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RESEARCH ARTICLE

Bioindicator beetles and plants in desertified and eroded lands in Turkey

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Abstract: The xerophilous vegetation with characteristic insect assemblages is described in the main agricultural regions and native landscapes of Turkey. Long term intensive investigations documented vast biotic degradation of soil and vegetation (commonly referred to as desertification) by overgrazing, construction, recreation etc. Two main types of xeric landscape are under investigation: 1) natural highly specific deserts, semi-deserts, dry mountain slopes and screes; and 2) anthropogenic, newly emerged, floristically impoverished desertified areas. The presence of a multi-species insect assemblage on a xerophilous plant in certain area testifies its indigenous nature, whereas the absence of the specific consortium suggests recent plant invasion. The examples of the first case are the consortia of 3–6 species of Coleoptera, mainly Buprestidae, Chrysomelidae, and Curculionoidea, on some Apiaceae, Asteraceae, Brassicaceae, Chenopodiaceae, Ephedraceae (*Ephedra* spp.) and Polygonaceae (*Calligonum polygonoides* L.). Extreme examples of anthropogenic vegetation are overgrazed wormwood steppe and semidesert which lack usually diversified coleopterous consortia, including the most characteristic of this landscape, e.g., tenebrionids, and orthopterans. Rapid disappearance of the xerophilous complexes from the extraordinarily diversified and largely uninventoried Turkish biota makes preservation of the endangered plant and animal assemblages in different climatic zones of Turkey an urgent task.

Key words: Xerophilous, erosion, desertification Curculionoidea, Chrysomelidae, Buprestidae.

Introduction

Desertification is a relatively new term but it is also an old issue in the European Mediterranean zone corroborated by the abundance of historical references highlighting the concern of different cultures on important land degradation processes in the region (Rubio 2003). Desertification (representing soil degradation) is one of the nature-induced (climate change, hydrological cycle) and human-induced challenges (population growth, urbanization and food production) of global environmental change. Both natural and human-induced components closely interact and contribute to fatal outcomes: primarily to extreme weather events and hydro-meteorological disasters (drought, flash floods and storms) and environmentally-induced human migration (Brauch 2003).

The Mediterranean Region is one of the most affected by these degradation processes. While in the northern Mediterranean the desertification impacts are more related to environmental problems, in the southern Mediterranean countries, desertification is also a very severe social and food security problem. In the future those problems can spread to the whole Mediterranean area. The combat against desertification must involve the sustainable use of water and soil resources and vegetation cover. The task really is urgent and all the governments should contribute to solving it. On the other hand, the Mediterranean Region is one of the most threatened by the climate change, which can speed up the desertification process. Some indicators of the degree of desertification are related to environmental, social, economic, technological and political issues (Bermúdez & Gómez 2003). Desertification is the consequence of a series of important degradation processes in the Mediterranean environments, especially in semi-arid and arid regions, where water is the main factor limiting land use performance. Among the most important processes of desertification are soil erosion and salinization particularly affecting hilly areas and lowlands, respectively (Kosmas & Yassoglou 2003). Land degradation and desertification represent one of the most striking sets of processes affecting the Mediterranean Region and causing persistent deterioration of the physical, chemical and biological properties of the land components, especially the soil (Zdruli *et al.* 2003).

Desertification and erosion are important environmental problems in Turkey (Gültekin *et al.* 2006a, b). Productive agricultural, forest and pasture lands were destroyed by urbanization, industrialization, increasing tourism and recreation activities, overgrazing and other agricultural uses in recent years. Combating desertification and deforestation and control of erosion are among the main duties of the Ministry of Environment and Forestry. Afforestation, improving pasture and meadows, land rehabilitation and erosion, flood and landslide control activities must be conducted efficiently as well as rehabilitation of forest ecosystems. In addition to implementation of the new technologies, it will be useful to increase public awareness (Karakurt 2003).

Desertification has been recognized as an environmental problem by many international organizations such as the UN, NATO and FAO. The UN has been studying the possibility of desertification control since the early seventies because of negative effects of desertification on the economy and its causing unbalanced food production which are especially conspicuous in areas with dense population. In 1992, at the Rio de Janeiro Environment Conference, the UN particularly stressed the desertification of many countries, such as Turkey. Desertification in Turkey is generally caused by incorrect land use, excessive grazing, forest fires and uncontrolled wild plant picking. Soil erosion is also a significant land degradation factor due to topographical conditions and salinization of agricultural soils in Turkey. Urbanization and soil sealing also have become serious problems on the fertile agricultural lands. Due to anthropogenic destruction of forests, the steppe vegetation gradually became dominant in Anatolia. This is particularly alarming since Turkey is famous in Europe and the Middle East for its high biodiversity. Turkey occupies a special place in the global concern in terms of desertification because of its biodiversity, agricultural potential, high population, social and economical structure, topographical factors and strategic regional location. Communication between scientists, decision makers and international non-profit organizations must be improved (Camci *et al.* 2003).

According to the Turkey Second National Report (Anonymous 2002), erosion is one of the most severe rural environmental problems affecting to a varying degree 81% of the total land surface. About 73% of the cultivated land and 68% of the prime agricultural land is prone to erosion. Stream bank erosion affects 57.1 million ha while wind erosion degrades another 466000 ha. As a result, about one billion tons of soil is carried away each year. The proportion of areas prone to erosion is at a "critical" level in some provinces of the country where the area of forested land is also relatively high. This indicates that agricultural land in these provinces mostly consists of difficult-to-hold soils of steep slopes where agricultural plots have been created through deforestation. The share of severe erosion also is larger in areas where agriculture is practiced without any soil conservation measures. Erosion has other negative impacts, such as reducing the life of dams through siltation.

To understand such a complex biological and anthropogenic phenomenon as desertification requires a multidisciplinary approach. In this paper we present the results of both botanical and entomological studies as plant and insect communities provide a clear picture of desertification and its impact on the environment.

Xerophytes are plants adapted to arid environments. Although present in various types of landscape, xerophytes are most abundant in deserts where they constitute or dominate native vegetation. Perfectly adapted to xeric environments, many xerophytes easily expand their ranges when the climate in the areas adjacent to their current range gets drier or degradation of native vegetation results in destruction and change of the soil. This is why many eastern inland Eurasian ruderal plants and weeds easily increase their propagation to Europe and the Mediterranean where woodlands are still being reduced and the climate in the recent decades is apparently getting warmer. The study of xerophytes in the rather poorly known Anatolian deserts and dry steppes is essential both for registration of the existing native desert plant communities and for monitoring the expansion of desert plants and entire communities, i. e., the desertification process. The xerophilous flora of Eastern Turkey includes many poorly known taxa including highly specialized endemic species and even genera, some apparently still waiting for scientific description. Quite recently, a new species of a xerophilous plant genus, *Stroganovia* Kar. & Kir., new to the Turkish flora and a specialized herbivore of the weevil genus *Ceutorhynchus* Germar, 1824 were discovered in the Aras valley and described (Dorofeyev *et al.* 2004; Dorofeyev 2006); an interesting assemblage of weevils was found on an endemic NE Turkish plant genus *Tchihatchewia* Boiss. characteristic of steep mountain slopes and screes (Korotyaev & Gültekin 2003), and a number of other previously poorly known members of xerophilous plant communities in arid regions have been found together with their herbivores. The present work aims to provide an inventory, complete description, photographs, and an entomological investigation of the xerophytes mostly in eastern Turkey with special emphasis on the families Chenopodiaceae, Brassicaceae, Apiaceae, Ephedraceae, and Asteraceae playing important roles in most types of the xerophilous plant communities.

All these plant families have many specialized herbivores among the Coleoptera (beetles). This insect order, comprising 24 superfamilies with 211 families of insects

(Bouchard *et al.* 2011) with hard integument and extreme diversification of habits, constitutes a core of the invertebrate xerophilous assemblages both in the steppe (Korotyaev 2000; Konstantinov *et al.* 2009) and deserts (Kaplin 1981; Mamaev *et al.* 1982; Korotyaev *et al.* 1983; Alexeev & Volkovitsh 1989; Soyunov 1991; Volkovitsh & Alexeev 1992, 1994; Konstantinov *et al.* 2009). Many desert plants and those forming communities on screes have specialized herbivores among Coleoptera (Tokgayev & Nepesova 1964; Krivosheina 1975; Gurbannepesov & Begov 1976; Korotyaev & Gültekin 2003; Korotyaev *et al.* 2012). Of these, species of the families Buprestidae and Chrysomelidae, and of the superfamily Curculionoidea, are predominant. Many of them are not only specific to certain hosts, but have rather limited distribution and are characteristic of particular types of plant communities. Being so narrowly specialized, these beetles can indicate certain important features of plant communities which they inhabit. For example, in the recent decade with repeated unusually warm summers several species of butterflies and beetles of more southern distribution have been recorded in many European countries, including southern regions of Russia neighbouring Turkey (Korotyaev 2013). These observations were possible because distribution of the relevant insect families in Europe is known in detail, so that even single appearances of conspicuous insects are usually immediately noticed by specialists. Revealing entire complexes of specialized herbivores or wood-borers on some xerophilous plant would mean its establishment long ago in a particular area and the likelihood of its native presence there. On the contrary, absence of specialized herbivores on a plant in a particular area when it possesses a multi-species consortium in other parts of its range would most probably mean its recent appearance in this area. Consequently, Coleoptera are good indicators of the desertification process when their fauna and trophic associations in the region are well known. Sometimes Coleoptera may facilitate the desertification process themselves, as, for example, the leaf-beetle *Theone silphoides* (Dalman, 1823) defoliating *Artemisia* L. in the Caspian Lowland, the area with rapidly progressing desertification, which is an increasing problem in the entire steppe zone of Russia (Vinogradov 2015). *Artemisia* is one of the edificatory plants in these deserts subject to overgrazing, but even when the pasture load is controlled the recent leaf-beetle outbreaks facilitated the increased degradation of the vegetation and the progressive erosion. Another example is a heavy damage to the *Ulmus* L. windbreaks by *Xanthogaleruca luteola* (Müller, 1776) (Chrysomelidae) in the southeastern parts of European Russia (Kalyuzhnaya *et al.* 1995), followed by an outbreak of this chrysomelid in Ukraine in the recent years (Zhavoronkova 2007). The expansion of the desert landscape brings aggressive complexes of xerophilous insects closer to crops; this is especially dangerous to sugar beet, which may be attacked by many weevils and some leaf-beetles associated with wild Chenopodiaceae as often happens in Middle Asia (Brunner, 1954). Urban and suburban afforestations also become subject to attack by desert herbivores, especially in dry seasons and years, which has been shown recently in Turkmenistan, where the Moroccan locust, *Dociostaurus maroccanus* (Thunberg, 1815) (Orthoptera, Acrididae) damaged ornamental *Pinus eldarica* Medw. (Pinaceae) and *Biota orientalis* (L.) Endl. (Cupressaceae) in the Koiten Dagh and Kopet Dagh mountains (Kokanova 2014).

Investigation of the xerophilous plants and associated arthropods is essential for the scientific description and understanding of the desertification and erosion processes typical of arid regions and intense in the greatest part of Turkey. Making inventories of the flora and fauna are the first steps in the evaluation of these processes, providing primary data on the composition of the plant associations in native deserts, on mountain slopes and in the anthropogenically desertified and eroded areas, and on insects associated with these plants. The list of the desert flora enables recognition of the pioneers of desert communities in their expansion outside native range and monitoring the desertification process.

Because of a wide and somewhat loose use of the term "desertification", and also due to a poor knowledge of the distribution and floristic composition of the native desert and semidesert plant associations in Turkey, we prefer to use the term "biotic degradation" with respect to the vegetation and soil instead of "desertification" until the expansion of a particular desert plant or an entire desert plant community is proved. Consequently, we tried first to make a brief review of the native deserts and semideserts in Turkey with preliminary characteristics of the assemblages of insects, primarily Coleoptera, associated with desert plants, especially with those dominating desert communities, or with species of a particular interest of any kind, scientific or economic. Revealing insect assemblages specific to a certain desert plant helps understanding whether this plant is an aborigine of a particular area (then it may have a species-rich insect assemblage, = consortium) or is newly established there (in the latter case the plant often being deprived of specific herbivores or harbouring a few of them, usually those with highest capability of dispersal).

We used the same approach to investigate the erosion of mountain slopes caused by the transfer of the ground (mostly small stones or clay) by gravity greatly facilitated by water, wind, and seismic activity. This natural process is perfectly modeled by soil disturbance in the course of construction of roads, power lines, etc., so that mountain slopes along relatively old roads are covered by vegetation hardly distinguishable from that existing on native screes and detritus or clay slopes. Insect assemblages associated with these plant communities are very species-rich and characteristic (Dorofeyev *et al.* 2004; Korotyaev & Gültekin 2003; Gültekin & Korotyaev 2011; Korotyaev *et al*. 2012).

Bioindicators are organisms whose biological functions are closely correlated with specific environmental factors (Gerhardt 2002). A set of bioindicators from a particular locality can provide quick, yet reliable, information on the state of the environment, i.e., whether it is maintaining a relatively stable condition or there is evidence of a disturbance which may shortly result in a complete loss of the integrity of the natural complex.

Because of the lack of detailed maps of the vegetation of Turkey, we have tried to elaborate a general presentation of the state of the soil and vegetation with characteristic insect assemblages in the main agricultural regions, natural deserts and semideserts, heavily overgrazed areas near springs, Mediterranean coastal sand dunes and lagoons, at field margins, roadsides, and on dry slopes and screes of a natural and anthropogenic origin. Based on data on the general distribution and ecological features of the insects associated with particular xerophilous plants or plant communities, we have tried to select insect species and associations characteristic of the examined plants and phytocoenoses and to estimate their role as possible bioindicators of native desert communities of various types, and of the processes of the soil and vegetation degradation (= desertification or erosion in general).

Material and methods

A species inventory of Coleoptera of the families Buprestidae, Chrysomelidae, and the superfamily Curculionoidea associated mainly with plants of the families Chenopodiaceae, Brassicaceae, and Ephedraceae in Eastern Turkey has been compiled based on field investigations and literature data. Material also was searched for on plants of other dominate families in some desert and other xerophilous communities, e.g., Asteraceae, Zygophyllaceae, Peganaceae, Polygonaceae, Papaveraceae, Caryophyllaceae, and Apiaceae (Table 3). Distribution of plants of these families in eastern Turkey has been documented by herbarium specimens, with taxonomic and distributional studies of phytophages of some poorly known plants performed when necessary.

In June 19 – July 14, 2005, 70 localities were examined by our research team (L. Gültekin, B. A. Korotyaev, M. G. Volkovitsh and V. V. Dorofeyev) on a more than 7000 km long trip in the 26-day expedition in Turkey. The list and characteristics of the localities are given in Table 1 and Fig. 1. In addition, L. Gültekin has conducted expeditions (more than 3000 km) for further investigations on some species which can be possible bioindicators, mostly those of the erosion process. The observations were illustrated with many photographs taken with digital cameras. Plants and insects were collected in most of the localities visited, and preliminary descriptions of the vegetation and flora in the places of the most intense and/or productive collecting were made by V. I. Dorofeyev.

Table 1. List of locations investigated in 2005 in Turkey.

Location	Province	Label data 1	Label data 2	Latitude (North)	Longitude (East)	Altitude (m)	Date
TR05-01	Ankara	Hwy 140	17.5 km E of Esenboğa	40˚08'06.4"	33˚12'13.0"	1344	20.06.2005
TR05-02	Ankara	Hwy 140	21.4 km E of Esenboğa	40˚08'44.0"	33˚14'54.8"	1174	20.06.2005
TR05-03	Kırıkkale	Hwy 200	39.2 km SE of Esenboğa	39˚55'26.5"	33˚22'36.1"	696	20.06.2005
TR05-04	Kırıkkale	Hwy 200	11 km NW of Kırıkkale	39˚55'43.2"	33˚25'16.2"	672	20.06.2005
TR05-05	Ankara	Tuz Gölü	18 km NW of Şereflikoçhisar	39˚05'33.2"	33˚23'34.8"	918	21.06.2005
TR05-06	Ankara	Hwy 750	43.7 km S of Ankara	39˚30'58.8"	32˚52'04.8"	1162	22.06.2005
TR05-07	Konya	Düden Gölü	6.95 km SE of Kulu	39˚03'42.1"	33˚08'13.5"	973	22.06.2005
TR05-08	Ankara	Tuz Gölü	25.6 km NW of Şereflikoçhisar	39˚08'49.3"	33˚19'42.9"	921	22.06.2005
TR05-09	Ankara	Tuz Gölü	18.6 km SE of Şereflikoçhisar	38˚48'53.8"	33˚36'16.7"	943	23.06.2005
TR05-10	Aksaray	Tuz Gölü	44.2 km NW of Aksaray	38˚37'00.3"	33˚45'18.9"	920	23.06.2005
TR05-11	Aksaray	Tuz Gölü	36 km NW of Aksaray	38˚37'02.3"	33˚42'46.8"	924	23.06.2005
TR05-12	Aksaray	Hwy 300	11.1 km SW of Aksaray	38˚19'37.4"	33˚53'26.0"	951	23.06.2005
TR05-13	Konya	Tuz Gölü	33.9 km NW of Eskil	38˚37'20.8"	33˚08'55.6"	916	23.06.2005
TR05-14	Konya	Hwy 715	40 km NE of Konya	38˚13'24.0"	32˚45'03.8"	991	24.06.2005
TR05-15	Konya	Hwy 330	32.6 km NE of Beyşehir	37˚51'49.9"	32˚00'42.2"	1364	24.06.2005
TR05-16	Konya	Hwy 330	19.5 km NE of Beyşehir	37˚49'44.8"	31˚50'18.3"	1189	24.06.2005
TR05-17	Isparta	Hwy 330	8.8 km WNW of Şarkikaraağaç	38˚02'31.5"	31˚26'55.9"	1228	24.06.2005
TR05-18	Burdur	Hwy 685	22.4 km SE of Isparta	37˚37'34.4"	30˚43'51.5"	602	25.06.2005
TR05-19	Burdur	Aksu River (Suçatı env.)	31.9 km SE of Isparta	37˚32'37.4"	30˚46'31.3"	331	25.06.2005
TR05-20	Antalya	Hwy 695	31.8 km E of Manavgat	36˚48'58.8"	31˚46'02.0"	586	25.06.2005
TR05-21	Antalya	Hwy 695	4.5 km NE of Akseki	37˚04'55.1"	31˚45'48.0"	1325	26.06.2005
TR05-22	Antalya	Hwy 695	12.7 km NE of Akseki	37˚08'26.6"	31˚52'25.5"	1510	26.06.2005
TR05-23	Konya	Alacabel Geçidi	22.7 km NE of Akseki	37˚13'35.6"	31˚52'52.4"	1614	26.06.2005
TR05-24	Konya	Hwy 340	4.6 km E of Bozkır	37˚11'07.6"	32˚17'05.3"	1377	26.06.2005
TR05-25	Karaman	Hwy 350	8.5 km E of Ayrancı	37˚23'18.9"	33˚46'45.3"	1177	27.06.2005
TR05-26	Konya	Hwy 350	64.7 km NE of Ayrancı	37˚38'16.5"	34˚19'57.6"	1155	27.06.2005
TR05-27	Konya	Hwy 750	70.9 km SSE of Aksaray	37˚46'35.5"	34˚14'23.0"	1043	27.06.2005
TR05-28	Nevşehir	Kapadokya (= Cappadocia)	Ŭçhisar env.	38˚38'03.8"	34˚48'37.8"	1263	28.06.2005
TR05-29	Nevşehir	Pancarlık	3.6 km SW of Ŭrgüp	38˚36'50.5"	34˚54'15.0"	1117	28.06.2005

		Valley					
TR05-30	Nevşehir	Pancarlık Valley	4.2 km SW of Űrgüp	38°36'39.4"	34°53'26.7"	1120	28.06.2005
TR05-31	Niğde	Hwy805	10.7 km SW of Niğde	37°54'33.4"	34°39'30.0"	1215	28.06.2005
TR05-32	Adana	Toros Dağları	11.2 km NW of Pozantı	37°30'17.9"	34°48'47.8"	893	29.06.2005
TR05-33	Adana	Toros Dağları	7.8 km SW of Pozantı	37°21'45.2"	34°49'21.6"	1026	29.06.2005
TR05-34	Hatay	Burnaz, sea shore	16.2 km NW of Dörtyol	36°55'33.0"	36°02'32.8"	6	30.06.2005
TR05-35	Hatay	Amanos (= Nur) Dağları	17.8 km NE of Dörtyol	36°56'49.2"	36°21'21.1"	1485	30.06.2005
TR05-36	Hatay	Amanos (Nur) Dağları	16.5 km NE of Dörtyol	36°56'23.9"	36°20'08.5"	1363	30.06.2005
TR05-37	Hatay	Amanos (Nur) Dağları	14 km NE of Dörtyol	36°55'17.2"	36°19'36.4"	1205	30.06.2005
TR05-38	Hatay	Amanos (Nur) Dağları	10 km NE of Dörtyol	36°54'48.0"	36°16'33.0"	579	30.06.2005
TR05-39	Hatay	Amanos (Nur) Dağları	7.6 km NE of Dörtyol	36°54'02.9"	36°15'13.1"	269	30.06.2005
TR05-40	Osmaniye /Gaziantep	Nurdağı Geçidi	13.8 km SW of Nurdağı	37°06'39.2"	36°38'29.7"	1148	01.07.2005
TR05-41	Hatay	Hwy 410, Akbez env.	18.2 km SSW of İslahiye	36°51'15.4"	36°34'49.6"	397	01.07.2005
TR05-42	Gaziantep	Hwy 410	20 km SSE of İslahiye	36°50'36.3"	36°41'31.5"	457	01.07.2005
TR05-43	Kahramanmaraş	Hwy 360	9.7 km E of Pazarcık	37°29'46.2"	37°24'50.3"	936	02.07.2005
TR05-44	Adıyaman	Hwy 360	15.8 km SW of Gölbaşı	37°40'42.8"	37°31'28.9"	985	02.07.2005
TR05-45	Adıyaman	Hwy 360	12 km E of Gölbaşı	37°44'55.6"2	37°46'26.5"	803	02.07.2005
TR05-46	Adıyaman	Hwy 360, Körkün Dağı	3.8 km ESE of Gölbaşı	37°46'22.3"	37°40'56.2"	923	02.07.2005
TR05-47	Adiyaman	Hwy 360, Körkün Dağı	10 km NE of Gölbaşı	37°50'50.9"	37°43'15.5"	810	02.07.2005
TR05-48	Malatya	Hwy 850, Malatya Dağları	36 km SW of Malatya	38°09'02.7"	37°58'14.0"	1221	02.07.2005
TR05-49	Elazığ	Hwy 300	4 km SW of Kovancılar	38°41'56.1"	39°49'19.9"	1054	03.07.2005
TR05-50	Elazığ	Hwy 300	9.2 km NE of Kovancılar	38°45'24.5"	39°56'47.8"	979	03.07.2005
TR05-51	Elazığ	Hwy 300	23.4 km NE of Kovancılar	38°52'47.4"	40°01'19.1"	1193	03.07.2005
TR05-52	Bingöl	Hwy 300, Kuruca Geçidi	24 km W of Bingöl	38°57'24.3"	40°14'20.5"	1738	03.07.2005
TR05-53	Bingöl/Erzurum	Hwy 950, Çirişli Geçidi	13 km N of Karliova	39°27'42.1"	41°03'07.5"	2108	03.07.2005
TR05-54	Erzurum	Hwy 950	10 km SW of Tortum	40°13'24.9"	41°28'30.5"	2128	05.07.2005
TR05-55	Erzurum	Hwy 950	7.7 km NNW of Tortum	40°21'10.9"	41°30'37.8"	1414	05.07.2005
TR05-56	Erzurum	Kargapazarı Dağları	5.1 km NE of Tortum	40°19'24.5"	41°35'30.9"	1715	05.07.2005
TR05-57	Erzurum	Hwy 950	1.8 km SSW of Tortum	40°16'30.5"	41°33'27.7"	1670	05.07.2005
TR05-58	Erzurum	Hwy 925, Dumlu Dağı	33.2 km NW of Erzurum	40°08'54.7"	41°01'52.5"	1991	06.07.2005
TR05-59	Kars	Hwy 080, Aras valley	24.8 km E of Kağızman	40°07'36.5"	43°23'41.8"	1070	07.07.2005
TR05-60	Iğdır	Hwy 080, Aras valley	18 km W of Tuzluca	40°06'22.6"	43°27'11.1"	1055	07.07.2005
TR05-61	Iğdır	Hwy 080, Aras valley	9 km NW of Tuzluca	40°06'27.3"	43°35'12.0"	1019	07.07.2005
TR05-62	Iğdır	Hwy 080, Aras valley	11.9 km SE of Aralık	39°47'46.0"	44°36'41.8"	830	08.07.2005
TR05-63	Iğdır	Aras valley	8.2 km W of Aralık	39°53'56.9"	44°25'15.8"	851	08.07.2005
TR05-64	Iğdır	Aras valley, Bulakbaşı	6.6 km SE of Karakoyunlu	39°57'07.2"	44°15'29.9"	848	09.07.2005
TR05-65	Iğdır	Aras valley	18.5 km W of Iğdır	39°57'52.0"	43°49'53.5"	1072	09.07.2005
TR05-66	Iğdır	Aras valley	17 km W of Iğdır	39°59'24.3"	43°51'48.3"	954	09.07.2005
TR05-67	Kars	Hwy 080, Aras valley	11.7 km SW of Kağızman	40°06'39.8"	42°59'21.7"	1271	10.07.2005
TR05-68	Kars	Hwy 080, Aras valley	9 km E of Karakurt	40°08'18.4"	42°42'23.8"	1401	10.07.2005

TR05-69	Kars	Hwy 080, Aras valley	10.6 km SW of Karakurt	40˚07'37.5"	42˚29'29.2"	1497	10.07.2005
TR05-70	Erzurum	Hwy 955, Aras valley	27.9 km SSW of Köprüköy	39˚43'56.7"	41˚47'55.9"	1798	10.07.2005
PH-1	Konya	Hwy 715	25.1 km SSW of Cihanbeyli	38˚26'39.1"	32˚49'23.9"	964	24.06.2005
PH-2	Konya	Hwy 330	Konya env.				24.06.2005
PH-3	Karaman	Hwy 715	35 km NW of Karaman	37˚18'16.5"	32˚51'56.1"	1057	26.06.2005
PH-4	Karaman	Hwy 350	18.7 km NE of Karaman	37˚15'39.3"	33˚24'43.8"	1041	26.06.2005
PH-5	Niğde	Hwy805	10.7 km SW of Niğde	37˚54'33.4"	34˚39'30.0"	1215	28.06.2005
PH-6	Adıyaman	Hwy 360	23.2 km SW of Gölbaşı	37˚36'30.9"	37˚30'09.2"	851	02.07.2005

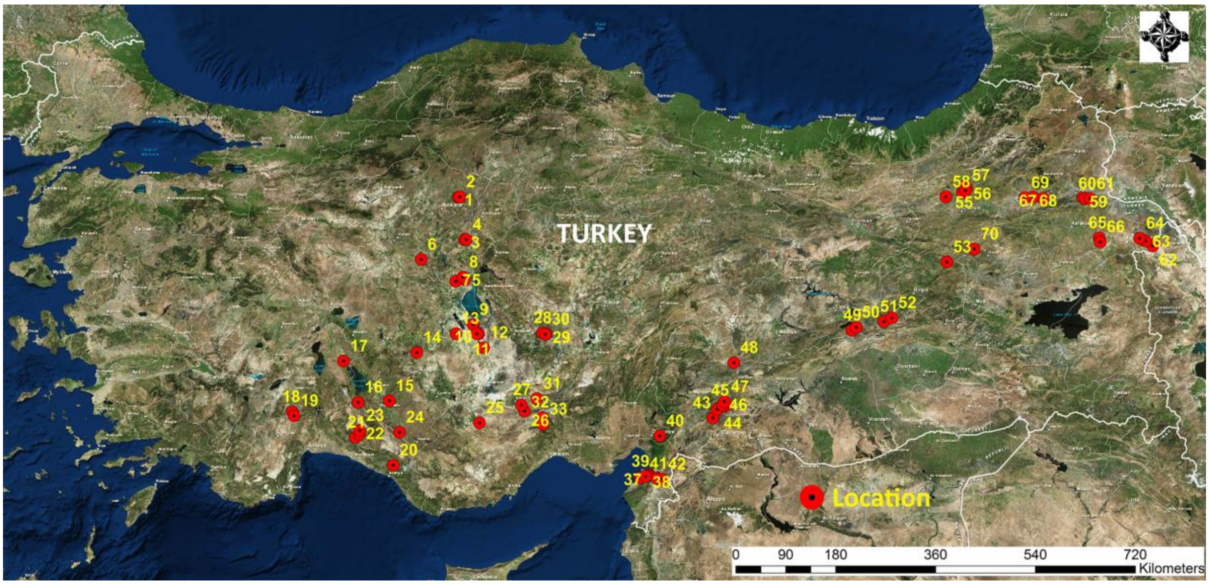

Figure 1. Investigation region visited by research team in 2005 and route with location numbers.

In June 3–21, 2006, the research team included L. Gültekin, A. S. Konstantinov, B. A. Korotyaev, M. G. Volkovitsh, and V. I. Dorofeyev, the length of the route was 5000 km, with 48 sites examined (Table 2) and many digital images of the landscape taken. The list and characteristics of the localities are given in Table 2 and Fig. 2. Investigations performed during the trips mentioned have resulted in the following preliminary observations and conclusions. The combined investigation locations are presented on the map in Fig. 3. We greatly appreciate preparing maps for this paper using ArcGIS 10.1 software by Dr. Metin Demir (Atatürk University, Erzurum).

Additional field investigations were conducted in 2014 and 2015 by L. Gültekin, B. A. Korotyaev and V. I. Dorofeyev with 8000 km long field trips in Eastern Turkey.

Table 2. List of locations investigated in 2006 in Turkey.

Location	Province	Label data 1	Label data 2	Latitude (North)	Longitude (East)	Altitude (m)	Date
TR06-01	Adana	Tuz Gölü	3.1 km SW of Tuzla	36˚41'00.4"	35˚04'06.6"	1	04.06.2006
TR06-02	Adana	Tuz Gölü	2.2 km SW of Tuzla	36˚41'07.9"	35˚04'54.3"	2	04.06.2006
TR06-03	Adana	Hwy E-90	15 km ENE of Adana	37˚01'15.8"	35˚29'05.9"	114	04.06.2006

TR06-04	Hatay	Amanos Mountain (= (Nur Dağları)	10 km NE of Dörtyol	36°54'51.7"	36°16'31.1"	559	05.06.2006
TR06-05	Hatay	Amanos Dağları	11.5 km NE of Dörtyol	36°54'52.0"	36°17'51.1"	865	05.06.2006
TR06-06	Hatay	Amanos Dağları	16 km NE of Dörtyol	36°56'29.1"	36°20'08.7"	1387	05.06.2006
TR06-07	Hatay	Amanos Dağları	18.3 km NE of Dörtyol	36°56'58.1"	36°22'07.6"	1605	05.06.2006
TR06-08	Osmaniye /Gaziantep	Nurdağı Geçidi	6 km SE of Hasanbeyli	37°06'43.7"	36°36'29.0"	1156	06.06.2006
TR06-09	Gaziantep		7.4 km S of Nizip	36°56'38.7"	37°46'39.2"	501	07.06.2006
TR06-10	Gaziantep	Fırat (= Euphrates) River valley	2.8 km NE of Karkamış	36°51'16.3"	38°00'45.0"	346	07.06.2006
TR06-11	Gaziantep	Fırat River valley	7.2 km N of Karkamış	36°53'58.1"	38°00'49.8"	362	07.06.2006
TR06-12	Gaziantep		11.4 km NW of Nizip	37°05'18.1"	37°42'36.5"	612	08.06.2006
TR06-13	Gaziantep	Altındağ env.	12.7 km NW of Nizip	37°06'01.6"	37°40'14.8"	643	08.06.2006
TR06-14	Şanlıurfa		13.9 km N of Birecik	37°09'14.8"	37°58'46.3"	667	08.06.2006
TR06-15	Şanlıurfa	Halfeti Road	23 km N of Birecik	37°14'10.9"	37°55'37.5"	645	08.06.2006
TR06-16	Şanlıurfa	Fırat valley, Halfeti env.	23 km N of Birecik	37°13'52.9"	37°53'06.1"	394	08.06.2006
TR06-17	Şanlıurfa	Hwy E-90	~50 km ENE of Şanlıurfa	37°13'30.8"	39°23'25.2"	663	09.06.2006
TR06-18	Şanlıurfa	Hwy 905 (Ceylanpınar Road)	13.8 km SE of Viranşehir	37°06'40.4"	39°51'08.9"	467	09.06.2006
TR06-19	Şanlıurfa	Arslanbaba River	19.6 km SE of Viranşehir	37°03'40.1"	39°52'22.0"	456	09.06.2006
TR06-20	Mardin	Mardin Dağları, Hop Geçidi	14.9 km NE of Mardin	37°24'44.9"	40°50'52.0"	1024	10.06.2006
TR06-21	Mardin	Mardin Dağları, Hwy 380	28.8 km E of Midyat	37°26'50.5"	41°01'43.5"	1105	10.06.2006
TR06-22	Batman	Dicle River valley	~5 km W of Hasankeyf	37°43'24.7"	41°18'46.9"	476	10.06.2006
TR06-23	Batman	Batman Çayı (River)	14.8 km N Batman	38°01'04.0"	41°09'46.0"	572	11.06.2006
TR06-24	Batman	Hwy 360	13.5 km E of Kozluk	38°08'56.1"	41°38'49.7"	842	11.06.2006
TR06-25	Bitlis	Bitlis Çayı (River)	8.9 km NE of Baykan	38°13'06.4"	41°51'58.2"	853	11.06.2006
TR06-26	Bitlis	Bitlis Çayı (River)	7.2 km SW of Bitlis	38°21'23.7"	42°03'00.3"	1362	11.06.2006
TR06-27	Bitlis	Van Gölü, SW shore	16.8 km ESE of Tatvan	38°28'24.4"	42°28'40.8"	1669	12.06.2006
TR06-28	Bitlis/Van	Alacabük Dağı, Kuskunkıran Geçidi	45.7 km EES of Tatvan	38°22'36.4"	42°47'15.5"	2242	12.06.2006
TR06-29	Bitlis	Alacabük Dağı	38.3 km E of Tatvan	38°21'11.7"	42°41'12.2"	1815	12.06.2006
TR06-30	Bitlis	Van Gölü, SW shore	20.2 km E of Tatvan	38°28'31.8"	42°31'02.9"	1685	12.06.2006
TR06-31	Bitlis	Van Gölü, SW shore	15.9 km E of Tatvan	38°28'08.5"	42°27'59.3"	1657	12.06.2006
TR06-32	Muş	Hwy 300	17.8 km NW of Güroymak	38°38'43.2"	41°50'51.8"	1290	13.06.2006
TR06-33	Muş	Hwy 959, Karakale Dağı	33.4 km E of Muş	38°44'55.9"	41°52'40.0"	1368	13.06.2006
TR06-34	Muş	Hwy 959, Otluk Dağları	41.7 km ENE of Muş	38°52'13.0"	41°56'33.8"	1740	13.06.2006
TR06-35	Muş	Hwy 959	30.3 km E of Muş	38°41'58.6"	41°50'22.0"	1297	13.06.2006
TR06-36	Muş	Hwy 955, Seferek Geçidi	3.4 km SE of Varto	39°07'51.8"	41°27'46.1"	1470	14.06.2006
TR06-37	Muş	Hwy 955	9.5 km NE of Varto	39°11'58.0"	41°33'22.7"	2001	14.06.2006
TR06-38	Erzurum	Hwy 955	15.1 km N of Hınıs	39°29'32.0"	41°41'34.0"	2029	14.06.2006
TR06-39	Erzurum	Hwy 955, Aras valley	39.6 km N of Hınıs	39°42'33.9"	41°47'30.9"	1796	14.06.2006
TR06-40	Erzurum	Hwy 955, Aras valley	27.9 km SSW of Köprüköy	39°43'56.7"	41°47'55.9"	1798	14.06.2006
TR06-41	Bayburt	Hwy 915	20 km N of Bayburt	40°25'21.4"	40°14'57.1"	1560	16.06.2006
TR06-42	Bayburt	Hwy 915, Soğanlı Dağı	25.9 km N of Bayburt	40°28'59.3"	40°15'35.8"	1740	16.06.2006
TR06-43	Bayburt	Hwy 915, Soğanlı Dağı	27 km N of Bayburt	40°29'37.9"	40°15'20.8"	1950	16.06.2006
TR06-44	Gümüşhane	Hwy 885, Kelkit Road	14.3 km S of Gümüşhane	40°20'04.8"	39°31'26.8"	1487	17.06.2006
TR06-45	Gümüşhane	Hwy 885, Kelkit Road	20.4 km S of Gümüşhane	40°16'32.0"	39°29'19.4"	1766	17.06.2006
TR06-46	Gümüşhane	Çilhorozdağı Geçidi	13.1 km W of Kelkit	40°03'53.9"	39°16'53.0"	1606	17.06.2006
TR06-47	Gümüşhane	Hwy 915, Vauk Dağı	24.7 km ESE of Gümüşhane	40°23'04.2"	39°45'23.4"	1547	18.06.2006
TR06-48	Bayburt	Hwy 915, Kop Geçidi	33.9 km SE of Bayburt	40°02'11.7"	40°30'42.5"	2437	18.06.2006

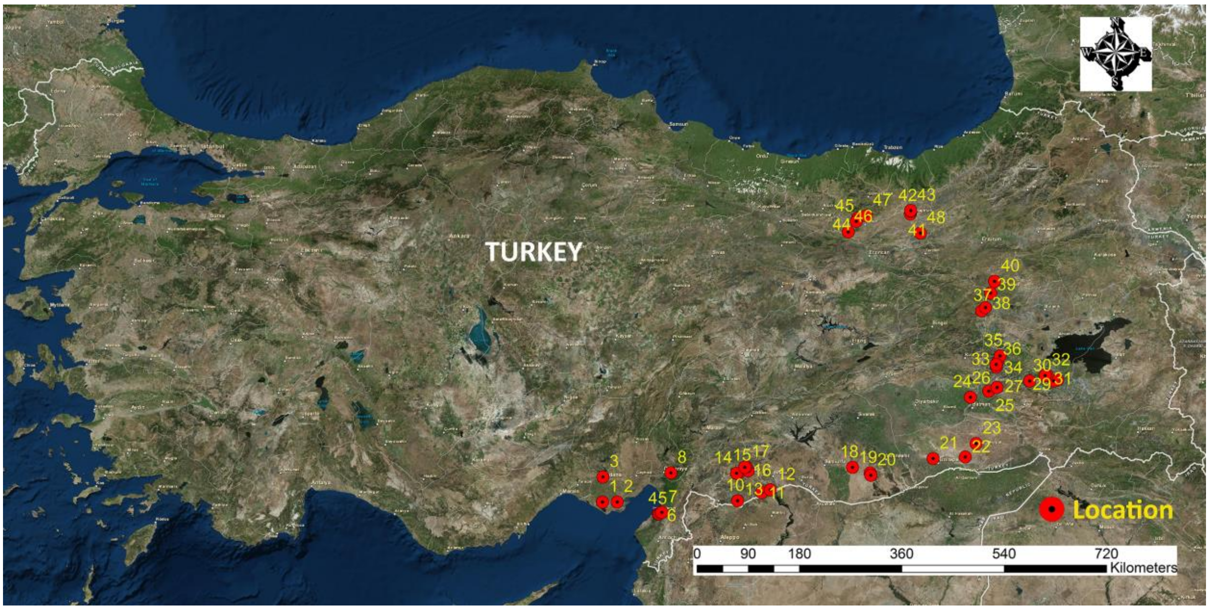

Figure 2. Investigation region visited by research team in 2006 and route with location numbers.

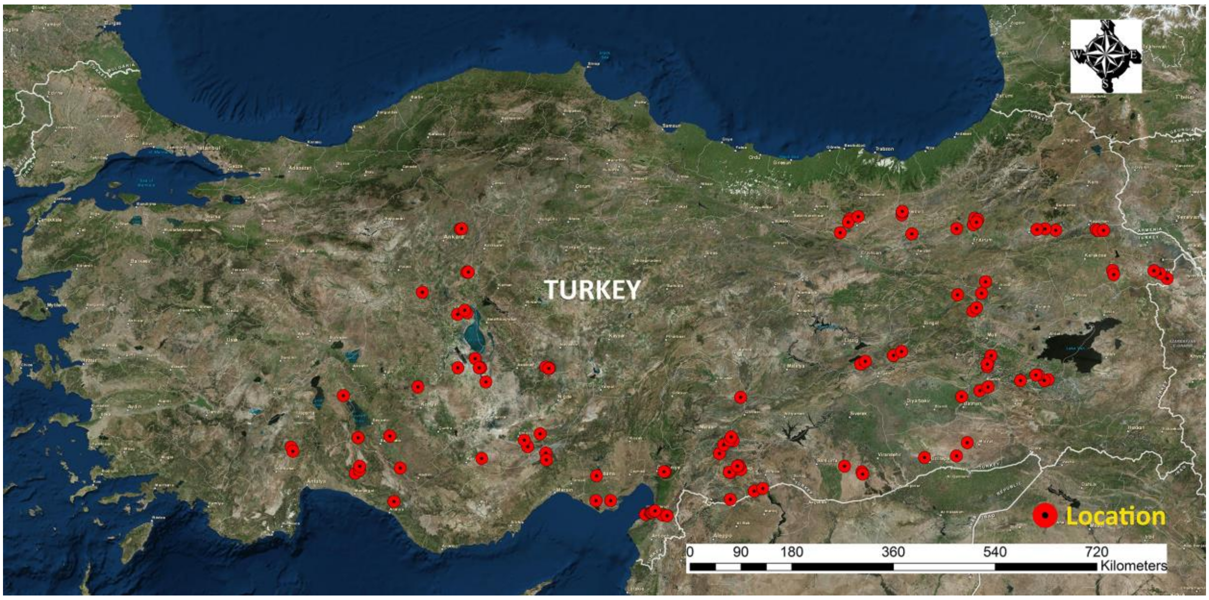

Figure 3. Investigation region and locations visited by research team in 2005–2006.

Results

Erosion in Turkey

Two types of erosion are distinguished in the area studied. The first one is a horizontal or wind erosion, usually associated with horizontal transfer of soil particles (Figs. 4A–B). The second type is gravitative erosion (Figs. 4C–D). Erosional processes in Central and Eastern Turkey are greatly facilitated by overgrazing, mostly by sheep and goats, because the abrasive wearing of soil by hoofs accelerates dehydration. Sheep and goats produce

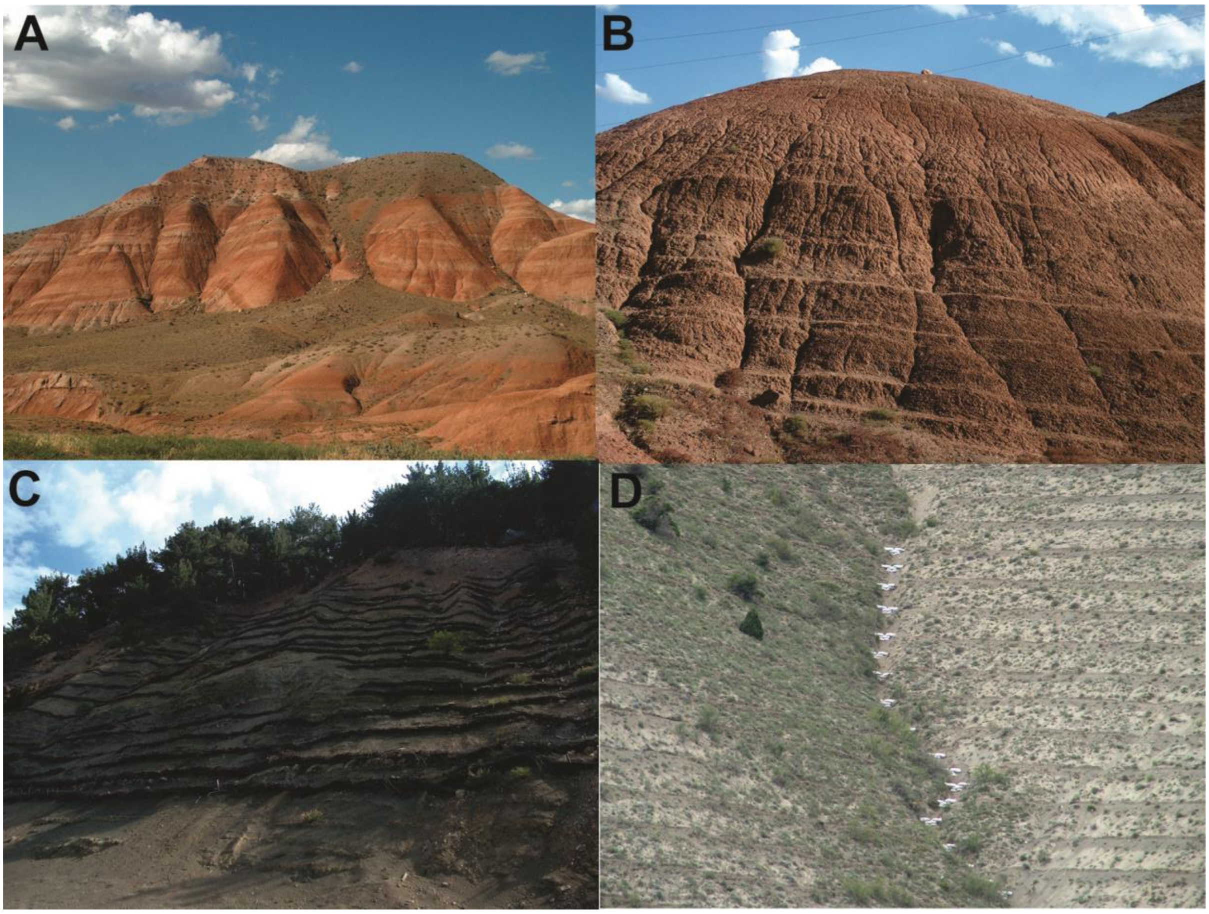

Figure 4. Scenery of erosional processes in Turkey. **A–B,** wind erosion associated with horizontal transfer of soil; **C–D,** gravitative erosion.

approximately equal mechanical action on soil (Figs. 5A–E), but goats, because of their widest panthophagy, cause a much greater damage to vegetation compared to that caused by any other domesticated animal.

Processes of erosion are very widespread within the large territory of Central and Eastern Turkey from the Mediterranean to the Black Sea areas, being especially dramatic in plains areas of Central Anatolia with its arid climate, and in the semidesert badlands of Northeast Turkey. Transects over all climatic zones of Turkey have revealed noticeable appearances of erosion in various types of landscape and in the regions with different prevailing types of vegetation. The obvious economic growth of the country manifested by the intense construction, rapid development of the road net over the entire territory of Turkey, and the increase of rural population with the subsequent intensification of pasture and agriculture, is associated with the increased disturbance of soil and the reduction of natural vegetation, which also negatively affects soil and climate. All native types of vegetation, including saline and sand deserts and stony semideserts, are being rapidly substituted by anthropogenic vegetation with impoverished and usually less specific flora (mostly by crops or construction areas). We have observed disappearance of a small fragment of a gravel desert with a population of *Ephedra* sp. in Aras valley near Tuzluca Village between 2003 (when we collected several specific weevils on *Ephedra* L.) and 2005 – when the site already had been transformed into a field. In the same period, a large area with very characteristic

Figure 5. Overgrazing in Central Anatolia. **A**–**B,** overgrazing by sheep causing serious wind erosion; **C**–**E,** sheep and their hoof trace on desertified ground.

vegetation composed of many subendemic and endemic plants (with insect assemblages including species new to science, not yet described) on mountain slopes along a road in Erzurum Province was completely destroyed for broadening the road. This is why we tried to make as many collections as possible in the typical xeric habitats to provide at least collection representation of many species of plants and insects endangered by human activity.

According to the general impression from our investigations, wind erosion is a much more widely distributed destructive process in Turkey than gravitative erosion, although the latter may lead to catastrophic floods in the mountains, especially dangerous in the maritime Mediterranean and Black Sea areas. We have encountered (in 2005) 18 locations with most sharply expressed results of wind erosion. Of these, in three locations (TR-05-59; TR-05-60; TR-05-61) horizontal erosion is increased by gravitative erosion. Eroded areas are examined in the following locations: TR-05-05; TR-05-07; TR-05-08; TR-05-09; TR-05-10; TR-05-11; TR-05-12; TR-05-13; TR-05-25; TR-05-31; TR-05-59; TR-05-61; TR-05-62; TR-05-63; TR-05-64; TR-05-65; TR-05-66. In addition to these locations, we have seen erosional problems at PH-1, PH-2, PH-3, and PH-4 but we could take only photographs there because there was no time for investigation. In addition, we have been doing investigations from 2003 till autumn 2005 in a flat denudated saline area of several hectares 3–4 km E of Erzincan (Fig. 6A) with only a single species of plant common, *Lepidium crassifolium* Waldst. & Kit. (Brassicaceae) (Fig. 6B), and an associated weevil species *Melanobaris* sp. pr. *semistriata* (Boheman, 1836) (Fig. 6C). In early June 2014, this habitat was found being used for construction. According to the data from L. Gültekin's spring expeditions, Erzincan Province has the most serious gravity erosion problem along the Euphrates River valley.

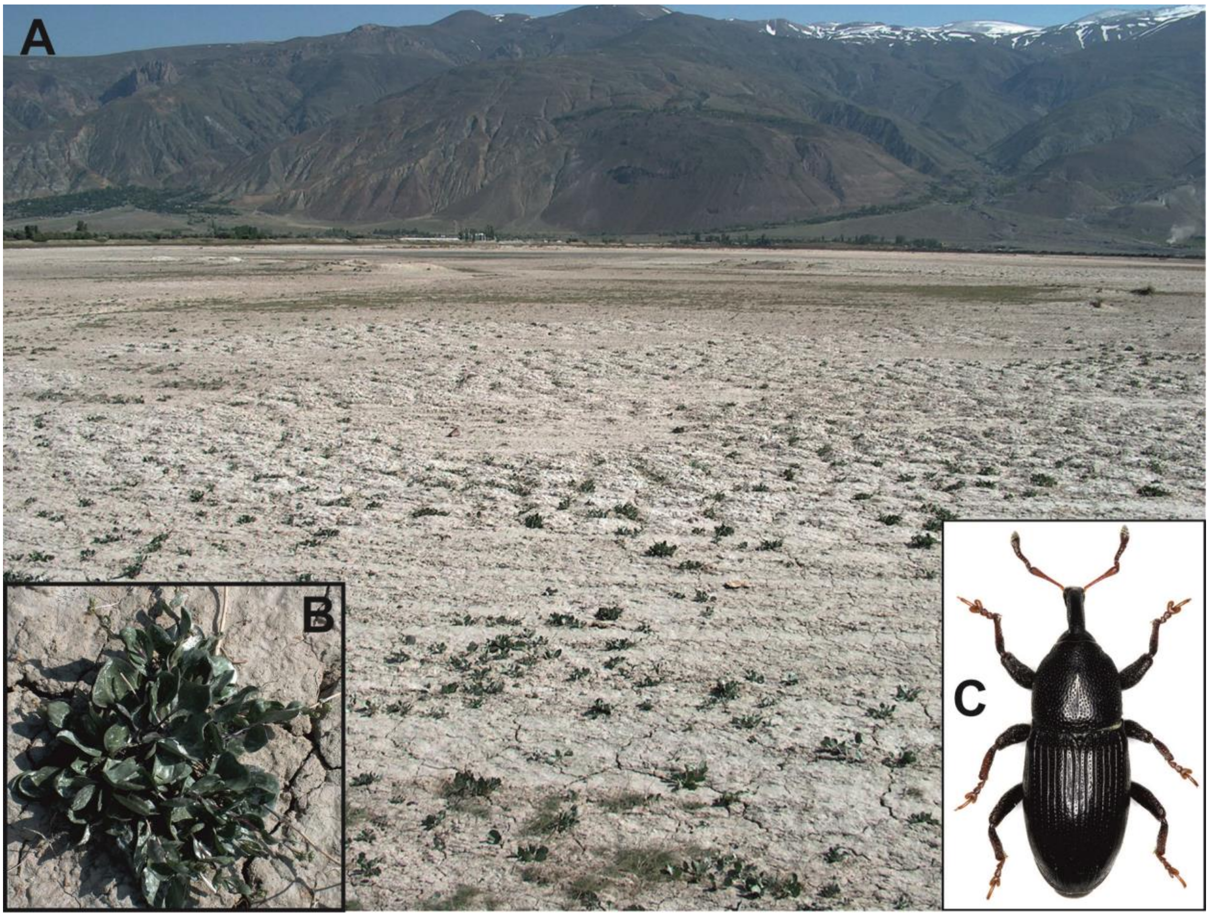

Figure 6. Desertification near Erzincan with scarce vegetation dominated by *Lepidium crassifolium* Waldst. & Kit. **A,** desertified habitat; **B,** *Lepidium crassifolium*; **C,** *Melanobaris* sp. pr. s*emistriata* Boh.

In 2006, we found in Şanlıurfa Province (TR06-19) (Figs. 7A–B) one of the most strongly desertificated and eroded locations which was highly overgrazed by sheep, goats and cows. Vegetation there is almost destroyed, with only a few ruderal species and weeds of the genera *Phlomis* L. (Fig. 7C), *Centaurea* L. (Fig. 7D), *Onopordum* L. (Fig. 7E) and *Cousinia* Cass. remaining.

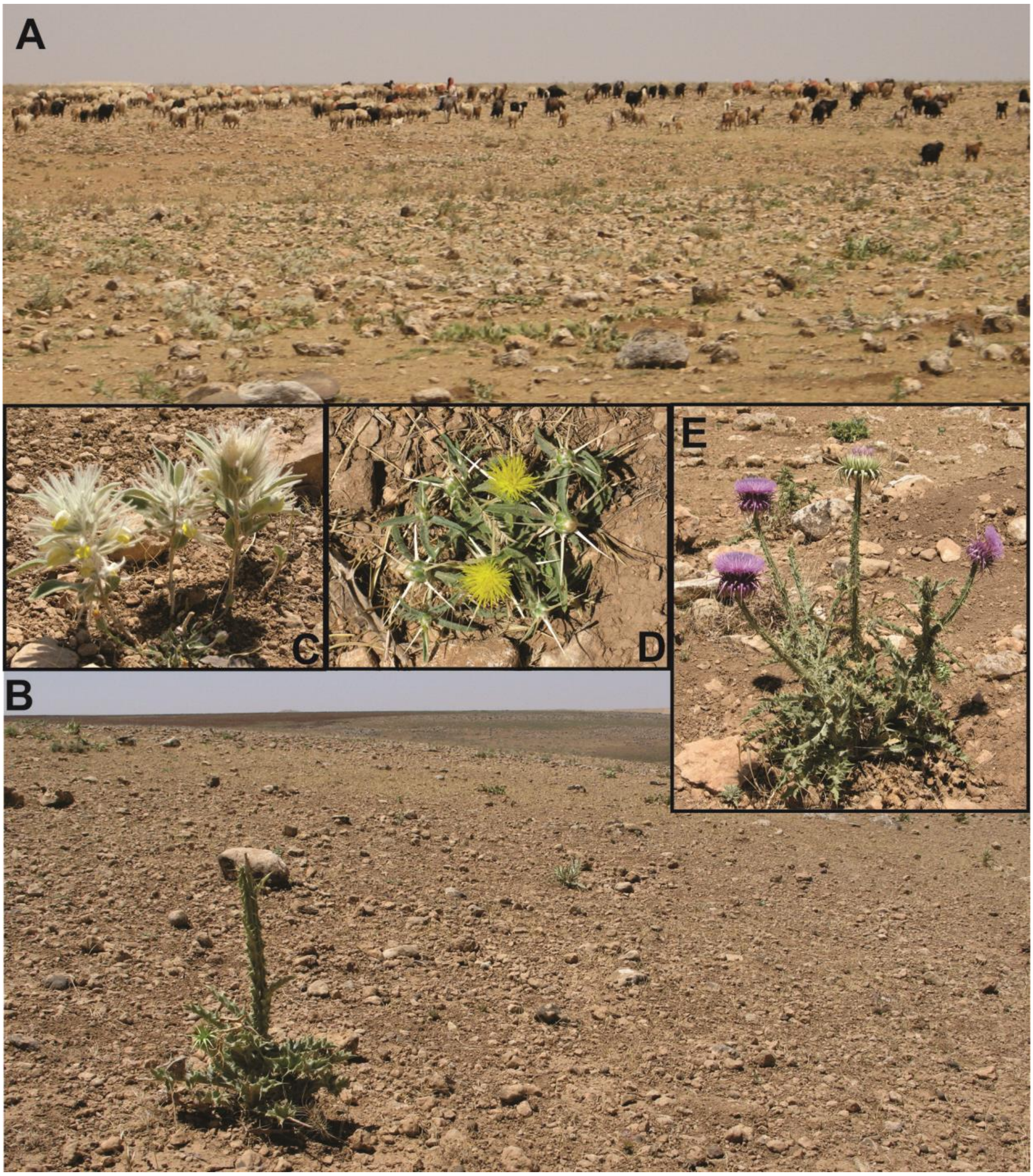

Figure 7. Desertification process in Şanlıurfa Province in the location TR06-19. **A–B,** vegetation highly overgrazed by sheep, goats and cows; **C,** *Phlomis* L.; **D,** *Centaurea* L.; **E,** *Onopordum* L.

Desert and semidesert associations

The largest still existing desert massifs are probably those in the Aras valley in the most northeastern corner of Turkey. These are sand deserts several kilometers long dominated by *Calligonum polygonoides* L. (Figs. 8A–B); the neighbouring sand deserts with one species of *Salsola* L.; multi-species chenopod deserts with *Alhagi* Gagnebin on saline soils; and stony or gravel deserts and semideserts along Aras in Iğdır Province. Although possessing a fairly impoverished fauna and often being considerably overgrazed, these deserts are apparently the last westernmost refuges of the Turanian (= lowland Middle Asian) biota now largely extinct from the Transcaucasia and present only east of the Caspian Sea. Many plants still harbour species-rich herbivorous assemblages not known from other parts of Turkey, and some species of beetles are endemic to Northeast Turkey and south-eastern Transcaucasia, e.g., *Bruchela kasparyani* Korotyaev, 1988, *B. sugonyaevi* Korotyaev, 1988, *B. verae* Korotyaev, 1988, *B. hesperidis* Iablokoff-Khnzorian, 1957 (Anthribidae: Urodontinae), *Perapion* (*Hemiperapion*) *horvathi* (Schilsky, 1901) (Apionidae), *Titanomalia komaroffi* (Faust, 1877) (Nanophyidae) known previously only from Eastern Caucasus and found together with *Geranorhinus seidlitzi* Kirsch, 1874 near Iğdır in May 2015, *Geranorhinus seidlitzi* (described and known only from SE Transcaucasia from a few records of the XIX century and found near Iğdır in May 2015; new record for Turkey); *Tanymecus tenuis* Reitter, 1903 (Korotyaev *et al.* 2015), *Theodorinus transcaucasicus* Korotyaev, 1989 (Curculionidae). For preservation of these relatively (as compared to the agricultural areas) small refuges of a native desert biota, the arrangement of nature reserves is most desirable.

A unique sand desert dominated by bushes of *Calligonum polygonoides* L. in the TR-05-65 location in Iğdır Province (northwestern lowland area of Ağrı Mountain) is apparently the most interesting among the desert associations (Figs. 8A–B). *Capnodis excisa excisa* Ménétriés, 1848 (Buprestidae) (Fig. 8C), a large jewel beetle oligophagous on this plant, is quite common here and occurs outside this area only east of the Caspian Sea in the deserts of Middle Asia, Iran, and Middle East. In addition to this buprestid, two specialized weevils live on *Calligonum* L., and several other desert insects occur in the desert, including a characteristic ant-lion. Several species of lizards e.g., *Eremias strauchi* Kessler, 1878 (Fig. 8D), some of them also narrowly distributed, and a tortoise *Testudo graeca* Linnaeus, 1758 (Fig. 8E) live here. This means that the desert fragment we found, although small and impoverished, still preserves many of its characteristic biocoenotic features and components and may be a model of the aborigine vegetation. Unfortunately this area is being intensely forested in recent years; many hectares are covered with planted *Robinia pseudoacacia* L. with the mid-May aspect dominated by ruderal *Lepidium vesicarium* L. and *Sisymbrium loeselii* L. (the latter plant is allelopathic against other species growing around it, i. e., suppressing their germination and growth). These species are good forage plants for the honey bee *Apis mellifica* Linnaeus, 1761 but are unequal substitutes for an endemic, highly characteristic natural complex of the *Calligonum* sand desert.

Several dozens beetle species have been found in the deserts of Northeastern Anatolia, many of which are associated with the genuine desert plants and are potential bioindicators of the degradation of vegetation. One of these insects is a bark beetle, *Thamnurgus pegani* Eggers, 1933 (Curculionidae: Scolytinae), previously known only from Middle Asia where it develops on a desert and semidesert ruderal plant, *Peganum harmala* L. (Mandelshtam *et al.* 2011), indicative of the overgrazed areas and dominating vast territories because cattle do not eat this plant. In Turkey, we collected *Thamnurgus pegani* only in the Aras valley in spite of the wide distribution of *Peganum harmala* (Fig. 9A) in Central Anatolia and even in the mountain part of the Black Sea Region. Thus, the occurrence of *Peganum harmala* outside

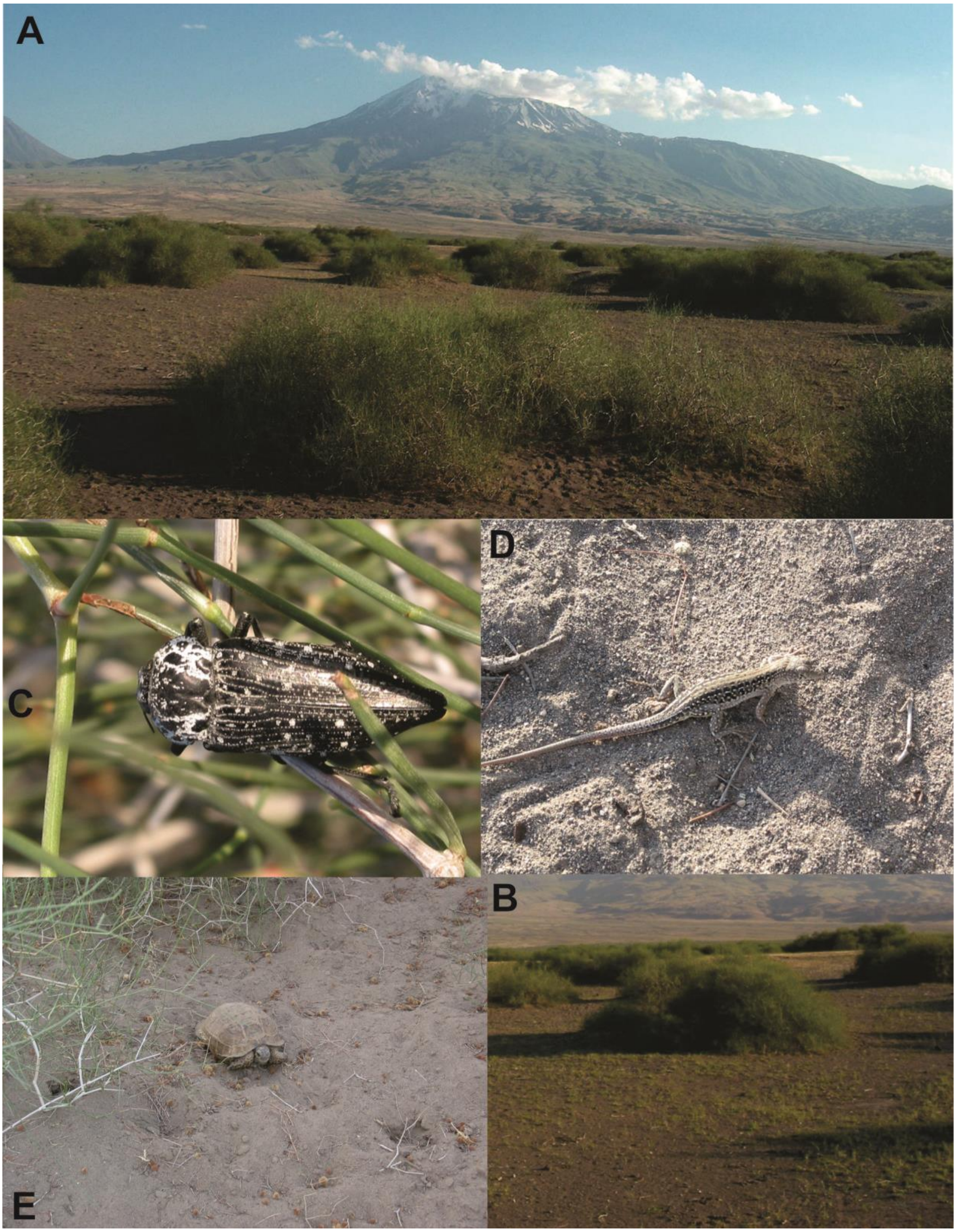

Figure 8. A unique massif of sand desert dominated by *Calligonum polygonoides* L. bushes in the TR05-65 location in Iğdır Province (Ağrı Mountain northwestern foothill area). **A–B,** *Calligonum polygonoides* L.; **C,** *Capnodis excisa excisa* Mén.; **D,** *Eremias strauchi* Kessler, 1878; **E,** *Testudo graeca* L.

the Aras valley may have a comparatively recent origin following biotic degradation of soil and vegetation (Fig. 9B).

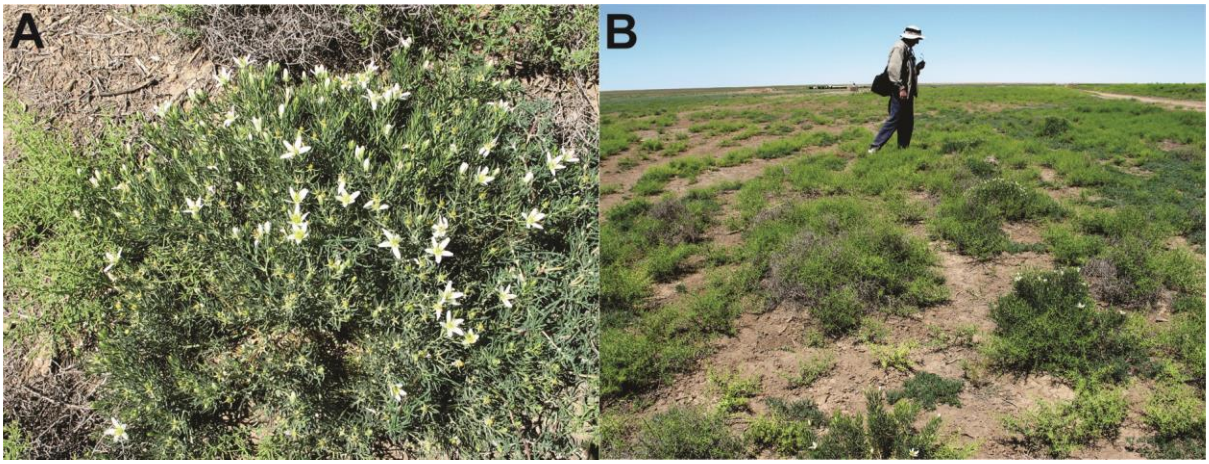

Figure 9. Plant of *Peganum harmala* L. and degraded soil in Central Anatolia. **A,** *Peganum harmala*; **B,** degraded soil area with *P. harmala*.

Many plants in the NE Turkish deserts and semideserts harbour multi-species insect assemblages specific not to a particular plant species but in some instances also to the plant community including this species. This is particularly true for the plant species playing an essential role in the phytocoenoses, the so-called edificatory species. To these, many species of the genus *Artemisia* L., some gramineans, and chenopods belong.

Of the dicotyledonous plants, species of the genus *Artemisia* (wormwoods) are especially abundant in many types of xerophilous vegetation (Figs. 10A–B). According to Turkish Plant Data Service (TÜBİVES), 22 species of *Artemisia* occur in Turkey, of which a few perennial semi-shrubs, very resistant to overgrazing, dominate vegetation on vast territories. The vegetation of the lowland territories of inner Anatolia is of the semi-desert type and is dominated by *Artemisia fragrans* Willd. (Menitsky 1984). Lots of insects from different orders are associated with all parts of *Artemisia* plants. In the model groups, several species of the Buprestidae, of which *Sphenoptera* (*Chilostetha*) spp. (namely *S. tezcani* Niehuis, 1999, collected on *Artemisia* in Aras valley, and endemic *S. leventi* Kalashian & Volkovitsh, 2007 swept from *Artemisia* at Lake Tuz shore), *Meliboeus caucasicus* Abeille de Perrin, 1896 and *Agrilus sericans* Kiesenwetter, 1857 are most common, tunnelling *Artemisia* roots and stems; adults of *Pachnephoptrus weisei* (Reitter, 1892) (Chrysomelidae) feed on foliage in great numbers, while larvae feed probably on roots; several species of *Ptochus* Schoenher, 1826 and *Leucomigus candidatus* (Pallas, 1771) (Curculionidae) feed on roots in the larval stage and on foliage, as adults; at least 3 species of *Pseudorchestes* Bedel, 1894 (Curculionidae) mine leaves; and *Taphrotopium cuprifulgens* (Schilsky, 1906) (Apionidae) induces galls on stems. Some of these beetles are specialized on one or a few closely related species of hosts, others develop on many. A widespread *Artemisia absinthium* L. has two specialized herbivores in NE Turkey, the apparently monophagous *Pseudorchestes smreczynskii* (Dieckmann, 1958) and *Microplontus* sp. (both Curculionidae). In the middle section of Aras valley, roots of *Artemisia* sp. pr. *marschalliana* Sprengel are attacked by *Baris nesapia* Faust, 1887, also a curculionid.

Often species of both wingless and rapidly flying beetles occur only in some parts of the host range, with distribution probably being limited by the climate. Such species seem to be indicative of particular types of plant communities, either of the desert or the semidesert or the dry steppe type. The successive changes of the beetle consortia on *Artemisia* are apparent when moving from the desert zone in Iğdır Province to semideserts and dry steppes in Kars Province, where different species of the wingless *Ptochus* Boh. (Fig. 10C) and alate, highly agile *Pseudorchestes* Bed. (Fig. 10D) live on similar looking and closely related or conspecific *Artemisia*. Species-rich assemblages of beetles were found on *Artemisia* also in the upper part of the Euphrates valley near Erzincan where small areas of the saline semidesert associations with big plants of xerophilous *Artemisia* occur in the floodland but are threatened by numerous cattle from the neighbouring cities. Narrow stripes of halophilous vegetation with two species of *Artemisia* which have not yet lost their specific consumers still persist around Lake Tuz but are heavily overgrazed and polluted.

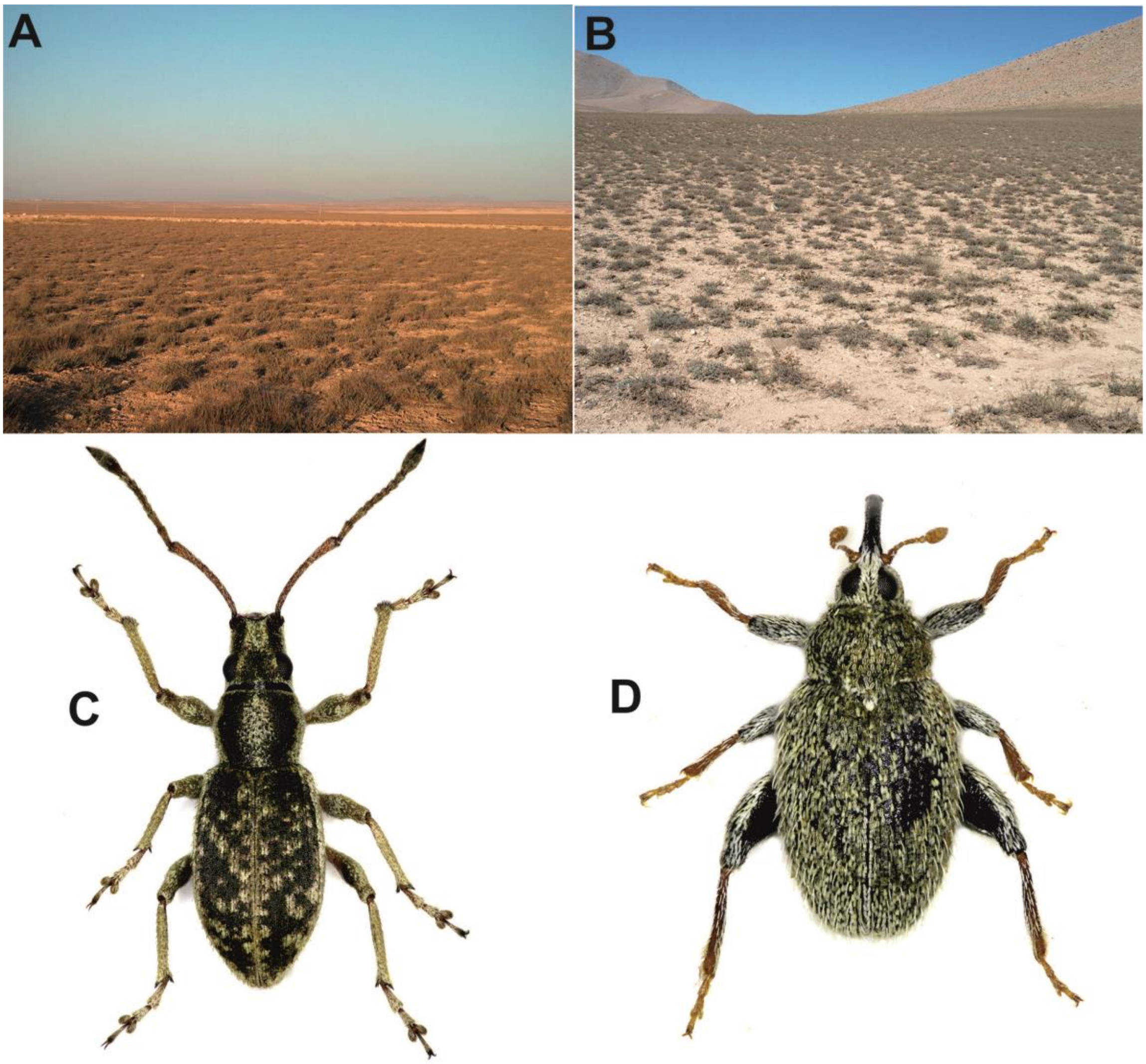

Figure 10. *Artemisia* sp. at desertified areas in Central Anatolia and associated weevils. **A–B,** *Artemisia* sp. in desertificated areas; **C,** *Ptochus* sp.; **D,** *Pseudorchestes* sp.

Many species of Orthoptera (grasshoppers and locusts) live in the native well-preserved wormwood-dominated communities, and the large plants provide food and shelter to other insects, first of all Tenebrionidae, the beetle family most prosperous in the arid landscape of Middle and Central Asia. This is often observed also in the Aras valley with a long, more or less continuous stripe of the *Artemisia*-dominated dry steppes, semideserts and deserts approximately from the Çobandede Bridge near Horasan downstream to Nakhichevan border. Vast areas in Central Anatolia (in Aksaray, Nevşehir, and Konya provinces) are dominated by *Artemisia* spp. (often co-dominated by Chenopodiaceae) and produce an impression of a desert or a semidesert but have no such characteristic attributes of genuine Asian deserts as orthopterans and tenebrionids. No or very few Buprestidae or weevils were found in these localities with overgrazed *Artemisia*-dominated vegetation in Central Anatolia. The same is true for a several square kilometer area along Aras some 50 km upstream of Köprüköy Village in Erzurum Province. These findings may exemplify the expansion of the *Artemisia*-dominated ruderal plant communities to the overgrazed territories, but may also indicate the latest stages of the biotic degradation of the native wormwood-dominated associations. A profound study in these areas is necessary to understand which actually is the case. We would like to stress, however, that the absence of characteristic insect assemblages on common plants is an alarm signal showing either a drastic impoverishment of the biodiversity and the biotic degradation, or the appearance of a plant new for a particular area, which may also indicate serious change of the environment, probably due to a biotic degradation as well.

In addition to several species of *Artemisia*, some other plants are characteristic of deserts and semideserts in NE Turkey.

Atraphaxis spp. (Polygonaceae) are common on eroded slopes and in ravines, probably due to their high resistance to erosion and damage by cattle. (In southern Mongolia, *Atraphaxis pungens* Jaub. & Spach occurs in steppefied deserts near springs where only branches over 1 cm thick remain on the plants regularly grazed by camels). This genus is most typical of semideserts and northern deserts of Middle and Central Asia, where its species are attacked by dozens of specialized feeders from several insect orders, including an endemic weevil genus *Macrotarrhus* Bedel, 1906 with over 20 species. An apionid weevil [(*Perapion chioneum* (Khnzorian, 1957)], a buprestid (*Agrilus araxenus* Iablokoff-Khnzorian, 1960; new record for Turkey), and several leaf-beetles are common on *Atraphaxis* L. in the lower course of Aras, whereas only leaf-beetles live on this plant in the mountainous areas north of Erzurum. All species of beetles found on *Atraphaxis* in Turkey are narrowly distributed and constitute an autochthonous, specific element of the Anatolian (mostly NE Anatolian) biota.

Chenopodiaceae are especially diversified and abundant in arid landscapes, and many of them have very species-rich insect consortia (Gültekin *et al.* 2004). In total, at least 36 Turkish species of weevils [21 species of Lixinae, 10 species of Baridinae, *Metadonus anceps* (Boheman, 1842) (Hyperinae), *Anthypurinus loginovae* Korotyaev, 1990 (Ceutorhynchinae), *Ita korotyaevi* Meregalli & Borovec, 2011, *Philernus ponticus* Korotyaev, 1979 and *Ph. gracilitarsis* (Reitter, 1899) (Curculioninae); two latter species are new records for Turkey] (see Table 3) develop only on Chenopodiaceae, some of them being specialized on a single or a few plant species. *Suaeda altissima* (L.) Pall., *Salsola tragus* L. and *S. dendroides* Pall. are very common in the desertified, usually overgrazed saline habitats. Four species of the weevil tribe Lixini [*Lixus kraatzi* Capiomont, 1875, *L. subulatus* Faust, 1891, *L. reitteri* Faust, 1891 and *Hypolixus astrachanicus* (Faust, 1883)] usually occur on these plants in Iğdır Province and thus may be considered bioindicators of degraded saline habitats. All these species belong to the Turanian (plain desert Middle Asian and South-Eastern Transcaucaian) biota.

The Buprestidae is the second coleopteran family in the number of species associated with Chenopodiaceae (see Table 3). Many species of buprestids [e.g., *Sphenoptera* (*Chrysoblemma*) *sancta* Reitter, 1890, *Sphenoptera* (*Ch*.) *tamarisci beckeri* Dohrn, 1866, *Sphenoptera* (*Ch.*) *scovitzii* Faldermann, 1835] tunnel stems and roots or induce root galls (Korotyaev *et al.* 2005) on perennial semi-shrubs like *Noaea* Moq., *Salsola orientalis* S. G. Gmel., *S. dendroides* Pall. etc. Buprestidae are followed by Chrysomelidae represented by a few species of the flea-beetle genus *Chaetocnema* Stephens, 1831 and four or five species of the subfamily Cassidinae. Infestation of the roots of *Halocnemum strobilaceum* (Pall.) Bieb. by a cerambycid *Xylotrechus* (*Kostiniclytus*) *volkovitshi* Shapovalov, 2014 belonging to the Turanian subgenus first found in Turkey and buprestid *Acmaeoderella* (*Carininota*) *flavofasciata* (Piller & Mitterpacher, 1783) larvae, also were found. Some species of Chenopodiaceae dominate xerophilous vegetation on vast areas and have been investigated in more detail. We will briefly describe here three of them, *Seidlitzia florida* (Bieb.) Bunge, *Camphorosma lessingii* Litv., and *Halocnemum strobilaceum* (Pall.) Bieb.

Seidlitzia florida (Fig. 11A, B) is an annual ruderal plant, the commonest of Chenopodiaceae in lowland NE Turkey, where it dominates really large areas with overgrazed vegetation. It is often the only green plant in badlands along Aras in Iğdır Province. The plant occurs in a wide range of habitats, both on clay and gravel. At least 10 species of weevils feed on it, occasionally in great numbers, e.g., *Conorhynchus lacerta* Chevrolat, 1873, *Entymetopus limis* (Ménétriés, 1849), *Lixus reitteri* in Aras valley, and *Chromonotus vittatus* (Zoubkoff, 1829) (Fig. 11C) at the Ağrı Mt. foothill. *Anthypurinus loginovae* (Fig. 11D) is probably monophagous on this plant, at least in Turkey, and restricted

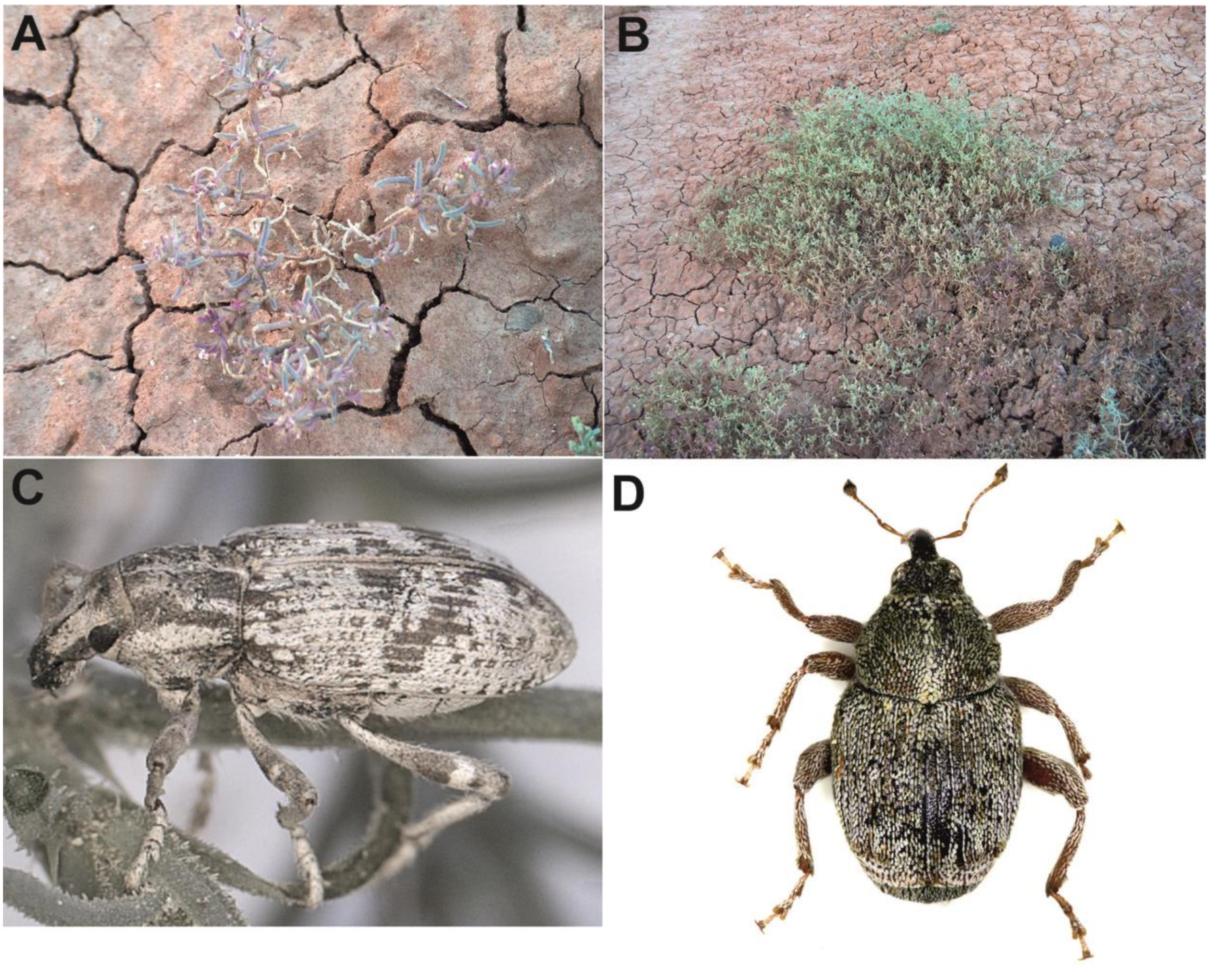

Figure 11. Plant of *Seidlitzia florida* (Bieb.) in desertified location and associated weevils. **A–B,** *Seidlitzia florida*; **C,** *Chromonotus vittatus* Zoubk.; **D,** *Anthypurinus loginovae* Kor.

to the desert lowland part of Northeast Turkey. This alate weevil, capable of active dispersal, has a spotted distribution and is often apparently missing from large and dense populations of the host, but occasionally occurs (accompanied by the non-specific weevils *Ita korotyaevi* and *Philernus gracilitarsis*) on the narrow stripes of *S. florida* along dry waterbeds on slopes in the completely eroded badlands. *Seidlitzia florida* may be considered a bioindicator of soil degradation and probably is an important soil-fixing plant on the eroded clay slopes. The presence of *Anthypurinus loginovae* apparently indicates a pretty well-established population of *S. florida*.

Camphorosma lessingii Litv. (Fig. 12A) is a prostrate perennial halophilous plant, occurring in Aras valley at the elevations of 1400–2000 m and occupying large areas in Central Turkey around Lake Tuz and south of it at elevations from 900 to about 1000 m. We have not found *C. lessingii* in the desert zone in Iğdır Province and consider it a dry steppe and semi-desert xerophyte. The plant is highly resistant to overgrazing and occurs in the areas where only small *Artemisia* sp. cf. *santonica* L. also grows; in certain localities *C. lessingii* is the only green plant. Although we have found only four species of beetles usually associated with *C. lessingii*, the assemblage is very characteristic. One beetle is a little known buprestid, *Sphenoptera* (*Chilostetha*) *syriaca* Jakovlev, 1908, developing in roots. Three other species are weevils: *Metadonus anceps* (Boheman, 1842), alate, with ectophytic larvae, widely spread in Eurasia and feeding on many Chenopodiaceae, and two wingless, closely related endemic, apparently monophagous species of *Baris* Germar, 1817 (Baridinae) with root-boring, tunnelling larvae: *B. grandicollis* Schultze, 1905 in Central Turkey, and *B. goekseli* Korotyaev & Gültekin, 2003 (Fig. 12B) in the upper Aras basin. The presence of two allopatric species in different parts of the country implies their autochthonous origin and long association with the host. We found *B. grandicollis* only close to salt lakes Tuz and Düden (slightly south of the latter) in relatively humid microhabitats and could not find it at a distance from the water. *Baris goekseli* is common in Aras valley at an elevation of 1650 m but does not occur at an elevation of about 1800 m some 20 km upstream of the Çobandede Bridge and at the eastern foothills of Ağrı Mt. at an elevation somewhat above 2000 m. It seems that both species are rather stenobiont, and at least *B. grandicollis* may be a bioindicator of the expansion of *C. lessingii*: the absence of *B. grandicollis* may indicate a comparatively recent invasion of the plant to a certain area.

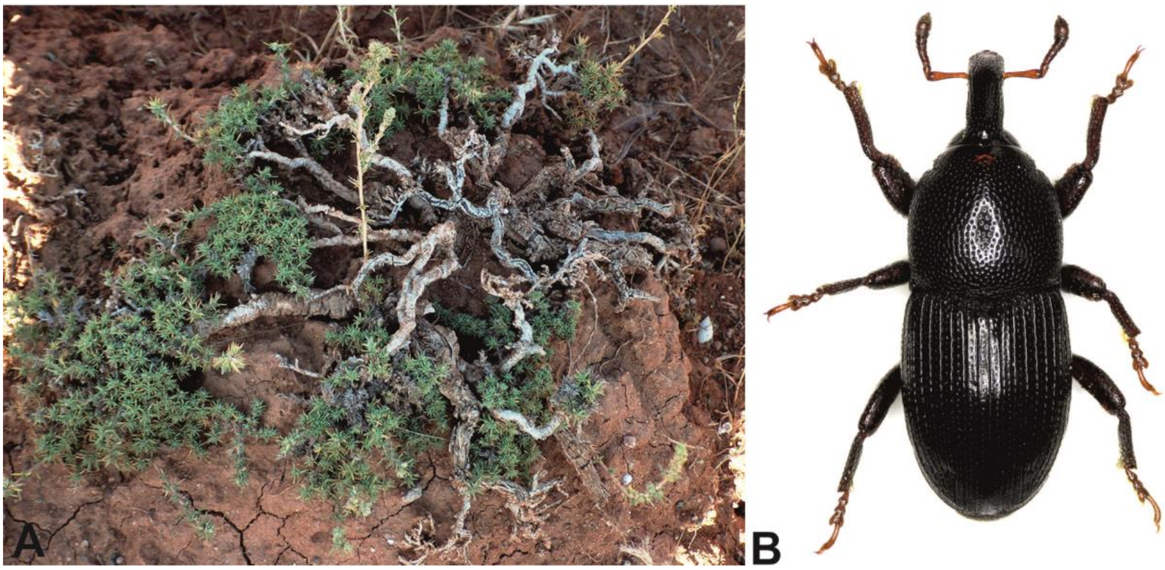

Figure 12. A, *Camphorosma lessingii* Litv. and **B,** *Baris goekseli* Korotyaev & Gültekin.

Halocnemum strobilaceum (Figs. 13A–B) is an indicator of high chloride salinity around seas and salt lakes in the areas with desert climate. This perennial plant forms large prostrate semi-shrubs around salt lakes in Central Turkey, but also dominates vegetation on the supposedly recently eroded areas more distant from Lake Tuz. Only one of the three weevils associated with this plant in the Northern Caucasus, the wingless *Philernus ponticus* has been found in Turkey. Similarly to the presence of two wingless *Baris* on *Camphorosma* L., the occurrence of the wingless *Ph. ponticus* presumes a long existence of *H. strobilaceum* in Central Turkey, and the absence of this weevil on this plant in a particular locality may indicate recent establishing of *H. strobilaceum* there. A stem boring buprestid, *Acmaeoderella* (*Carininota*) *flavofasciata* (Piller & Mitterpacher, 1783 (Figs. 13C–E), lives on *H. strobilaceum* in addition to the weevil. This is a new host record for this species, which is represented on *H. strobilaceum* by a supposedly specialized ecological form, probably also long-ago established on the plant. In contrast to *Philernus ponticus*, *A. flavofasciata* exhibits a high level of infestation of the host and lives in drier parts of its habitat.

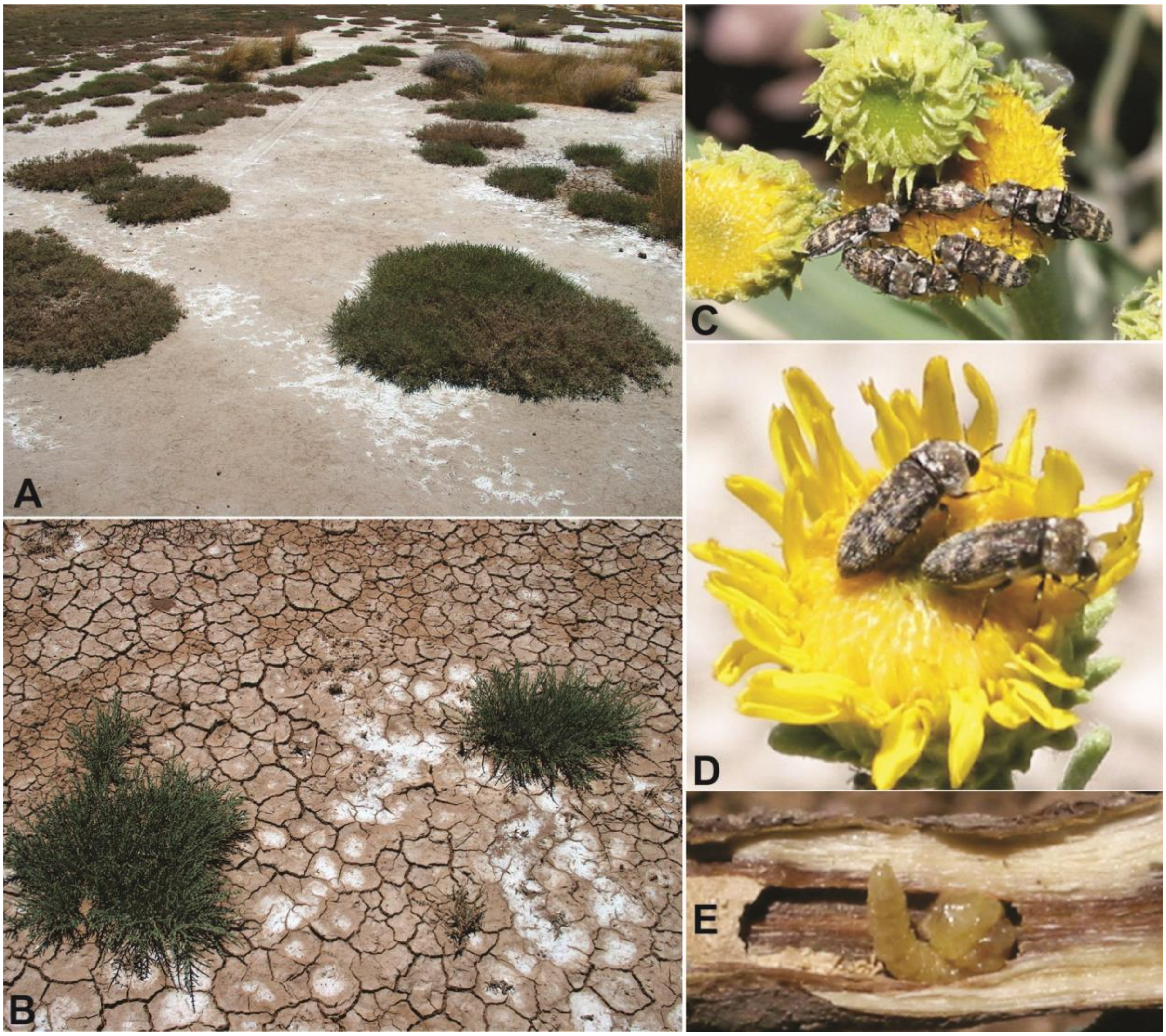

Figure 13. *Halocnemum strobilaceum* (Pall.) Bieb. and *Inula* sp. in Central Anatolia with associated jewel beetle. **A–B,** *Halocnemum strobilaceum*; **C–E,** *Acmaeoderella* (*Carininota*) *flavofasciata* (Piller & Mitterpacher): **C–D,** adults on *Inula* sp. flowers; **E,** larva in stem of *Halocnemum strobilaceum.*

A dense population of *Halocnemum strobilaceum* was investigated on June 4, 2006 at the Mediterranean coast close to Tuzla Village (Karataş District), at the locations TR06-01 and TR06-02, southwest of Adana around a small lagoon, which has temporary connection with the sea. No specific beetle was found on this chenopod, but a few weevils do occur on an annual succulent (probably *Salsola* sp.) along a dry waterbed of a small canal. One species of these weevils is very close to *Baris kirschi* Faust, 1882, a Middle Asian desert species apparently monophagous on *Halocnemum strobilaceum* (Korotyaev *et al.* 1993), which we never found on this plant in Turkey. As no Middle Asian or Ciscaucasian weevil occurs on *H. strobilaceum* on the Mediterranean coast near Adana, we presume that the *Baris* sp. pr. *kirschi* belongs not to the Middle Asian, but to the Mediterranean fauna and develops on plant other than *Halocnemum strobilaceum*.

A very typical saline desert plant is *Nitraria schoberi* L. (Nitrariaceae), occurring in the lower section of the Aras valley downstream of Kağızman and at the Lake Tuz shore. Two specialized genera of Coleoptera are associated with this plant in Asia, and both have been found in Turkey. A seed beetle, *Rhaebus mannerheimi* Motschulsky, 1845 (Chrysomelidae: Bruchinae), lives in Aras valley and at Lake Tuz, whereas the weevil *Margaritapion nitrariae* (Ter-Minassian, 1970) (Apionidae) occurs only in Aras valley. Ranges of both species extend eastwards as far as Mongolia. Both insects have been found in Turkey only recently (for *Margaritapion* Korotyaev, 1990, see Korotyaev & Gültekin 2002) and represent here an element of the Middle and Central Asian biota, which has become extinct in Transcaucasia, has not been reported from Iran, but still remains in small refuges in Turkey. The few populations of *N. schoberi* we have found in Turkey all include several dozen bushes situated within saline areas with a square of 3–5 hectares and can easily become extinct. Preservation of some of these populations is greatly desirable (Gültekin *et al.* 2006a, b).

Ephedra L. (Fig. 14A) is a highly characteristic xerophilous genus of the very ancient order Gnetales of gymnosperms. It includes in Turkey four species (TÜBİVES) of shrubs and semi-shrubs most typical of the screes in the middle course of Aras; some species also occur in the flood-land deserts, steppe-like xerophilous vegetation of the mid-altitude mountains north of Erzurum, at higher elevation (2000 m) near Lake Van, on the stony slopes along the Fırat (Euphrates) River, in the Mediterranean maquis in Mersin Province, in hilly areas of Central Turkey (Kırıkkale) and in the maquis-like vegetation in the Black Sea Region. Small populations of the northernmost steppe species *E. distachya* L. occur in Central Anatolia in and around Cappadocia. Over 60 species of the weevil tribe Oxyonychini (Curculionidae: Ceutorhynchinae) classified into 21 Palaearctic genus-group taxa all live on *Ephedra* (Colonnelli 1995, 2004, 2005). Of these, 10 species are known from Turkey, and three more species occur in the neighbouring parts of the Aras valley in Azerbaijan and Armenia. The greatest species diversity is found in the semi-desert and desert parts of the Aras valley (four species) and in the hot depressions between Lazistan Mt. Range and Kop Mountain (four species). Only one species has been found in the maquis-like landscape of the Black Sea Region; one is known from the Mediterranean Region, one from Central, and one from mountain Southern Anatolia.

In the number of species, the Turkish fauna of Oxyonychini equals that of Spain. They are the largest in the European Mediterranean area, but Morrocan fauna, with 11 species, is the largest in the entire Mediterranean Region (Colonnelli 2004, 2005). Considering an almost complete lack of material from the southern part of Turkey (except for the record of *Pseudoxyonyx aghadjaniani* Hoffmann, 1957 from Adana where we could not find any *Ephedra*) and the high probability of finding additional species in NE Turkey, one may anticipate a fairly voluminous fauna of Oxyonychini in the country. Characteristic

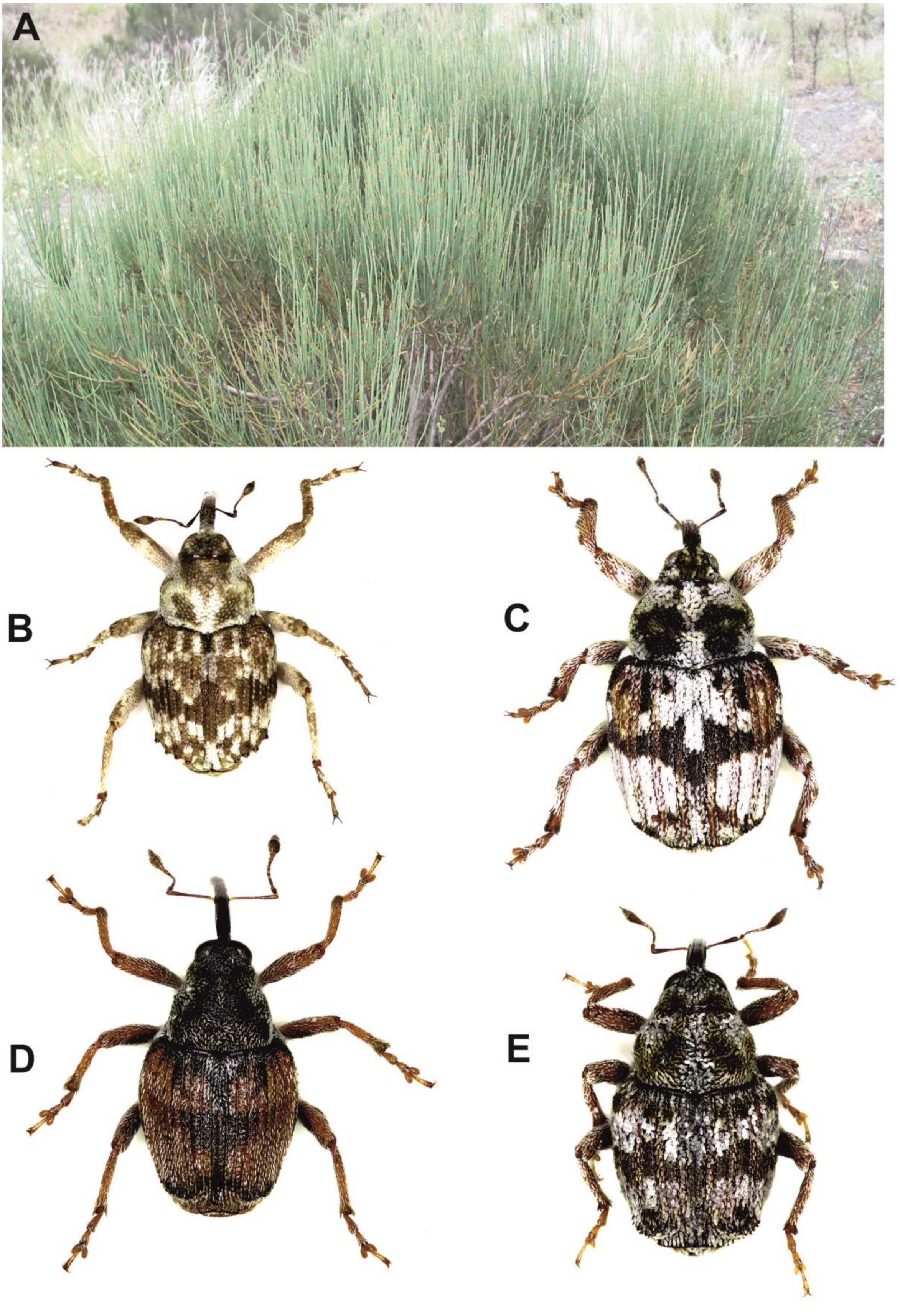

Figure 14. *Ephedra* L. plant and associated weevils of the tribe Oxyonychini. **A,** *Ephedra* sp.; **B,** *Oxyonyx brisouti* (Faust, 1885); **C,** *Neoxyonyx strigatirostris* (Hochhuth, 1847); **D,** *Barioxyonyx daghestanicus* Korotyaev, 1992; **E,** *Theodorinus transcaucasicus* Korotyaev, 1989.

features of the Turkish fauna of this tribe are the lack of species known from Mediterranean sand beech, the habitat of several endemic species in southern Europe and Israel; presence of a Central Asian species, *Oxyonyx brisouti* (Faust, 1885) (Fig. 14B) in Eastern Turkey separated from the rest of its range by Transcaucasia and northern Iran; and the concentration of most of the Oxyonychini species (seven out of the 10 known from the country) in the northeastern corner of Turkey. The latter feature may be due to a more intense collecting in this part of the country, but lack of material from the Mediterranean coast and Cappadocia, the areas where a lot of collecting has been done, presumes poor, if any, fauna in these regions. No Oxyonychini were found on two populations of *Ephedra distachya* L. in Cappadocia.

The distribution of Oxyonychini species (Figs. 14B–E) in Turkey is very similar to that of the genus *Magdalis* Germar, 1817 of the weevil subfamily Mesoptiliinae, associated with conifers and broad-leaved trees: most species are restricted to the peripheral maritime areas of the country, with its central part being almost deprived of species (Barrios 1995). These two similar distributional patterns probably mean that the climate of Central Anatolia is too harsh for the nemoral, Mediterranean and temperate desert faunas.

Gravitative erosion

Eroded slopes are seen everywhere along roads in the mountains (Figs. 4C–D). They are completely deprived of vegetation along newly constructed roads but the pioneer vegetation starts to appear very soon because screes and clay slopes are widespread natural habitats with their characteristic, species-rich and largely endemic flora. It seems that succession in the arid landscape runs faster and involves more species than in the forests where vegetation under the canopy often is scarce and composed of a few species, which can exist only in the shade. The sun-exposed slopes with herbaceous and semi-shrub vegetation in the rocky areas destroyed probably will remain devoid of plant cover for long periods because of lack of available substrate even for pioneer plants. Vegetation starts to return faster on the clay slopes where the plants can anchor the substrate, but it is very uniform and often consists of a single or very few herbaceous plant species. The recently eroded areas in the mountains, even with already well-developed herbaceous vegetation, at least with respect to the height and density of the herbage, usually possess surprisingly poor insect assemblages. The reason is that most of the (rather few) forest insects associated with herbs are adapted to shaded areas and would not live on the sun-exposed substrate. The active and widespread insects associated with common weeds gradually become established in the new roadside habitats but the process probably requires decades inside relatively large forest massifs.

Although we have done only little investigation of the eroded slopes in the forests, we would point out the necessity of strict protection of the mountain forests to avoid catastrophic floods which develop very rapidly in the deforested areas where huge masses of the ground deprived of vegetation holding it with their roots easily become eroded and abraded by water steams after rains. The experience of protecting mountain forests in Japan has shown this to be an effective way of preventing floods in a densely populated country.

We observed a characteristic type of gravitative erosion in the Mediterranean Region of Turkey, in Mersin Province, 25 km S of Mut, where a clay hill in a relatively dry area is being terraced for planting apricot groves (Fig. 15). The pioneer vegetation on the terraced slope in early May 2015 was composed almost exclusively of two crucifers, the predominantly Euro-Mediterranean *Rapistrum rugosum* (L.) All. and *Erucaria* sp. Very few species of phytophagous beetles were found feeding on the plants which were in several stages from first rosettes to fructifying specimens. The Chrysomelidae were represented by a not abundant uniformly-black *Phyllotreta* sp. and *Entomoscelis* sp. that concentrated on a few young *Rapistrum rugosum* plants and damaged their leaves severely. Weevils also were scanty; only *Ceutorhynchus pallidactylus* (Marsham, 1802) was common on both crucifers. In addition, a single individual of an Eastern Mediterranean species *Rhytideres albidus* Petri, 1915 known only from Turkey; a few individuals of *Lixus albomarginatus* Boheman, 1842 and a series of the Eastern Mediterranean *Aulacobaris kiesenwetteri* (Faust, 1890) were found. The latter species was relatively common on *Rapistrum rugosum* although in Central Anatolia we collected it only on *Erysimum* sp., and one specimen had been reared from a stem of this plant.

Figure 15. A characteristic type of gravitative erosion in the Mediterranean Region of Turkey, in Mersin Province.

We have not examined the development of the beetle assemblages in the dry mountain areas, which are hardly described in the literature as well, but have seen and partly investigated many of those, apparently representing different stages of their highly dynamic history. Several types of plant associations dominating on screes and clay slopes are widespread in Central and Eastern Anatolia from Ankara in the west to Erzurum in the east. They are formed by representatives of many genera of Cruciferae (= Brassicaceae), *Papaver fugax* Poir. and probably related species (Papaveraceae), a few species of Caryophyllaceae, several species of *Galium* L. (Rubiaceae), *Centaurea* L. (Asteraceae), *Erodium* L. (Geraniaceae), a number of Lamiaceae etc. Many of these species are annual or biennial plants capable of rapid exploration of eroded habitats, and many harbour multi-species consortia of herbivores also characterized by high agility. Several complexes of weevils associated with these crucifers were studied briefly or in more detail, partly in the course of the previous studies (Korotyaev & Gültekin 2003; Dorofeyev *et al.* 2004). We found in July, 2005 an endemic Turkish weevil species of the genus *Ephimeronotus* Faust, 1904, *E. samai* (Talamelli, 2001), in a typical ruderal plant assemblage at the newly constructed road south of Bingöl.

An extensive collection of weevils and buprestids associated with plants of the genera *Phlomis* L. (Figs. 16A–B) and *Stachys* L., family Lamiaceae, has been made. Plants of these two genera, rejected by cattle, are common xerophytes on eroded lands, often dominating herbaceous associations in overgrazed pastures in Central and Southern Anatolia. Two weevil genera, associated with Lamiaceae, have high species diversity in Turkey: *Thamiocolus* C. G. Thomson, 1859 (Ceutorhynchinae) (Fig. 16C) and *Labiaticola* Alonso-Zarazaga & Lyal, 1999 (Baridinae), both of them being represented by several species on *Phlomis*. Genus *Thamiocolus* with eight species on *Phlomis* in Turkey has an exceptionally rich representation, including mostly monophagous or narrowly oligophagous species, of which four are subendemic to Turkey. Host plants and distribution have been investigated for most of Turkish species of *Thamiocolus* and *Labiaticola* which should provide a better knowledge of the consortia of these xerophytes indicative of overgrazing. Also two widely distributed and presumably oligophagous buprestid species are associated with *Phlomis* spp., these are the stem borer *Acmaeoderella* (s. str.) *serricornis* (Abeille de Perrin, 1900) and the leaf miner *Trachys phlyctaenoides* Kolenati, 1846 (Fig. 16D). Some perennial *Phlomis* in mountain Mediterranean areas seem to be particularly important in protecting steep eroded stony slopes at roads from further destruction.

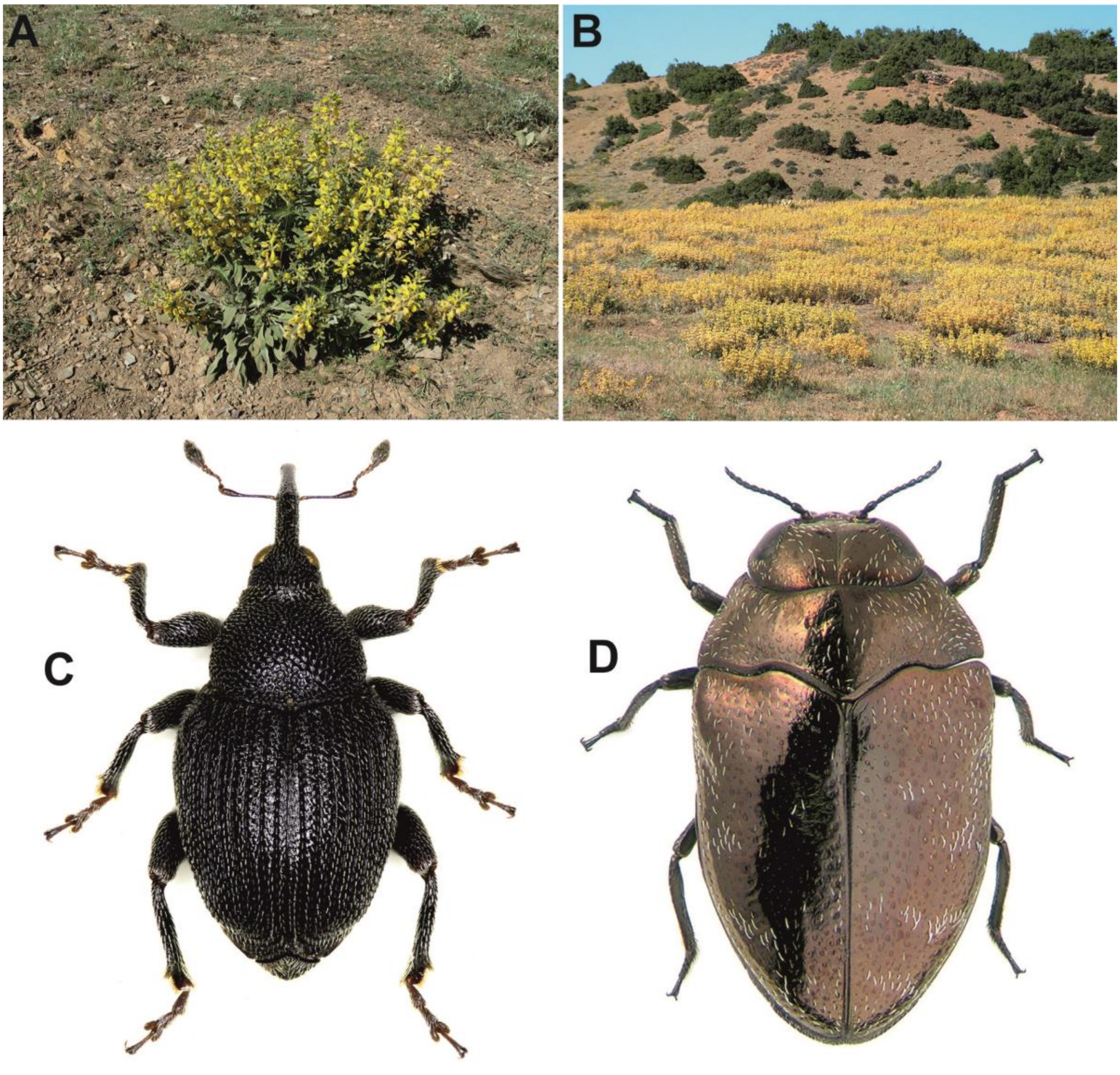

Figure 16. *Phlomis* sp. from Mediterranean Turkey and associated beetles. **A–B,** *Phlomis* sp. (Isparta Prov.); **C,** *Thamiocolus anthracinus* Colonnelli; **D,** *Trachys phlyctaenoides* Kolenati (Photo: K. V. Makarov, http://www.zin.ru/animalia/coleoptera/rus/traphlkm.htm).

A very characteristic plant assemblage occurs in Eastern Turkey at elevations over 2000 m on steep gravel and detritus slopes (TR05-53). It is dominated by three plants, *Rheum ribes* L. (Polygonaceae), *Prangos ferulacea* (L.) Lindl. (Apiaceae), and *Cousinia sivasica* Hub.-Mor. *Rheum ribes* (Figs. 17A–C) was our main target as a bioindicator of eroded slopes in high mountain ranges. This plant has stems grooved, leafy below, leafless above, up to 40 cm, bearing reddish powdery scales. Distribution in Turkey: Kars (S of Kağızman); Erzincan (Keşiş Mt., 2600 m); Van (Erek Mt., 2500–2600 m) (Davis 1967). Distribution in the World: Israel, Lebanon, Armenia, northern Iran, Iraq. The petioles are gathered for food very commonly in Turkey (Davis 1965–1988). We have found this plant also in Kop Mountain (Erzurum–Bayburt provinces border) at elevation 2300 m, and 36 km NW of Aziziye (Ilıca), Serçeme River valley (Erzurum Province) at elevations 1600–1800 m. *Rheum ribes* forms dense population in the location TR05-53 (Bingöl–Erzurum provinces border, 13 km N of Karlıova, Çirişli Geçidi, 2000–2300 m) on the deforested and eroded mountain (Figs. 17B–C). A weevil *Petrocladus* sp. (Curculionidae: Ceutorhynchinae) (Fig. 17E), a jewel beetle *Capnodis marquardti* Reitter, 1913 (Buprestidae) (Fig. 17D), and a leaf beetle, *Labidostomis brevipennis* Faldermann, 1837 (Chrysomelidae: Clytrinae) are specialized coleopterous herbivores associated with *Rh. ribes* in this location, all of them common on the plants. We found a large plant population at TR06-38 and collected the same weevil and leaf beetle species. We also observed *L. brevipennis* laying eggs on leaves (Fig. 17F). Several sites of this habitat with its characteristic plant and insect assemblages should be protected because gathering of the *Rh. ribes* petioles by local people, combined with a fairly intense grazing of the vegetation on slopes, may result in extinction of *Rh. ribes*, a not very common plant with a highly specific assemblage of beetles, most of which are endemic of Turkey.

The genera *Prangos* Lindl. (Fig. 18A) and *Ferula* L. (Figs. 18C–D) (family Apiaceae) play an important role in the composition of the vegetation on dry stony and clay slopes, often growing in deforested places and protecting soil from erosion. In addition to *Prangos ferulacea* Lindl., four species of *Prangos* and several species of *Ferula* have been investigated. About 10 species of three subgenera of the weevil genus *Lixus* Fabricius, 1801 and several species of Buprestidae, some of them very common, live on *Prangos* and *Ferula* in Eastern Turkey. *Prangos ferulacea* is also an important bioindicator of erosion. A weevil species *Lixus furcatus* Olivier, 1807 (Curculionidae: Lixinae) is quite common on *P. ferulacea* and its immature stages develop in the stems.

In addition to the above record, the following species of *Prangos* have been investigated. *Prangos lophoptera* Boiss., Erzurum Prov.: 36 km NW of Aziziye (= Ilıca), 1950 m. *Prangos uloptera* DC., 14–15 km W of Aşkale, Erzurum–Erzincan provinces border, 1850 m; 10 km N of Tortum, 1350 m; Kars Prov.: 25 km NW of Kağızman, along Kağızman–Kars road, 1550 m; 14 km E of Karakurt, 1400 m. Two *Prangos* species were not identified: one on Kop Mountain, 1800–2300 m (Bayburt and Erzurum provinces), and the other on Vauk Mountain, 1450–1550 m (Gümüşhane Province).

Biological investigations have been conducted on a recently described new species, *Lixus petiolicola* Gültekin & Korotyaev, 2011 (Fig. 18B), which lives in petioles of *Prangos* sp. on Vauk Mountain. Its habitat is eroded stony and rocky slopes dominated by the above mentioned *Prangos* sp. and another *Prangos* species, on which the very closely related *Lixus furcatus* lives. *Lixus cylindrus* (Fabricius, 1781) is an extremely rare species that we found on *Ferula* sp. in Aras valley (Kars Province, 30 km E of Horasan, 1450 m) on stony mountain slopes.

The genus *Ferula* can possess importance equal to that of *Prangos*. Species of *Ferula* occur in habitats similar to those of *Prangos*, and *Lixus cylindrus* lives in these habitats.

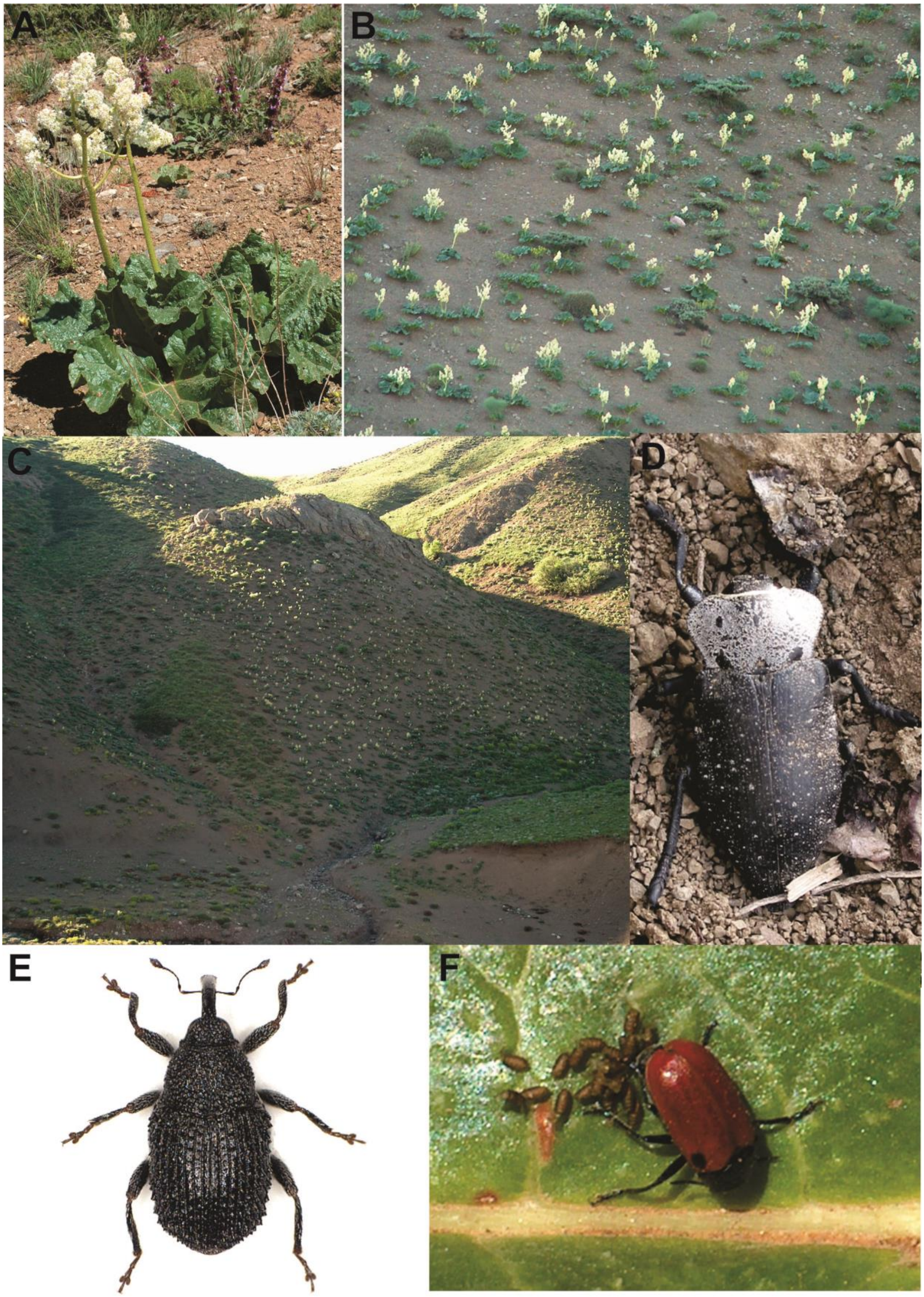

Figure 17. Çirişli Pass (Bingöl–Erzurum provinces border) with dominating plant *Rheum ribes* L. **A,** *Rheum ribes*; **B–C,** deforested and eroded slope covered with *Rh. ribes*; **D,** *Capnodis marquardti* Reitter; **E,** *Petrocladus* sp.; **F,** female of *Labidostomis brevipennis* Fald. laying eggs on *Rh. ribes*.

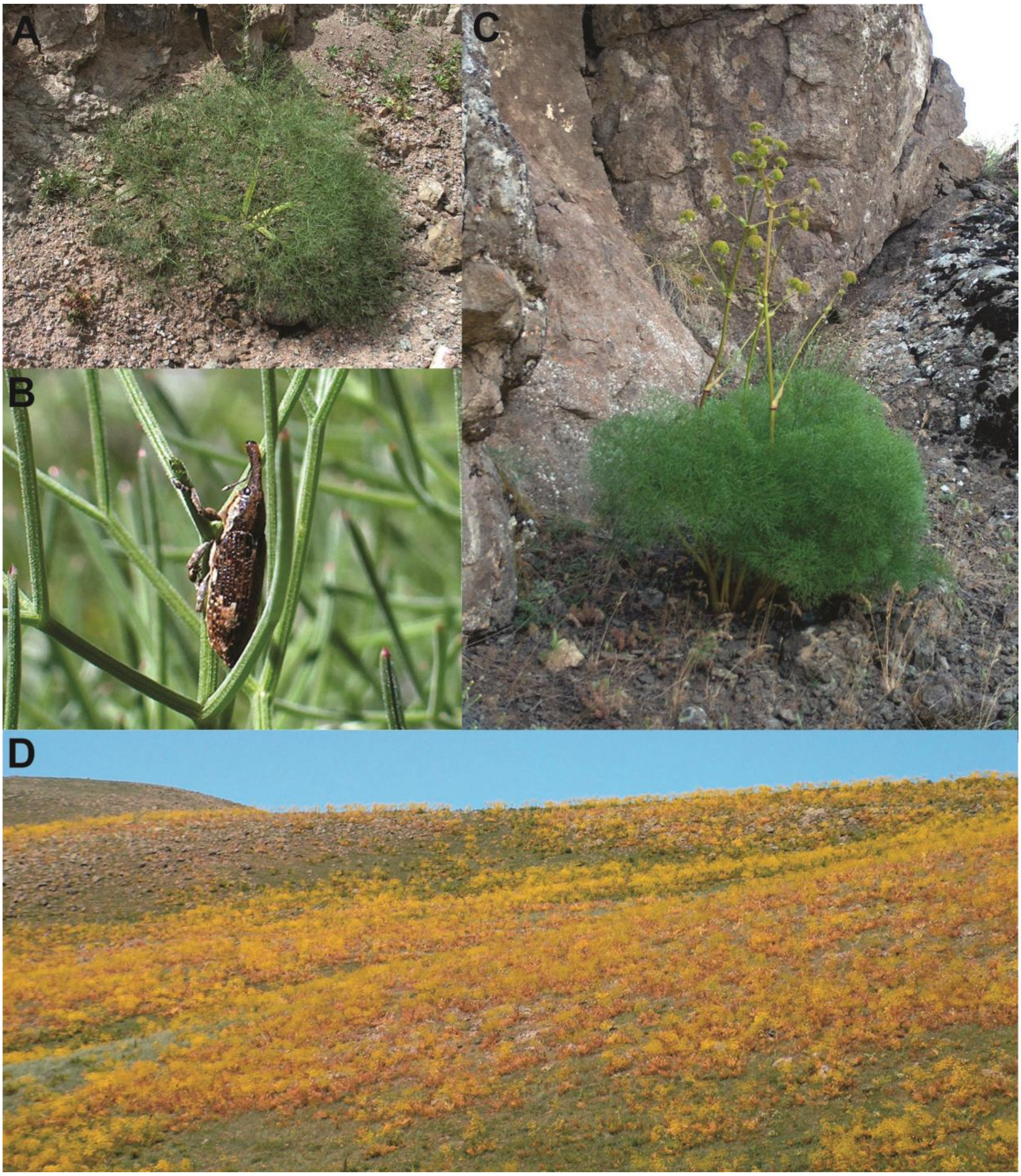

Figure 18. *Prangos* Lindl. and *Ferula* L. plants in the deforested and eroded mountain slopes in Northeastern Turkey. **A,** *Prangos*; **B,** *Lixus petiolicola* Gültekin & Korotyaev; **C–D,** *Ferula*.

Several species of the *Lixus* subgenus *Callistolixus* Reitter, 1916, and also oligophagous buprestid species *Anthaxia anatolica* Chevrolat, 1838 are associated with *Prangos* and *Ferula* in Eastern Turkey.

Erosion, ruderal plants and weeds

In the course of the study of insect assemblages on eroded areas we have found that complexes of weevils associated with ruderal vegetation in Turkey are species-rich and include many endemic and subendemic species. This is partly accounted for by the highly specific and diversified flora of the country composed of plant taxa widely exploited by weevils elsewhere. Wide distribution of the disturbed habitats (those subjected to pasture, erosion, and other forms of anthropogenic effects) in densely populated Central Anatolia provides extensive opportunities for weevils associated with weeds and ruderal plants.

During the investigation of the plant and insect complexes inhabiting places with degraded vegetation and soil in Turkey, a population of a conspicuous plant unfamiliar to us and looking like a large *Malva* plant was noticed along the highway in Elazığ Province (TR05-51) and examined. The plant proved to be *Centaurea kurdica* Reichardt (Fig. 19A), an endemic of the Irano-Turkish floristic Province (Davis 1965–1988), with five weevils of the tribe Lixini associated, two of them representing undescribed species of the genus *Larinus* Dejean, 1821. We found and examined *C. kurdica* at sites TR06-15 and TR06-21 (Şanlıurfa and Mardin provinces), and also collected there the same two *Larinus* species (Fig. 19B). In addition to these species, a long series of a poorly known weevil, *Pseudorchestes araxicola* Korotyaev, 1992 (Curculionidae: Curculioninae: Rhamphini) (new record for Turkey), described from Nakhichevan, and an *Eustenopus* Petri, 1907 (Curculionidae: Lixinae) species were collected from *Zoegea leptaurea* L., also an element of the Irano-Turkish Province, along the highway, and four specimens of *Cercomorphus bos* Abeille de Perrin, 1895 (Anthribidae: Urodontinae), known only from the original description based on material from Israel, were swept from the roadside vegetation. A few kilometers from this place, a rare apionid, *Ceratapion rhopalorrhynchum* Khnzorian, 1967, was swept from a dense spot of several species of *Centaurea* and other asteraceans at the roadside. In another close locality, a rare flea-beetle *Hermaeophaga ruficollis* Lucas, 1849 (Chrysomelidae) was found in a fallow field on a widespread ruderal plant *Chrozophora tinctoria* (L.) A. Juss. (Euphorbiaceae). We found *Zoegea leptaurea* as a dominant plant along the road at the location TR06-18 (Şanlıurfa Prov.) and swept from it *Pseudorchestes* sp., but no *Eustenopus*.

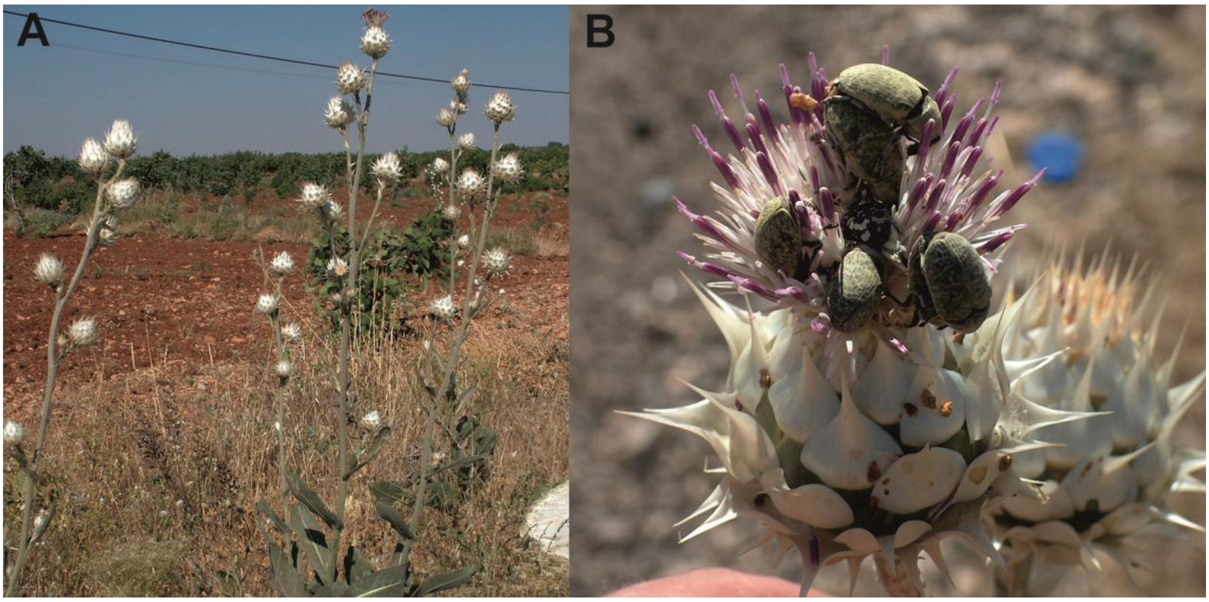

Figure 19. A, *Centaurea kurdica* Reichardt; **B,** *Larinus* spp. on flowerhead of *C. kurdica*.

The set of the interesting findings in Elazığ Province is one of numerous examples of a high diversity of specialized rhynchophorous herbivores on ruderal vegetation in Anatolia. A characteristic feature of the Turkish fauna of weevils associated with weeds and ruderal plants is a high proportion of the endemic and subendemic species (Korotyaev *et al.* 2012), although usually weed herbivores are widespread species. The typical examples are the largest Palaearctic urodontid, *Bruchela densata* Reitter, 1897 which is endemic to Turkey, apparently monophagous on an endemic SW Asian crucifer, *Boreava orientalis* Jaubert & Spach; *Coeliastes rustemi* Korotyaev, Gültekin & Colonnelli, 2002 (Curculionidae: Ceutorhynchinae) on the subendemic *Wiedemannia multifida* (L.) Boiss. (Lamiaceae); *Larinus filiformis* Petri, 1907 (Curculionidae: Lixinae) on *Centaurea solstitialis* L. (Asteraceae), and *Aulacobaris licens* (Reitter, 1895) (Curculionidae: Baridinae) (new record for Turkey) and *Ceutorhynchus isatidis* Colonnelli, 2003 (Curculionidae: Ceutorhynchinae) on *Isatis glauca* Aucher ex DC. (Brassicaceae). Several other weevils from the same and other families and subfamilies may be added to this list.

Their hosts often occur not only in the ruderal habitats but also in the fields, i.e., may be weeds in the strict sense. This is true for some species of *Isatis* L., often painting large areas of barley fields yellow; the closely related *Boreava orientalis* Jaub. et Spach occasionally co-dominating with *Isatis*, especially at field margins, and *Wiedemannia* Fisch. et C. A. Mey. in the thinned or low crops. Weevils associated with these plants usually infest them at field margins and occur in greater numbers in the neighbouring natural habitats, but *Bruchela densata* (Reitter, 1897) in NE Anatolia was found only in the fields (Korotyaev *et al*. 2012); the only record outside fields was that in June of 2005 at the highway roadside near Ankara. This is the only example of the weevil's preference for host plants growing in the field over those in natural (including ruderal) habitats known to us, potentially of great interest to biocontrol researchers.

Other examples are ruderal and semidesert species of the tribe Cardueae, *Cirsium baytopae* P. H. Davis & Parris and *Cousinia* spp., which are host plants of four species of the weevil tribe Lixini. *Cirsium baytopae* is a host of two species of the recently described genus *Nefis* Gültekin, 2013, *N. brevirostris* (Hochhuth, 1851) and *N. ochroleucus* (Capiomont, 1874), and also of *Larinus fucatu*s Faust, 1891 and *L. darsi* Capiomont, 1874. *Nefis ochroleucus* and *L. fucatus* feed also on *Cousinia urumiensis* Bornm. and *Cousinia* sp. The host record of *Larinus darsi* is new to science. The four mentioned species have been collected mostly in the semidesert and desertified locations on these ruderal plants and they may be good indicators of ruderal desertified areas. In addition, two plant species *Serratula serratuloides* (Fisch. & C. A. Mey.) Takht. (in the Aras valley and at the location TR06-34) and *Pulicaria dysenterica* (L.) Bernh. (TR06-34) are hosts of a *Larinus* species and *Nefis korotyaevi* Gültekin, 2013 respectively (Gültekin 2013). Both plants are found on highly eroded sandy slopes and could play an important role in preventing erosion of the slopes.

Ruderal weevil complexes are generally composed of highly agile species capable of rapid dispersal and colonization of the newly established and often short-lived plant communities. Their species-richness in Turkey may be partly accounted for by the wide distribution of the screes and dry clay slopes in the mountains of Central and Eastern Anatolia where easily movable substrate facilitates habitation of weeds and pioneer plants preferring constantly and quickly changing environments. The ecological closeness and historical relationships of the mountain-slope and ruderal communities are impressively exemplified by the pink- or violet-painted spots on mountain slopes or on fallow fields among crops dominated by *Wiedemannia multifida* Benth. (Fig. 20A) or *Hesperis schischkini* Tzvel. (Fig. 20C), with specialized weevils *Coeliastes rustemi* Korotyaev, Gültekin & Colonnelli, 2002 (Fig. 20B) and *Ceutorhynchus oculatus* Colonnelli, 1987 (Fig. 20D) respectively, on them, in both kinds of habitats. Highly diversified and specific weevil assemblages are associated with these characteristic plant communities in Turkey over a wide range of altitudes providing a variety of potential agents of biological control of weeds originating from Anatolia and adjacent lands.

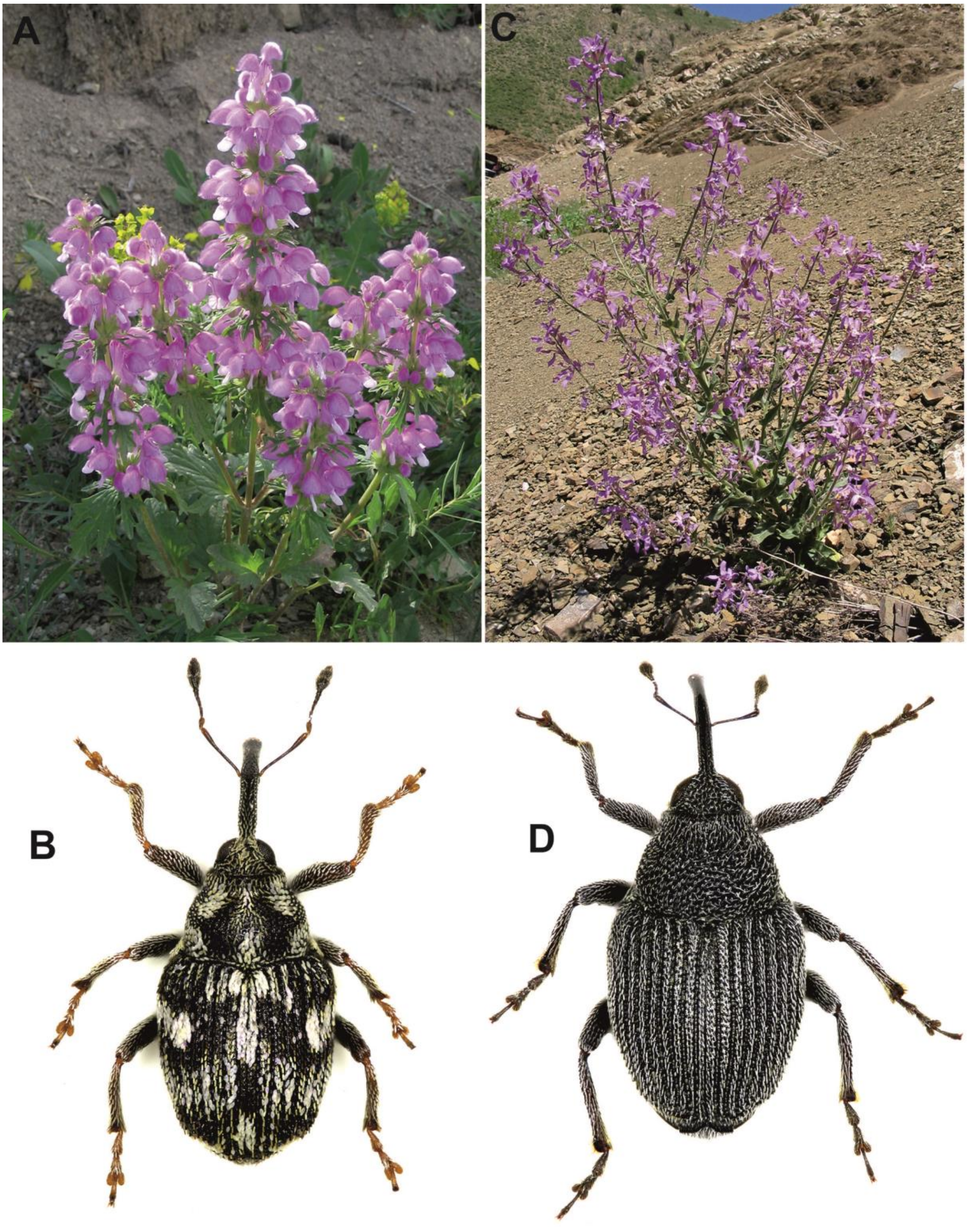

Figure 20. Ruderal plants and weevil complexes in Northeastern Turkey. **A,** *Wiedemannia multifida* (L.) Boiss.; **B,** *Coeliastes rustemi* Korotyaev, Gültekin & Colonnelli; **C,** *Hesperis schischkini* Tzvelev; **D,** *Ceutorhynchus oculatus* Colonnelli.

Table 3. Beetles (Buprestidae, Chrysomelidae and Curculionoidea) associated with xerophytes in Turkey.

Plant species	Insect species	Collected stages	Immature stages localizations	Locality
Ephedra spp.	*Barioxyonyx daghestanicus* Korotyaev, 1992 (Curculionidae)	Adults	Larva ?in seeds	Kars Prov.
	Barioxyonyx helenae Korotyaev, 1994 (Curculionidae)	Adults	Larva ?in seeds	Bayburt Prov.
	Neoxyonyx strigatirostris (Hochhuth, 1847) (Curculionidae)	Adults	Larva ?in seeds	Erzurum and Kars provinces
	Oxyonyx brisouti (Faust, 1885) (Curculionidae)	Adults	Larva ?in seeds	Erzurum Prov.
	Protoxyonyx lunatus (Reitter, 1890) (Curculionidae)	Adults	Larva ?in seeds	Bayburt, Kars, and Erzurum provinces
	Platypteronyx auritus (Kirsch, 1878) (Curculionidae)	Adults, pupae	Larva and pupa in seeds	Erzurum, Kars, and Artvin provinces
	Platypteronyx maximi Colonnelli, 2005 (Curculionidae)	Adults	Larva ?in seeds	Niğde Prov.
	Pseudoxyonyx aghadjaniani Hoffmann, 1957 (Curculionidae)	Adults	Larva ?in seeds	Adana Prov.
	Theodorinus transcaucasicus Korotyaev, 1989 (Curculionidae)	Adults	Larva ?in seeds	Kars and Iğdır provinces
	Theodorinus giustocaroli Colonnelli, 2005 (Curculionidae)	Adults	Larva ?in seeds	TR05-03
Stipa sp.	*Clema ?freudei* Cobos, 1963 (Buprestidae) (New record of the genus for Turkey)	Adults	Larva in stems	TR05-05
Calligonum polygonoides L.	*Capnodis excisa excisa* Ménétriés, 1848 (Buprestidae)	Adults	Larvae in roots	TR05-63
	Perapion horvathi (Schilsky, 1901) (Curculionoidea: Apionidae)	Adults	Unknown	TR05-63
	Ptochus sp. (Curculionidae)	Adults	On roots in the soil	TR05-63
Rheum ribes L.	*Capnodis marquardti* Reitter, 1913 (Buprestidae) (First record of host plant)	Adults, larvae	In roots	TR05-53
	Labidostomis brevipennis Faldermann, 1837 (Chrysomelidae)	Adults and eggs	Eggs on leaves	TR05-53 TR06-38
	Petrocladus sp. (Curculionidae)	Adults	Larvae in petiole	TR05-53, TR06-38
	Agrilus (*Spiragrilus*) *araxenus*	Adults	Unknown	TR05-55

Atraphaxis spp.	Khnzorian, 1960 (Buprestidae) (New record for Turkey)			
	Pachybrachys spp. (several cryptic species) (Chrysomelidae)	Adults	Case-bearing larvae on leaves and in detritus under plants	Northeastern Turkey
	Perapion chioneum (Khnzorian, 1957) (Curculionoidea: Apionidae)	Adults	Unknown	Kars Prov.
Peganum harmala L.	*Thamnurgus pegani* Eggers, 1933 (Curculionidae: Scolytinae)	Adults	Larvae in stem	Iğdır Prov.
Camphorosma lessingii Litv.	*Sphenoptera* (*Chilostetha*) *syriaca* Jakovlev, 1908 (Buprestidae) (First record of host plant)	Larvae, pupae, adults	In the roots	TR05-05, TR05-07
	Baris grandicollis Schultze, 1905 (First record of host plant) (Curculionidae)	Adults	In the roots	TR05-07
	Baris goekseli Korotyaev & Gültekin, 2003 (Curculionidae)	Adults	Larvae in the roots	Aras valley
	Metadonus anceps (Boheman, 1842) (Curculionidae)	Adults	Larvae on leaves	TR05-07, Aras valley
Halocnemum strobilaceum (Pall.) Bieb.	*Acmaeoderella* (*Carininota*) *flavofasciata* (Piller & Mitterpacher, 1783) (Buprestidae) (new host record)	Larvae, pupae, adults	In stems	TR05-11, TR05-27
	Philernus ponticus Korotyaev, 1979 (Curculionidae)	Adults	Unknown	TR05-05
	Ita korotyaevi Meregalli & Borovec, 2011 (Curculionidae)	Adults	Unknown	TR05-05
	Xylotrechus (*Kostiniclytus*) *volkovitshi* Shapovalov, 2014 (Cerambycidae)	Adult	In lower part of stem	TR05-27
Seidlitzia florida (Bieb.) Boiss.	*Anthypurinus loginovae* Korotyaev, 1990 (Curculionidae)	Adults	Unknown	Aras valley
	Conorhynchus lacerta Chevrolat, 1873 (Curculionidae)	Adults	Unknown	Aras valley
	Entymetopus limis (Ménétriés, 1849) (Curculionidae)	Adults	Unknown	Aras valley
	Chromonotus vittatus (Zoubkoff, 1829) (Curculionidae)	Adults	Unknown	Aras valley
	Philernus gracilitarsis (Reitter, 1899), sp. propria, see Korotyaev, 1979 (Curculionidae)	Adults	Unknown	Aras valley
	Ita sp. (Curculionidae)	Adults	Unknown	Aras valley

Noaea ?mucronata (Forssk.) Asch. & Schweinf.	*Sphenoptera* (*Chrysoblemma*) *sancta* Reitter, 1890 (Buprestidae)	Adults, larvae	In roots	TR05-04, TR05-25, TR05-26, TR05-28, TR05-64
Suaeda altissima (L.) Pall.	*Agrilus* (*Aridagrilus*) *transversesulcatus* Reitter, 1890 (New record for Turkey) (Buprestidae)	Adults	In roots	Aras valley
	Lixus kraatzi Capiomont, 1875 (Curculionidae)	Adults	Unknown	TR05-62
	Lixus subulatus Faust, 1891 (Curculionidae)	Adults	Unknown	TR05-62
	Hypolixus astrachanicus (Faust, 1883) (Curculionidae)	Adults	Unknown	TR05-62
	Lixus rubicundus Zoubkoff, 1833 (Curculionidae)	All stages	In stems	In many locations
Chenopodium sp.	*Lixus rubicundus* Zoubkoff, 1833 (Curculionidae)	All stages	In stems	In many locations
	Temnorhinus hololeucus (Pallas, 1781) (Curculionidae)	All stages	On root crown in capsule	Erzurum and Iğdır provinces
Salsola ?orientalis S. G. Gmelin	*Sphenoptera* (s. str.) *latesulcata* Jakovlev, 1886 (Buprestidae) (New record for Turkey)	Adults	Unknown	TR05-66
Salsola tragus L.	*Lixus reitteri* (Faust, 1891) (Curculionidae)	Adults	Unknown	TR05-62
Salsolae (*Climacoptera* Botsch., *Horaninovia* Fisch. & C. A. Mey., *Salsola* spp.), *Atriplex* L.	*Sphenoptera* (*Chrysoblemma*) *tamarisci beckeri* Dohrn, 1866 (Buprestidae)	Adults	Larvae in root galls	TR05-65
	Sphenoptera (*Chrysoblemma*) *scovitzi* Faldermann, 1835 (Buprestidae)	Adults	Larvae in root galls	TR05-64, TR05-65
	Ulobaris loricata (Boheman, 1836) (Curculionidae) (New record for Turkey)	Adults	Larvae in roots	Iğdır Prov.
	Elasmobaris alboguttata (Brisout, 1870) (Curculionidae) (New record for Turkey)	Adults	Larvae in roots	Iğdır Prov.
	Baris memnonia (Boheman, 1836) (Curculionidae) (New record for Turkey)	Adults	Larvae in roots	Iğdır Prov.
	Baris limbata (Brisout, 1870) (Curculionidae) (New record for Turkey)	Adults	Larvae in roots	Lake Tuz (2005)
	Cosmobaris scolopacea (Germar, 1819) (Curculionidae)	Adults	Larvae in stems	In many locations
	Sphenoptera (s. str.) *tragacanthae* (Klug, 1829) (Buprestidae)	Adults	Larvae in the lower parts of stems and in roots	TR05-54, TR05-58, TR06-25, TR06-28, TR05-53, TR05-54
	Sphenoptera (s. str.) *coracina* (Steven, 1829) (Buprestidae)	Adults, larvae	Larvae in stems	TR06-34

Astragalus (*Tragacantha*) spp.	*Acmaeodera* (s. str.) *chalcithorax* Obenberger, 1935 (Buprestidae)	Adults, larvae	Larvae in stems	[Recorded from Turkey]
	Acmaeoderella (*Carininota*) *mimonti decorata* (Marseul, 1865) (Buprestidae)	Adults, larvae	Larvae in stems	Collected in numerous locations
	Anthaxia (s. str.) *amasina* Daniel, 1903 (Buprestidae)	Adults, larvae	Larvae in stems and branches	Collected in numerous locations
	Anthaxia (s. str.) *lgockii* Obenberger, 1917 (Buprestidae)	Adults, larvae	Larvae in stems	[Recorded from Turkey]
	Anthaxia (s. str.) *adiyamana* Svoboda, 1994 (Buprestidae)	Adults, larvae	Larvae in stems and branches	[Recorded from Turkey]
Nitraria schoberi L.	*Rhaebus mannerheimi* Motschulsky, 1845 (Chrysomelidae: Bruchinae)	Adults	Larvae in seeds	Kars (Kağızman vicinity) and Ankara provinces (Lake Tuz)
	Margaritapion nitrariae (Ter-Minassian, 1970) (Curculionoidea: Apionidae)	Adults	Unknown	Kars Prov. (Kağızman vicinity)
Tribulus terrestris L.	*Microlarinus rhinocylloides* Hochhuth, 1847 (Curculionidae)	Adults	Larvae in stem	Iğdır and Kars provinces
Artemisia spp.	*Sphenoptera* (*Chilostetha*) *tezcani* Niehuis, 1999 (Buprestidae)	Adults	Swept from *Artemisia*	Kars Prov.
	Sphenoptera (*Chilostetha*) *leventi* Kalashian & Volkovitsh, 2007 (Buprestidae)	Adults	Swept from Artemisia	TR05-05
	Meliboeus (s. str.) *caucasicus* Abeille de Perrin, 1896 (Buprestidae)	Adults, larvae	Larvae in stems	TR05-05, TR05-57, TR05-59
	Agrilus (*Xeragrilus*) *zigzag* Marseul, 1866 (Buprestidae)	Adults	Larvae in stems	[Recorded from Turkey]
	Agrilus (*Xeragrilus*) *albogularis* Gory, 1841 (Buprestidae)	Adults	Larvae in stems	[Recorded from Turkey]
	Agrilus (*Xeragrilus*) *sericans* Kiesenwetter, 1857 (Buprestidae)	Adults	Larvae in stems	TR05-55, TR05-67
	Pachnephoptrus weisei (Reitter, 1892) (Chrysomelidae)	Adults	Larvae probably on roots in the soil	Kars Prov.
	Ptochus spp. (at least 3 species) (Curculionidae)	Adults	Larvae probably on roots in the soil	Over entire northern half of Turkey
	Leucomigus candidatus candidatus (Pallas, 1771) (Curculionidae)	Adults	Larvae on roots	Aras valley
	Pseudorchestes spp. (at least 3 species) (Curculionidae)	Adults	Larvae mining leaves	Found in many locations

	Taphrotopium cuprifulgens (Schilsky, 1906) (Curculionoidea: Apionidae)	Adults	[Probably inducing galls on stems]	Found in several locations
Artemisia absinthium L.	*Pseudorchestes smreczynskii* (Dieckmann, 1958) (Curculionidae)	Adults	Larvae mining leaves	Erzurum Prov.
	Microplontus sp. pr. *rugulosus* (Herbst, 1795) (Curculionidae)	Adults	Larvae probably in stem	Erzurum Prov.
Artemisia sp. pr. *marschalliana* Spreng.	*Baris nesapia* Faust, 1887 (Curculionidae)	Adults	Larvae in roots	Kars Prov.
Echinops sphaerocephalus L. and *Echinops pungens* Trautv.				
	Larinus onopordi (Fabricius, 1787) (Curculionidae)	All stages	Larvae in flowerhead	In numerous locations
	Larinus rudicollis Petri, 1907 (Curculionidae)	All stages	Larvae in capsule on stem	Bingöl Prov. and TR05-41
Echinops orientalis Trautv.	*Larinus capsulatus* Gültekin, 2008 (Curculionidae)	All stages	Larvae in capsule on stem	Aras valley
	Larinus inaequalicollis Capiomont, 1874 (Curculionidae)	All stages	Larvae in flowerhead	Erzurum Prov.
Echinops sp.	*Larinus hedenborgi* Boheman, 1845 (Curculionidae)	Adult	Unknown	TR06-09, TR06-10, TR06-11, TR06-14
Echinops sp.	*Meliboeus* (*Meliboeoides*) *parvulus* Küster, 1852, *M.* (*Meliboeoides*) *adlbaueri* Niehuis, 1989 (Buprestidae)	Adults	Larvae in stems	TR05-04, TR05-17, TR05-29; TR06-30
Serratula serratuloides (Fisch. & C. A. Mey.) Takht.	*Larinus* sp. pr. *leuzeae* Fabre, 1870 (Curculionidae)	All stages	In flowerhead	Aras valley
Xeranthemum annuum L.	*Larinus sibiricus* Gyllenhal, 1835 (Curculionidae)	All stages	In flowerhead	In numerous locations
	Ceratapion sp. (Curculionoidea: Apionidae)	Adults	Larvae probably mining stems	Kars Prov.
	Pseudorchestes sp. (Curculionidae)	Adults	Larva mining leaves	Muş Prov.
Cousinia spp.	*Nefis ochroleucus* (Capiomont, 1874) (Curculionidae)	All stages	In flowerhead	In numerous locations
	Nefis brevirostris (Hochhuth, 1851) (Curculionidae)	All stages	In flowerhead	In numerous locations
	Larinus fucatus Faust, 1891 (Curculionidae)	All stages	In flowerhead	In numerous locations
Pulicaria dysenterica (L.) Gaertn.	*Nefis korotyaevi* Gültekin, 2013 (Curculionidae)	Adults	unknown	TR06-34
Centaurea kurdica	*Larinus gigas* Petri, 1907 (Curculionidae)	All stages	In flowerhead	TR05-51
	Larinus sp. pr. *carthami* (Olivier,	All stages	In	TR05-51, TR06-

Reichardt	1807) (Curculionidae)		flowerhead	15, TR06-21
	Larinus sp. pr. *vitellinus* Gyllenhal, 1835 (Curculionidae)	All stages	In flowerhead	TR05-51, TR06-15, TR06-21
Centaurea behen L.	*Larinus carthami* (Olivier, 1807) (Curculionidae)	All stages	In flowerhead	TR06-13
	Larinus vitellinus Gyllenhal, 1835 (Curculionidae)	All stages	In flowerhead	TR06-13
Centaurea polypodiifolia Boiss.	*Larinus araxicola* Gültekin, 2006 (Curculionidae)	All stages	In flowerhead	Aras valley
Centaurea depressa Bieb.	*Larinus nubeculosus* Gyllenhal, 1835 (Curculionidae)	Adults	unknown	TR05-29
Cirsium baytopae P. H. Davis & Parris	*Larinus darsi* Capiomont, 1874 (Curculionidae)	Adults	Unknown	TR05-31
	Larinus fucatus Faust, 1891 (Curculionidae)	All stages	In flowerhead	In numerous locations
	Nefis brevirostris (Hochhuth, 1851) (Curculionidae)	All stages	In flowerhead	In numerous locations
	Nefis ochroleucus (Capiomont, 1874) (Curculionidae)	All stages	In flowerhead	In numerous locations
Jurinea mollis (L.) Rechenb.	*Larinus atomarius* Capiomont, 1874 (Curculionidae)	Adults	unknown	TR05-29
Zoegea leptaurea L.	*Eustenopus* sp. pr. *villosus* (Boheman, 1843) (Curculionidae)	All stages	In flowerhead	TR05-51
Phlomis tuberosa L.	*Thamiocolus virgatus* (Gyllenhal, 1837) (Curculionidae) (New record for Turkey)	Adults	Unknown	Erzurum Prov.
	Thamiocolus nubeculosus (Gyllenhal, 1837) (Curculionidae)	Adults	Unknown	Erzurum Prov.
	Labiaticola sibiricus (Faust, 1890) (Curculionidae) (New record for Turkey)	Adults	Unknown	Erzurum Prov.
Phlomis pungens Willd.	*Thamiocolus uniformis* (Gyllenhal, 1837) (Curculionidae)	Adults	Unknown	Erzurum Prov.
	Labiaticola melas (Boheman, 1836) (Curculionidae)	Adults	Unknown	Northeastern Turkey
Phlomis spp.	*Thamiocolus volkovitshi* Korotyaev (New record for Turkey) (Curculionidae)	Adults	Unknown	TR05-37, TR06-06
	Thamiocolus anthracinus Colonnelli, 2005 (Curculionidae)	Adults	Unknown	TR05-52
	Labiaticola atricolor (Boheman, 1844) (Curculionidae)	Adults	Unknown	Found in many locations all over the country
	Labiaticola eumicteroides	Adults	Unknown	Found in many

	(Hoffmann, 1962) (Curculionidae) (New record for Turkey)			locations all over the country
	Labiaticola syriacus (Faust, 1897) (Curculionidae)	Adults	Unknown	Found in many locations all over the country
	Trachys phlyctaenoides Kolenati, 1846 (Buprestidae)	Adults, larvae	Leaf miner	TR05-05, TR05-09, TR05-48; TR06-20, TR06-26
	Acmaeoderella (s. str.) *serricornis* (Abeille de Perrin, 1900) (Buprestidae) (New host record)	Adults, larvae	Larvae in stems	TR05-05, TR05-25, TR05-29, TR05-48, TR06-09, TR06-14
Erodium sp.	*Habroloma aureum* (Semenov, 1890) (New record for Turkey and first record of host plant) (Buprestidae)	Adults, mines	Leaf miner	TR05-62, TR05-64
	Zacladus asperatus (Gyllenhal, 1837) (Curculionidae)	Adults	In seeds	In several locations in Northeastern Turkey
Crambe orientalis L.	*Psylliodes* sp. (Chrysomelidae)	Adult	On leaves	TR05-70; TR06-40
	Lixus circumcinctus Boheman, 1835 (Curculionidae)	All stages	Larvae in stems	Collected in many locations
	Melanobaris crambephaga (Korotyaev & Gültekin, 1999) (Curculionidae)	All stages	Larvae in roots	Erzurum Prov.
Isatis glauca Aucher	*Psylliodes* sp. (Chrysomelidae)	Adults	?In stems	Erzurum Prov.
	Lixus sp. (Curculionidae)	Adults	In stems	Found in several locations in Erzurum and Erzincan provinces
	Aulacobaris licens (Reitter, 1895) (Curculionidae) (New record for Turkey)	Adults	Larvae in roots	Widely distributed in Turkey
Lepidium crassifolium Waldst. & Kit.	*Lixus myagri* Olivier, 1807 (Curculionidae)	Adults	In roots	Erzincan Prov.
	Melanobaris ? semistriata (Boheman, 1836) (Curculionidae)	Adults, pupae	In roots	Erzincan Prov.
Tchihatchewia isatidea Boiss.	*Lixus ochraceus* Boheman, 1842 (Curculionidae)	All stages	In stem	Erzurum Prov.
	Melanobaris gloriae Korotyaev & Gültekin, 2003 (Curculionidae)	All stages	In stem	Erzurum Prov.
Ferula orientalis L.	*Lixus siculus* Boheman, 1835 (Curculionidae)	All stages	In petiole	Erzurum and Kars provinces
Ferula szowitsiana DC.	*Lixus farinifer* Reitter, 1892 (Curculionidae)	Adults, eggs	In petiole	Erzincan Prov.
	Acmaeoderella (*Euacmaeoderella*) *villosula* (Steven, 1830) (Buprestidae)	Adults	Larvae in stems	Collected in numerous locations

Ferula spp.	*Acmaeoderella* (*Euacmaeoderella*) *gibbulosa* (Ménétriés, 1832) (Buprestidae)	Adults	Larvae in stems	Collected in numerous locations
	Anthaxia (s. str.) *anatolica* Chevrolat, 1838 (Buprestidae)	Adults	In stems	TR06-26
Prangos uloptera DC.	*Lixus furcatus* Olivier, 1807 (Curculionidae)	All stages	In stems	In numerous locations
	Lixus obesus Petri, 1904 (Curculionidae)	All stages	In seeds	Kars and Bitlis-Van provinces border
Prangos ferulacea (L.) Lindl.	*Lixus furcatus* Olivier, 1807 (Curculionidae)	All stages	In stems	In numerous locations
	Lixus cylindrus (Fabricius, 1781) (Curculionidae)	All stages	In petioles	Erzurum and Kars provinces
Prangos lophoptera Boiss.	*Lixus furcatus* Olivier, 1807 (Curculionidae)	All stages	In stems	In numerous locations
Prangos sp.	*Lixus petiolicola* Gültekin & Korotyaev, 2011 (Curculionidae)	All stages	In petioles	TR06-47
Prangos spp.	*Acmaeoderella* (*Euacmaeoderella*) *gibbulosa* (Ménétriés, 1832) (Buprestidae)	Adults	Larvae in stems	Collected in numerous locations

Discussion

To briefly summarize the results of the study

1)- Two types of erosion (= biotic degradation) processes are found and shown to be widespread in Turkey: horizontal, or wind erosion, and gravitative erosion. The former leads to devastation of large plains areas and their loss to the economy; the latter causes catastrophic floods in the mountains after rainfalls. Both the processes deserve serious attention and preventive measures. Wind erosion resulting largely from overgrazing has greatly expanded, in the southern half of the area, where Angora sheep are bred. The heavy floods in southern Turkey in the autumn 2006 show the great danger of this type of emergency in the mountain areas, especially those in the mountains along the Black Sea and the Mediterranean Sea. It is extremely important to preserve forests also in the resort areas with the densest population and heaviest recreation load to avoid erosion of the mountain slopes which may easily lead to catastrophic floods. Wind erosion is less evident and apparently less developed in the plant-growing areas where the soil is fixed by the roots of cultivated plants.

2)- In the search of the native xerophilous plant communities, a number of natural complexes were found which we consider extremely important to protect as the examples of the highly specific and species-rich aborigine Anatolian biota. It is important not only for having reference sites for applied and basic scientific investigations, but also for possible use of the preserved natural complexes for education of the increasing numbers of Turkish and foreign students. Considering the importance of the foreign tourism in the Turkish economy, we presume that organization of the protected areas for cultural and scientific tourism will increase the number of visitors to the country and promote scientific and cultural cooperation. Northeastern Anatolia is also an important source of potential agents of biological control of weeds (especially for many *Centaurea*, crucifers and Chenopodiaceae) rather than an area where Lixinae are considerably threatening the harvests (Gültekin *et al.* 2004). Of particular importance we consider the preservation of the two natural complexes below.

A. A relatively large fragment of the *Calligonum*-dominated sand desert along Aras River in Iğdır Province, with several aborigine insects including a large buprestid *Capnodis excisa excisa* Ménétriés, 1848 being common on *Calligonum*. No desert of this type west of Turkmenistan had been investigated before our study.

B. Highly specific semidesert insect assemblages combining Mediterranean, Middle Asian, Pontian, and autochthonous Central Anatolian species are still remaining around Lake Tuz among the heavily degraded area subjected to overgrazing, pollution, and construction. Preservation of the shoreline of Lake Tuz would not require expensive measures except prevention of the pollution by chemicals from the highway along the northern shore and prohibition of the construction in the immediate vicinity of the lake. In addition, several small areas around Lake Tuz should be preserved, e.g., near Lake Düden etc., to cover a wider range of the unique natural complexes. It will help to preserve not only insects and the landscape, but also beautiful endangered flamingos often feeding in these shallow lakes. A set of protected areas should be arranged in various types of landscape and vegetation to preserve their examples for cultural, educational, and scientific purposes.

3)- A number of plants may be considered indicators of the desertification (= biotic degradation) of the soil and vegetation. The presence of these plants without their specialized herbivores most probably indicates a recent appearance of plants in certain areas. For example, an occurrence of *Peganum harmala* west of the Aras basin is probably a recent phenomenon because the distribution of a monophagous scolytid, *Thamnurgus pegani* (Coleoptera, Solytidae), common on *P. harmala* in the deserts of western Middle Asia, in Turkey is limited by the Aras valley.

4)- An absence of characteristic insects from a particular type of a plant community, for example, an absence of orthopterans and wingless tenebrionid beetles in the semidesert-like communities dominated by *Artemisia* spp. and *Salsola* spp. in plains areas indicates either a high degree of devastation of this natural complex *in situ*, or (less commonly) a recent invasion of this plant community into a certain area so that the specific insect consortia have not established on their hosts yet.

Prospective suggestions and approaches

We consider it worthwhile to extend investigations of this sort to the whole territory of Turkey. This may give full representation of the distribution of the erosional processes in all types of native and anthropogenic landscapes from the Balkans to Eastern Turkey. We also suggest conducting special investigations aimed at a detailed scientific documentation for the arrangement of 5 special protected areas to preserve

a) the relict *Calligonum* sand desert in Iğdır Province;

b) Lake Tuz with the surrounding landscape;

c) a mountain association dominated by *Rheum ribes* L.;

d) the unique known population of the relict endemic crucifer *Sisymbrium elatum* K. Koch and the section of the river around it in Erzurum Prov.; it is situated in the close vicinity of the construction area along the highway and is close to being completely destroyed;

e) the unique known population of *Stroganovia leventii* V. I. Dorofeyev, 2004 an endemic Turkish plant species representing an exotic genus.

Special investigations of this kind would give a scientific description of the natural complexes which should be protected, determine the borders of these complexes and the protective measures required, and elaborate possible scientific and educational use of these complexes.

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