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PESTS, AGRICULTURAL

PESTS, AGRICULTURAL. "Pest" refers to any animal or plant causing harm or damage to people or their animals, crops, or possessions, even if it only causes annoyance (see Hill, 1983, p. 6). Pests belong to a broad spectrum of organisms including insects, mites, ticks (and other arthropods), mice, rats, and other rodents, slugs, snails, nematodes, cestodes (and other parasites), weeds, fungi, bacteria, viruses (and other pathogens). The present article is confined to summary information on the most important insect pests that damage fruit trees and field crops in Persia. Forest insects, stored-product insects, and insects that damage livestock are not treated here.

HISTORICAL BACKGROUND

Pre-Avestan sources. The zoological encyclopedias from the Sumerian and Akkadian periods (2900-2154 BCE), known as *Harra-Hubullu*, have been described elsewhere (see LOCUSTS). Other than locusts and numerous stored-product insects, the following agricultural pests are mentioned: (1) pests of field, garden and vegetables; (2) corn worm; (3) sesame worm; (4) date worm; (5) wood worm (Landsberger, p. 127); (6) cucumber fly (apparently the melon fly, Myiopardalis pardalina Bigot.; Landsberger, p. 131); (7) butterflies of the field (Landsberger, p. 134). The mole cricket is described as follows (Landsberger, p. 135): "It is common everywhere. It lives almost exclusively in underground tunnels dug by [the insect] itself. It causes great damage by continuous burrowing and damaging the roots of agricultural crops. It feeds on grubs and other worms. It is very greedy, and the female feeds on a few of [its own] offspring." The females of mole crickets were known to the

Sumerians and Akkadians in this remote period. However, the fact that first instar nymphs remain in the breeding chamber and are fed by the mother (see mole crickets, below) may have led them to think of cannibalistic behavior in the females.

Avestan sources. In the Avesta, pest control (i.e., "destroying all noxious creatures") was considered the "bounden duty of the faithful" (Abivardi, p. 453; see also Pur-e Dāvud, pp. 178-79; Wolff, pp. 298, referring to *Yt.* 21.1, and 414, referring to *Vd.* 16.12). Its importance is reflected in the old annual celebration of the Feast of Vermin (Jašn-e ḵarafstra) by the Zoroastrians of Kerman, which used to be held at the beginning of summer (see Pur-e Dāvud, pp. 195-96; Abivardi, pp. 454-55; cf. Boyce, p. 202). This feast was attended by both men and women, mostly from the priestly families. All participants wore white clothing and killed the vermin in cities and villages with special rods called *ḵarafstrāgān* "vermin-beaters" (or "vermin-killers"; see Pure-e Dāvud, p. 186). Vermin collected at this feast were gathered in special places and treated with certain drugs that were used to destroy and decompose them. Wherever the vermin were killed, an herbal oil mixed with castor oil and gum tragacanth (obtained from *Astragalus* spp., especially *A. gummifer*) was burnt. Garlic, rue, and vinegar were also employed.

Post-Avestan sources. Additional information about the agricultural pests of Persia comes from the Talmud (Abivardi, pp. 455-57), which was compiled under the Parthians and Sasanians (2nd to 5th century CE). Other than locusts and stored-product insects, the following agricultural insect pests are mentioned there (see Bodenheimer, pp. 44-45): "The worm in [the] stem" (see below); "vine vermin" (*Lobesia botrana* Schiff.); "*Heh*" of the pomegranate (*Euzophera puniciella* (Zell.)), and the honeydew moth (*Cryptoblabes gnidiella* (Mill.)). "The worm in [the] stem (or in the root) of olive trees" (probably *Zeuzera pyrina* (L.)) was so important that its control through pruning the infested trees was included in the Jewish regulations. The Jews were permitted to prune even during the Sabbath year, in which any work, treatment, or cultivation on Saturdays was prohibited (ibid.).

The only remaining book on agriculture from the Sasanian period is the *Warz-nāma* (Mid. Pers. **Warz Nāmak*). This is a translation of a Greek work on agriculture, composed by Cassianus Bassus (fl. 6th century CE). Chapter III includes information on the pests of seeds, and the protection of seeds from pests, and Chapter VIII is entitled "Pests and their Control" (Abivardi, p. 465). A Persian version of this book has been prepared for publication (see Rašid-al-

Din, ed. Sotuda and Afšār, Introd., pp. 52-55).

Books relating to later periods mainly contain information on the use of insects in medicine or repelling both biting or stinging medical insects and the insects of the household or stored products (see, e.g., Abivardi, pp. 474, 478-80). The *Jamiʿ al-ʿolum* or *Ketāb al-Settini* (publ. 1170-1209) of the theologian Faḵr-al-Din al-Rāzi (b. 1149 at Ray, d. 1209 in Herat) has a section on pest control (Abivardi, p. 493; MS in the Senate Library, Tehran, no. 1365: see Rašid-al-Din, ed. Sotuda and Afšār, Introd., p. 62). The larvae of a butterfly (*Pieris* sp.) is reported in 1263 by Zakarīāʾ b. Moḥammad Qazvini (tr. Wiedemann, pp. 279-80): “This [insect] is said to appear in a large population and to result in serious damage to vegetables”; “dogs, wolves, and birds are said to eat the worms”(i.e., the caterpillars of this insect; see Abivardi, pp. 496-97).

We lack any information on the contents of a relevant chapter of the *Tohfat al-bahādor* of Šams-al-Din Moḥammad Dinsari (comp. 1271) entitled “Part I....and measures for the protection of plants against pests” (see Rašid-al-Din, ed. Sotuda and Afšār, Introd., p. 64; Abivardi, p. 500). It is also unfortunate that in a recent edition of Rašid-al-Din’s *Āṯār va aḥyā* (14th cent. CE) the following chapters are missing: Chap. 14, on locust control; Chap. 18, entitled “ ....pests attacking trees, fruits, (and) crops, and their control;” and Chap. 19, “Protection of (stored) grains, legumes, sweets, grape wine, and similar things” (Rašid-al-Din, *Āṯār va aḥyā*, ed. Sotuda and Afšār, Introd., p. 14; Abivardi, pp. 501-2). Nevertheless, the available chapters provide important information about the protection of seeds from pests, sericulture, and aphids (Abivardi, pp. 502-4), such as the following note on an apple pest (Abivardi, p. 502; Rašid-al-Din, ed. Sotuda and Afšār, p. 12):

The apple tree is mostly damaged by a worm which appears in spring and eats the leaves and spins a web. As a result [the fruit] is weakened and falls; it is especially more [abundant] in humid years. In some regions it is more prevalent. As this pest is [found] more in Isfahan and the tree is grown more in this city, its behavior is better known, [since] it has been more investigated. The method of control is as follows: when the worm appears for the first time, a wooden ladder is used to clean up the tree of worms [and their] webs, using an old piece of cotton which is rubbed on the stems [twigs]. If every day they clean up a few trees, the worm will not grow to eat the leaves and damage the trees. This method is not practiced in any other provinces; as the pest occurs, it is left undisturbed until the fruit is totally destroyed.

Considering the description of the foregoing insect and its abundance in Isfahan, this pest is believed to be the *Hyponomeuta malinellus* Zell. (Pers. *lisa-ye sib*) which is still considered to be one of the major apple pests in Persia (see Esmaili et al., p. 315) .

In *Āṯār va aḥyā*,Rašid-al-Din also listed twenty advantages of scioning, including its benefits for protection of plants against pests (Rašid-al-Din, p. 111). He also believed that high humidity favors the proliferation of various insects (in particular, aphids) on trees and other plants (idem, p. 172):

In such conditions, different kinds of mosquitoes and small black creatures [apparently aphids] are produced on the tree from which a sweet known as honeydew [Pers. *gaz angabin*] and similar things are yielded. Notwithstanding this fact, some people, who are unaware of this phenomenon, think that *gaz angabin*, which is seen in willow plantations, is produced from air humidity and dew. The sweet (honeydew) produced by these creatures [aphids] damages all the foliage of the plant. It is said that [the plant] has been infested with *širina* and in some provinces, *šira* [a term still commonly used for aphid infestation].

Other books from the Mongol era also have chapters on agricultural pests, but details (other than their titles) have not been reported (e.g., *Yāqut al-ʿolum*: Abivardi, p. 504; *Davāzdah bāb dar ʿelm-e falāḥat*: Abivardi, pp. 514-15).

Persian sources from the Safavid and post-Safavid periods include Qāsem b. Yusofʾs *Eršād al-zerāʿa* (comp. 1516; ed. Moširi, 1977; Abivardi, p. 514). Topics include, for example: (1) the effect of the planting date on the damage of a foliar pest of the sugar beet (probably *Spodoptera* spp.; ed. Moširi, p. 138); (2) the role of manure (plant nutrition) in reducing the worms of apple trees (p. 184); (3) the use of colocynth (*Citrullus colocynthis* Schrad.) as protection against worms (p. 184); (4) planting colocynth under fig trees as a method of combating *šira-e safid* (i.e., “white honeydew,” unidentified, p. 189).

The *Toḥfat al-moʾmenin* (comp. 1669; see Abivardi, pp. 515-23) of Mir Moḥammad Zamān Tankāboni, known as Moḥammad Moʾmen Ḥosayni, refers to the method of protecting grape vines against pests by rubbing “clay of vine”on the vines (Ḥosayni, p. 519). It also describes the method of using the gum of asafetida (*Ferula assa-foetida* L.) in the irrigation water inlet to prevent the production of worm(s) in the field (ibid., p. 522).

During his travels in Persia (1665-75), the French jeweler Sir John Chardin reported on the public belief in using birds in the biological control of locusts (see LOCUST, and Abivardi, pp. 524-25). Engelbert Кдmpfer, a German physician who stayed in Persia in 1683-88 (ibid., pp. 525-27), describes the use of asafetida in irrigation water, or around a tree, to eradicate date-palm worms (Muntschick, pp. 89-91).

With the exception of the Feast of Vermin (see Avestan sources, above), which was carried out on a large scale, relatively effective efforts to control pests in Persia were confined mainly to the pests of the household, of stored products, and those of medical importance. The first records of extensive campaigns against an agricultural pest, however, may be of those practiced during the reign of Nāder Shah (r. 1736-48) in which the Persian army mobilized to fight against the senn pest (*Eurygaster* spp.) in their winter quarters (see ʿAbd-Allāhi, p. 24; Zomorrodi, pp. 77-78). During the winter campaigns, all plants in the infested mountains that sheltered this pest were burnt in order to kill the over-wintering insects. This method continued to be practiced up to the first decades of the twentieth century (Abivardi, p. 532). In addition, peasants were paid, on a weight basis, to gather the senn pest from the fields (Zomorrodi, pp. 78-80). None of these measures, however, was significantly effective (Abivardi, p. 532). These shortcomings in pest control were gradually overcome by the work of Prof. Jalāl Afšār, the father of Persian entomology, in 1923. Thanks to his efforts, as well as the contributions of other pioneer Persian entomologists and official steps toward the establishment of international cooperation (Zomorrodi, pp. 99-102, 133-36, 156, 162-66, 169-72, 215-16), the way was paved for the development of modern entomology in this country (see Abivardi, pp. 532-61).

INSECT PESTS OF AGRICULTURAL IMPORTANCE

In order to avoid treating a single insect under different hosts, the insects are presented in accordance with the zoological systematics already used by the present author (see Abivardi, pp. 564-793, and below). Only summary descriptions of important insects that damage field crops and fruit trees are reported. Aphids and scale insects, however, are mentioned in more detail.

(1) Order Orthoptera

The most important insect pests of this order in Persia are locusts and mole crickets (*Grylltalpa* spp.). The order Orthoptera has already been described

and the locusts of Persia have been discussed elsewhere (see LOCUST).

Mole crickets (*Abdozdak*; FIGURE 1) were known to the Sumerians and Akkadians in the period 2900-2154 BCE (see Historical Background, above). They have incomplete metamorphosis, and are characterized by various adaptations to a subterranean habit; i.e. the forelegs are greatly expanded and armed with strong teeth for digging; the eyes and antennae are reduced; ovipositor is vestigial. Winged species are strong fliers, but apterous and brachypterous species occur; and a subterranean nest is constructed for breeding purposes (Hill, 1983, p.157). First instar nymphs remain in the breeding chamber and are fed by the mother. The adults (2-3 cm in length) and other instars feed on roots, tubers, underground stems, and ground fruits such as strawberries (Hill, 1987, p. 192).

Among about fifty species known worldwide, three species—*Gryllotalpa gryllotalpa* L. (FIGURE 1), *G. africana,* and *G. hexadactyla*—which are able to fly, are among the important pests of Persia (Abivardi, pp. 609-11). These species are polyphagous, attacking many herbaceous crops, especially at the seedling stage. Some shrubs (e.g. tea) are also attacked in propagating beds (Hill, 1983, p. 162). In Persia, they are particularly injurious in seed beds, gardens, and vegetables plots, and damage field crops, especially maize, tobacco, potatoes, flax, and rice (Abivardi, p. 610).

(2) Order Hemiptera

This order is divided into two suborders, namely Homoptera and Heteroptera. While in Homoptera the wings are uniform, in Heteroptera the apical portion of the wings is more membraneous than the remainder. Metamorphosis is usually gradual, and rarely complete (Abivardi, p. 615).

Suborder Homoptera

This suborder comprises a very diverse group in which aphids, coccids (scale insects), whiteflies, leafhoppers, psyllids, plant-hoppers, spittle bugs, and lantern bugs are represented. They have piercing-sucking mouthparts and usually undergo incomplete metamorphosis. Nevertheless, their metamorphosis is sometimes complete, especially in males. The members of this suborder, in particular aphids and leafhoppers, have gained special importance because of their contribution as vectors in the transmission of plant viruses. Over 80 percent of insect vectors that transmit plant viruses and

pathogens belong to this suborder (Abivardi, p. 615).

A distinctive feature of aphids, some scales, and other sucking insects is the production of honeydew. This is the clear, sticky dropping that lands on the leaves or anything else below the plant or tree upon which aphids are feeding. Honeydew-coated objects soon become covered by one or more black or brown fungi known as sooty molds.

In the following sections we present some summarized information on (i) aphids, (ii) scale insects, and (iii) whiteflies. (For further information on these species and other species of this group, see Abivardi, pp. 615-48; Afšār, pp. 70-72; Esmaili et al., pp. 187-226; and Ḵānjāni, pp. 182-84, 530-36, 598-600.)

(i) Aphids (or Plant Lice)

Aphids (Pers. *šata*) are small (about 2 mm long), soft-bodied insects which attack nearly all indoor and outdoor plants including vegetables, field crops, and fruit trees. FIGURE 2 illustrates different stages of an aphid. There are hundreds of different species of aphids, some attacking only one plant and many attacking numerous ones. A characteristic common to all species is the presence of two tubes, called cornicles, on the back ends of their bodies. The cornicles secrete defensive substances. In some species they are quite long, while in others they are very short and difficult to see.

Aphids feed by sucking up plant juices through a food channel in their beaks, while at the same time injecting saliva into the host. While light infestations are usually not harmful to plants, higher aphid populations cause leaf curl, wilting, stunting of shoot growth (FIGURE 3), and delay in the production of flowers and fruit.

Aphids have unusual and complex life cycles that allow them to build up tremendous populations in relatively short periods of time. Most species overwinter as fertilized eggs glued to stems or other parts of plants. Nymphs that hatch from these eggs become wingless females known as stem mothers. There are no males present at this time. Stem mothers reproduce parthenogenetically (without mating), and their eggs are held within their bodies until they hatch so that young are born alive. All offspring are females that soon mature and begin to reproduce in the same manner. This pattern continues for as long as conditions are favorable. With the return of autumn's shorter days and cooler temperatures, a generation appears that includes both

males and females. After mating, these females lay the fertilized eggs that overwinter and eventually hatch into stem mothers the following spring.

(ii) Scale Insects

These insects (Pers. *šepešak*) are a peculiar group which look quite different from typical insects. They are small, immobile (except the crawlers; see below), with no visible legs or antennae, and attach tightly to the plant on which they are feeding. Among numerous species reported from Persia (see, e.g., Abivardi, pp. 617-29, 635-38, 640, 645-46; Esmaili et al., pp. 195-210), many are common and serious pests of trees, shrubs, and indoor plants. Like aphids, scale insects also feed on plant sap, using their long, threadlike mouthparts (stylets). Heavily infested plants grow poorly and may suffer dieback of twigs and branches. Occasionally, an infested host will be so weakened that it dies.

Scale insects are difficult to control. As adult scales are protected from insecticides by waxy coverings, control measures must be aimed at unprotected immatures (crawlers) or the overwintering stage. While dormant oils are effective during the overwintering stage of most species, summer sprays require accurate identification of the pest species in order to determine hatching dates of crawlers that are prone to insecticides.

Scale insects are divided into the following two groups: (a) armored scales, and (b) soft scales.

(a) Armored Scales

Armored scales are so named because they secrete a protective cover over their bodies. Most species overwinter as eggs beneath the female cover. In spring, eggs hatch into tiny mobile crawlers that migrate to new feeding sites. After a few days, crawlers settle, insert their mouthparts, and begin feeding. Soon they secrete a protective cover and lose their legs. Large populations can build up unnoticed before plants begin to show visible symptoms. One of the most common armored scale pests is San Jose scale (*Quadraspidiotus perniciosus* (Comst.), Pers. *šepešak-e San Jose:* FIGURE 4) which attacks apple, pear, peach, plum, and ornamental trees and shrubs. It is one of the most destructive scale insects worldwide.

(b) Soft Scales

In general, soft scales are larger and more convex than armored scales

(FIGURE 5a). Soft scales usually cover themselves with wax, but they lack the detachable protective cover for which armored scales are named. Most soft scales overwinter as immature, fertilized females. In spring they resume feeding, mature, and lay eggs. These hatch into tiny crawlers. After locating suitable feeding sites, crawlers settle and begin feeding. Some species lose their legs once they have settled, but others retain them and are able to crawl short distances to find suitable overwintering sites in the fall.

One of the most devastating soft scales is the cottony cushion scale (*Icerya purchasi* Mask., Pers. *šepešak-e ostrāliāʾi*; FIGURE 5a). This polyphagous insect, which is an important pest of citrus worldwide, is at present widely distributed in citrus-growing areas of Persia. It was first observed near Bābol in 1928; by 1931 it had invaded a large area of orange plantations. Colonies of a coccinellid, known as the Vedalia beetle (*Rodolia (Novius) cardinalis* Muls., Pers. *kafš-duzak-e vedāliā:* see FIGURE 5b), were imported from France and distributed in the infested plantations, and these gave excellent control (Abivardi, p. 812; Zomorrodi, p. 35).

The adult female of *I. purchasi* is a distinctive insect, being quite large (about 3.5 mm), with a brown body covered with a layer of wax. The most conspicuous part of the insect is the large, white, fluted egg-sack which is secreted by the female (Hill, 1983, p. 211; for additional information, see Abivardi, pp. 535, 616, 648, 509, 813, and Esmaili et al., p. 206).

(iii) Whiteflies

Whiteflies (Pers. *magas-e safid*) are tiny, flying insects that derive their name from the mealy white wax covering their wings and body. While adult whiteflies are similar in appearance, the immature stages are more distinctive. Whiteflies suck phloem sap, causing leaves to wilt and drop when populations are large. Honeydew excreted by nymphs collects dust and supports the growth of sooty mold. Consequently, large infestations blacken entire trees and attract ants, which interfere with the biological control of whiteflies and other pests. FIGURE 6 illustrates different stages of a whitefly, *Bemesia* sp., infesting a cucurbit leaf.

Suborder Heteroptera

The members of this group may be found in both terrestrial and aquatic habitats. All of them, however, have piercing-sucking mouthparts. While some

are predacious, others feed on plants, sucking their sap. They are of special economic importance because they have toxic saliva that they inject into a plant, producing necrosis and the death of tissues. This, in turn, may result, in severe cases, in the death of foliage and branches (Abivardi, p. 648).

The most important member of this suborder, which frequently threatens wheat plantations in Persia is, without doubt, the senn pest (wrongly spelled sunn pest: Pers. *senn-e gandom*), belonging to two genera i.e. *Eurygaster* and *Aelia*. The famous, devastating species is *Eurygaster integriceps* Put. (FIGURE 7) which occupies most of the literature referring to the economic Heteropera of Persia (Abivardi, pp. 648-62). For comprehensive information on the status of this insect pest in Persia, see especially ʿAbd-Allāhi; see also Esmaili et al., pp. 170-77; Ḵānjāni, pp. 105-9; and Zomorrodi, pp. 347-58, 427, 528, 602-3, 615-16, 635-36, 654-55, 670-71.

(3) Order Thysanoptera

The members of this order, commonly known as thrips, are small insects, winged or wingless. The winged species have two pairs of wings with few or no veins, fringed with long hairs (FIGURE 8). Thrips have piercing-sucking mouthparts and undergo intermediate metamorphosis, accompanied with one or two inactive pupal instars. While some feed on plants, they may also cause skin irritation in humans (Abivardi, pp. 662-64). They also act as vectors of important plant viruses such as tomato spotted wilt virus and peanut yellow spot virus (Abivardi, p. 662).

Esmaili et al. (pp. 228-31) report on the occurrence of *Thrips frisi* Uzo. in the tea plantations of northern Persia and *Thrips tabaci* Lim. throughout this country. The latter species is an important, polyphagous insect attacking annual plants, in particular tobacco, onions, beans, sugar beets, tomatoes, potatoes, peas, and different cucurbits especially watermelons (Esmaili et al., pp. 228-31). The leaves of plants attacked by *T. tabaci* are silvered and flecked. Heavy attacks lead to the wilting of young plants, and occasionally to the death of entire crops (Hill, 1983, p. 279).

(4) Order Coleoptera

This order includes beetles and weevils characterized by having forewings that are thickened and hardened into elytra protecting the delicate, folded hind wings. They undergo complete metamorphosis, and both larvae and

adults possess mouthparts specialized for chewing. Coleoptera is represented by numerous important economic species which feed on living plants, damaging roots, trunk, branches, buds, leaves, flowers, and fruits. While some families, such as ladybirds (Coccinellidae), are mostly effective predators (e.g. FIGURE 5b), many destructive pests of stored products belong to this order (Abivardi, pp. 665-722). The following species are some examples of families representing the most devastating members of Coleoptera in Persia:

Family *Scarabaeidae* (White Grubs)

These larvae, which are known as white grubs, are easily recognized by their broad and fleshy appearance, white or grayish white color together with the C-shaped body, having well-developed thoracic legs rarely used for locomotion (FIGURE 9a). While larvae of some subfamilies (e.g. Dynastinae) attack above-ground parts of plants, the larvae of other subfamilies (e.g. Melolonthinae) such as *Melolontha melolontha* (L.: Pers. *kermhā-ye safid-e riša,* FIGURE 9b) are mainly root-feeding and in some cases may become exceedingly injurious. Other species highly injurious to Persian agriculture are as follows:

The date palm fruit stalk borer, *Oryctes elegans* Prell., from the subfamily Dynastinae, is a major pest of the date palm in southern parts of Persia. While the larvae feed on the petioles in the crown and on sap from the base of the fronds. the adults feed on the fronds midribs and the rachis of inflorescence (Abivardi, p. 670).

The larvae of the scarab beetle, *Pentodon idiota* Herbst, are polyphagous and feed on the roots of different plants. The larvae also attack the roots of sugar cane, causing serious damage in cane-growing regions of Persia (Abivardi, p. 668).

Polyphylla olivieri Cast. is also a very polyphagous species distributed in many regions of Persia, in particular in temperate zones. It is considered an important pest of field crops and orchards. Its larval period lasts 2-3 years, during which the grubs live in the soil and feed on the roots and/or tubers of sugar beets, potatoes, etc. resulting in serious damage (Abivardi, pp. 667-74; Esmaili et al., pp. 242-43).

Family *Buprestidae* (Metallic Wood Borers)

The adult insects have often brilliant, metallic colorations, Although members of this family are typically inhabitants of hot moist forests, several genera such

as *Sphenoptera*, and *Capnodis* (FIGURE 10) are of significant importance throughout Persia (Abivardi, pp. 674-81; Rajabi, 1976, pp. 10-11, 29-53). The adult beetles, which visit flowers and feed on pollen and buds, may also gnaw at young branches and leaves. The larvae, according to the species, may bore into the roots and/or burrow galleries in the trunk. One of the species of *Sphenoptera* (i.e., *S. kambyses* Obenb.), which is widely distributed in Persia, is considered a highly dangerous xylophagous insect and the most destructive beetle of the family in this country (Rajabi, 1976, p. 31). Furthermore, the Mediterranean flathead woodborer, *Capnodis tenebrionis* L. (FIGURE 10), which is widely distributed in Persia, is an injurious pest of cultivated fruit trees (Abivardi, p. 676).

Family *Cerambycidae* (Longicorn, or Long-Horned, Beetles).

These insects derive their name from their long antennae (FIGURE 11), sometimes exceeding their body length. The larvae (grubs) have three pairs of highly reduced thoracic legs, as well as nine pairs of prolegs, which aid them in locomotion. The prothorax is large and broader than the remaining segments. The grubs bore into the wood of trees or sometimes into the roots or pith of herbaceous plants (Abivardi, pp. 690-98; Rajabi, 1976, pp. 94-96). The Rosaceae branch borer, *Osphranteria coerulescens* Redt., for example, causes extensive damage to living fruit and other trees of the family Rosaceae in Persia as it bores in the branches. The Red Indian palm beetle, *Pseudophilus testaceus* Gah., is another important species of this family, considered one of the most injurious pests of date palm plantations in Persia.

Family *Chrysomelidae* (Leaf Beetles)

This is a large family with great diversity of form and habitat. Among numerous subfamilies, the subfamily Chrysomelinae includes the most injurious pests of this family. For instance, the well-known Colorado Potato Beetle, *Leptinotarsa decemlineata* (Say) (Pers. *Susk-e barg-ḵār-e sib-zamini*; FIGURE 12a), which was, until 1984, considered a quarantined pest in Persia, is now a serious pest of potatoes in Azarbaijan (Abivardi, p. 703, 706; Zomorrodi, p. 611). This insect feeds exclusively on the foliage of cultivated and wild plants in the family Solanaceae. It is, however, a major pest of potatoes, eggplant and tomatoes. Adults and larvae feed on foliage in the same manner (FIGURE 12b). If Colorado potato beetles are present early in the season, they will clip small tomato or eggplant transplants or emerging potato shoots at the ground level. Two other important pests of this family in Persia are: sugar beet

flea beetles, and cereal leaf beetles (Abivardi, pp. 704-7; Khanjani, pp. 154-56).

The sugar beet flea beetle (Pers. *kak-e čoḡondar-e ḡand:Chaetocnema tibialis* Ill.) is one of the limiting factors in production of sugar beets in Persia. Sometimes farmers are forced to replant their field. Presently, it is widespread throughout the country wherever sugar beets are grown (Abivardi, p. 705; Ḵānjāni, pp. 461-62).

The cereal leaf beetle (Pers. *susk-e barg-ḵār-e ḡallāt:Eulema melanopus* L.) which is widespread in Europe, western and central Asia, is also a serious cereal pest in northeastern United States. It is a vector of a virus on cocksfoot grass in Europe (Hill, 1983, p. 458). This insect has been reported from different areas of Persia, where it feeds on the leaves of wheat, barley, maize, and rye, resulting in crop reduction (Abivardi, p. 706; Ḵānjāni, pp. 154-56).

Family*Curculionidae* (Weevils)

This is currently the largest family of animals in the world (Abivardi, pp. 708-20). They may be identified by a proboscis-like projection of the head, the rostrum (snout). An important pest of this family is the alfalfa weevil (Pers. *Sarḵortumi-ye barg-e yonja*: *Hypera postica* (Gyll.); FIGURE13a), which is a highly injurious pest of alfalfa in Persia (Esmaili et al., pp. 253-54). It is presently considered the major pest of alfalfa in all alfalfa-growing areas of this country (Ḵānjāni, pp. 2-4). FIGURE 13b illustrates an example of its damage. Some other members of this family, e.g. granary weevils and rice weevils, are devastating pests of stored grain throughout the world.

Family *Scolytidae* (Bark Beetles)

Bark beetles, which are sometimes grouped as a subfamily of the family Curculionidae (Scolytinae), are usually given a family rank (i.e., Scolytidae). The adults bore tunnels under the bark of trees and construct extensive breeding galleries. FIGURE 14 illustrates the galleries of the larger shot-hole borer, *Scolytus mali* Becht., under the bark of a tree. Bark beetles are mostly pests of timber, but some species bore into thin branches and twigs and are pests of fruit trees, tea, coffee, and other small trees and bushes (Abivardi, pp. 708, 719; Hill, 1983, p. 418). According to Rajabi (1976, pp. 116-17, 134-35) most of the bark beetles are not considered serious threats to trees in Persia. Only trees predisposed to water and/or nutrient deficiency, i.e., weak trees, suffer from bark-beetle attack (e.g., Rajabi, 1976, pp. 9-10).

(5) Order Diptera

The most important members of this order are flies or mosquitoes that have been of great medical importance since antiquity. The metamorphosis is complete. The larvae are legless, usually with the head reduced and retracted. The main agricultural pests of Diptera comprise leaf miners and flies attacking different parts of plants (Abivardi, pp. 720-22; Afšār, p. 72; Esmaili et al., pp. 440-46). Among these, fruit flies (Tephritidae) have gained great importance worldwide. They are a well-defined group of flies, generally easily recognized with having mottled wings (FIGURE 15). The larvae are phytophagous, often living inside fruits, but some are found in flower heads, and inside stems and leaves. The major pests of this family in Persia are the Mediterranean fruit fly (Medfly: *Ceratitis capitata* (Wied.: Pers. *magas-e mediterāna*) (Hill, 1983, p. 386; Zomorrodi, pp. 554-56, 604-5); the cherry fruit fly *Rhagoletis cerasi* L.: Pers. *magas-e gilās,* and or Melon Fly *Myiopardalis pardalina* (Big.: Pers. *magas-e ḵarboza*) (Esmaili et al., pp. 440-46; Zomorrodi, pp. 334-35).

(6) Order Lepidoptera

This order is divided into two groups (see Abivardi, pp. 722-84): (1) Rhopalocera (butterflies: Pers. *ruzparakhā*) and (2) Heterocera (moths: Pers. *šabparakhā*). Adults of both groups are characterized by having scaly wings and a proboscis that is coiled up under the head like a watch spring when not in use. Adults contribute to plant pollination, but the larvae (caterpillars) are mostly plant feeders. While butterflies include few important pest insects, the most destructive species of this order belong to moths which are further divided into (a) Microlepidoptera (Abivardi, pp. 730-57) and (b) Macrolepidoptera (Abivardi, pp. 758-84). Only a single species of Rhopalocera and several species of Heterocera will be described:

Group *Rhopalocera* (Butterflies)

Although this group represents a great number of species of butterflies in Persia (see Abivardi, pp. 106-237), it has only a few pests of agricultural importance. Among the known pests the citrus butterfly is treated in this section.

(i) Citrus Butterfly, *Papilio demoleus* L.

This butterfly (Pers. *parvāna-ye barg-ḵār-e nāranj*; FIGURE 16), is sometimes called the lemon (or lime) butterfly. It is one of the important pests of citrus in

southern Persia (Abivardi, pp. 728-29). The caterpillar usually feeds on citrus leaves. It prefers, however, blossoms and young leaves. Larval infestation of young trees of nurseries and orchards results in a great loss of foliage, general weakness and sometimes the death of the trees.

Group *Nematocera* (Moths)

The group nematocera, which includes all small or large moths, represents devastating pests of agriculture worldwide. They are arbitrarily divided into two sections: (i) Microlepidoptera and (ii) Macrolepidoptera.

(i) Microlepidoptera

This group, which includes very small moths of the order Lepidoptera (usually < 20 mm long), comprises numerous, highly injurious insects of agriculture (see Abivardi, pp. 730-57) such as *lisa-ye sib* or the apple small ermine moth, *Hyponomeuta malinellus* Zell. (Esmaili et al., pp. 315-17), the codling moth (Pers. *kerm-e sib:* Rajabi, 1986, pp. 88-122; Esmaili et al., pp. 333-35; FIGURES 17a and 17b); the potato tuber moth (Pers. *bid-e sib zamini:* Zomorrodi, p. 612; FIGURES 18a and 18b); the pink bollworm (Pers. *kerm-e sorḵ-e panba:* Esmaili et al., pp. 342-43; Zomorrodi, pp. 627-28; FIGURE 19); the peach twig borer; or Rice Stem Borer (Pers. *kerm-e sāq ḵār-e berenj*: Rajabi, 1986, pp. 65-71; Zomorrodi, pp. 537-47, 562, 593-94); the European corn borer (Pers. *kerm-e sāq ḵār-e orupāʾi-ye ḏorat*: Ḵānjāni, p. 351: FIGURES 20a and 20b); the quince moth (Pers. *kerm-e beh*: Rajabi, 1986, pp. 134-37), and leafminers (FIGURE 21).

(ii) Macrolepidoptera

This group (see Abivardi, pp. 758-84) includes large moths; one of the largest being the larger emperor moth, *Saturnia pyri* L. (Pers. *par[-e] tāvus-e golābi*), with a wingspan of about 140 mm (FIGURE 22). Macrolepidoptera possesses numerous important agricultural pests in Persia, many of which belong to the family Noctuidae (Abivardi, pp. 764-81). Some important ones are as follows: the leopard Moth (*Zeuzera pyrina* L., Pers. *parvāna-ye feri*) from the family Cossidae (FIGURE 23: Esmaili et al., pp. 395-97); or the black cutworm, (*Agrotis ipsilon* (Hfn.): Pers. *šab-para-ye zemestāni*: FIGURES 24a and 24b); the spiny bollworm (*Earias insulana* (Boisd.): Pers. *kerm-e ḵārdār-e panba*: Zomorrodi, pp. 310-13, 473-78, 515, 528); the beet armyworm (*Spodoptera exigua* Hb., Pers. *kerm-e barg-ḵār-e čoḡondar-e qand*: FIGURES 25a and 25b; the old-world bollworm, or tomato fruitworm, (*Helicoverpa armigera* Hbn., Pers. *kerm-e*

ḡoza-e panba; FIGURE 26); the African cotton leafworm, (*Spodoptera littoralis* (Boisd.): Pers. *kerm-e barg-ḵār-e panba*; FIGURE 27), all from the family Noctuidae, and the gypsy moth (*Lymantria dispar* L., Pers. *parvāna-ye abrišambāf-e nājur*; FIGURE 28), from Lymantriidae.

(7) Order Hymenoptera

This order comprises such known groups as ants, bees, wasps, ichneumon flies, and sawflies. While many of them possess biting mouthparts, some have developed a sucking apparatus for feeding. They have complete metamorphosis, and the larva is usually legless but with a distinct head (Abivardi, pp. 784-86). The wheat stem sawfly, (*Cephus pygmeus* L., Pers. *zanbur-e sāq-ḵār-e gandom*; FIGURE 29: Esmaili et al., pp. 422-24; Ḵānjāni, pp. 200-2), and the pistachio nut borer, (*Eurytoma plotnikovi* Nik., Pers. *zanbur-e maḡz-ḵār-e pesta*; FIGURE 30 showing an *Eurytoma* species as an example: Esmaili et al., pp. 426-27) are among the most injurious species of this order in Persia. While *C. pygmeus* larva does great injury to wheat by boring in the stalks, *Eurytoma* species feed inside the seeds and kernels of the pistachio in different areas of Persia, causing up to 50 percent crop loss.

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