (L.) 5. Aedeagus of *Sitophilus zeamais* Mots. 6. Section through adeagus of *S. zeamais* Mots. 7. Dorsal view of *S. granarius* (L.)

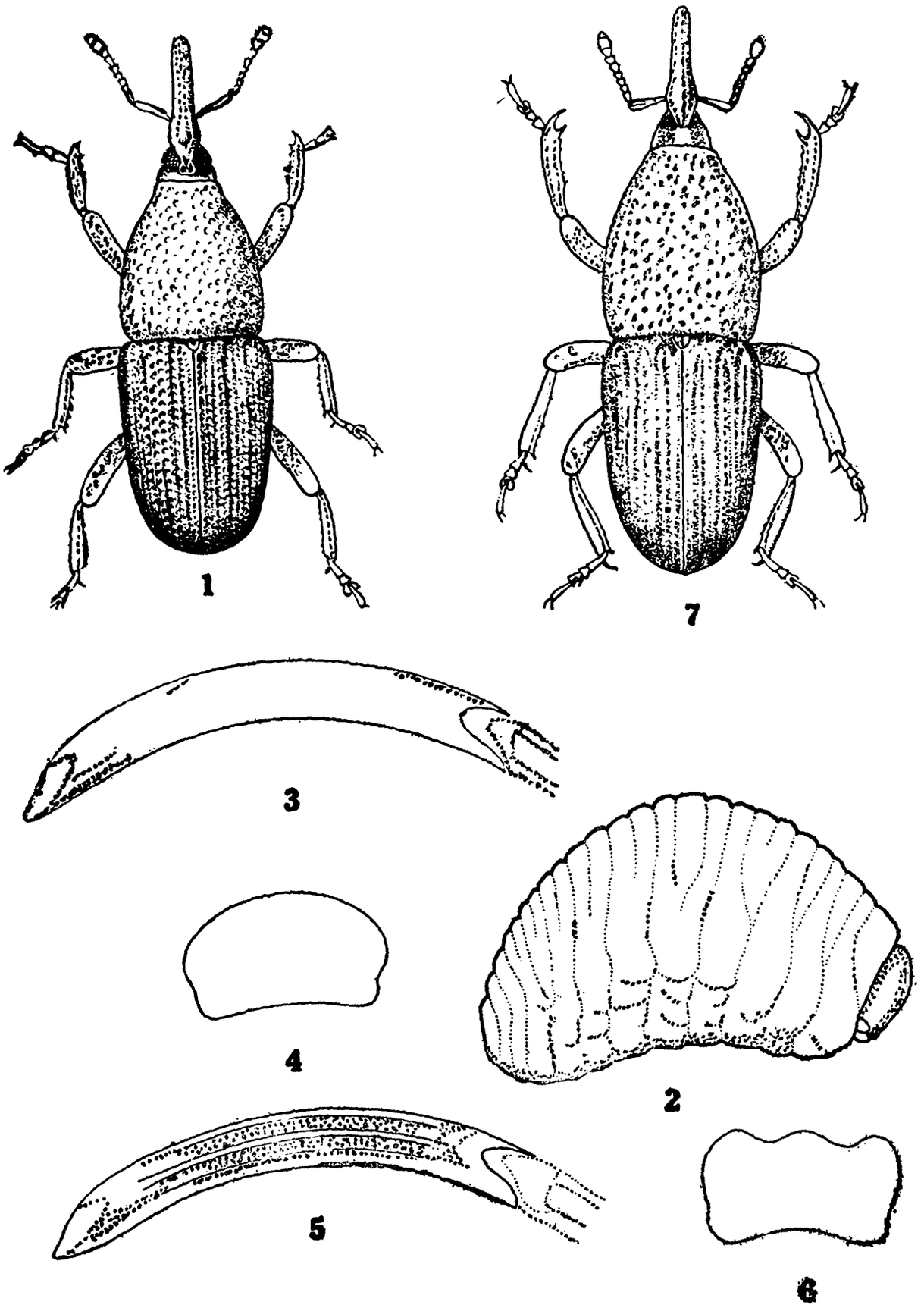
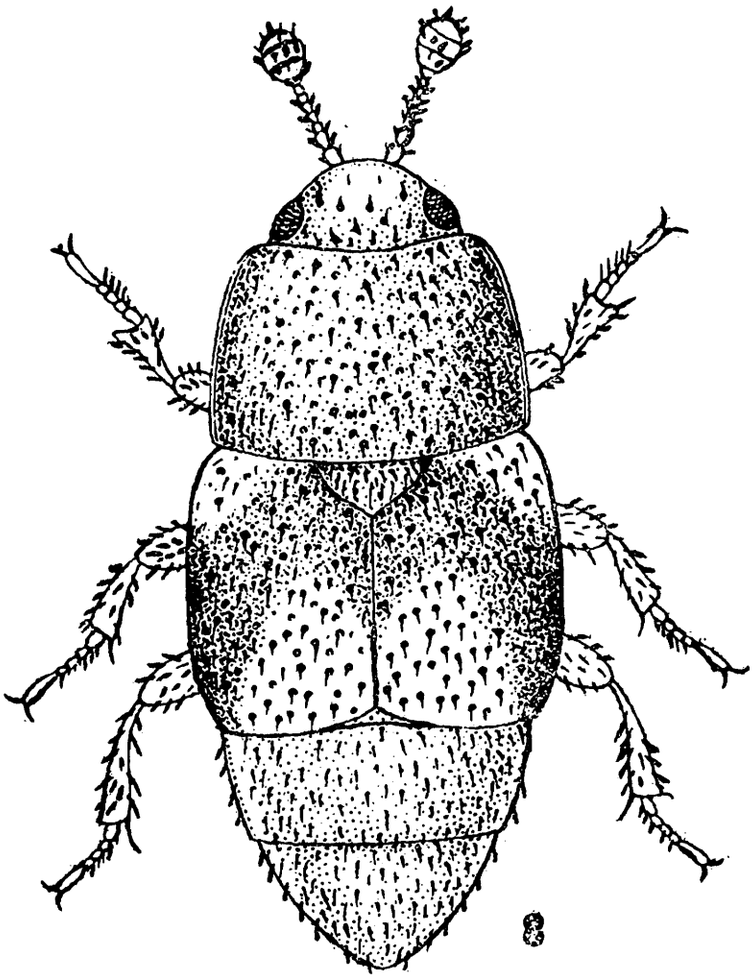


Fig. 1

FIG. 2

Fam. 2. Nitidulidae
Fig. 8. Dorsal view of *Carpophilus dimidiatus* (F.) 9. Larva of *Carpophilus hemipterus* (L.)

Fam. 3. Cleridae
10. Dorsal view of *Necrobia rufipes* (Degeer)



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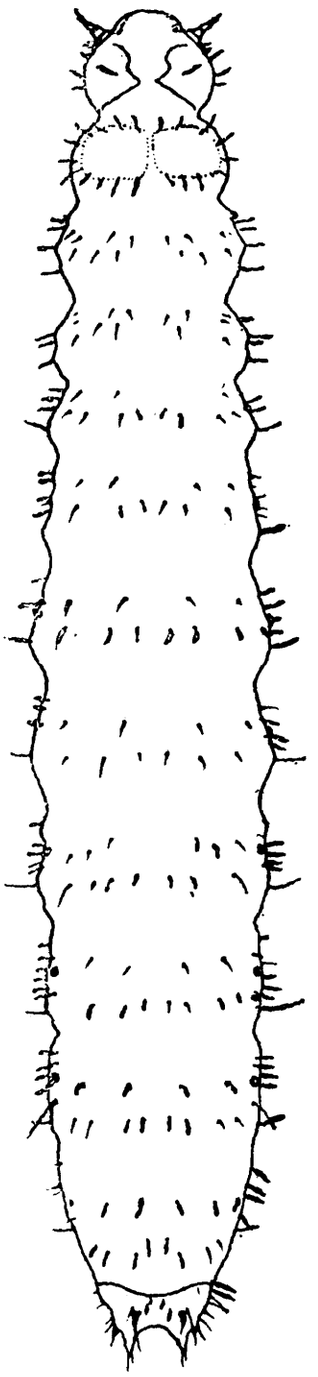

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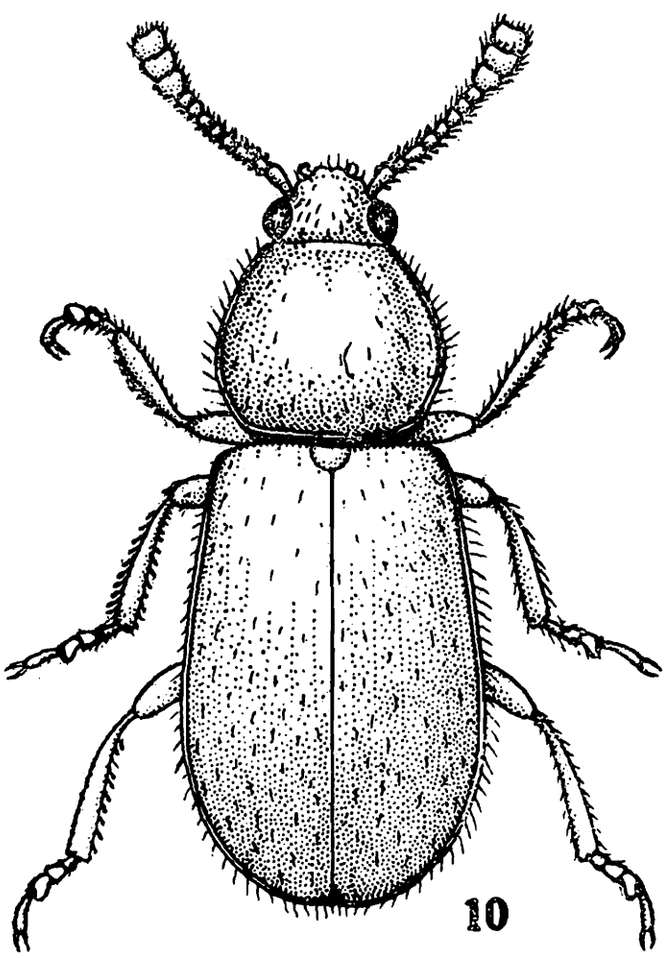

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Fig. 2

FIG. 3

Fam. 4. Silvanidae
Fig. 11. Dorsal view of *Oryzaephilus surinamensis* (L.) 12. Infested cashew nut by *O. mercator* (Fauvel) 13. Dorsal view of head-prothorax of *O. mercator* (Fauvel) 14. Larva of *O. mercator* (Fauvel) 15. Dorsal view of *Ahasverus advena* (Waltl) 16. Larva of *Ahasverus advena* (Waltl)

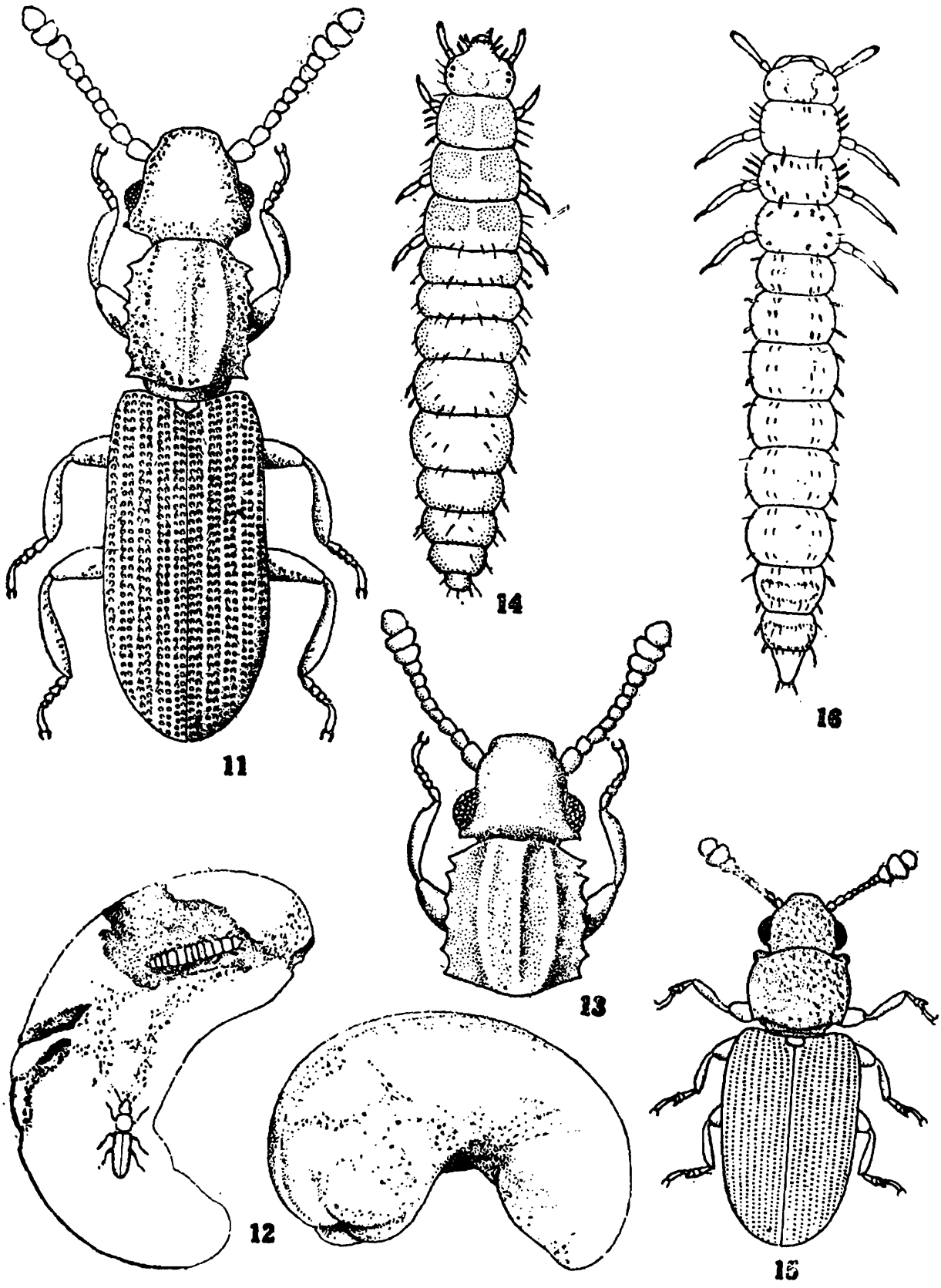

Fig. 3

FIG. 4

Fam. 5. Cucujidae

Fig. 17. Dorsal view of *Cryptolestes pusillus* (Schönherr) 18. Sclerite associated with male genitalia of *C. pusillus* (Schönherr) 18a. Sclerite associated with female genitalia of *C. pusillus* (Schönherr) 19. Dorsal view of *Cryptolestes ferrugineus* (Stephens) 20. Sclerite associated with male genitalia of *C. ferrugineus* (Stephens) 20a. Sclerite associated with female genitalia of *C. ferrugineus* (Stephens)

Fam. 6. Bostrychidae

Fig. 21. Dorsal view of *Rhizopertha dominica* (F.) 22. Larva of *R. dominica* (F.) 23. Infested by *R. dominica* (F.) 24. Larva of *R. dominica* (F.) within a gram 25. Female pupa of *R. dominica* (F.)

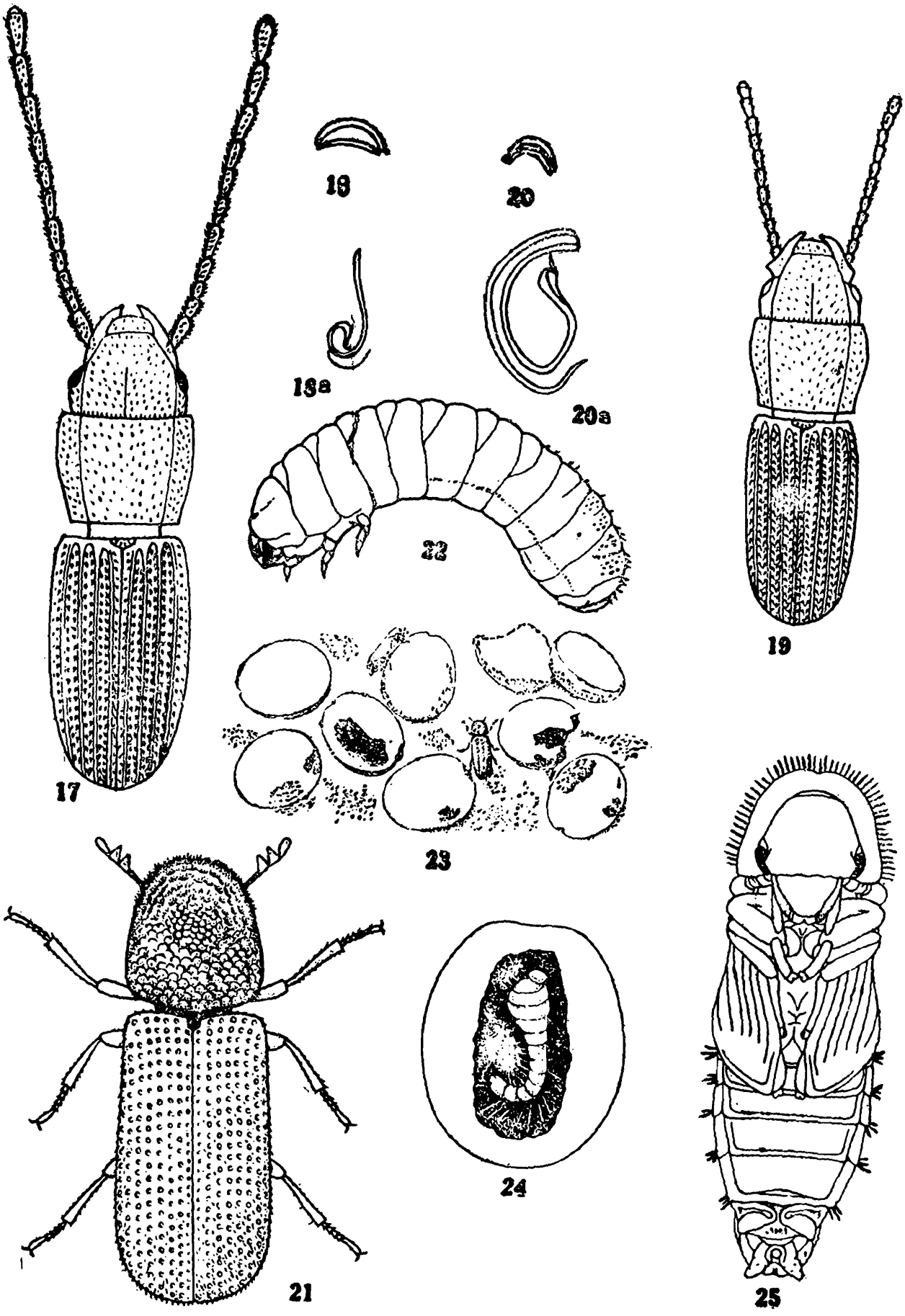

Fig. 4

FIG. 5

Fam. 7. Bruchidae

Fig. 26. Dorsal view of *Callosobruchus maculatus* (F.) 27. Dorsal view of *Callosobruchus chinensis* (L.) 29. Dorsal view of *Callosobruchus analis* (F.) 30. Dorsal view of *Caryedon serratus* (Olivier)

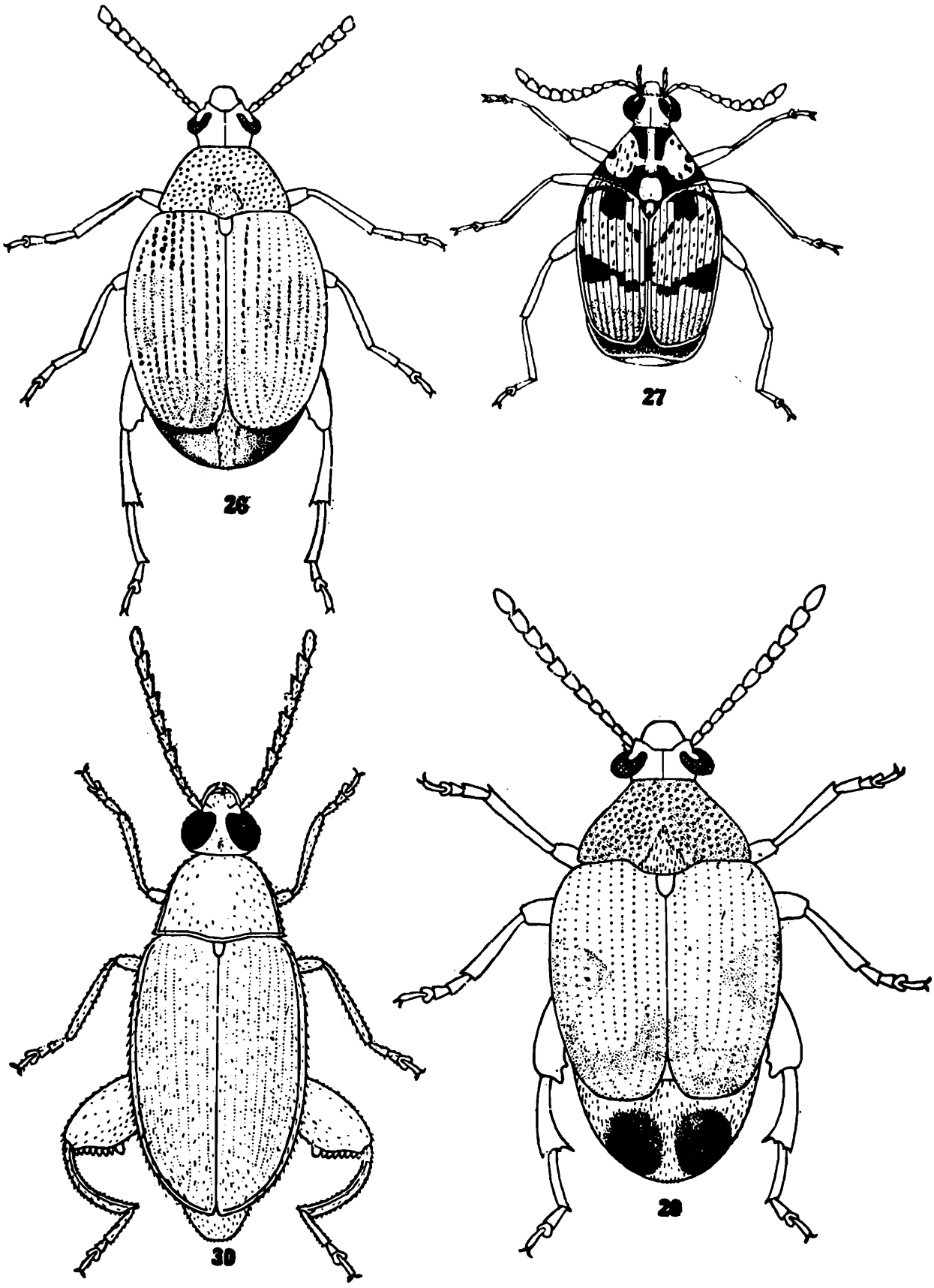

Fig. 5

FIG. 6

Fam. 7. Bruchidae

28. Larva of *C. chinensis* (L.) 31. Larva of *C. serratus* (Olivier) 32. *C. serratus* (Olivier) on infested seed of *Tamarindus indica*. 33. Dorsal view of *Bruchus pisorum* L. 34. Larva of *Bruchus pisorum* L.

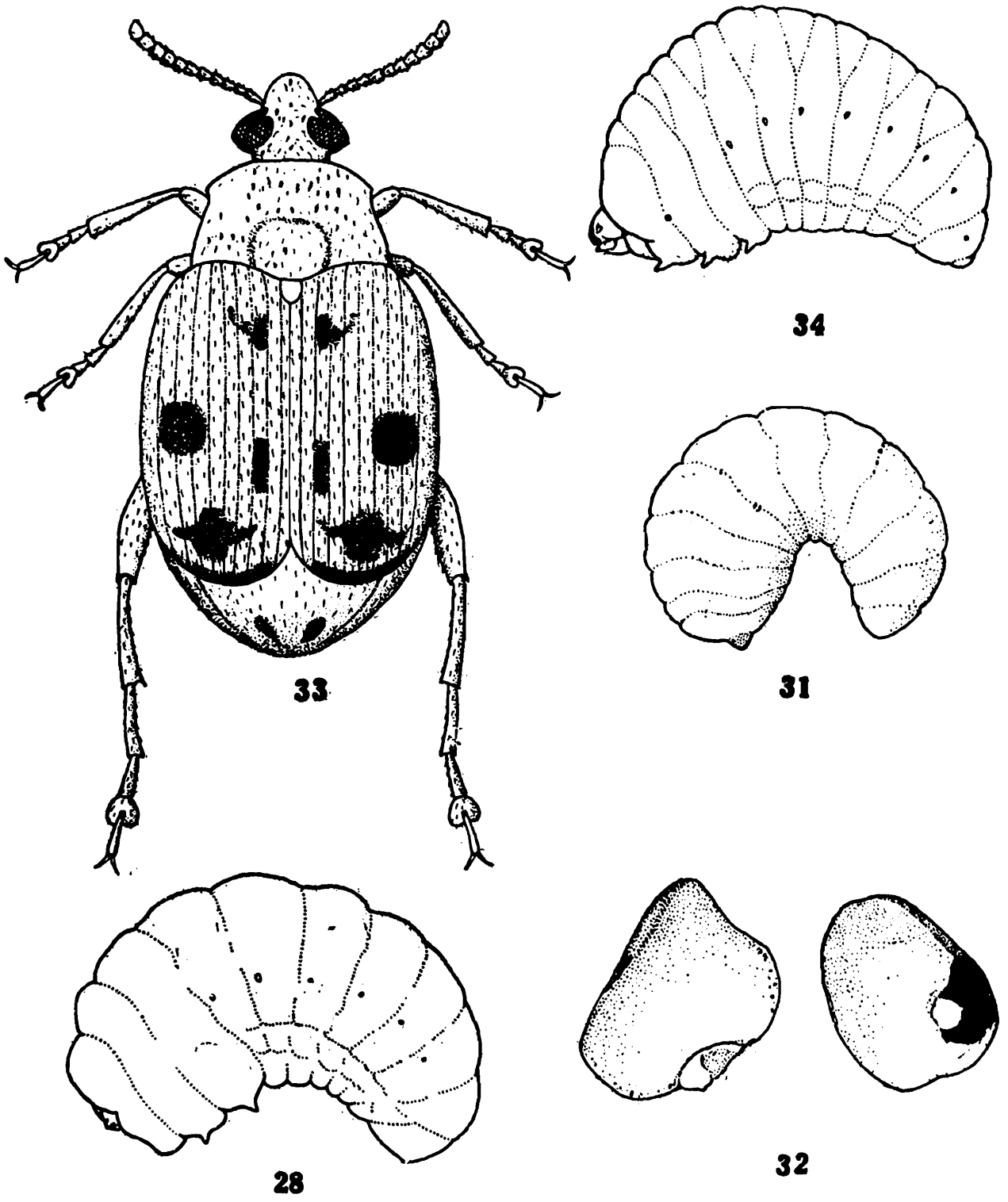

Fig. 6

FIG. 7

Fam. 8. Anobiidae
Fig. 35. Lateral view of *Lasioderma serricorne* (F.) 36. Dorsal view of *L. serricorne* (F.) 37. Larva of *L. serricorne* (F.), 38. Dorsal view of *Stegobium paniceum* (L.) 39. Larva of *S. paniceum* (L.)

Fam. 9. Dermestidae
Fig. 40. Dorsal view of *Trogoderma granarium* Everts 41. Larva of *T. granarium* Everts

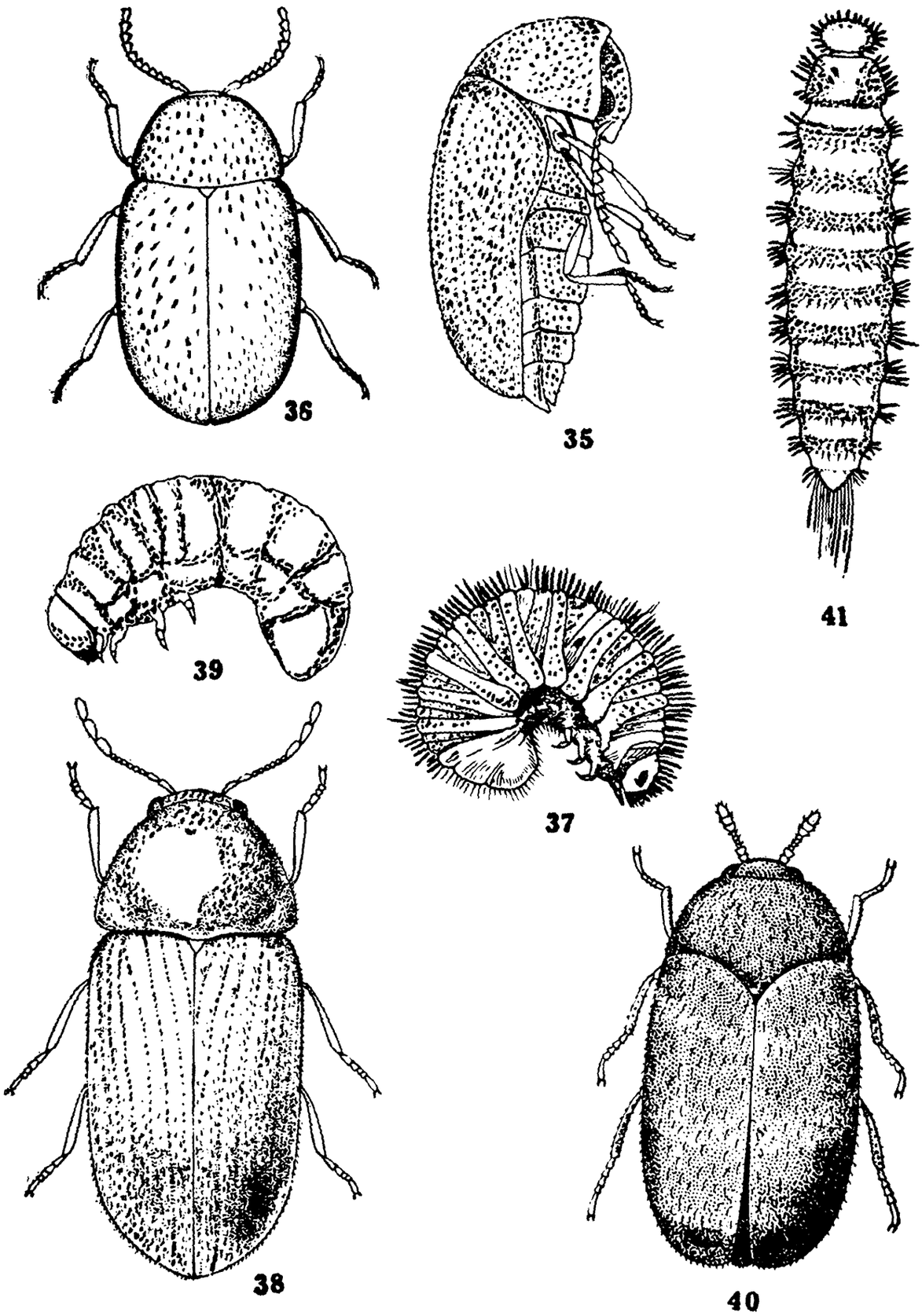

Fig. 7