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Notes on the ecology of *Prionotropis willemsorum* (Massa & Ünal, 2015) in Greece and Albania

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Abstract

The global distribution of *Prionotropis willemsorum* in Albania and Greece was updated based on the latest results from 2024. Habitats were analysed in order to reconsider the ecological preferences of this species and the current status of the each of the five subpopulations. We compared our results to what is known about the much better studied *Prionotropis azami* Uvarov, 1923, and concluded that their preferred habitats were similar. To facilitate the study of *P. willemsorum*, we identified among the Orthoptera present in the localities, which ones could be considered "Companion" and used as predictors of probability of presence. *Arcyptera spp*., as well as *Saga hellenica* Kaltenbach, 1967 and *Stenobothrus fischeri* (Eversmann, 1848) were identified as valid covariates; all have steppe affinities, like *P. willemsorum.*

Keywords: Companion species, habitat preferences, steppe

Zusammenfassung

Die globale Verbreitung von *Prionotropis willemsorum* in Albanien und Griechenland wurde auf der Grundlage der neuesten Ergebnisse von 2024 aktualisiert. Die Lebensräume wurden analysiert, um die Präferenz der Art und den aktuellen Status jeder der fünf Teilpopulationen neu zu bewerten. So haben wir beispielsweise einen Vergleich mit der viel besser untersuchten *Prionotropis azami* Uvarov, 1923 angestellt und festgestellt, dass ihre bevorzugten Lebensräume ähnlich sind. Um die Untersuchung von *P. willemsorum* zu erleichtern, identifizierten wir unter den Orthopteren, die an den Fundorten vorkommen, diejenigen, die als „Begleitarten" betrachtet und als Prädiktoren für die Wahrscheinlichkeit des Vorkommens verwendet werden könnten. *Arcyptera spp.* sowie *Saga hellenica* Kaltenbach, 1967

und *Stenobothrus fischeri* (Eversmann, 1848) wurden als gültige Kovariaten identifiziert; alle haben wie *P. willemsorum* eine Steppenaffinität.

Schlüsselwörter: Begleitarten, Habitatpräferenzen, Steppe

Introduction

Discovered at the end of the 19th century by Brunner von Wattenwyl (1882) in the Greek region of Epirus, but without any precise indication of locality, the specimen(s) was (were) identified as *Prionotropis appula* (Costa, 1836). It was found again more than a century later at a single locality near Aristi, north of Ioannina (Foucart & Ponel 1999, Willemse & Willemse 2008). Only a decade ago, the species present in Greece was separated from *P. appula* on the basis of morphological criteria (Massa et al. 2015) and named *Prionotropis willemsorum* (Massa & Ünal 2015).

Prionotropis willemsorum remains a poorly known species in terms. It was only in 2021, after a targeted survey campaign throughout the Zagori region, that its distribution range was widely extended (Lemonnier-Darcemont et al. 2022). Today, more than ten localities spread over four distinct geographical sectors are recorded in Greece, including a more northerly observation in 2024 located on Mt Nemercka near the Albanian border, which is possibly connected with the Albanian population discovered in 2023 in the extreme northwest of the same massif (Lemonnier-Darcemont & Darcemont 2023). These observations lead to a reconsideration of the preferred habitats of *P. willemsorum*, initially based on low altitude localities in Greece. These sites were the first to be discovered and are characterised by habitats in the process of being closed (including pre-forest habitats) associated with changes in grazing systems over recent decades.

The habitats where *P. willemsorum* is found vary from region to region in Greece and Albania. Our aim was to identify, on the basis of some common denominators, the habitat preferences for this taxon. The new observations presented here highlight some ecological similarities with closely related species such as *P. azami,* a relatively well studied species (Repetto 2000, Lemonnier-Darcemont 2002, 2004, 2006, Bence 2021, Catteau & Scala 2022). We also tried to identify “companion” Orthoptera species, with the aim of using some of them as indicators of the presence of *P. willemsorum* to help us find more sites in the future. As some of these “companion” species have a longer phenology and are easier to find, knowledge of these species will be useful in optimizing searches.

Material and Methods

Following our discovery of *P. willemsorum* in Albania in 2023, we searched for the species in the south-eastern extension of the Nemerçkë massif in Greece (Mt Nermercka) in spring 2024. We also continued our research in Albania on the north-western extension of Mt Trebeshinës on the same limestone substrate. The searches were carried out in late spring, which normally corresponds to the period

of occurrence of adults but which varies more or less from year to year, depending on the weather conditions. It is important to bear in mind that this species is never abundant, that its relatively short phenology can vary over the years, that its populations fluctuate among years, and that weather conditions are important for studies. If the temperature is too high or low on a sunny day, or if the day is cloudy, they remain hidden in shelters. Based on the localities discovered so far, suitable habitats have the following characteristics:

- Limestone substrate
- Open or semi-open habitat
- Presence of stones and bare soil and predominance of herbaceous layer

In order to refine the potentially favourable areas, we first recorded various parameters in the localities where the species was present, in order to be able to find among them potential covariates that could be used as predictors of the presence for future searches:

- Geological structure, elevation, orientation, degree of slope
- Vegetation belt (Quezel & Medail 2003), plant composition and structure
- "Companion" species of Orthoptera

The plant composition and structure were analysed within a wide area around observation locations.

Searches for the target species were conducted as follows: In each potentially favourable locality, we began by searching for the species (adult or juvenile) randomly for 30 to 60 minutes. For each detected individual of *P. willemsorum*, we recorded the GPS position, sex, and life stage. We noted also any other Orthoptera species encountered, indicating their relative abundance. If no *Prionotropis* was found after 30 minutes, we stopped and move on to another potentially favourable locality.

After this phase, we drew a polygon that encompassed all GPS-recorded spots. Within this polygon, we analysed the soil, stones and vegetation structure according to Prodon (1988). Whenever weather conditions allowed, we used a drone for estimating the percentage of cover of each layer more precisely (Fig. 1). The drone used was a dji Mavic Pro with a 1/2.3" 12 Mpix, 26 mm CMOS camera (78.8° angle of view). Within the polygon, the most common plants characterising the habitat were identified. These species were selected based on their relative abundance, which was determined to be the most important factor. In addition, but not for each studied locality, all plant species were identified around each specific point where *P. willemsorum* was found. The method was adapted from Gröning et al. (2007) and Bröder et al. (2018). Inside a circle of 80 cm radius, which corresponds to an area of about 2 m^2, the vegetation was analysed on a more precise scale. We then averaged these local diagnoses over the entire area, in order to better understand the structure of the species' preferred habitat within the polygon.

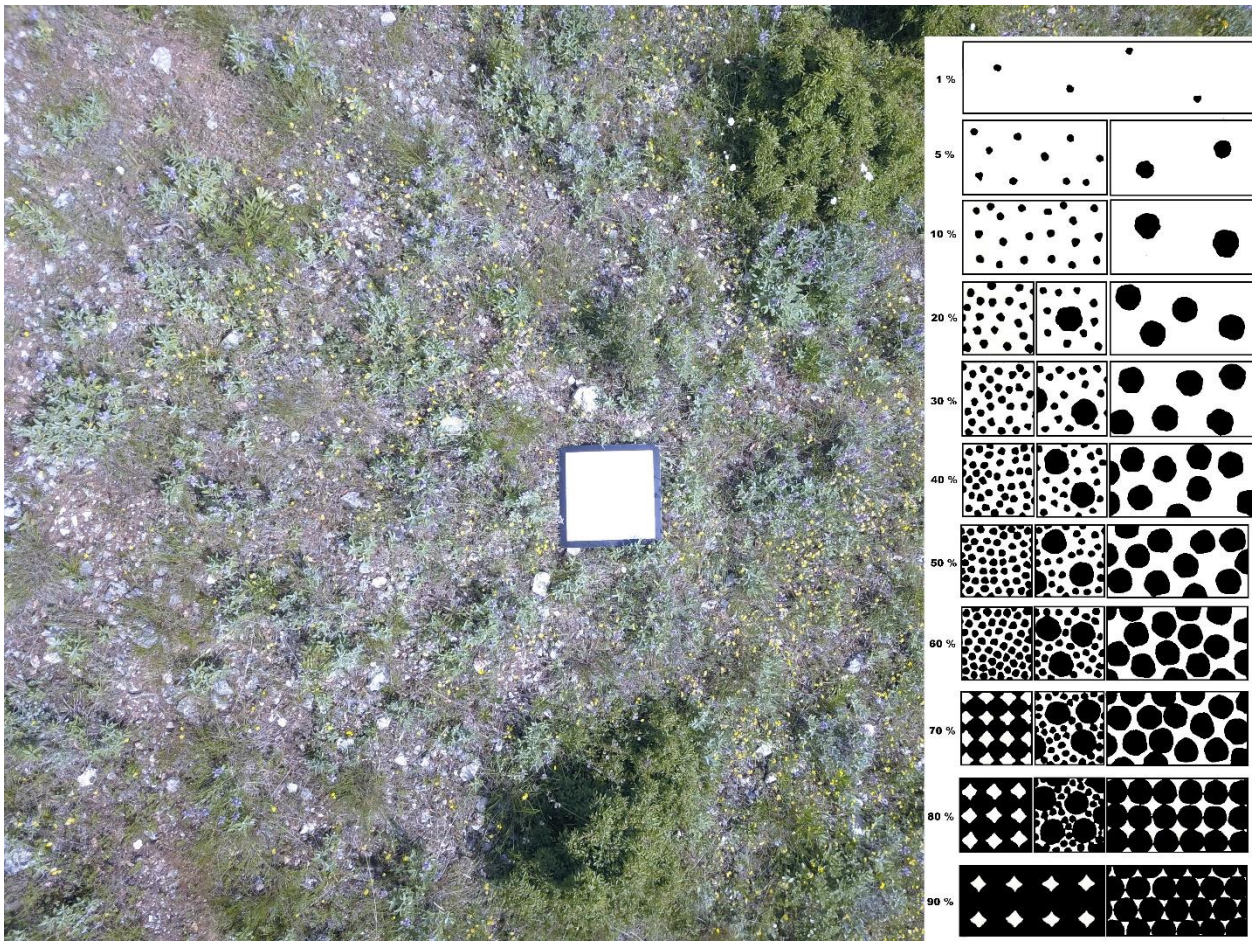

Fig. 1: Ortho-photo taken with a drone and density table according to Prodon (1988). The white square in the centre of the picture is 50x50 cm.

We also recorded individual occurrences of some accompanying Orthoptera species on the study sites. We excluded all orthopteran species considered ubiquitous because we assumed that their presence or absence will have no impact on the probability of the presence of *Prionotropis* (i.e. the probability of habitat suitability). A species is ubiquitous when its ecological valence is high. The valence can be defined by the Species Specialization Index (SSI) proposed by Julliard et al. (2006), which reflects the ability of a given species to occupy different habitats:

$$SSI = \sqrt{\frac{H-h}{h}}$$

where h = Σ habitats occupied by the taxon and H = total number of habitats defined in the study region. The higher the SSI, the lower is the ecological valence of the species. We decided on an SSI threshold at h = H / 4 (Lemonnier & al 2011).

Among the species (or genus, if the species within the genus have similar ecological requirements) of low ecological valence, i.e. with a SSI higher than the threshold, present on the localities, only those found on at least 50% of the localities were kept for analysis and conclusion.

The selection of plants was similar, excluding ubiquitous species, but paying particular attention to plants that are indicators of anthropogenic use when dominant,

such as plants that are not eaten by livestock (e.g. *Phlomis fructicosa*), which could indicate a threat on the habitat such as overgrazing. Each plant is potentially indicator of some habitats and/or evolution of habitats linked to land use. However, for the purposes of this analysis, only plants that were considered to be habitat indicators were included in the result table. For *Prionotropis*, we considered as "potential indicators for this species" the plants present in more than half of the localities and which are easy to find and identify for a non-specialist.

Concerning the *Prionotropis* species, the extreme fluctuation of populations depending on the years (Lemonnier 2004, Willemse & Hochkirch 2016), the difficulty to predict an optimal date of appearance of the adults for a given site as well as the low abundance of the species did not allow us to develop a reliable and sufficiently informative quantitative measurement method. To do so, it should be based on an average over several consecutive years, assuming that no new threats have occurred during this period. This cannot be done for *P. willemsorum* before a decade has elapsed in order to collect sufficient data.

Results

The global distribution of the species is fragmented into five areas (Fig. 2). Each area is constituted by a set of localities that are assumed to host the same subpopulation. The delineation of areas 1 to 3 was informed by a study of the presence/absence of the species across the Zagori region in Greece (Lemonnier-Darcemont et al., 2022). An overview of these five areas is provided in Table 1.

In Greece, the different localities where the species has been observed are distributed in four areas: 1. Elafotopos / Kato pedina, 2. Mesovouni / Aristi, 3. Vassiliko /Aidonochori, and 4. Mt Nemercka. The first three are located between 730 m and 1130 m of altitude in the supra-Mediterranean vegetation belt, as have been described in Lemmonier-Darcemont et al. (2022). The last one (40.045, 20.489 lat./long.) was discovered in 2024 by the authors of this paper in the mountain-Mediterranean belt and includes the highest observation point of this species (1480 m asl). In Albania, only one area, but larger, has been found up so far, extending at least between 1180 m and 1450 m altitude, in the mountain-Mediterranean belt: 5. Mt Nemërçkë (Malëshovë).

The table 2 presents a set of data characterising each of these areas. Each data set results from a combination of different localities within the areas. An additional column shows the average for the whole distribution. For comparative information, results from the same type of data using a similar protocol from field studies for *P. azami* in south-eastern France are also presented, but without usage of a drone and only with an average analysis of vegetation within the polygon (Lemonnier-Darcemont 2002). The results show that the vegetation structure of the occupied habitats by these two Pamphagidae are similar (Table 2). Importantly, the habitat should consist of at least 40% of herbaceous layer, 10% of stones and 10% of dwarf shrubs (0-1m) to ensure the sustainability of the suitable habitat. The latter two are used as necessary shelters.

Fig. 2: Map of the fragmented distribution of *P. willemsorum* with photos of biotopes

The most characteristic plants are represented by Lamiaceae which are often dominant in all the localities sampled for *P. willemsorum* and *P. azami*: *Thymus* spp*., Salvia officinalis, Satureja montana, Lavandula latifolia*, etc. In addition, certain plants with steppe affinities such as species of the genus *Juniperus* ssp. or the Poaceae such as *Stipa pennata* are also among the most common plants recorded at these localities. The following plants are present in more than half of the localities of *P. willemsorum* and can be used as potential indicators, if associated with others: *S. pennata, Thymus* spp*., S. officinalis* and *Juniperus* spp. The following plants, which are only present at some of the areas, seems to be no indicators: *Ostrya carpinifolia, Quercus trojana, Pistacia terebinthus*. These plants indicate changing habitat conditions.

Stenobothrus fischeri, Arcyptera labiata (Brulle, 1832)*, Arcyptera microptera* (Fischer von Waldheim, 1833) and *Saga hellenica* can be considered as companion species of *P. willemsorum*. In contrast, *Celes variabilis* (Pallas, 1771) and *Peripodisma tymphii* F. Willemse, 1972, have low ecological valence and were no typical companion species - despite of their steppe affinities - because they occur in less than 50% of the habitats occupied by *P. willemsorum*.

Table 1: Overview of areas of distribution of *P. willemsorum*.

	P. willemsorum				
	Greece				Albania
	Area 1 Elafotopos / Kato pedina	**Area 2** Mesovouni / Aristi	**Area 3** Vassiliko / Aidonochori	**Area 4** Mt Nemercka	**Area 5** Mt Nemër-çkë
Physical characteristics					
Surface (km²)	2	1	9	1	14
Altitude range (m)	890-1030	730-840	750-1130	1400-1480	1150-1450
Type locality		Mesovouni			
Studies					
Number of found localities in the area	3	2	7	1	2
Number of studied localities in the area	2	2	4	1	1
Year of discovery of the first locality	2018	1986	2017	2024	2023
Year of definition of the area	2022	2022	2022	2024	2024
Land use					
Grazing by cattle	No	In excess	In some spots	No	No
Grazing by small ruminants	Decreased	Replaced by cattle	Decreased	Moderate	Important
Current threats					
Decrease of biodiversity		Observed	Suspected		
Closure of habitats by woody plants	Observed	Observed	Observed		

The aforementioned observations indicate that the typical ecological preferences of *P. willemsorum* are more closely aligned with those of steppe habitats, exhibiting a high degree of similarity to those of *P. azami*. The areas deviating from this optimum are probably relict areas, resulting from an evolution linked to changes in anthropic practices. This is particularly the case for areas 1 and 2, which are highly endangered, and area 3 (Lemonnier-Darcemont et al. 2022).

Table 2: Global overview of main associated data with potential co-variates. X means "presence", blank means "absence" in the area.

	P. willemsorum						***P. azami***
	Greece				Albania		France
	Area 1	Area 2	Area 3	Area 4	Area 5	Mean	Mean
Vegetation belts							
Meso-mediterranean						0%	20%
Supra-mediterranean	X	X	X			60%	55%
Montane-mediterranean				X	X	40%	25%
Vegetation - overview							
Edge, clearing of ligneous vegetation	X	X	X			60%	50%
Meadows			X	X	X	60%	70%
Vegetation - structure							
Bare soil	10%	10%	5%	4%	10%	8%	7%
Stones and rocks	35%	10%	15%	30%	25%	23%	17%
Herbaceous layer	35%	55%	50%	55%	50%	49%	44%
Dwarf shrubs < 1 m	10%	20%	20%	10%	10%	14%	24%
Ligneous > 1 m	10%	5%	10%	1%	5%	6%	8%
Typical plants							
Stipa pennata	X			X	X	60%	75%
Thymus spp.		X		X	X	60%	80%
Salvia officinalis	X		X		X	60%	
Juniperus spp.	X	X	X	X	X	100%	100%
Lavandula latifolia						0%	70%
Satureja montana						0%	80%
Euphorbia spinosa						0%	60%
"Companion" species							
Stenobothrus fischeri	X	X	X	X	X	100%	80%
Arcyptera spp.	X (*labiata*)	X (*labiata*)	X (*labiata*)	X (*labiata*)	X (*microptera*)	100%	80% (*kheili*)
Saga spp.		X (*hellenica*)	X (*hellenica*)	X (*hellenica*)	X (*hellenica*)	80%	50% (*pedo*)
Calliptamus siciliae							60%

Discussion

Prionotropis willemsorum is a species with steppe affinities similar to *P. azami.* Its presence in Greece in more closed forest habitats is probably the result of environmental change, particularly due to the decline in sheep and goat grazing.

Even though we did not find the species in the Mediterranean belt, it cannot be excluded that it is not present there, given the low prospecting pressure exerted in the southern Balkans. *P. azami* in France, which shows similar ecological preferences, is also found in a few sites in the Mediterranean belt. Compared to France, the elevation limits of the Mediterranean vegetation belts in Greece and southern Albania are higher due to a hotter climate (Quezel & Medail 2003) and therefore the species could be found at higher elevations. As *P. azami* occurs up to 1500 m in France, it cannot be excluded that *P. willemsorum* occurs at a much higher altitude.

Although the plants listed in the table are indicators of potential suitable habitats, they cannot be used alone. Only in combination with the vegetation structure, other indicator plants and Orthoptera companion species, they indicate an increased probability of the presence of *P. willemsorum*.

Companion species of Orthoptera with a wider phenology and higher abundance provide a complementary tool to help us refine the potential suitable sites for future studies. Other additional species that characterise suitable habitats for *P. willemsorum* could be studied in the future. We are thinking, for example, of the butterfly *Melanargia russiae* (Esper, 1783), a species sharing the same ecological preferences which were almost always occurred in suitable localities.

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