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The relationship between distribution of the genera *Tomares* Rambur, 1840 and the distribution of the larval host plant *Astragalus* L. (Turkey) (Lepidoptera: Lycaenidae)

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Abstract

The aim of this study is to reveal the patterns that shape the current distribution of the genus *Tomares* Rambur, 1840 in Turkey. For this purpose, the relationship between the distribution of the larval food plant *Astragalus* species of the genus *Tomares* was examined. For this reason, the data of *Astragalus* species preferred by larvae were investigated. Larvae of *Tomares* prefer 14 species of the genus *Astragalus* as food plants. Only seven of them are distributed in Turkey: *Astragalus ponticus* Pall., *A. utriger* Pall., *A. macrocephalus* Willd., *A. micropterus* Fisc., *A. ornithopodioides* Lam., *A. densifolius* Lam, *A. physodes* L. The connection between the distribution areas of the *Tomares* species and *Astragalus* species in Turkey are discussed.
Keywords: Lepidoptera, Lycaenidae, *Tomares*, larvae, host plants, *Astragalus*, distribution, Turkey.

La relación entre la distribución del género *Tomares* Rambur, 1840 y la distribución de la planta nutricia de la larva *Astragalus* L. (Turquía) (Lepidoptera: Lycaenidae)

Resumen

El objetivo de este estudio es revelar los patrones que conforman la distribución actual del género *Tomares* Rambur, 1840 en Turquía. Para ello, se examinó la relación entre la distribución de las especies de *Astragalus*, planta nutricia de las larvas del género *Tomares*. Para ello, se investigaron los datos de las especies de Astragalus preferidas por las larvas de mariposa. Las larvas de *Tomares* prefieren 14 especies del género *Astragalus* como plantas nutricias. Sólo siete de ellas se distribuyen en Turquía: *Astragalus ponticus* Pall., *A. utriger* Pall., *A. macrocephalus* Willd., *A. micropterus* Fisc., *A. ornithopodioides* Lam., *A. densifolius* Lam, *A. physodes* L. Se discute la conexión entre las áreas de distribución de las especies de *Tomares* y las especies de *Astragalus* en Turquía.
Palabras clave: Lepidoptera, Lycaenidae, *Tomares*, larvas, plantas nutricias, *Astragalus*, distribución, Turquía.

Introduction

Tribe Tomarini is a monotypic genus represented by genus *Tomares* Rambur, 1840, which involves approximately 10 species and is distributed from Europe and North Africa to Central Asia. Taxonomy of the genus is controversial since the samples lack diagnostic characteristics by which they can be explicitly assigned to species. Generally, most of the *Tomares* species show individual and local variability in the size of adult individuals with the base colour intensity and the shade and size of the

orange spots, which can sometimes completely disappear, on their wings (Nazari et al. 2020). What they all have on their forewings are a red-orange spot with broad black-brown edges and a red-orange spot on the anal area of the black-brown hindwings. Caterpillars live as endophag on the flower clusters of specific *Astragalus* species; or they live as ektophag on the flowers of specific *Onobyrchis* species. Caterpillars live as endophag on the flower clusters of specific *Astragalus* species; or they live as ektophag on the flowers of specific *Onobyrchis* species (Hesselbarth et al. 1995).

Tragacanth gum (*Astragalus* spp.) is an important plant which is distributed considerably in Turkey. Its most important industrial area of usage is the production of tragacanth resin. They are destroyed by being disrooted to obtain tragacanth gum in some areas and to be used as fuel and provender in other areas in Anatolia. Some of its species are important food plants for larvae, especially for the Lycaenidae. There are 459 taxa known belonging to 60 sections of genus *Astragalus* L., which is widely distributed in Turkey with an endemism rate of %51 (Ekici et al. 2015; Aytaç et al. 2020; Tunçkol et al. 2020; Duman et al. 2020). Larvae of *Tomares* prefer *Astragalus*, *Astracantha*, and *Onocrychis* from leguminosae (Leesmants et al. 1986; Koçak, 1983, 1987; Weidenhoffer & Vanek, 1977; Hesselbarth et al. 1995; Tuzov et al. 2000; Rákosy & Craioveanu, 2015; Bury & Savchuk, 2015; Seven, 2014; Nazari & Ten Hagen, 2020).

The taxonomic status of some species remains controversial, due to distinct morphological characters (Weidenhoffer & Bozano, 2007; Nazari & Ten Hagen, 2020) and differences in ecology and distribution (Hesselbarth et al. 1995; Van Oorschot & Wagener, 2000). In our study, distribution maps of the *Tomares* Rbr. and larval food plant *Astragalus* L. species, which are distributed in Turkey, were prepared in order to contribute to the solution of these problems. The relationship between the distribution of adult *Tomares* and the larval food plant is insufficient for explaining the distribution model of *Tomares* in Turkey.

Material and Methods

In the study, distribution maps of *Tomares* and larval food plants were determined, and distribution maps were prepared. The necessary food plant data for distribution maps were obtained from the literature. Related literatures are given in the food plant section. Hesselbarth et al. (1995) and Koçak & Kemal (2018) are used for the names and distributions of the species without considering the most recent studies on their systematic status. Chamberlain et al. (1970) used for the distribution of *Astragalus* species. The distribution of species belonging to the genus *Astragalus* is shown in blue on the map of Turkey. Species are marked with symbols of different colors in blue. The study is related to the second author's master's thesis.

Results

The larvae of the genera *Tomares* prefer 14 species from the genus of *Astragalus* L. as food plants (*Astragalus macropterus* DC*, A. ponticus* Pall.*, A. dasyanthus* Pall.*, A. schahrudensis* Bunge*, A. utriger* Pall.*, A. suprapilosus* Gontsch.*, A. macrocephalus* Willd.*, A. micropterus* Fisch*, A. ornithopodioides* Lam.*, A. densifolius* Lam.*, A. physodes* L.*, A. macrocarpus* DC*, A. leptostachys* Pall.*, A. vulpinus* Willd.). Of these, *A. macropterus* DC, *A. schahrudensis* Bunge*, A. dasyanthus* Pall.*, A. suprapilosus* Gontsch.*, A. macrocarpus* DC, *A. leptostachys* Pall. and *A. vulpinus* Will. do not show distribution in Turkey.

The genera *Tomares* which show distribution in Turkey and their food plants.

Tomares romanovi (Christoph, 1882)

Distribution in Turkey: Ağrı, Bingöl, Bitlis, Diyarbakır, Elazığ, Hakkari, Kars, Mardin, Siirt, Tunceli, Van, Batman, Şırnak, Iğdır (Map 1).

Host plants of larva: *Astragalus finitimus, Onobrchis radiata*, (Weidenhoffer & Vanek, 1977; Hesselbarth et al. 1995; Tuzov et al. 2000); *Astragalus schahrudensis* (Christoph, 1882; Korb 1924; Zhdanko, 1997). (Map 1)

Tomares callimachus (Eversmann, 1848)

Distribution in Turkey: Bitlis, Diyarbakır, Elazığ, Hakkari, Kars, Malatya, Kahramanmaraº, Mardin, Siirt, Şanlıurfa, Van, Şırnak, Iğdır (Map 2)

Host plants of larva: *Astragalus leptostachys, A. macropterus, A. physodes, A. vulpinus* (Nazari et al., 2020); *Astragalus physodes* (Korb, 1924); *Hedysarum candidum, Astragalus utriger, Astragalus suprapilosus* (Bury & Savchuk, 2015); *Onobrychis radiata* (Weidenhoffer & Vanek, 1977) (Map. 2)

Adult feeds on the nectar of *Onobrychis cornuta* and *Aethionema speciosum* and *Geranium* sp. (Koçak & Kemal, 2011). The plants they visit sometimes, although rarely: *Holosteum umbellatum, Geranium tuberosum*, *Erysimum cuspidatum, Iris pumila* and *Alyssum spp*. (Bury & Savchuk, 2015).

Tomares (nogelii) nesimachus (Oberthür, 1893)

Distribution in Turkey: Adana, Ankara, Antalya, Bilecik, Çankırı, Çorum, Elazığ, Erzincan, Gaziantep, Gümüşhane, Hatay, Isparta, İçel, Kayseri, Konya, Malatya, Kahramanmaraş, Mardin, Muğla, Niğde, Sivas, Tokat, Tunceli, Şanlıurfa, Yozgat, Bayburt, Karaman (Map 3).

Host plants of larva: *Astragalus densifolius* (İçel) (Leesmants et al. 1986); *Astragalus macrocarpus* in İsrail (Larsen & Nakamura, 1983), *Astracantha* spp. (Oorschot & Wagener 2000). Adult feeds on the nectar of *Astragalus ponticus* Çağlayan (Erzincan) (Hesselbarth et al. 1995), *A. macrocephalus finitimus, A. ornithopodioides* (Koçak, 1983).

Tomares (nogelii) nogelii (Herrich-Schäffer, [1851])

Distribution in Turkey: Adana, Afyon, Amasya, Ankara, Antalya, Bolu, Çankırı, Çorum, Diyarbakır, Elazığ, Eskişehir, Gaziantep, Isparta, İçel, Kayseri, Konya, Malatya, Kahramanmaraş, Nevşehir, Niğde, Samsun, Sivas, Tokat, Tunceli, Yozgat, Kırıkkale (Map 4)

Host plants of larva: *Astragalus ponticus* (Hesselbarth et al. 1995); *Astragalus micropterus* (Koçak, 1987). Adult feeds on the nectar of *Astragalus microcephalus, A. ornithopodioides* (Koçak, 1983), *Aethionema* (Koçak & Kemal, 2011), *A. ponticus* (Hesselbarth et al. 1995) (Map. 4).

Tomares (nogelii) dobrogensis Caradja, 2005

Distribution in Turkey: Adana, Ankara, Bolu, Nevşehir, Eskişehir (Map 5).

Host plants of larva: *Astragalus ponticus* (Rákosy & Craioveanu, 2015; Tuzov et al. 2000; Bury & Savchuk, 2015;), *Astragalus macrocephalus* (Seven, 2014); *Astragalus dasyanthus* (Bury & Savchuk, 2015) (Map. 5).

Two subspecies are known to be from Turkey (ssp. *monotana* from Bolu, 1939, ssp. *uighurica* from Adana, Ankara, and Osmaniye).

Tomares nogelii cesa Koçak, Seven & Kemal, 2000

Distribution in Turkey: Elazığ (type locality) (Map 6).

Host plants of larva: Unknown.

Tomares desinens Nekrutenko & Effendi, 1980

Distribution in Turkey: Van (Koçak & Kemal, 2005), Iğdır (Koçak & Kemal, 2012) (Map 7).

The population in Van province is represented by the subspecies *ssp.mebeb* Koçak & Kemal,

2005. Koçak & Kemal (2018) have not included these species in their studies. The existence and distribution of the species in Turkey ought to be researched.

Host plants of larva: Unknown. Adults feed on the nectar of *Erysimum* sp. (Koçak & Kemal, 2011).

Results and Discussion

Nazari & Ten Hagen (2020) examined various species of genus *Tomares* by using the barcoding and nuclear DNA methods. Molecular studies demonstrate that the genus is monophyletic and is divided into two in terms of biotope, being Africa and Asia (Krupitsky et al. 2021). Genus *Tomares* came in sight between early Oligocene and early Miocene, probably in Southwestern Asia. The division of the youngest ancestor of *Tomares* occurred between mid to late Miocene and mid to late Pliocene, possibly as a result of increasing drought and habitat fragmentation. The differentiation of the Asian lineage appeared during Pliocene and Pleistocene in Southwestern Asia, and it overlapped with *Astragalus* (Fabaceae), the host plant of *Tomares* (Krupitsky et al. 2021). There are approximately over 400 species of *Astragalus* known in Turkey (Donner, 1990). Currently, there are 459 species reported, %51 of them being endemic (Duman et al. 2020). According to the literature, larvae of *Tomares* prefer *Astragalus* plants the most among leguminosae. Species of *Astragalus genus* are common in Turkey; however only 7 species of it are known as food plants of *Tomares* larvae. This can be associated with the fact that lack of studies on the biology of the *Tomares* species. When looking at the distribution of Tomares species and food plants, it is seen that the distribution of food plants and Lepidoptera does not match in some places, and the are distributed outside the food plants (Map 1-7).

Tomares nogelii is one of the most widely distributed species. Its larvae have been reported to feed on *Ast. micropterus* and *Ast. ponticus* (Hesselbarth et al. 1995). Generally, the distribution of this species and the distribution of the food plants in Turkey draw a correspondence (Map 4). Yet, in areas having records of some species, the relevant *Astragalus* species are absent. Conceivably, *T. nogelii* larvae may prefer other species of *Astragalus*. It has already been reported in some studies that they are fed on *Astragantha* (Oorschot & Wagener, 2000).

Kovancı et al. (2009) was recorded of the *T. nogelii* from Bursa. In that study, the dominant plants in the habitat were *Astragalus angustifolius* Lam. and *Astragalus sibthorpianus* Boiss. however, no larvae were obtained from these plants. In the study, it was reported that these two plant species could be larval food plants of *T. nogelii*. However, this *Astragalus* species has not been recorded as a food plant for nogelii in any study to date.

Tomares nesimachus larvae feed on *Astragalus densiflora* (Leesmants et al. 1986). The distribution of this species and the larvae food plant show correspondence (Map 3). However, the relevant *Astragalus* species cannot be seen in places having records of some species. In these places, it might be possible that *T. nesimachus* larvae prefer distinct *Astragalus* species. Thus, *Astragalus macrocarpus* is given as a food plant in Israel (Larsen & Nakamura, 1983).

Koçak (2000) were discussed the taxonomical status of *Tomares nogelii*. In that study, are offered superspecies categorie for *nogelii.* In the sudy, is classified *nogelii*, dobrogensis and *nesimachus* as distinct species in the superspecies of *nogelii*. Koçak et al. (2000) were definied ssp. *uighurica* under the species *dobrogensis* from Ankara and ssp. *cesa* were definied under the species *nogelii* from Elazığ. Nazari & Ten Hagen (2020) state that *T. nogelii* and *T. nesimachus* are different sister species. In the study by Krupitsky et al. (2021), the two species were declared to be the same species and offered as synonyms for each other. On the maps prepared with data analyses in our study, it is evident that there is a correlation between the geographical distribution of these two species. The large overlapping of the distribution range of the two species in the same geography raises doubts about them being separate subspecies. It is also noteworthy that the *Astragalus* species which are preferred

by the larvae are different. These inconsistencies indicate that the discussions about these taxa will continue.

T. dobrogensis, found in Eastern Romania, Ukraine, and Crimea in Europe, are reported from four provinces in Turkey (Koçak & Kemal, 2018). Known in Europe, the larvae food plant *Astragalus ponticus* is extensively distributed in Turkey. However, the distribution of this plant species does not correspond to the records of *Tomares nogelii dobrogensis* in Turkey. Another food plant record known in Europe is *A. dasyanthus* (Bury & Savchuk, 2015). This plant species is not distributed in Turkey. In the study of Seven (2014), it is noted that the lays eggs on *Astragalus macracephalus* and the photographs of the egg are given. In the distribution map prepared, it is seen that the records of the larval food plant and the distribution areas of the adults do not overlap with each other (Map 5). Although molecular studies confirm that this species is a subspecies of nogelii, it is thought-provoking that both subspecies are distributed in the same region. This raises the following question; I wonder if the nominant species in Europe and the populations in Turkey are different from each other? Could the larvae of this taxon prefer only *Astragalus macrocephalus* plant in Turkey? In fact, Koçak et al. (2000) named the populations of sp. *dobrogensis* in Central Anatolia as ughurica. In order to answer these questions, more samples from different regions in Turkey and studies on their biology are needed. Insufficient published data for this species may elucidate the question of why species are more limited than their food crop distribution.

Adults of *Tomares romanovi* were reported in a hilly area covered with mixed forest (*Quercus, Crataegus, Prunus, Acer, Celtis*), malacophil plants and grasses (Koçak & Kemal, 2011). Known larvae food plant is *Astragalus finitimus* (Weidenhoffer & Vanek, 1977 Hesselbarth et al. 1995; Tuzov et al. 2000) and *Astragalus schahrudensis* (Christoph, 1882; Korb, 1924; Zhdanko, 1997). *A. schahrudensis*, do not show distribution in Turkey. *Astragalus finitimus* is considered as *A. macrocephalus* ssp. *finitimus* in Turkey. Upon examining the distribution, it can be seen that it is also distributed in such areas where the larvae food plant is not distributed at (Map 1). Additionally, even though the larvae food plant is widely distributed, the distribution of sp. *romanovi* is limited to Eastern Anatolia. Thus, it bears the possibility of this species benefitting from *Astragalus* species different from the known ones.

T. callimachus feeds on *Astragalus physodes* (Nazari & Ten Hagen, 2020; Korb, 1924). Ssp. *acikirensis,* the subspecies of this plant species is distributed in Turkey (Aytaç, 2020). The distribution of this plant species does not tally with the distribution range of sp. *callimachus* (Map 2). The distribution range of *utriger,* another larvae food plant, and the distribution range of this species overlaps only in two places. This situation reinforces the possibility of sp. *callimachus* larvae feeding on other *Astragalus* species, just like sp. *romanovi* larvae. In other respects, it is reported by Koçak & Kemal (2011) that adults of this species feed on *Onocrychis*. This species, not being reported as a larvae food plant thus far, might be used as larvae food plant for the reason that the adults feed on them. In fact, it is stated in the study of Hesselbarth et al. (1995) that *Tomares* live as ectophag on the flowers of specific *Onobyrchis* species. Thus, it can explain why the species do not correspond to the distribution of *Astragalus* species.

T. desinens is represented by *mebeb* subspecies in Turkey (Krupitsky et al. 2021). Faunistic records belong to only two places (Map 7). Its habitat tragacanthic mountain steppe has been greatly degraded and overgrazed, on the roadside where *Astragalus campylosema* (?) and *Hedysarum* grow, Hilly place covered by mixed forest (*Quercus, Crataegus, Prunus, Acer, Celtis*), with malacophyllous plants and grasses. *T. desinens* adults feed on the nectar of *Erysimum* sp. (Koçak & Kemal, 2011). Each of which can be potential larvae food plants.

Current data on the larvae food plants of *Tomares* species is not enough to clarify the relation between the distributions of the species and food plants. More data on the biologly of *Tomares* species are needed.

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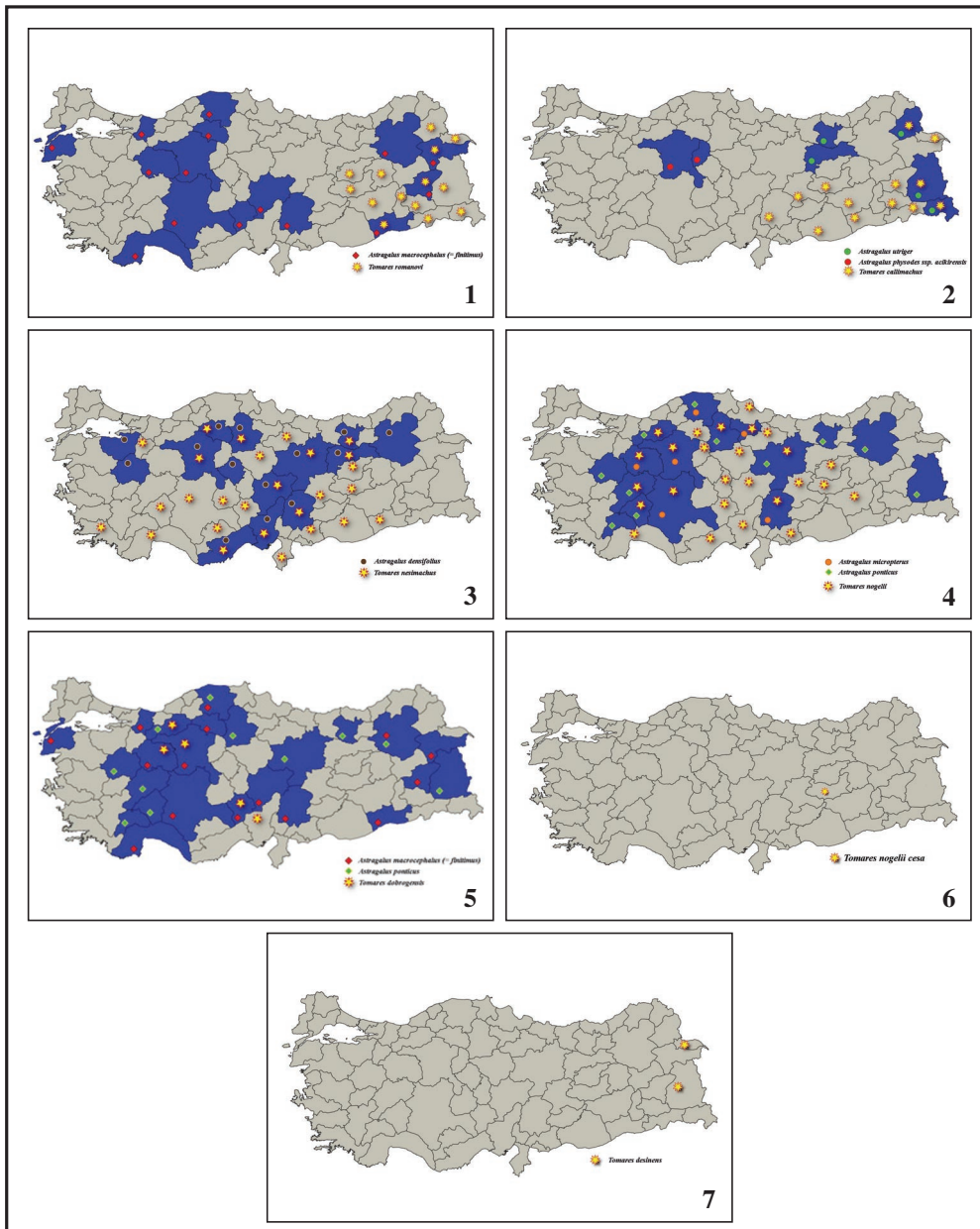

Table 1. Distribution maps of the genus *Tomares* and of host plants of the genus *Astragalus* species. **1.** Distribution maps of *T. romanovi* and *Astragalus* spp. **2.** Distribution maps of *T. callimachus* and *Astragalus* spp. **3.** Distribution maps of *T. (nogelii) nesimachus* and *Astragalus* spp. **4.** Distribution maps of *T. (nogelii) nogelii* and *Astragalus* spp. **5.** Distribution maps of *T. (nogelii) dobrogensis* and *Astragalus* spp. **6.** Distribution maps of *T. (nogelii) cesa.* **7.** Distribution maps of *T. desinens.*