Zoodiversity, **58**(6):513–526, 2024
DOI 10.15407/zoo2024.06.513

UDC 595.768.23:595.764.1(691)

REDESCRIPTION AND BIOLOGICAL OBSERVATIONS ON *MAXIMUS STRABUS* (COLEOPTERA, CURCULIONIDAE)

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Redescription and Biological Observations on *Maximus strabus* (Coleoptera, Curculionidae). Gültekin, N. — Biological observations of *Maximus strabus* (Gyllenhal, 1834) (Coleoptera, Curculionidae) were conducted on two populations associated with two halophytic plants, *Bassia hirsuta* (L.) Asch. and *Suaeda altissima* (L.) Pall. in the Aras River valley. The species is redescribed and the diagnostic morphological characters, including variations, are compared with digital images. The species hibernates as an adult under stones and becomes active in early spring when it starts feeding on the rosettes of its host plants. The legless larvae are soil dwellers and feed on the roots of their host plants, including the lateral branches of the roots; the mature larvae form individual soil capsules and pupate inside. A new generation of adults emerges in late summer. The species is univoltine in the Aras River valley.

Key words: Lixinae, Cleonini, *Maximus*, life cycle, morphology, variation, host plants, Aras river valley.

Introduction

Weevils are a diverse group of beetles belonging to the superfamily Curculionoidea, which is one of the largest beetle superfamilies (Oberprieler et al., 2007). They are characterized by their distinctive elongated rostrum, and comprise a vast array of species with different ecological roles and habitats.

Cleonini (Coleoptera, Curculionidae) is a tribe of weevils belonging to the subfamily Lixinae, part of the larger weevil family Curculionidae. The tribe Cleonini is highly diverse, with species occupying a variety of habitats worldwide, ranging from forests to grasslands and wetlands to arid environments. The adaptability of Cleonini to different habitats contributes to their overall diversity. Most Cleonini species prefer xerophytic habitats (Arzanov & Grebennikov, 2017; Anderson, 1987; Volovnik, 2010; Meregalli, 2014; Stejskal & Trnka, 2014).

The larvae of Cleonini generally occur around roots and root necks of their host plants, feeding on these parts and inducing galls (Volovnik, 2010; Trnka et al., 2015). Alternatively, larvae of some species move freely in the soil and pupate within soil capsule (Gültekin et al., 2019, 2021). Over a dozen Cleonini species are recognized as pest of sugar beet (Lukjanovitsh, 1958), with certain species of *Asproparthenis* Gozis (e. g. *A. punctiventris* Germar) being particularly destructive (Ter-Minassian, 1958, 1988; Tóth et al., 2007; Lemic et al., 2016), other Cleonini species are important in the biological control of weeds (Stinson et al., 1994; Story et al., 2006; Gültekin et al., 2019).

Recent studies of Cleonini in eastern Turkey have produced new insights into their ecology (Gültekin et al., 2022), natural enemies (Gültekin et al., 2020), and taxonomy, including discovery of new species (Korotyaev et al., 2020).

Maximus Alonso-Zarazaga & Lyal, 2009 is a Palaearctic cleonine genus with 14 species, among them two species distributed in Anatolia (Alonso-Zarazaga et al., 2023; Meregalli, 2017; Gültekin, 2018, 2021). *Maximus strabus* (Gyllenhal, 1834) was originally described in *Bothynoderes* Schoenherr, 1823. Its type localities include the "Caucasus, Odessa, and Persia" (Schoenherr, 1834). A brief redescription of this species, along with drawings of the male genitalia and imago, was provided by Ter-Minassian (1988), who also compiled data on host plants of adults, which include *Salsola dendroides* Pall., *Suaeda* Forssk. ex J. F. Gmel. and *Tamarix* L. Although the redescription of *Maximus strabus* was previously provided by Ter-Minassian (1988), present work includes detailed information on the mouthparts, metathoracic wings, metendosternite, and genitalia, which were absent from Ter-Minassian's earlier work. Therefore, it is important to publish this new enlarged redescription in English, making it accessible to a wider audience.

The research area, Aras River valley, refers to the geographical region along the Aras River, which flows through parts of Turkey, Armenia, Azerbaijan, and Iran. The Aras River originates in Turkey and flows eastward, eventually reaching the Caspian Sea. The valley and its surrounding areas support diverse ecosystems and rich biodiversity. The river and its riparian zones provide habitats for various plant and animal species. Additionally, the valley encompasses extensive sandy desert ecosystems and halophytic habitats.

Material and Methods

Research locations. The field investigations were conducted in Aras Valley, Iğdır Province in the locations TR21-02 and TR21-03 during 2019–2021 from early spring to late summer. The specimens were collected by hand when adults were feeding on their host plants or walking on the ground. Sampling for morphological investigations were done in two following locations: TR21-02: Turkey: Iğdır Prov., Tuzluca, Turabi Vill. Road, 1017 m a. s. l., 40° 3'24.39" N 43°44'34.82" E; TR21-03: Turkey: Iğdır Prov., 8 km W of Aralık, 854 m, 39°54'52.97" N 44°22'13.84" E. These two locations are approximately 50 km apart. The soil in Tuzluca location is salted clay. The name of the district "Tuzluca" means "salty" that refers to the salty soil in this region. In contrast, soil in Aralık district is sandy.

Morphological study. The beetles were killed using ethyl acetate and pinned. Measurements were taken using an ocular micrometer attached to a Leica S8APO stereo microscope. To investigate internal morphology, the mouthparts, thorax, wings, abdomen, and genital structures were dissected, cleaned in 10 % KOH, rinsed with distilled water and ethanol, and then mounted on a slide with glycerol. Morphological terminology follows Oberprieler et al. (2014), Lyal (2023), Velázquez de Castro (1998) and Arzanov & Grebennikov (2017). Specimens are preserved at the Biodiversity Science Museum of Atatürk University, Erzurum (Turkey).

Biological observations. Locations TR21-02 and TR21-03 were visited at 10–15 day intervals throughout the duration of the field study. The following aspects were observed: life cycle, adult feeding, mating, and oviposition patterns, micro habitats for immature stages, behaviour and hibernation. For certain biological observations, including mating, host plants were transplanted into rearing containers with sandy soil. Five pairs of weevils were collected from two locations when they were copulating and placed separately from each other in different containers. Transplanted host plant pots were brought to the apartment balcony. Separated males and females from two locations were released into pots from cross populations. To observe whether adult flight abilities, 20 individuals in two open pots were counted daily during a week.

Photographing. Photographs of external structures were taken with a Canon DSRL 70D camera attached to Leica Z16APO Macroscope with Canon EOS Utility software. Internal morphological features were photographed with Leica DM750 light microscope with Leica MC190 HD camera. Leica LAS software was used for control and image processing. The digital images were stacked using Adobe Photoshop CS 6.0. software.

Results

Maximus strabus (Gyllenhal, 1834) (figs 1–13)

Bothynoderes strabus Gyllenhal, 1834: 230.

Material examined. **Type: Syntypes:** “Schoenherr Collection — SMNH”; the box label: “Strabus Schh., Bothynod. Id. II. P. 230.5, 125”. “Paratypus”, red printed label, “P dom. ?Senobros, Caucas. Steven”, “Bothynoderes strabus Gyllenhal, 1834, Lectotypus, 2012, Meregalli des.”, 1 ♀. “TYPUS” red printed label, “Persia Falderm.”, handwritten, 1 ♂. “Paratypus”, red printed label, “Cl: adspersa., Besser. Cy Odessa. Bess.”, handwritten, 1 ♂ (fig. 1). A ♀ with labels “Paratypus”, “Cleon: tenebros: e Caucasus: Steven” was examined by B. A. Korotyaev (personal communication).

Non-type: Turkey: Iğdır Prov., 6 km E of Tuzluca, along Turabi Vill. road, 1017 m, feeding on *Bassia hirsuta,* 14.05.2019, 20 ♂, 15 ♀, N. Gültekin; 13 ♂, 8 ♀, N. Gültekin leg., feeding on *Bassia hirsuta*; 15.04.2021, 40° 3'24.39" N 43°44'34.82" E, 20 ♂, 15 ♀, N. Gültekin leg., feeding on *Bassia hirsuta*; Gaziler Village, 15.05.2020, 9 ♂, 3 ♀, E. Aykut leg.; Yıldırım Vura, 15.05.2020, 2 ♂, E. Aykut leg.; 5-6 km W of Aralık, along Ramazankent Vill. road, 854 m, 39°54'52.97" N 44°22'13.84" E, 18.06.2019 4 ♂, 2 ♀, N. Gültekin, C. Gözüaçık, E. Aykut leg., feeding on *Suaeda altissima*;15.07.2020 7 ♂, 2 ♀, N. Gültekin leg., feeding on *Suaeda altissima*.

Fig. 1. Syntype of *Bothynoderes strabus* Gyllenhal, 1834: A — dorsal view; B — lateral view; C — labels.

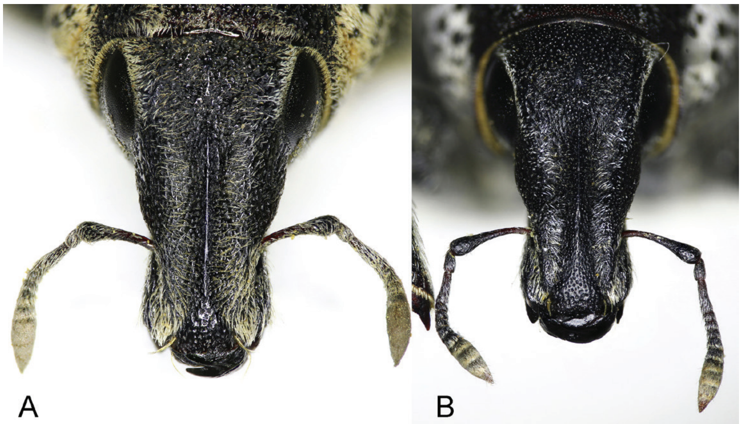

Fig. 2. *Maximus strabus* (Gyllenhal, 1834), rostrum and head an anterodorsal view: A — Aralık; B — Tuzluca.

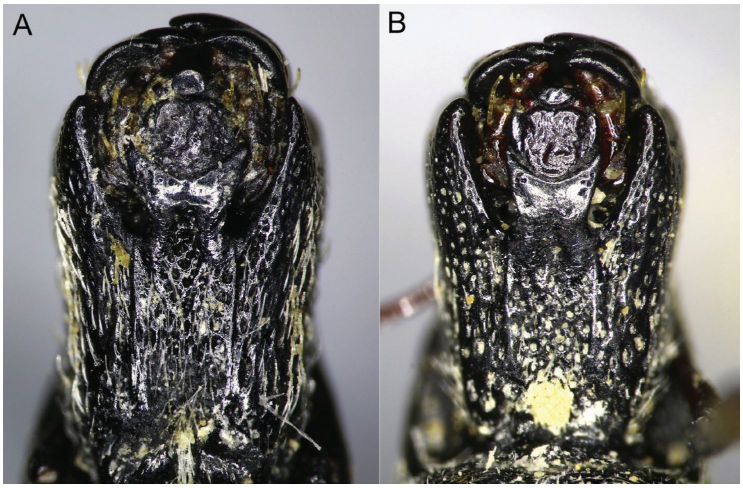

Fig. 3. *Maximus strabus* (Gyllenhal, 1834), rostrum in ventral view: A — Aralık; B — Tuzluca.

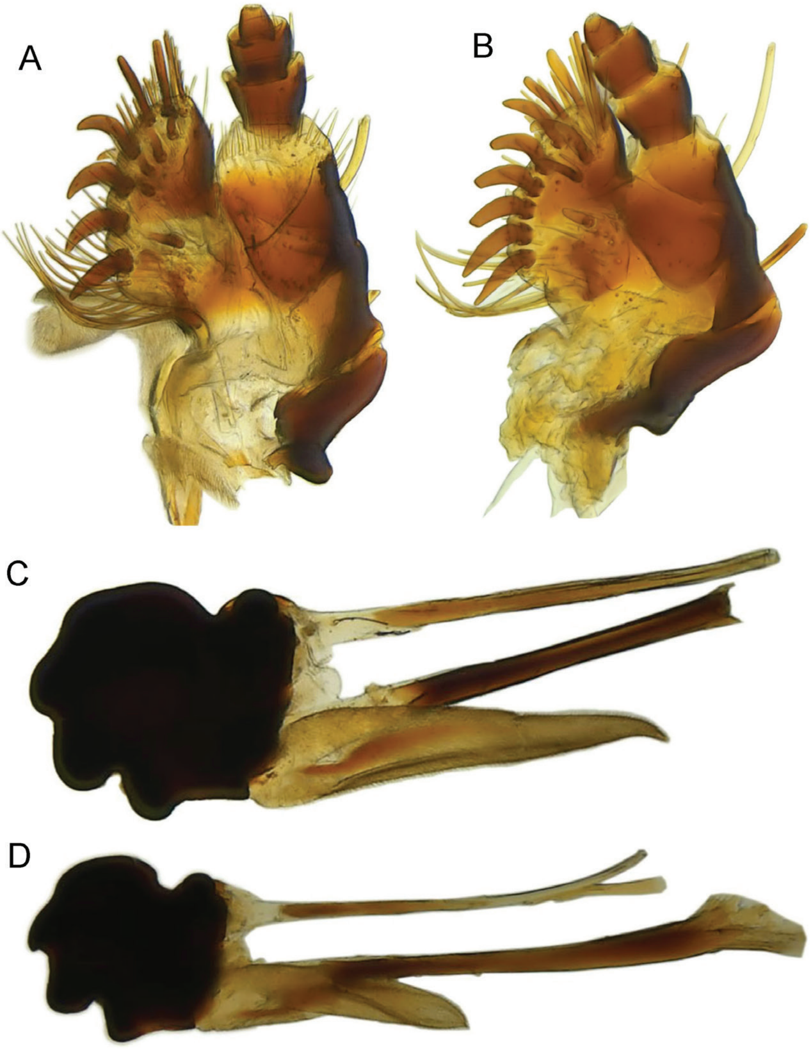

Fig. 4. *Maximus strabus* (Gyllenhal, 1834), mouth parts, maxilla and mandibule: A, C — Aralık; B, D — Tuzluca.

Remark. The lectotype designation has not been published yet (personal communication: Massimo Meregalli). For this reason, the type specimens cited above are considered to be syntypes.

Redescription

Body size: 10.3–20.2 mm.

Color and pattern. Integument black, scape dark brown in basal half, dorso-apical margin of pronotum dark reddish brown. Scales greyish, on rostrum and antenna piliform. Scales on prothorax and elytra bifid or multifid with 2–3 branches at apex, scales on the ventral surface of thorax multi branched. Scales on metathorax much longer. Scales denser on lateral surface of prothorax forming wide lateral band, arranged in small groups in some areas on lateral surface of elytra, small roundish spot present on preapical prominences. Scales on legs, especially on ventral surfaces, shaped as semi-raised greyish hairs.

Head, rostrum, and antenna (fig. 2). Forehead wider than base of rostrum. Interocular pit small and superficial; eyes medium sized, oval and slightly convex, ventral part slightly narrower than dorsal part. In dorsal view, rostrum conical, medium-long, shorter than pronotum length and thicker than profemur, gradually and significantly narrowing from the base to the place of antennal insertion, lateral surface flattened, subgena slightly widened anteriorly. Median keel wide, convex and pointed like a blade ridge, epifrons with two depressed areas extending longitudinally at middle, two hollow lines superficial on frons. Anterior margin of epistome slightly indented in middle. Antennal inserted about apical 1/3 of rostrum; scrobe narrow; scape thin and curved in basal half, gradually widened apically, clavate; 1st funicular antennomere a little thicker than 2nd and shorter than half length of latter; 2nd funicular antennomere elongate, 4 times as long as 3rd, subconical, gradually widened apically; 3rd funicular antennomere rather short, 4–7th antennomeres gradually widened. Antennal club spindle-shaped and elongate. In lateral view, rostrum straight. In ventral view (fig. 3), scrobes not merged at base of rostrum, occipital sutures cariniform, prementum trapeziform, first labial palpomere and ligula visible, mandible with two teeth (figs 4, C–D), galea+lacina of maxilla with multiple teeth, maxillary palp somewhat longer than galea+lacina (figs 4, A–B).

Prothorax. Pronotum subrectangular, lateral margins feeble and gradually converging from basal to apical constriction, apical collar distinct. Posterior margin slightly attenuate posteriorly in middle. Anterior margin slightly produced over head; postocular lobe moderately developed. Anterior margin of prosternum emarginate, two tubercles present on prosternum in front of procoxa. Pronotal disc slightly convex, with a thin carina in basal half, extending longitudinally in middle. Lateral surface of prothorax with 15-20 shiny, black, flattened tubercles. Punctures on pronotum small to medium-sized. Scutellum visible in dorsal view (figs 5, A–B). Furcal arms of metendosternite (figs 5, C–D) distinctly longer than lateral arms.

Elytra subparallel-sided in basal half, weakly expanded in middle, then gradually narrowed toward rounded apex (fig. 5, B). Interstriae almost equal in width, interstria III slightly convex in basal part. Striae superficial, narrow and composed of small separated punctures. Humeri poorly developed. Wings fully developed and folded in resting position (fig. 6, A) or reduced without folding (fig. 6, B). Wing venation as follows: C, Sc, RA, MP1+2, Cu, AP3+4 and radial cell developed (figs 7, A–B).

Legs. Femur stout. Middle part of profemur more distinctly swollen that of other pairs. Metafemur a little longer than other femora. Tibia expand slightly and gradually from base to tip, outer margin of protibia almost straight (figs 8, A–B), both inner and outer edges of metatibia incurved inward at apical 1/3, and widened in an angular manner

Fig. 5. Thorax parts of *Maximus strabus* (Gyllenhal, 1834): A — mesothorax, Aralık; B — fused mesothorax with elytra including sutural interstria, Tuzluca; C, D — metendosternite (C — Aralık, D — Tuzluca).

Fig. 6. *Maximus strabus* (Gyllenhal, 1834), wing, resting position (elytron removed): A — Aralık; B — Tuzluca.

Fig. 7. *Maximus strabus* (Gyllenhal, 1834), wings: A — Aralık; B — Tuzluca.

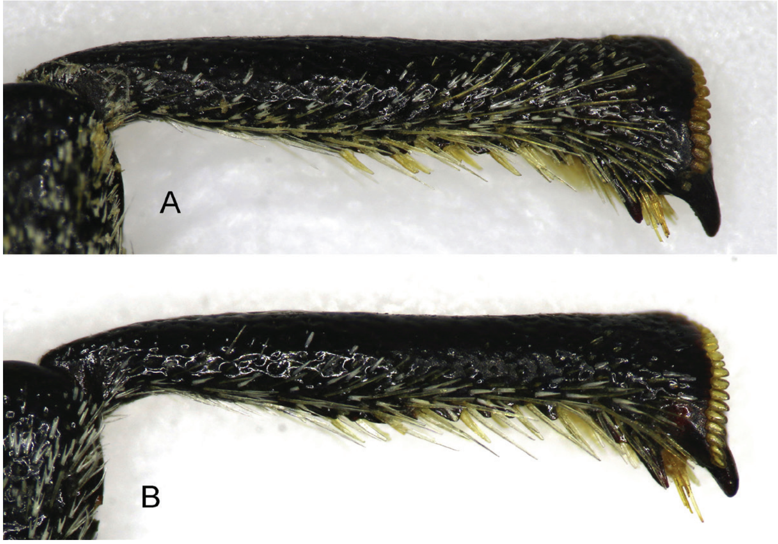

Fig. 8. *Maximus strabus* (Gyllenhal, 1834), protibia, female: A — Aralık; B — Tuzluca.

Fig. 9. *Maximus strabus* (Gyllenhal, 1834), lateral view of metatarsus, female: A — Aralık; B — Tuzluca.

at tip. Mucro long, premucro of female protibia long and sharp, apical setal comb densely present. Premucro of mesotibia shorter than that on protibia. In males, short and narrow premucro present only on protibia. First tarsomere slightly longer than second, this longer on metatarsi, second tarsomere trapeziform, third tarsomere slightly wider than second and medium-long. Latero-ventral margins of tarsomeres 1–3 armed with series of spines, which are more prominent on 1st and 2nd tarsomeres and more densely arranged on metatarsi (figs 9, A–B). Tarsal pads wider under third tarsomere compare to second tarsomere, almost absent under first tarsomere (figs 10, A–B). Tarsomere 5 cylindrical, curved, gradually expanding towards tip, slightly shorter than total length of tarsomeres 1–3. Claws connate basally, and divergent apically.

Male terminalia. Penis tubular, in dorsal view (figs 11, A–B), gradually and slightly narrowing from basal to apical half, then weakly swollen, again narrowing more pronouncedly in apical 1/4 and ends in a short, blunt triangular plate at apex. Spiculum gastrale curved (figs 11, C–D), sternite 8 as in figs (11, E–F).

Female terminalia. Sternite 8 (figs 12, A–B) with short apodeme, internal angle wide, blades inclined inward. Gonocoxites converging posteriorly and bearing a few erect setae, stylus subcylindrical, with 1 or 2 erect setae at apex (figs 12, C–D). Spermatheca C-shaped (figs 12, E–F).

Sexual dimorphism. In females the rostrum is slightly longer than in males, 1st and 2nd abdominal ventrites concave in the middle in male, and only 1st ventrite in female with a superficial sunken area. Protibial premucro in females longer than in male. Male protarsi with tarsal pads distinctly wider than female protarsi (figs 10, A–B).

Variations. Adult body length in "Tuzluca" population ranges from 9.5 to 17.5 mm, that in the "Aralık" population, from 11.2 to 21.1 mm. Median keel on rostral dorsum is sharper in the Aralık population (fig. 2, A) than in the Tuzluca one (fig. 2, B); anterior margin of ligula somewhat prolonged anteriorly in the Aralık population (fig. 3, A), straight in the Tuzluca one (fig. 3). In the Aralık population, apex of palpiger with dense hairs and a short setaceous hair, lacinal setaceous hairs rather short; four curved lacinial teeth (fig. 4, A); in the Tuzluca population, apex of palpiger with very few hairs, and long seta, lacinial seta short; six curved lacinal teeth (fig. 4, B). Mandibles of both populations look much similar (figs 4, C–D). Mesothorax (fig. 5, A) in the Aralık population is not fused with elytra in majority of the specimens, in contrast to the Tuzluca population where mesothorax and elytral suture are fused in most of specimens. Hemiductus of metendosternite is larger in the Aralık population and anterior tendon is invisible there (fig. 5, C); hemiductus is smaller in the Tuzluca population, in its specimens is visible (fig. 5, D). Wings are fully developed and apically folded in resting position under elytra in majority of specimens of the Aralık population (figs 6, A; 7, A), while in the Tuzluca population wings are reduced in size or intermediate and not folded in resting position under elytra (figs 6, B; 7, B). In male, posterior margin of sternite 8 in specimens of the Aralık population is somewhat emarginate medially (fig. 11, E), and almost straight in the Tuzluca population (fig. 11, F). Apodeme of female sternite 8 with distal widening in the Aralık population (fig. 12, A), and without it in the Tuzluca population (fig. 12, B). Nodulus and ramus of spermatheca are reduced in the Tuzluca population (fig. 12, F) as compared to the Aralık one (fig. 12, E).

Distribution. Afghanistan, Armenia, Azerbaijan, China (Xinjiang), Croatia, Iran, Kazakhstan, Moldova, Mongolia, Portugal (Azores), Romania, Russia (Southern and Central European part, Western Siberia), Syria, Tajikistan, Turkey, Turkmenistan, Ukraine, Uzbekistan (Meregalli and Fremuth 2013; Meregalli 2017; Alonso-Zarazaga et al., 2023).

Distribution in Turkey. Iğdır (Gültekin 2018; Gültekin et al., 2021).

Fig. 10. *Maximus strabus* (Gyllenhal, 1834), ventral view of protarsus: A — male; B — female.

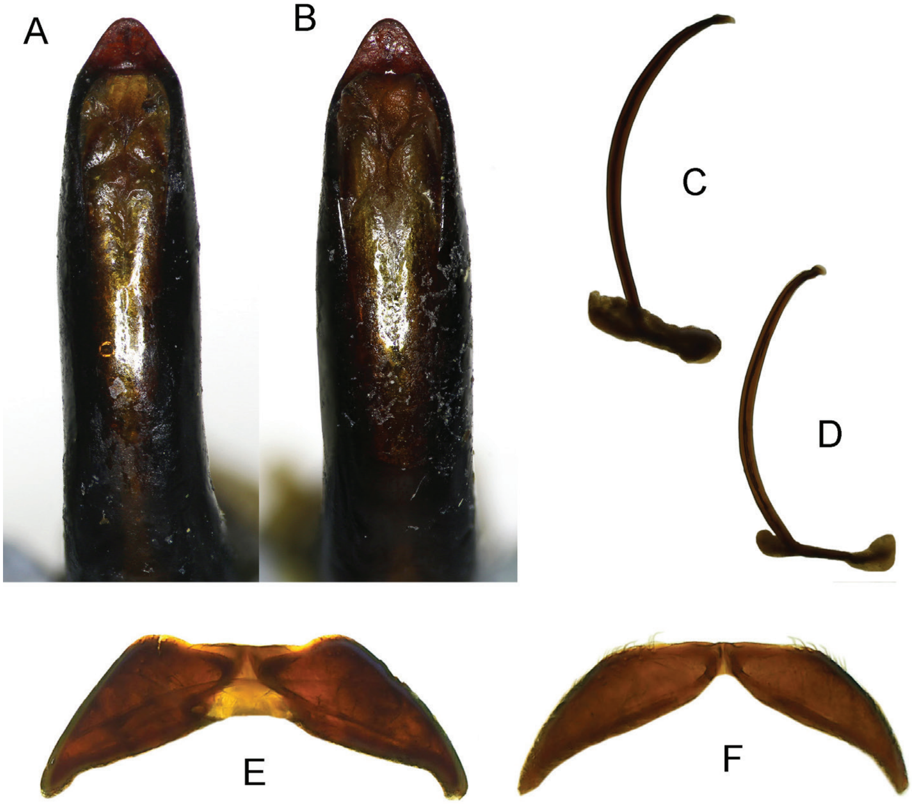

Fig. 11. *Maximus strabus* (Gyllenhal, 1834), male genitalia: A–B — penis; C–D — spiculum gastrale; E–F — male sternite 8. (A, C, E — Aralık; B, D, F — Tuzluca).

Biological data. Adult and larval hosts of *M. strabus* are *Bassia hirsuta* (L.) Asch. and *Suaeda altissima* (L.) Pall. These plants occur in halophytic habitats in Iğdır Province (Temel et al., 2017).

Maximus strabus hibernates at adult stage under stones (fig. 13, A), gains activity in early spring, and begins feeding on rosette plants (fig. 13, B). Adults copulate on the ground or on leaves while females are feeding. The eggs are enclosed with a secretion on roots of rosette plants, legless larvae are soil inhabitants and feed on roots including lateral branches (fig. 13, C). Mature larvae make individual soil capsules (fig. 13, D) and pupate inside (fig. 13, E). A new generation adults (fig. 13, F) emerge from soil in late summer. The species produces one generation in a year. The adults have ability to dig themselves in soil and sheltering there at night. In the late morning, adults usually emerge from soil or soil cracks and enter soil before the sunset. In the hottest summer periods adults rest in the soil cracks 10–15 cm deep in as small groups or individually in climbing position.

The observation of mating revealed that male and female individuals accepted each other immediately after releasing to the posts and copulations occurred. Rather small males can successfully copulate with females almost twice as large. This behaviour was observed

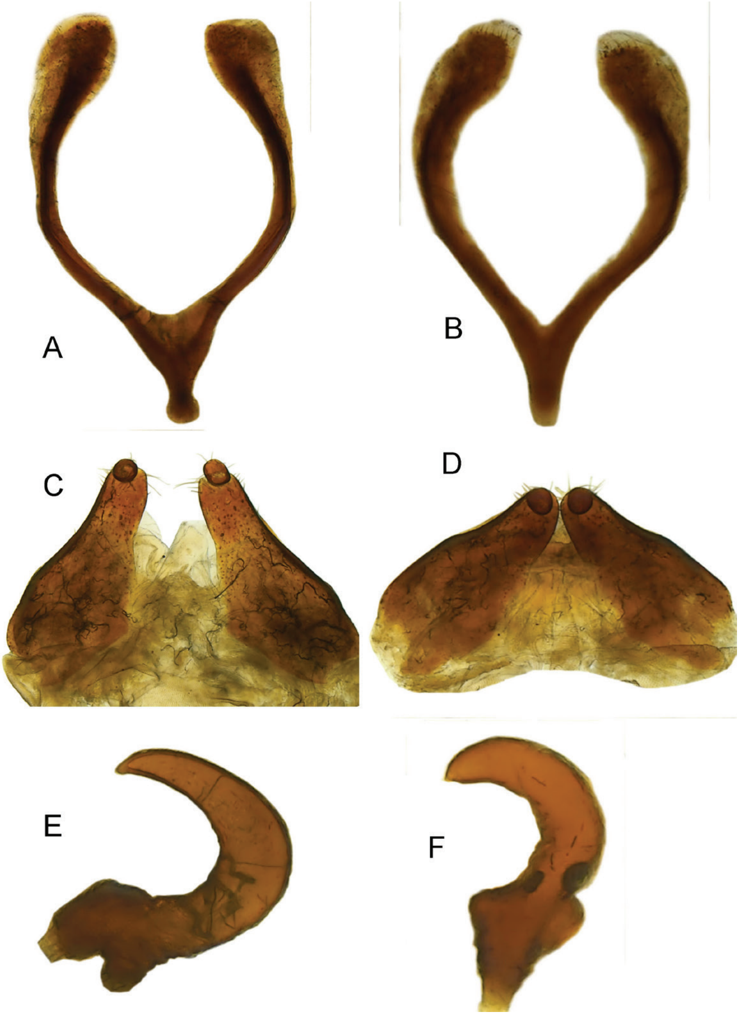

Fig. 12. *Maximus strabus* (Gyllenhal, 1834), female genitalia: A–B — spiculum ventrale; C–D — gonocoxite; E–F, spermatheca. (A, C, E — Aralık; B, D, F — Tuzluca).

in natural condition in disturbed habitats and in mating pots.

Observation of flight behaviour did not show any attempt to fly. Daily counts of individuals in open pots confirmed this by showing no decrease in the number of adults.

Discussion

According to the Ter-Minassian (1988), host plant range for adults of *Maximus strabus* includes *Salsola dendroides* Pall., *Suaeda* Forssk. ex J. F. Gmel. and *Tamarix* L. First two plants are Amaranthaceae and the third one Tamaricaceae. In the same paper it was indicated that a number of genera and species of Cleonini prefers Amaranthaceae as host plants and *Liocleonus clathratus* (Olivier, 1807) host plant is *Tamarix* for both larvae and adults. In current research, *Bassia hirsuta* (L.) Asch. and *Suaeda altissima* (L.) Pall. are confirmed host plants both larval stage and adult. In research territory, some of the adults of *M. strabus* were observed feeding on *Chenopodium* sp. and *Atriplex* sp. plants. But no data gathered by me for larval stage feeding.

Based on current research on *Maximus strabus*, adult body size range of the "Tuzluca" population is somewhat smaller than in the "Aralık" population. The immature stages of

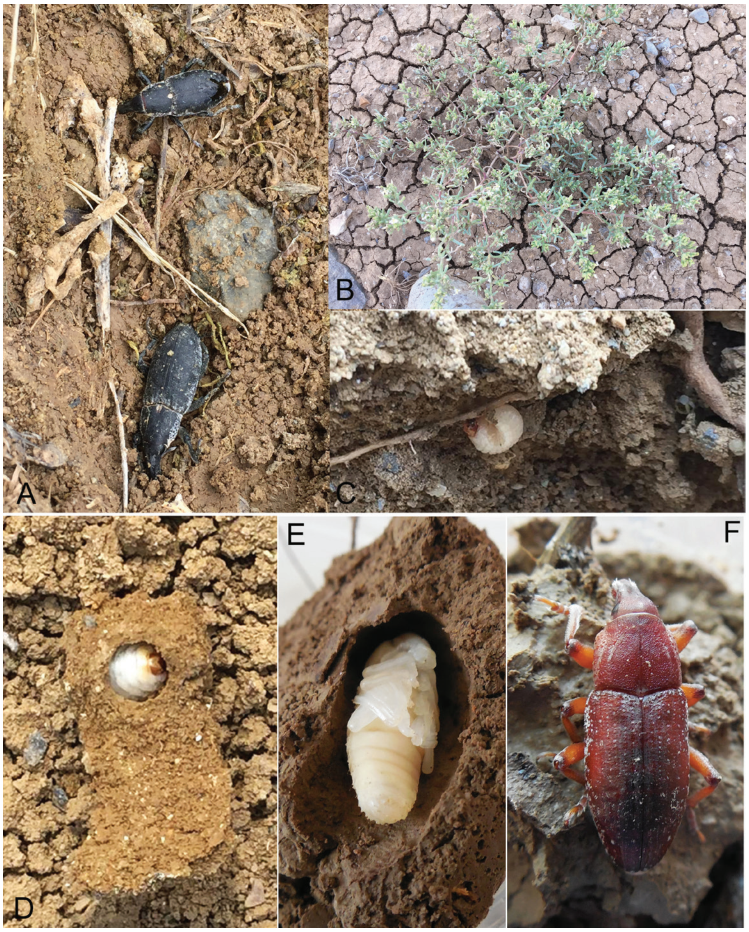

Fig. 13. Life cycle of *Maximus strabus* (Gyllenhal, 1834): A — hibernating adults found under stones; B — host plant *Bassia hirsuta* (L.) Asch.; C — larva feeding on lateral branch of a root; D — mature larva inside soil pupal cell; E — pupa in soil cell; F — newly emerged from soil adult.

the weevil species live in soil and these body size differences can be affected by soil structure. Clayish soil seems to restrict body size, whereas sandy soil allows for larger larvae and, subsequently, larger pupae and adults. Another contributing factor could be the availability of food and the size of the host plant's root system. The variation of the mouthparts, especially that of the maxilla, can be linked to a host plant structure. These assumption approach above were based on field observation: the Tuzluca location where clayish soil present and fine root system of host plant in contrast sandy soil and thick root system having in different host plant in the Aralık location.

According to Meregalli (2014), most Cleonini weevils have functional hind wings, though many genera are brachypterous or wingless. The first notes on polymorphism and photographs of reduced wings in *M. strabus* were provided by Korotyaev et al. (2020) based on specimen from Iğdır (Turkey). The most common variation is the differences between fully developed, intermediate and reduced metathoracic wings in the two different populations. The study of ten specimens at each site showed that when the size of the wings was reduced to a greater extent, the fold at the apical end did not appear. This proves the existence of the polymorphism of such morphological variations in different individuals within the population of the same species.

Observation results in the open container experiment and in the field show that no flight attempt was made by *M. strabus*. However, in an opportunistic observation at Aralık site during this study (10 July 2019), at rather high temperatures in a sandy desert habitat, an individual of *Temnorhinus hololeucus* (Pallas, 1781) was able to fly from one host plant to another (Gültekin et al., 2021). Actually, there is a little information about flight ability of Cleonini weevils. Volovnik et al., (2021) listed seven species from this tribe as active fliers: *Asproparthenis punctiventris* (Germar, 1823), *Bothynoderes affinis* (Schrank, 1781), *Temnorhinus brevirostris* (Gyllenhal, 1834), *Eurycleonus talamellii* Meregalli, 2005, *Conorhynchus conirostris* Gebler, 1829, *Cleonis pigra* (Scopoli, 1763), and *Cyphocleonus dealbatus* Gmelin, 1790. But they omitted *Temnorhinus hololeucus* published earlier by Gültekin et al. (2021). In addition, Jilg et al., (2024) mentioned active flight ability of *Pachycerus* cf. *segnis* (Germar, 1823).

Acknowledgements

I would like to express my sincere thanks to Johannes Bergsten (Swedish Museum of Natural History, Stockholm) for the training on the digital photography software ZereneStack and his kind help during my visit there, Alexander S. Konstantinov (Systematic Entomology Laboratory, USDA), ARS, c/o Smithsonian Institution, National Museum of Natural History, Washington, USA) for linguistic suggestions, Boris A. Korotyeav (Zoological Institute, Russian Academy of Sciences, St. Petersburg) and Massimo Meregalli (Department of Life Sciences and Systems Biology, University of Torino, Torino) for information on syntype. This study was partly supported by Iğdır University Scientific Research Project Council (BAP) 2019-FBE-A14 project.

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Received 2 November 2024
Accepted 10 December 2024