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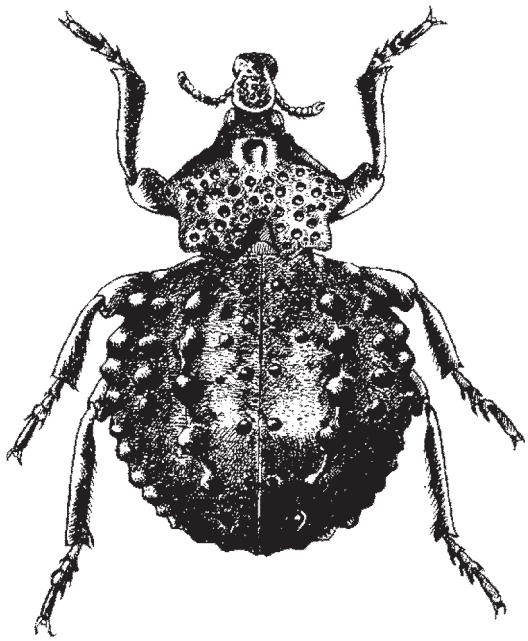

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Hibernation places and behavior of the some weevil species (Coleoptera: Curculionidae)

Места зимовки и поведение некоторых видов жуков-долоносиков(Coleoptera: Curculionidae)

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***Key words*:** hibernation places, behavior, Curculionidae, Eastern Turkey.
***Ключевые слова*:** локализация диапаузы, поведение, Curculionidae, Восточная Турция.

Abstract. Hibernation places and behavior of the 40 species of weevil from subfamilies Lixinae, Ceutorhynchinae, Baridinae, Gymnetrinae and Entiminae (Curculionidae) were determined in Eastern Turkey during 1997–2007. *Larinus latus* (Herbst), *L. fucatus* Faust, *Lixus ochraceus* Boheman, *L. furcatus* Olivier, *L. obesus* Petri, *L. siculus* Boheman, *L. korbi* Petri, and *Mononychus schoenherri* Kolenati prefer to migrate by flight before hibernation. *Cleonis pigra* (Scopoli), *Larinus onopordi* (Fabricius), *L. inaequalicollis* Capiomont, *L. ochroleucus* Capiomont, *L. sibiricus* Gyllenhal, *L.* sp. n. pr. *leuzeae* Fabre, *L. filiformis* Petri, *Herpes porcellus* Lacordaire and *Mononychus punctumalbum* (Herbst) display aggregation behavior under stone, bark, plants or in soil. *Conorhynchus hololeucus* (Pallas), *Mecaspis incisuratus* Gyllenhal, *Leucosomus pedesteris* (Poda), *Otiorhynchus brunneus* Steven, *O. latinasus* Reitter hibernate under stones and in plant litter. *Gymnetron netum* (Germar) and *Larinus puncticollis* Capiomont hide for hibernating in the larval galleries of *Lixus circumcinctus* in dry plant stem of Crambe orientalis, and *Lixus myagri* – in the root system of Lepidum latifolium, respectively. *Glocianus transcaucasicus* Korotyaev, *Ceutorhynchus inaffectatus* Gyllenhal and *C. rapae* Gyllenhal hide in soil cells, *Baris goekseli* Korotyaev et Gültekin and *Melanobaris crambephaga* (Korotyaev et Gültekin) also hibernate in soil. *Mogulones gnom* Khnzorian and *M. lineatus* (Gyllenhal) hide under rosette plants. *Lixus cardui* Olivier, *L. filiformis* (Fabricius), *L. myagri* (Olivier) and *L. circumcinctus* Boheman hibernate in their host plants stems or rootcrown without forming pupal cells. *Lixus bardanae* (Fabricius) and *L.* sp. n. pr. *korbi* Petri emerge from their host plants and hide under the litter of the same host plant for hibernation. All weevil species presented here hibernate in adult stage.

Резюме. В течение 1997–2007 были выявлены места зимовок и поведение 40 видов долгоносиков подсемейств Lixinae, Ceutorhynchinae, Baridinae, Gymnetrinae и Entiminae в Восточной Турции. Установлено, что *Larinus latus* (Herbst), *L. fucatus* Faust, *Lixus ochraceus* Boheman, *L. furcatus* Olivier, *L. obesus* Petri, *L. siculus* Boheman, *L. korbi* Petri и *Mononychus schoenherri* Kolenati совершают миграционные перелеты перед зимовкой. *Cleonis pigra* (Scopoli), *Larinus onopordi* (Fabricius), *L. inaequalicollis* Capiomont, *L. ochroleucus* Capiomont, *L. sibiricus* Gyllenhal, *L.* sp. n. pr. *leuzeae* Fabre, *L. filiformis* Petri, *Herpes porcellus* Lacordaire и *Mononychus punctumalbum* (Herbst) часто образуют скопления под камнями, корой растений или в почве. *Conorhynchus hololeucus* (Pallas), *Mecaspis incisuratus* Gyllenhal, *Leucophyes pedesteris* (Poda), *Otiorhynchus brunneus* Steven, *O. latinasus* Reitter зимуют под растительными остатками и под камнями. *Gymnetron netum* (Germar) и *Larinus puncticollis* Capiomont заселяют на зимовку личиночные галереи *Lixus circumcinctus* в сухих стеблях Crambe orientalis и *Lixus myagri* в корневой системе Lepidum latifolium. *Glocianus transcaucasicus* Korotyaev, *Ceutorhynchus inaffectatus* Gyllenhal и *C. rapae* Gyllenhal локазуются в ячейках почвы, *Baris goekseli* Korotyaev et Gültekin и *Melanobaris crambephaga* (Korotyaev и Gültekin) зимуют в почве. *Mogulones gnom* Khnzorian и *M. lineatus* (Gyllenhal) скрываются под розеточными листьями. *Lixus cardui* Olivier, *L. filiformis* (Fabricius), *L. myagri* (Olivier) и *L. circumcinctus* Boheman зимуют в стеблях кормовых растений или в корневой системе без образования полостей для куколок. *Lixus bardanae* (Fabricius) и *L.* sp. n. pr. *korbi* Petri выходят из кормовых растений и прячутся на зимовку в подстилку этих же растений. Все виды долгоносиков, рассматриваемые в данной работе зимуют в стадии имаго.

Introduction

Insects have a variety of methods for surviving the coldness of winter. Many insects can gain shelter through the winter in a variety of micro-habitats. Among these niches are under the soil, inside of plant tissue, wood of logs and trees, and even in plant galls [Gibo, 1972]. Insects that are inactive during the winter months undergo a state in which their growth, development, and activities are suspended temporarily, with a metabolic rate that is high enough to keep them alive; this dormant condition is termed diapause [Lees, 1956].

Hibernation and diapauses can be viewed in part as adaptations to minimize the need for energy; the insect has

different kind adaptations for the protect themselves from extreme abiotic factors and to save energy [Petersen, 1999]. Aggregations have considerable advantages; to reduce rates of water loss, maintenance of stable and favorable temperature of body, to protect themselves predators, parasitoids, and the likelihood of adverse abiotic conditions [Klok & Chown, 1999]. Flight is the most important mode of dispersal used by many species of winged insects to find suitable habitats or other essential resources such as food, mates and oviposition sites and for escaping the killing temperatures [Duan et al. 1998].

Although, there are some few specific data in literature about hibernation places of the weevils regarding agricultural pests [Duan et al. 1996, 1998], biological control agents [Fornasari, Sobhian, 1993; Sohbian, Fornasari, 1994; Briese, 1996ab; Gültekin et al., 2000, 2003], in ecological data set of some species [Scherf, 1964; Nikulina, 1989; Volovnik, 1996; Gültekin, Korotyaev, 2005; Cristofaro et al., 2002; Korotyaev, Gültekin, 2003; Gültekin, 2005, 2006], there is no specially study only hibernation places and behavior for weevils.

Since ecological and behavioral characters sometimes could be very useful as systematical tool to identify problematic taxa, long term ecological surveys conducted in the eastern Turkey. Data set (Table 1) presenting in this paper revealed during opportunistic field investigations, and special observation on some species.

Materials and Methods

Insect rearing. For observation behavior, weevil species were collected in their mature larvae and pupae stage respectively from Eastern Turkey during 1997—2007, and reared in laboratory until adults emerging. The stems or flowerhead of host plant for each species were placed in transparent rearing pot which covered by cotton tulle. They were waited rearing conditions to adult emergence up to late autumn and monitored daily. The species were identified by after.

When the new generation emerged, adults were transferred to rearing cage (50x50x80 cm) as separately each species which in the bottom soil, stone and host plant pierce similar the natural condition in the outdoor.

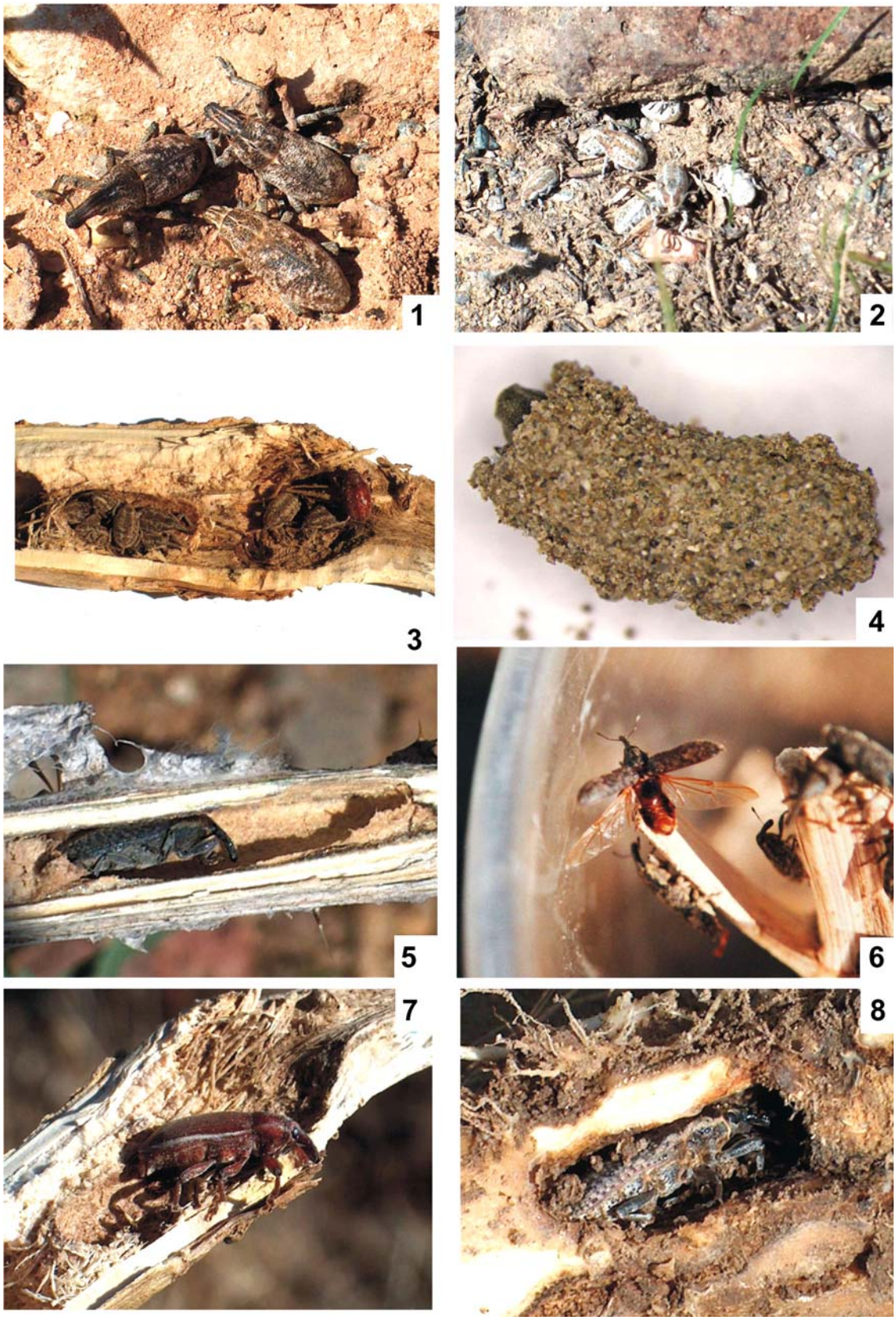
Hibernation place preference experiment. It was carried out different method each species group as their ecological behavior and desire for the observation behavior. As soon as the adults emerged, they were divided two groups that tendency of flight behavior (*Larinus latus* Herbst, 1784, *Lixus ochraceus* Boheman, 1836, *Lixus furcatus* Olivier, 1807, *Lixus obesus* Petri, 1904, *Lixus siculus* Boheman, 1836, *Lixus korbi* Petri, 1904 and *Mononychus schoenherri* Kolenati, 1859), hiding and aggregation tendency behavior (*Larinus onopordi* (Fabricius, 1787), *Larinus inaequalicollis* Capiomont, 1874, *Larinus ochroleucus* Capiomont, 1874, *Larinus sibiricus* Gyllenhal, 1836, *Larinus filiformis* Petri, 1907, *Larinus fucatus* Faust, 1884, *Mononychus punctumalbum* (Herbst, 1784)). Both of two group weevils were released to nature in different days at daytime period and monitored their behaviors. After start hibernation some species were held outside till next spring for control whether living or not. In addition, it was surveyed most of species hibernation places in field at very early spring or late autumn.

Results

Flight behavior observation. From the group of tendency of flight behavior *Lixus ochraceus* and *L. furcatus*, immature stages occur in stem of Tchihatchewia isatidae Boiss. and Prangos spp. respectively, new generation adults opened holes on stem for emerge to outside. It was observed that individuals are flying in cage continuously and try to escape (Fig. 6). Opening cage door, adults of both two *Lixus* species escaped by fly in ten minute very fast. According to monitoring at original habitat, new generation adults of *L. furcatus* walked on main stem of Prangos ferulacea (L.) Lindl. up to tip and then flight from here. Some specimens waited this tip part of plant 30—45 minutes before flight. At the commonly carried out investigations in T. isatidae and Prangos spp. habitats, it was not found any specimens hibernating in their original living locations. The same method was applied for *Lixus obesus*, *L. siculus*, *L. korbi*, *Mononychus schoenherri* and observed their migration behavior by fly before aestivation-hibernation.

Aggregation behavior observation. From the second group of hiding tendency behavior *Larinus* sp. n. pr. *leuzeae*, *L. onopordi*, *L. inaequalicollis* and *L. filiformis* released to field and observed that *L. onopordi* and *L. inaequalicollis* aggregated under stone, but of these *L. inaequalicollis* have strong aggregation behaviors which there were 13 individuals under only one stone. *L. onopordi* have moderately aggregation behavior that there were 1—3 specimens under only one stone. Forty nine individuals of *L.* sp. n. pr. *leuzeae* released on sandy and all of them immediately tried to go down 4—5 mm depth of sandy soil. This species also found in soil-litter under bushes of Ephedra L. at natural location. One hundred two new generations adult individuals of *L. filiformis* reared from Centaurea solstitialis flowerhead and they showed that strong aggregation behavior in rearing cage; hidden under plant bark and in sandy soil as 2—3 groups (Fig. 3). One of the aggregated groups was having over 30 individuals under dry plant bark. *Larinus ochroleucus* has strongly aggregation behavior which was observed both in field and laboratory. In the early spring, eight individuals were found as aggregated under one stone in natural habitat (Fig. 2). In the laboratory, about 30 individuals showed aggregation behavior as separately 5—6 groups. Four individuals *C. pigra* were hidden under a stone as aggregated in the natural habitat (Fig. 1) near E. orientalis plant. More than forty specimens *M. punctumalbum* was reared from Iris spuria L. seed capsules, half of them released to field, they entered in soil and under stone together with 2—3 specimens.

Hiding behavior observation. Adults of *Conorhynchus hololeucus* were found under host plant litter, *Leucosomus pedestris* (Poda, 1761) adult under stone solitarily in *Pinus* forest habitat, and *Mecaspis incisuratus* Gyllenhal, 1834 under stone near host plant an Apiaceae species. *Otiorhynchus brunneus* Steven, 1909 and *O. latinasus*



Figs 1-8. Hibernation places and behaviors: 1. *Cleonis pigra*; 2. *Larinus ochroleucus*; 3. *Larinus filiformis*; 4. *Ceutorhynchus rapae*; 5. *Lixus cardui*; 6. *Lixus furcatus*; 7. *Lixus circumcinctus*; 8. *Lixus myagri.*

Reitter, 1898 were found under Verbascum sp. and Crambe orientalis, respectively. An adult individual of *Pholicodes pancaucasicus* Davidian, 1992 were found under stone in very early spring, *Pholicodes altaicus* Schilsky, 1912 under plant litter of Beta trigyna in the environ of rootcrown at autumn. *Melanobaris crambephaga* (Korotyaev et Gültekin, 1999) new generation adults emerged from root of *C. orientalis* and entered in soil environ of their host plant. *Baris goekseli* Korotyaev et Gültekin, 2003 was found under host plant Camphorosma lessingii in soil.

Upon *Lixus* sp. n. pr. *korbi* Petri and *Lixus bardanae* (Fabricius, 1781) reached to adult stage in stem of their host plants Beta trigyna and Rumex crispus L., respectively opened a hole each specimen separately and abandoned their host. Former species hidden under litter environ of the plant on the ground mostly upward body position, having camouflage on body and not easy to see those in spite of more or less twenty specimens present environ of one host plant. Latter species adults mostly hidden between rootcrown and soil, some of them under plant litter.

Glocianus transcaucasicus Korotyaev, 1980, *Ceutorhynchus inaffectatus* Gyllenhal, 1837 and *Ceutorhynchus rapae* Gyllenhal (Fig. 4) mature larvae prepared soil cells. They had covered inside of this cell with a secretion that is shiny and this feature more distinct in the cell of *G. transcaucasicus*. After passed pupa stage here, new generation adult stayed without emerge and hibernated in this place. Covered secretion inside of soil cell, most probably protect these weevils from much water and humidity.

New generation adults of the *Mogulones gnom* Khnzorian, 1978 and *Mogulones lineatus* Gyllenhal, 1837 hidden under rosette their host plants at late autumn. Also, reared *Mogulones mendax* Schultze, 1898 specimens had emerged from soil in late summer and *Mogulones albosignatus* Gyllenhal, 1837 adults were found under stone near plant of the *Asperugo procumbens* L. in very early spring when they were hibernating.

Adults of *Gymnetron netum* (Germar) were found in the larval gallery of *Lixus circumcinctus* in dry plant stem of Crambe orientalis; similarly, *Larinus puncticollis* Capiomont in the larval gallery of *Lixus myagri* in the root system of Lepidum latifolium.

In plant tissue hibernation. New generation adults *Lixus cardui* (Fig. 5) and *Lixus filiformis* (Fabricius, 1781) hibernated in pupal niche without emerge of their host plants, immature stages occur in the stem of O. bracteatum, C. nutans, respectively. Larvae of *Lixus circumcinctus* Boheman, 1836 borer tunnel through stem to the reach rootcrown of Crambe orientalis L. and *C. tataria* Sebeok, pupated this place, passed to adult stage and hibernated in this place (Fig. 7). Biological stages of *Lixus myagri* (Olivier, 1807) occur in rootcrown of Lepidium latifolium L. (Fig. 8) and L. crassifolium Waldst et Kit, adults hibernated in the same place.

Discussion

Selection of hibernation places and showing some characteristic behavior of weevils might be depends on season of the completing their generation. Migrated weevils completed generation late summer between second weeks of July to second week of August. There are apparently short aestivation period before starting hibernation. For example, *Lixus siculus* new generation adults emerged from Ferula orientalis petiole in the third week of July (22 July 2003) in Aras Valley at the elevation 1400 m. This migration strategy to higher places can be getting advantage to save energy in spite of staying lowland area till reaching winter period. Second example, *Mononychus schoenherri* completed generation last week of July (29 July 2003) and as soon as emerged from seed of the *Iris iberica* migrated by fly, on the contrary *Mononychus punctumalbum* new generation adults emerged seed of *Iris spuria* in the first of September (4 September 2003) and hidden under stone and in soil in the same habitat.

According to Gültekin et al. (2003), *Larinus latus* prefers O. bracteatum as host plant and immature stages occur in flowerhead. Upon reached adult stage in this ecological niche, they waited 3—7 days in the same place before emergence. When they emerged from flowerhead in culture cage, the adults flight as turning in cage in the midday. Opening the cage door, the adults fly to direction of high altitude places. Waited control cage for determined where preferred places, the adults aggregated under stone. At the commonly carried out observations in *O. bracteatum* natural habitat it was not found any specimens hibernating in low altitude. Some *L. latus* specimens could not find main host plant when re-migrated to lowland area; when they are looking original host, adults feed some short period on different plants such as Cirsium palustre (L.) Scop., Carduus nutans L., Centaurea behen L. Centaurea solstitialis L., Echinops sphaerocephalus L. and Beta trigyna Waldst. et Kit. This behavior is also confirmed their migration behavior.

Although I have data only about few species from *Mogulones* Reitter genus, it can be early advance a hypothesis that this genus adult emerged from soil cell before hibernation, some species associated with their host plant rosette at autumn and hidden under plant for hibernating.

Results show that there are some correlation and typical behavior features in some species group or subgeneric level in spite of some of them having different. For instance two species *Lixus* (*L. cardui* and *L. filiformis*) from *Epimeces* Bilberg subgenus hibernated in their host plant; they are near species taxonomically. Member of the subgenera *Compsolixus* Reitter and *Lixogylptus* Reitter which is inhabitant of Brassicaceae, two species of *Lixus* (*L. circumcinctus, L. ochareceus*) show that the same behavior staying in rootcrown or stems of the host plants. A more sample, two species *Lixus* (*L. furcatus, L. obesus*) from *Callistolixus* Reitter subgenus which is Apiaceae feeder reflect the same pattern by fly-migration before hibernation.

On the contrary, some species which are closely related taxonomically can show different behavior pattern. The best an instance is *Lixus korbi* and *Lixus* sp. n. pr. *korbi*, both two species closely related but first one migrates by flight latter one stays environ of host plant on the ground among debris. Consequently, this kind data could be useful as a systematical tool to differentiate closely related and problematic species complex. Results presented in this paper to be able to contribute investigations biology and ecology of weevils which is some of them potential biological agents for weeds control and bioindicators desertification.

Table 1. Hibernation places and behavior of weevils in eastern Turkey.

Таблица 1. Места зимовок и поведение долгоносиков в Восточной Турции.

Weevil species	Host plants	Hibernation places and behavior
Subfamily: Lixinae		
Conorhynchus hololeucus	Chenepodium sp.	under host plant litter
Cleonis pigra	Carduus, Echinops spp.	aggregation under stone
Leucusomus pedestris		under stone solitarily
Mecaspis incisuratus		under stone
Larinus latus	Onopordum bracteatum	migrated by flight before hibernation
Larinus onopordi	Echinops spp.	aggregation under stone
Larinus inaequalicollis	Echinops orientalis	aggregation under stone
Larinus fucatus	Cousinia spp.	migrated by flight
Larinus ochroleucus	Cousinia spp.	aggregation under stone
Larinus sibiricus	Xeranthemum annuum	aggregation under stone
Larinus sp. n. pr. *leuzeae*	Serratulae serratuloides	aggregation and hiding
Larinus puncticollis	Centaurea spp.	in the larval gallery of *Lixus myagri*
Lixus cardui	Onopordum bracteatum	in stem of host plant
Lixus filiformis	Carduus spp.	in the stem of host plant
Lixus myagri	Lepidium latifolium,	in the rootcrown of host plant L. crassifolium
Lixus circumcinctus	Crambe orientalis,	in the rootcrown of host plant C. tataria
Lixus ochareceus	Tchihatchewia isatidea	in the stem of host plant
Lixus bardanae	Rumex crispus	environ of rootcrown in soil
Lixus korbi	Beta coralliflora	migrated by flight before hibernation
Lixus sp. n. pr. *korbi*	Beta trigyna	on soil among plant litter
Lixus furcatus	Prangos spp.	migrated by flight before hibernation
Lixus obesus	Prangos uloptera	migrated by flight before hibernation
Lixus siculus	Ferula orientalis	migrated by flight before hibernation
Subfamily: Ceutorhynchinae		
Mononychus punctumalbum	Iris spuria	aggregation
Mononychus schoenherri	Iris iberica	migrated by flight before hibernation
Glocianus transcaucasicus	Trogopogon dubias	in soil cell
Ceutorhynchus inaffectatus	Hesperis schischkinii	in soil cell
Ceutorhynchus rapae	Lepidium latifolium	in soil cell
Mogulones gnom	Anchusa sp.	under rosette plant
Mogulones lineatus	Onosma sericea	under rosette plant
Mogulones albosignatus	Asperugo procumbens	under stone near host plant
Mogulones mendax	Nonea pulla	emerged from soil
Subfamily: Baridinae		
Baris goekseli	Camphorosma lessingii	in soil under their host plant
Melanobaris crambephaga	Crambe orientalis	in soil under their host plant
Subfamily: Gymnetrinae		
Gymnetron netum	Verbascum sp.	in larval gallery of *Lixus circumcinctus*
Subfamily: Entiminae		
Herpes porcellus	Nonea pulla	aggregated under host plant
Otiorhynchus brunneus		under Verbascum sp.
Otiorhynchus latinasus		under Crambe orientalis
Pholicodes pancaucasicus		under stone
Pholicodes altaicus		under plant litter of Beta trigyna

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