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Occurrence and threats of *Prionotropis willemsorum* (Massa & Ünal, 2015) in Greece

Michèle Lemonnier-Darcemont[1] | Lisbeth Zechner[2] | Vassiliki Kati[3] | Nikolaos Filis[3] | Christian Darcemont[1]

[1]Groupement d'Études Entomologiques Méditerranée (G.E.E.M.), P.O. BOX 60, 48060 Parga, Greece

[2]CEN PACA - Pôle Bouches-du Rhône, Maison de la Crau, 2, place Léon Michaud, 13310 Saint-Martin-de-Crau, France

[3]Biodiversity Conservation Lab, Department of Biological Applications & Technology, University of Ioannina, Greece

Correspondence: Michèle Lemonnier-Darcemont; e-mail: michele.lemonnier-darcemont@geem.org
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Abstract

A first report on the occurrence of *Prionotropis willemsorum*, an orthopteran Pamphagidae endemic to Greece is drawn up. The threats that particularly impact the habitats where this species lives are also assessed. They are mainly linked to alterations in grazing practices, whether it is the abandonment or the change from herds of sheep and goats to cattle grazing. New localities were also discovered during our spring 2021 and 2022 surveys.

Keywords: endemic species, grazing practices, species conservation, Pamphigidae

Zusammenfassung

Vorkommen und Gefährdung von *Prionotropis willemsorum* (Massa & Ünal, 2015) in Griechenland. Ein erster Bericht über die Populationen von *Prionotropis willemsorum*, einer in Griechenland endemischen Heuschreckenart (Orthoptera, Pamphagidae) wird präsentiert. Die Bedrohungen, die insbesondere die Lebensräume dieser Art betreffen, werden ebenfalls bewertet. Sie hängen hauptsächlich mit Veränderungen der Beweidungspraktiken zusammen, einerseits die Aufgabe der Beweidung, andererseits der Wechsel von Schaf und Ziegenherden zu Rinderbeweidung. Bei unseren Erhebungen im Frühjahr 2021 und 2022 wurden auch neue Fundorte entdeckt.

Schlüsselwörter: Artenschutz, Beweidung, endemische Art, Pamphigidae

Introduction

The first observations of this Pamphagidae in north-western Greece, in Epirus region, date from the end of the 19th century (Brunner von Wattenwyl 1882). After more than a century without being reported, *Prionotropis willemsorum* was found in 1986 (Willemse & Willemse 2008), then in 1997 (Foucart & Ponel 1999), between Konitsa and Ioannina. Initially merged with the Italian taxon *P. appula* (Costa, 1836), the species was recently separated by Massa et al. (2015). Like all representatives of the Pamphagidae family, *P. willemsorum* is a grasshopper of massive shape and large size (♂: 37–43 mm; ♀: 46–51 mm). The female is squamipterus with wings reaching at most the second tergite (Fig. 1). Those of the male are clearly longer but on all the individuals that we have found, they did not exceed the sixth tergite (Fig. 2). It should be noted that this observation does not agree with the indication given in the determination key of Massa et al. (2015), which considers as one of the discriminating criteria the length of the wings reaching the epiprocte in *P. willemsorum.* Five larval stages (L1–L5) are a priori necessary before reaching the imago form.

The typical biotopes of this orthopteran species consist of more or less grazed calcareous grasslands on stony soils or on soils which present rocky outcrops, generally located close to more dense formations of persistent or deciduous oak groves, between 700 and 1000 m altitude approximately. They are located in the Zagori region, in the Pindus massif, between north of Ioannina and south of Konitsa. Adults are observed from late May to late June or early July.

Due to the small size of its populations and the extreme fragmentation of its habitats, this taxon is classified EN (endangered) on the IUCN red list (Willemse & Hochkirch 2016).

In this study field surveys and breeding tests were conducted in 2021 and 2022 in order to increase knowledge about the current distribution of *P. willemsorum* and to gain insights in its ecology and threats.

Fig. 1: *Prionotropis willemsorum* female, © 2021 Michèle Lemonnier-Darcemont.

Fig. 2 : *Prionotropis willemsorum* male, © 2022 Michèle Lemonnier-Darcemont.

Material and methods

Study area

In 2021, first field surveys were planned in the two main known localities of the species in May, the best time to find as many individuals as possible (first juveniles, then adults by the end of the month). The surveys have been continued in 2022.

1. North of Mesovouni, 735 m a.s.l. (= type locality, “4 km W Aristi” Massa et al. 2015)

2. Kato Pedina, 1030 m a.s.l.

Further surveys in favourable habitats located in the continuity of the already known localities, allowed us to discover new sites:

3. West of Elafotopos, 890-980 m a.s.l. discovered by L. Zechner in 2021, and visited in 2021 and 2022.

4. Between Vassiliko and Aidonochori at 750 m a.s.l., discovered in 2017 by Todd Boland. It was initially wrongly located near the Papingo village, and has just been relocated in October 2021 by the author (pers. comm.). This site has been confirmed by Apostolis Stefanifis and Olga Tzortzakaki in June 2021. It has been visited and extended in 2022.

5. Aristi, 840 m a.s.l. discovered by V. Kati and A. Stefanidis in 2021, and visited again in 2022.

6. Aidonochori south, 770-790 m a.s.l. discovered by M. Lemonnier-Darcemont and C. Darcemont in 2022

7. Vassiliko south, 790 m a.s.l discovered by M. Lemonnier-Darcemont and C. Darcemont in 2022

8. Vassiliko hill, 960-1030 m a.s.l. discovered by all the authors together in 2022

9. Vassiliko north, several distinct spots between 950 to 1130 m a.s.l. discovered by most of the authors.

In addition, the Willemse collection contains a reference from J.Th. Skovgaard, labelled Ioannina, 25.VI.1994: “Probably slopes of Mt. Mitsikeli, the only appropriate habitat in the surroundings of Ioannina town” (Willemse & Willemse 2008). An extensive survey of more than 40 localities with species absence (V. Kati, A. Stefanidis) suggests that the species is absent from Mitsikeli Mt. The assumption of presence on this mountain was wrong, or the species has disappeared there after 1994.

Several additional sites were visited (with absence data) all around the localities with presence data enabling us to obtain a good representation of the occupancy of the species.

Habitat description

In this preliminary study, a set of environmental parameters were assessed in order to characterize suitable habitats of *P. willemsorum*. The target was to provide an overview, relatively stable over one year, of each site where the species was observed. Each data collection included the soil type, land use by man (pastoralism, cultivation, etc.) or wildlife (grazing, digging the soil, etc.), characteristics of the plant formation and percentage cover of the main vegetation strata on a 1000 m² global view (bare soil, stones and rocks, herbaceous layer, dwarf shrubs (0–1m) and shrubs (1–4 m)). The identification of the main woody species enabled us to better assess the dynamics of vegetation. Photos of the habitat taken on the ground and also in aerial views with a drone (natural inclination and ortho-photos), in spring and in autumn, completed this analysis and informed us about the medium-term evolution of these landscapes in comparison with older existing satellite images taken in 2006 (Google earth). The drone used was a 'dji Mavic Pro' with a camera CMOS 1/2.3" with 12 Mpix., 26 mm (78.8° vision angle). Relative elevation used for pictures were: 5 m, 10 m, 20 m, 30 m, 50 m, 100 m, 200 m, and for one site, every 100 m up to 500 m.

Breeding tests

Breeding of two couples were done by M. Lemonnier-Darcemont in 2022 (Authorisation by the Hellenic Ministry of environment, ΥΠΕΝ/ΔΔΔ/116480/3825, dated 28/03/2022) in order to increase our knowledge on their biology and the duration of the egg diapause, which can provide insights for future conservation strategy. One couple of sub-adults (J5) were collected in Vassiliko south site on 16th May 2022. One couple of juveniles in stage 4 (J4) were collected in Aidonochori south site on 20th May 2022. The individuals were installed in a terrarium where we reconstituted a suitable microhabitat: soil and local plants, flat stones, etc., while respecting as much as possible the duration of sunshine and the temperature of their natural biotopes (UV lamps and heated) with provision of shaded shelters.

Results

Distribution area

All the sampling sites with presence data are in the typical villous oak zone (*Quercetalia pubescentis*) in the supra-Mediterranean belt. The figure 3 shows the extent of occupancy (EOO) of the species (i.e. the area contained within the shortest continuous imaginary boundary which can be drawn to encompass all the known sites of present occurrence). The most important area is the massive above and around Vassiliko village, extending to the south in a narrower bandwidth up to Kato Pedina. In the north, the species does not occur beyond the massive and do not reach the border with Albania. In the south, it seems that Kato Pedina is roughly the limit of the occupancy. The population is fragmented in some parts, certainly linked to the past and current use of the land (high cattle grazing pressure in some parts, abandonment of pasture by small ruminants in some other parts).

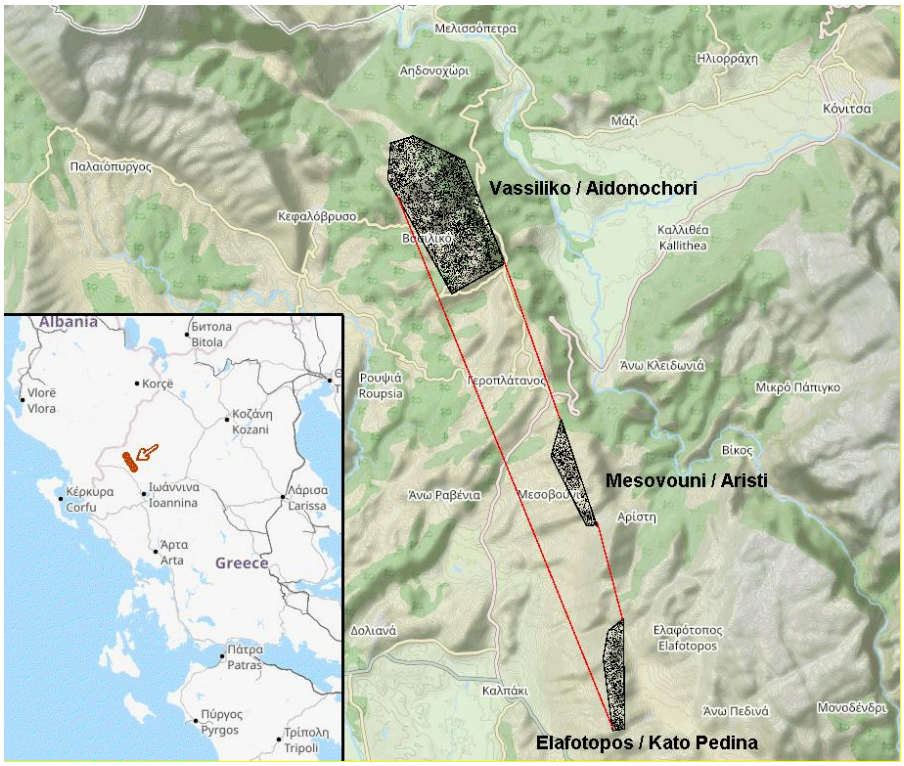

Fig. 3: Map of the extent of occurrence (red polygon) and areas of isolated populations (black areas).

Habitat parameters

The common point of the sites was the steppe origin, which was indicated by the presence of specific plants and grasshoppers having steppe affinities. All the sites showed different structures from, for instance, a set of xeric calcicolous grasslands distributed in a large area of more or less dense scrubland (with e.g. *Quercus coccifera*) to oligotrophic calcicolous grassland in a clearing of thermophilic oak forest of *Quercus trojana* and *Q. pubescens,* with *Ostrya carpinifolia* for some other sites.

The following plant species were also common throughout most of the site: *Elaeagnus angustifolia, Acer monspessulanum, Fraxinus ornus, Phlomis fructicosa, Juniperus oxycedrus deltoides, Thymus* sp.*, Cistus incanus criticus, Salvia officinalis.*

On the localities 1, 2, 3, 6 and 7, we measured the percentage of the different vegetation layers. We selected these localities for the analysis because we feared that the populations of these sites were potentially restricted and isolated because around these localities, the biotopes seemed inappropriate. On average, the following coverage rates were found: Bare soil: 10%, stones and rocks: 20%, herbaceous layer: 45%, dwarf shrubs (0–1m): 15%, and shrubs (1–4 m): 10%.

Phenology

Most of the hatching occurred during the second half of April, then the duration of the juvenile stages was variable depending on environmental factors (density of vegetation layer, orientation of the land, mean temperature, altitude, etc.). In the first half of May, at the same place, we found up to 3 different stages of juveniles.

Some of them became adults in the second half of May. The majority of them were adults in the first half of June. The total number of juvenile stages was 5. The variability of different juvenile stages at the same place is commonly observed with other Orthoptera, such as Saginae (M. Lemonnier-Darcemont, pers. com.).

Threats

On Mesovouni, the comparison of the aerial photo from 2006 (Google earth) with the pictures taken by the drone in 2021, showed an increase in woody plants with detrimental effects on herbaceous and steppe vegetation, which are favourable to *P. willemsorum* (Fig. 4).

In May 2004, we noticed the presence of goats and sheep, but no cattle in this area. In May and June 2021, we did not see any herd on the site but noted many cattle dry dungs and trampled areas. These indicated the presence of cattle, replacing sheep and goats, probably in early spring during peak flowering period, which could explain the low floristic diversity, compared to that observed at the same period of the year in 2004 (Fig. 5). The main threat identified for this site is the disappearance of the species' elective biotope, by the closure of the habitat but also by the impoverishment and homogenization of its plant formations, a probable consequence of the modification of the grazing system.

On Kato Pedina, the habitat appeared to be highly unstructured (predominance of stones), a probable consequence of strong grazing pressure in the past. This trend seems to be accentuated today by the intense presence of wild boars, observed more particularly in spring. We did not notice any recent traces of grazing, and the encroachment of *Quercus coccifera* could lead to its reduction in the medium term.

On Elafotopos, the observed trend is a progressive closure of the environment by woody plant formations, probably linked to grazing abandonment (Fig. 6).

Overall, on the Vassiliko massive, we noted a presence of cattle grazing but the grazing pressure was very low compared to the sites located more in the south.

Fig. 4: North of Mesovouni, evolution of habitat closing. Left: 2006 (Google earth view), right: 2021 (photo of the drone at 300 m elevation from the ground).

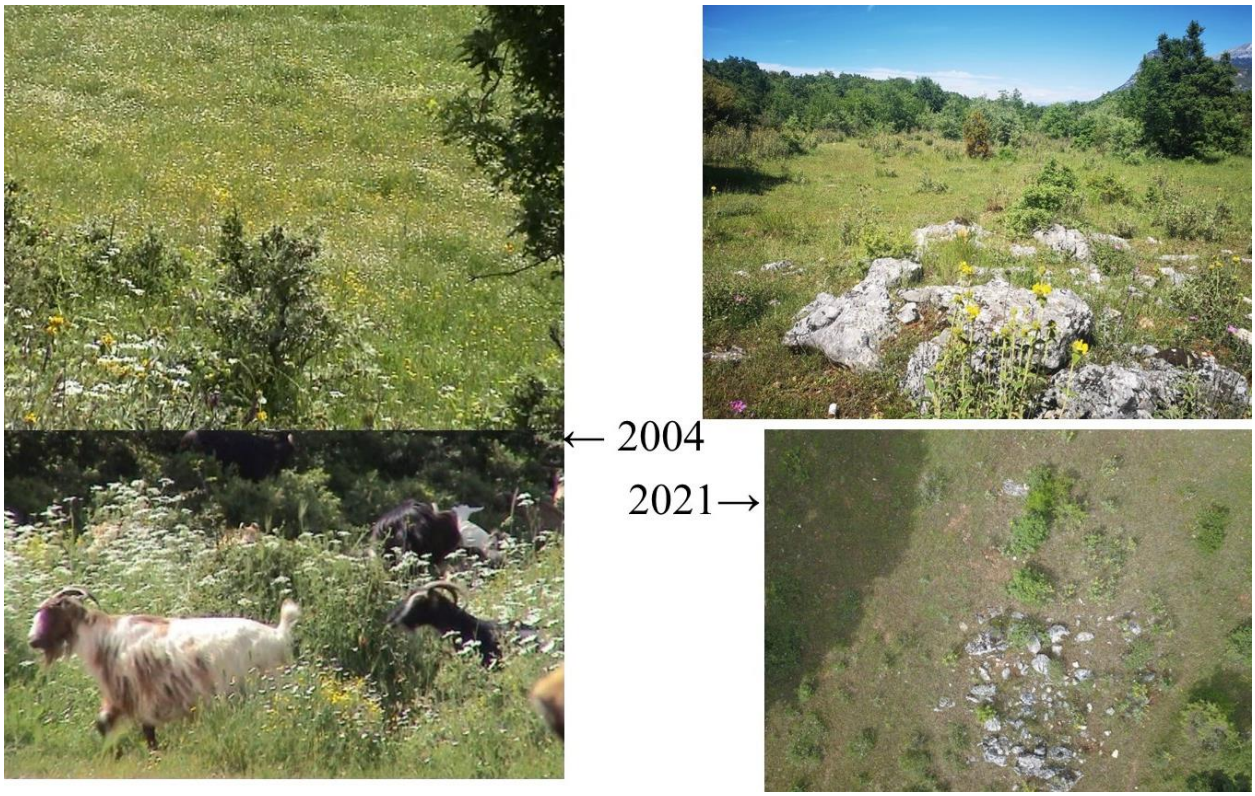

Fig. 5: North of Mesovouni, evolution of habitat diversity. Left: 2004, right: 2021.

Breeding results

Various plants from the area where insects have been sampled were eaten on a regular basis, in particular the flowers of Lamiaceae (*Phlomis* sp*., Salvia officinalis)* but also the flowers of Fabaceae (*Anthyllis vulneraria),* the leaves of Asteraceae *(Taraxacum* spp*.)*, Plantaginaceae *(Plantago* spp*.*). We successfully tested a few plants not present on the species' sites: the leaves of Scrophulariaceae (*Verbascum* sp*.),* and the zucchini was particularly appreciated. The consumption of wheat bran suggests that they also like some wild Poaceae.

The mating started in the first days of June (first observed the 4 June), and the males tried almost continuously to mate with the females up to their end of life. We have not yet information about the number of egg pods laid because we cannot assume that the manipulation of egg pods has no impact. The orientation in all axes may be important, we do not know at this stage. We will have to wait the hatchings, after one and several additional years to get more information.

The adults can live more than one month (i.e. up to mid-July), however we noticed a mortality of our two females at least two weeks earlier than the two males.

Our first female died without visible disease (on dissection, we found that the intestine was empty and the abdomen still contained a few eggs.) on 20th June and the second on 2th July 2022 despite a full intestine and more eggs. It may have died of exhaustion due to continuous harassment from males. Our first male was dead on 13th July, the second male on 20th July.

Fig. 6: West of Elafotopos, evolution of habitat closing. Bottom: 2006 (Google earth view), top: 2021 (photo of the drone at 500 m elevation from the ground).

Discussion

In the north of the occupancy, the populations seem to be more or less connected over the whole Vassiliko massive. However, in the south, the populations seem to be relatively isolated from each other. Therefore, it is important to verify whether there is a functional and efficient connection between certain geographically close sites, such as for example between Elafotopos and Kato Pedina, despite the progressive closure of the habitat by *Quercus coccifera*. If this isolation is confirmed, the risk of genetic impoverishment exists and in the long term the strong decrease in the number of individuals may lead to the disappearance of these populations. However, this problem (decrease because of genetic impoverishment) does not occur currently on isolated populations of *P. rhodanica* in Crau, France (A. Hochkirch, pers. com).

Our current vision regarding the main threat to all these sites is the change of the grazing system (Fig. 7): on the one hand, the drastic reduction of sheep and goat grazing and in certain sectors their substitution by cattle. On the other hand, grazing abandonment which leads to the reduction of open habitats.

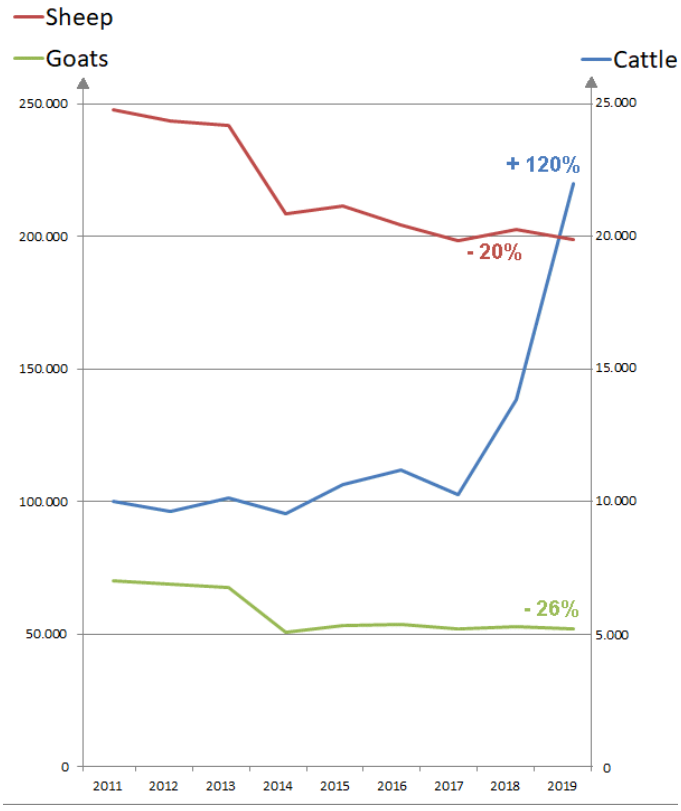

Fig. 7: Trend of livestock of sheep, goat and cattle in Ioannina region in the period 2011-2019. Scale on the left for sheep and goat, scale on the right for cattle. Source of data: Hellenic Statistical Authority. Data selected: non-enclosed animals. Cattle dedicated for meat.

In order to sustain existing populations, some targeted actions are important:

Mesovouni and Aristi: As cattle particularly appreciate the flower stalks, the urgent short-term action is to avoid their passage at the beginning of spring, period of maximum flowering. The structure of the vegetation is also altered with a decrease of the diversity of plants. Depletion of the flora results in an overall decline in food resources and is seriously damaging to insects that feed on them, such as

P. willemsorum. This alteration in plant diversity is further accentuated by the way cows graze, which pull up plants by surrounding them with the tongue rather than cutting them clean as done by small ruminants (Mosavat & Chamani 2013). In addition, given their weight, trampling is more damaging. As for parasite treatments, which could also be considered as a threat to Orthoptera, but have only been studied for Coleoptera (Cornille 2010), they are often more numerous for the meat sector than for animals from which milk is used, for which health regulations are more stringent and restrictive. In Greece, especially in this region, the majority of cattle are raised for meat, and sheep and goats are raised primarily for milk (Hellenic Statistical Authority https://www.statistics.gr/en/statistics/agr). In the medium term, cattle should not access this area and be replaced by sheep and goats.

Kato Pedina and Elafotopos: *P. willemsorum* depends on the sustainability of open or semi-open herbaceous formations. The increasing encroachment of the ligneous plants threatens the sustainability of these sites in the medium term. Abandonment of grazing seems to be at the origin of this situation and extensive grazing with small sheep and goat flocks would contribute to stop this phenomenon. In Kato Pedina where the impact of wild boars on already heavily eroded soil is an additional threat, monitoring and if necessary controlling of these ungulate populations is highly desirable.

Vassiliko and Aidonochori: *P. willemsorum* depends on the sustainability of open or semi-open herbaceous formations, particularly on the east side of the massive. On the west side and on the top, the main concern is the change of the grazing system (abandonment of grazing by small sheep and goat flocks and replacement by cattle). Today the cattle grazing pressure seems to be moderate but could have an impact if the cattle are present in-situ too early in spring and if the trend of the closure of the habitats continues. The main threat for the Vassiliko population is however the construction of a windfarm along the mountain ridge, which would severely impact the population due to land take and habitat loss (Kati & al 2021) and the creation of new dust road access for windfarm inducing a potential increase of land use due to easier access.

The link with the stakeholders involved in the grazing system of this area is of the utmost importance to guarantee the sustainable conservation of this insect.

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