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Pseudochazara amymone (Lepidoptera, Nymphalidae) in Albania: Variability analysis, androconial scales and new distributional data

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Abstract. For the first time a comparison of variable external characters of a series of males and females of *Pseudochazara amymone* (Brown, 1976) from southern Albania is conducted. *Pseudochazara amymone*, flying together with *P. mniszechii tisiphone* (Brown, 1980), was local and quite common in steep valleys on ophiolite substrate on two separate mountains, one of which is a recently discovered locality by Eckweiler (2012), while the other one is a new locality. An analysis of external characters of all specimens from the two localities suggests no statistically significant differences. In the field, patrolling *P. amymone* males are easily distinguished from *P. mniszechii tisiphone* males but this is not the case for females, and therefore we provide determination keys for males and females of these two species. These are based on a statistical analysis of a specimen series from one Albanian *P. mniszechii tisiphone* population compared with all *P. amymone* in this study. Photographs of androconia, copula and some extreme forms of *P. amymone* are presented. To encourage further research in this poorly explored country a map is included, showing all historical records of Papilionoidea from literature, including our own observations.

Samenvatting. Voor het eerst wordt een vergelijking gepubliceerd van de variabele uiterlijke kenmerken van een reeks mannetjes en wijfjes *Pseudochazara amymone* (Brown, 1976) uit Zuid Albanië. *Pseudochazara amymone* was lokaal en vrij algemeen in steile valleien op ophioliet gesteente in twee gescheiden gebergten en vloog samen met *P. mniszechii tisiphone* (Brown, 1980). Aan de auteurs werd bevestigd dat het eerste gebied de recent, door Eckweiler (2012) gevonden plaats is. Het tweede gebied is nieuw. Een analyse van de uitwendige kenmerken van alle exemplaren uit de twee gebieden suggereert geen significante verschillen. In het veld kunnen patrouillerende *P. amymone* mannetjes gemakkelijk onderscheiden worden van *P. mniszechii tisiphone* mannetjes maar dit is niet het geval bij de wijfjes. Daarom zijn determinatiesleutels voor beide taxa opgenomen (zowel voor mannetjes als wijfjes). Deze zijn gebaseerd op een statistische analyse van een Albanese *P. mniszechii tisiphone* populatie met alle *P. amymone* in deze studie. Foto's van de androconia, copula en sommige extreme vormen van *P. amymone* worden getoond. Om verder onderzoek aan te moedigen in dit zwak onderzocht land is een landkaart opgenomen die alle historische Papilionoidea gegevens inclusief onze eigen observaties weergeeft.

Resumé. For første gang gennemføres en sammenligning af de varierende eksterne kendetegn på en serie hanner og hunner af *Pseudochazara amymone* (Brown, 1976) fra det sydlige Albanien. *Pseudochazara amymone* forekom sammen med *P. mniszechii tisiphone* (Brown, 1980) lokalt, men ret almindeligt, i stejle dale med ofiolitiske mineraler i to adskilte bjergområder, hvoraf det ene er en nyligt opdaget lokalitet af Eckweiler

(2012), og det andet er en ny lokalitet. En analyse af alle eksemplarers eksterne kendetegn fra de to områder viser ingen statistisk signifikante forskelle. I felten kan patruljerende *P. amymone* hanner let adskilles fra *P. mniszechii tisiphone* hanner, men dette er ikke tilfældet med hunnerne, og derfor gives bestemmelsesnøgler til hanner og hunner af disse to arter. Disse er baseret på en statistisk analyse af en serie eksemplarer fra en albansk *P. mniszechii tisiphone* population og alle *P. amymone*. Fotos af duftskæl, parring og visse ekstreme former af *P. amymone* præsenteres. For at tilskynde andre til at foretage videre undersøgelser i dette så dårligt udforskede land inkluderes et udbredelseskort over alle hidtidige fund af Papilionoidea nævnt i litteraturen, inklusive vore egne fund.

Introduction

Brown's Grayling, *Pseudochazara amymone* (Brown, 1976) was discovered by John Brown in early July 1975 in NW Greece (type locality: "mountains just north of Ioannina") based on four males (Brown 1976) and years later a single female (oral communication). Since then, despite many efforts, almost all searches for this butterfly in Greece have turned out negative and no other voucher specimens are available. A lot of strange rumours, describing a rocket speed flight and strange nuptial behaviour, often followed these negative searches (Cuvelier 2010). Since its discovery, *P. amymone* has been the subject of speculation like hardly any other butterfly species in Europe and a myth has been created around it. Its taxonomic status is still uncertain. Because of the close resemblance in the genitalia of Albanian *amymone* with Turkish *Pseudochazara mamurra* (Herrich-Schaffer, [1846]), Eckweiler (2012) treated *amymone* as a subspecies of *P. mamurra*. DNA analysis might shed additional insights on the taxonomic position of the taxon *amymone* and is underway by an independent group (oral comm. Verovnik). In this article we chose to follow Fauna Europaea (de Jong 2013), which gives this taxon species status.

Albania is a country that, due to its political (50 years of communist regime and civil war) and infrastructural situation, only recently became open for travelling and lepidopterological investigation. Large parts of the country remain unexplored. It is not surprising that *P. amymone* remained undiscovered in Albania until recently. Here the faunistical elements of central Europe meet with those from the Balkans, the Mediterranean and Asia Minor.

Eckweiler had the idea to start searching for *P. amymone* in Albania in 2010. In July 2010 he discovered a first single *P. amymone* male and, in July 2011, five further males and one female in southern Albania. Before the publication of his observations, this discovery was again surrounded by mysterious communications. But at least this time strong proof of its existence, supported by the photographs of voucher specimens, was soon given (Eckweiler 2012). A short message on Facebook from van Swaay during the summer of 2012 also mentioning a few *P. amymone* from Albania was the only other evidence known to us at that time. This message included a photograph of a male *Pseudochazara*, sitting with closed wings that looked quite different from *Pseudochazara mniszechii tisiphone* (Brown, 1980). But even with both sources, the locality remained obscure and the given information again supported the extreme rarity of the butterfly. The article (Eckweiler 2012) made some suggestions concerning a potentially wider distribution area in Albania than the single undisclosed locality where the *P. amymone* had been found and the need for further surveys. Based on all of this, a joint trip to Albania was planned by the authors with the objective to search for further evidence and to study the biology of *P. amymone* in the country.

As this taxon is often associated with Turkish *Pseudochazara mamurra* (Herrich-Schäffer, 1852) (Gross 1978; Tolman and Lewington 1997; Eckweiler 2004; Tshikolovets 2011; Eckweiler 2012), we used Google Earth to search for potential localities of *P. amymone* similar to Turkish habitat photographs (Hesselbarth et al. 1995). With the available good resolution of satellite photographs it is possible to recognize the colour of the geological substrates together with a lot of topographical details. Such places seemed quite common in Albania and were far too numerous for a dedicated search. Pamperis (1997) also mentioned that in one Greek locality *P. amymone* is sympatric with *P. mniszechii tisiphone*, but flying at the end of the flight time of *P. mniszechii tisiphone*. This suggests a geology of dark red soil as in typical *Pseudochazara* biotopes. The habitat photograph from the Eckweiler paper (2012) also was suggestive of such soils and the pink flowers were an interesting clue for future field research. A geological map from Monjoie et al. (2008) helped us focus our research strictly on the south-eastern Albanian province of Korçë. On Google Earth these areas, mentioned as ophiolite nappes in the maps, looked a lot like some Turkish biotopes with steep, dark red, dry slopes in river valleys. Combined with the information about altitude, this enabled us to be very selective concerning target areas.

Our second objective was to explore areas in Albania that had never been explored before for butterflies. Before this field trip, we searched for all historical data from the sparse literature about Albanian butterflies. Maps of species and a global distribution map clearly showed how poor is the coverage for this country. We also intended to survey other areas in the provinces of Korçë, Kolonjë, Përmet, Tepelenë and Skrapar to increase the knowledge of the butterfly fauna from Albania in general. The detailed results of all our own observations will be published in a future faunistic publication.

Abbreviations

AL: androconium length; AB: androconium breadth; A: ratio AL/AB; FW: forewing; HW: hindwing; MM: Morten Schneider Mølgaard; N°: number; N/A: not applicable; oc.: ocelli; SC: Sylvain Cuvelier; SD: standard deviation; subm.: submarginal; UNS: underside; UPS: upperside; Var: variable.

Material and methods

Sample collecting and database construction

In two localities in the Albanian province Korçë (Boboshtiçë and Gjergjeviçë) males and females of *P. amymone* and *P. mniszechii tisiphone* were netted by both authors. A search for all potential references on the butterflies of Albania was made during the preparation for the trip. The relevant publications were gathered from different sources in order to build a database including as much historical data as possible (Abadjiev and Beshkov 1996a, b; Alberti 1965; Beshkov 1994; Beshkov 1995; Beshkov and Misja 1995; Gaskin 1990; Misja and Kurrizi 1984; Moucha 1963a, b; Murraj 1972; Płóciennik et al. 2009; Popescu-Gorj 1971; Rebel 1913; Rebel 1918; Rebel and Zerny 1931; Verovnik and Popović 2013a, b). Only the data from all species with rather precise indications of the locality were included in an Excel spreadsheet with coordinates in decimal degrees that were defined with Google Earth and an online coordinate conversion tool (Montana State University 2014). All data from our personal observations were included in this database. During our surveys, coordinates were obtained in the field with a GPS (Garmin Etrex Legend). A

map of Albania was adapted for use with DMAP distribution mapping software to produce distribution maps per species and one global coverage map of all Albanian butterfly species. During history the borders of Albania have changed. Some historical data now in fact concern localities that are situated in Montenegro, Kosovo and Macedonia. To be as complete as possible, we have maintained these observations in the coverage map.

Study of external characters

Since the discovery of *P. amymone* by Brown (1976), as far as is known to the present authors, there have been only 10 male and two female voucher specimens collected and included in publications. *Pseudochazara* species are very variable and difficult to identify. No comparative studies on the external characters of a good number of *P. amymone* specimens have been published so far and we had no precise idea about the variability of the external characters of both sexes.

The male holotype, figured in black and white, was for a long time the only documented picture of this species (Brown 1976). In his article, Brown described the external characters based on a very small series of four males: "*Upperside* similar to *graeca* but wings more rounded and with notably broad clear orange postdiscal bands more or less broken by grey-brown ground colour along v4 of forewing and enclosing blind black oc. in S 2, 5 and minute black oc. in S 3, 4 on forewing. Sex brand inconspicuous. Hindwing sometimes with small black ocellus in S 2 and dark grey submarginal line broken by orange along veins. Marginal grey band thin (1–2 mm wide). *Underside* ground colour pale yellow-grey but variable. Hindwing irrorate with darker scales and indistinct striae. Forewing length 26–27 mm. Female. Unknown."

Luckily, the two original photographs from this publication were available and they allow a better comparison. For this purpose, Jos Dils (Belgium) kindly provided the two photographs of the male holotype (Brown 1976) (Fig. 1). On the underside of the photograph it is written: "WATSONI ? Clench & ~~CHS~~ SCH" looking like a link to a *Pseudochazara* species from Afghanistan (Fig. 1). However, as we never received a reply from Brown, it is not possible to fully understand this detail.

Recently, two prepared male specimens were figured by Eckweiler (2012) that look different from the holotype but with such a small sample size it is difficult to estimate if this is within the normal range of variability. Concerning females, for a long time there was only one figure (Tolman and Lewington 1997) but recently a first photograph of the upper- and underside of a single female from Albania became available (Eckweiler 2012). Even fewer photographs of the butterfly in nature have been published and for all these documents there remained a degree of uncertainty concerning the final determination (Cuvelier 2010, Eckweiler 2012).

In the field, fresh males of *P. amymone* look quite different when flying than *P. mniszechii tisiphone* and identification is possible in a fair number of cases. As *Pseudochazara* species almost never sit with open wings, reliable identification in the field is often based on the underside of the wings and for both sexes it is difficult and depends on the freshness of the butterflies. Therefore we also sampled *P. mniszechii tisiphone* (Figs 5a–h) at Boboshtiçë, where this butterfly was extremely common, in order to compare the two taxa and to obtain determination keys for males and females of both species.

Potential variables of the external characters were selected and included in an Excel workbook containing separate worksheets per species and gender. After this first selection, the colour of the fringes was discarded as a variable due to the difficulty of formulating measurable criteria.

Figure 1. Upper and underside of the *P. amymone* holotype photographs, holotype collected in the mountains just N. of Ioánnina, Epiros, Greece, 650m, 10.vii.1975 (photograph: SC).

Drawings of measurement on UPS and UNS are included in Appendix 1. The following variables were analyzed: UPS FW: Var 1: length of FW from apex to point of attachment to thorax, fringes included (mm); Var 2: visual assessment of the oc. in S2 and S5 (blind= 0, white pupil= 1); Var 3: visual assessment of the number of spots in S3 and S4 (0, 1 or 2); Var 4: width of the submarginal band across the centre of the ocellus in S2 (mm); Var 5: Var 4/Var 1 (%); Var 6: visual assessment of the conspicuous sex brand in cell (absent= 0, present= 1). UPS HW: Var 7: visual assessment of the number of oc. in the submarginal area (0, 1, 2 or 3); Var 8: width of the submarginal band along vein 3 (mm); Var 9: Var 8/Var 1 (%). UNS FW: Var 10: visual assessment of the oc. in S2 and S5 (blind= 0, white pupil = 1); Var 11: visual assessment of the pale area from ocellus in S5 to the cell (uniform= 0, contrasted = 1); Var 12: visual assessment of the number of spots in S3 and S4 (0, 1 or 2); Var 13: visual assessment of the marginal line (diffuse= 0, sharp= 1); Var 14: visual assessment of the fine black line-shape markings in the basal area of the cell (absent= 0, present= 1); Var 15: length of the ocellus in S5 (mm); Var 16: shortest distance from the white centre of the ocellus in S5 to the margin (mm); Var 17: Var 15/Var 1 (%); Var 18: Var 15/Var 16 (%); Var 19: Var 16/Var 1 (%). UNS HW: Var 20: visual assessment of the number of oc. in the submarginal area (0, 1, 2 or 3); Var 21: visual assessment of the median band (absent= 0, present= 1);

We photographed the upper- and underside of all male and female specimens of *P. amymone* and *P. mniszechii*, each of us in our personal reference collections. A scale bar was included with each specimen (Appendix 1b). Each digital image was imported into Paint Shop Pro v. 6.02. A straight vector line was drawn on the butterfly in its own layer to measure the exact length of the desired parameter. Afterwards, the vector line was rotated into horizontal position and then moved onto the scale bar under the butterfly, making it possible to measure length in millimetres, at an accuracy level of 0.25 mm. The whole dataset was used for two analyses: a) a variability study between the two *P. amymone* populations and b) a comparison between all *P. amymone* and *P. mniszechii tisiphone*. Statistical analysis was performed with StatSoft STATISTICA 12. The Mann-Whitney U test was used to test for differences at 0.05 significance level in a two-tailed test.

Study of androconial scales

Androconial scales were removed from the upperside of the forewings of one *P. amymone* and one *P. mniszechii tisiphone* and photographed with a calibrated 5 megapixel Dino-Lite AD-7013MZT digital microscope with adjustable magnifications. The length and breadth of the androconia were measured according to the description by Wakeham-Dawson (2000) but at maximum magnification (×500).

Cartography

DMAP, distribution mapping software: http://www.dmap.co.uk/. — Dr. Alan Morton, Blackthorn Cottage, Chawridge Lane, Winkfield, Windsor, Berkshire, SL4 4QR, UK.

Results

Field notes

On 15.vii.2013, late in the afternoon, we started our search for *P. amymone* in a narrow valley with very steep slopes near Boboshtiçë (province of Korçë). On the dark red-grey slopes our attention was attracted by cushions of pink flowers that we identified as *Acantholimon echinus* (L.) Boiss. (Plumbaginaceae) and the whole area looked very similar to the published habitat photograph (Eckweiler 2012). The rest of the day we explored this area and found some *P. mniszechii tisiphone*, but we had not had a glimpse of *P. amymone*. We were, however, quite certain that we had to be near its habitat.

The next morning, 16.vii.2013, we entered deeper into the river valley and searched at 1100–1200 m altitude on SSW exposed steep rocky slopes with parts of loose gravel. On this ophiolite substrate (Fig. 2a) with characteristic red-grey colour, scattered tall grasses were growing, but otherwise the area was almost devoid of vegetation (Fig. 2b). Here *P. amymone* had just emerged and males (Fig. 2d) were already flying quite commonly. We observed the males showing a typical territorial behaviour: patrolling and chasing away other males. The females were searching for nectar sources and egg-laying places in the scattered tall grasses that were present in the biotope. The rumours of a rocket speed flight and strange nuptial behaviour appeared not to be true. The species is not shyer than other species in the genus *Pseudochazara*.

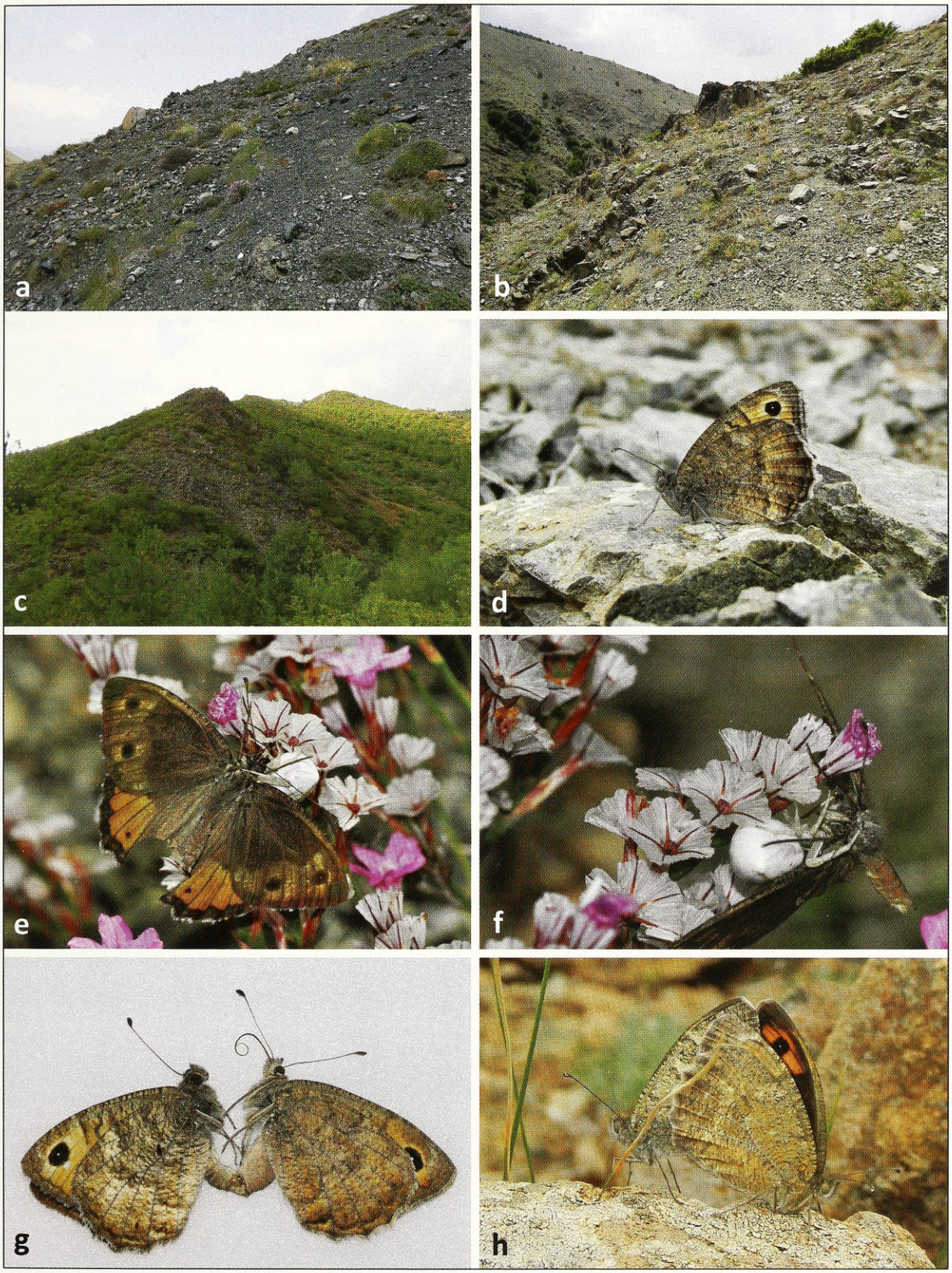

Figure 2. a–b. Habitat of *P. amymone*, Boboshtiçë, Albania, 16.vii.2013. **c.** Habitat of *P. amymone*, Gjergjeviçë, Albania, 18.vii.2013. **d.** ♂ *P. amymone*, Boboshtiçë, Albania, 16.vii.2013 (photographs: MM). **e.** ♂ *P. amymone* caught by a crab spider, Boboshtiçë, Albania, 18.vii.2013. **f.** *T. onustus* holding a ♂ *P. amymone*, Boboshtiçë, Albania, 18.vii.2013 (photographs: SC). **g.** Copula of *P. amymone*, Boboshtiçë, Albania, 16.vii.2013 (coll. & photograph: SC). **h.** Copula of *P. mniszechii tisiphone*, Gjergjeviçë, Albania, 18.vii.2013 (photograph: MM).

On 18.vii.2013, early morning, we again visited this locality and observed that some males were already getting worn. One male *P. amymone* (Fig. 2e), seen from afar sitting with open wings on flowers of *A. echinus*, had been caught by a crab spider (Fig. 2f) that was identified by Rop Bosmans (Belgium) as *Thomisus onustus* (Walckenaer, 1805), a common species in the Balkans. This butterfly also shows typical injuries on the hind wings caused by lizards that were common in the habitat. Females were already more numerous than two days earlier. Here, *P. amymone* flies sympatrically with *P. mniszechii tisiphone*. The males of these two species are easily distinguished in the field, but this is not the case for females. Flying males of *P. amymone* look smaller and also show a much more pronounced orange and black contrast. Although the females of *P. amymone* are a little smaller, this cannot be observed in the field. They also do not exhibit the contrasting orange and black colours and this makes it difficult in the field to distinguish females of these two species.

In Boboshtiçë, we observed the first ever known copula (Fig. 2g) and a pale form (Figs 3g–h) of a male *P. amymone*. After our trip, Eckweiler confirmed (oral comm., August 2013) that this was the locality where he originally discovered *P. amymone* in Albania.

During these explorations, on 18.vii.2013, we were able to extend the known distribution of *P. amymone* by approximately 25 km to the west, as the crow flies, as we discovered it in another remote mountain range in the westernmost part of the province of Korçë. This mountain range is physically separated from Boboshtiçë by a 10 km broad river valley, at 850 m altitude.

Entering a remote valley, we observed steep rocky slopes orientated to the SSW on ophiolite substrate, as we had seen in Boboshtiçë. On climbing these slopes we immediately observed a large population of *P. amymone*. The new biotope is situated near Gjergjeviçë (Fig. 2c) and in the upper part of the known altitudinal distribution (Pamperis 2009) of *P. amymone*, being at an altitude of 1200–1400 m. It has the same characteristics as the biotope at Boboshtiçë, except for one major difference: the presence of scattered bushy vegetation whereas the habitat at Boboshtiçë is completely open. We observed that *P. amymone* near Gjergjeviçë is also sympatric with and even outnumbering *P. mniszechii tisiphone* and here a copula of this species was photographed (Fig. 2h). The flight period of *P. amymone* was apparently the same as in Boboshtiçë, due to the general freshness of most of the specimens and the presence of good numbers of females as observed in the morning of the same day at Boboshtiçë.

Variability of *P. amymone* from two Albanian populations

To our big surprise, we noticed *P. amymone* was not rare at all in the two biotopes (Boboshtiçë and Gjergjeviçë) and that the habitat in both localities was very large but difficult, if not impossible, to explore. Nevertheless we sampled enough voucher specimens to get a better idea of the range of variation in external characters and to make a comparative study on the habitus of these two separate populations of *P. amymone*.

There are two limitations of our dataset which require further attention in the future when new populations are discovered. The sample size of 38 males and 19 females for such variable butterflies remains suboptimal and the sample size of the two localities is not equal. The range and mean of all variables for the two populations is given in Table 1. Males and females are figured (Figs 3a–h, 4a–f). All the variables of the two populations clearly overlap and there was not a single variable showing clear differences between the two populations. For these reasons the measure-

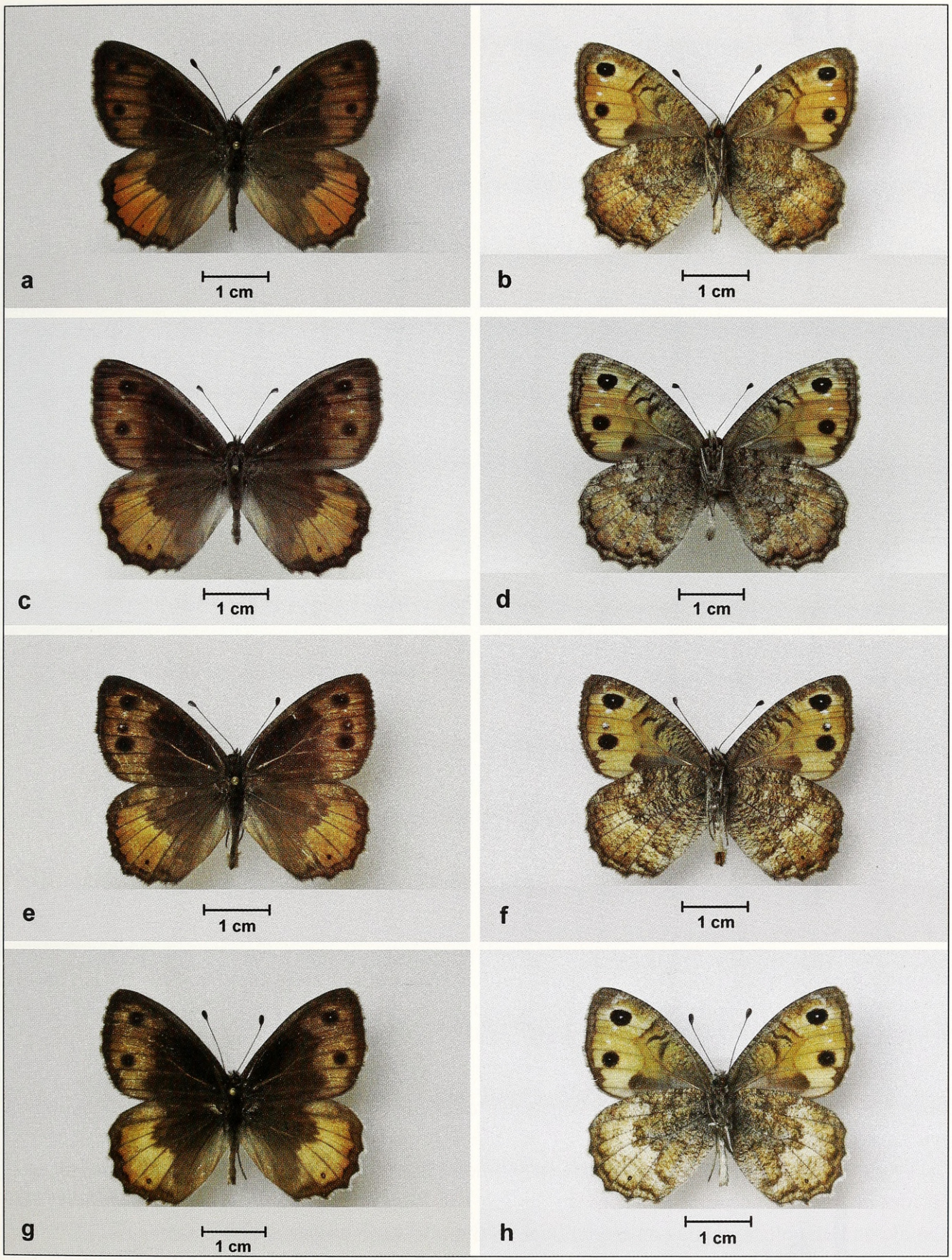

Figure 3. Variability in *P. amymone*. **a–b.** ♂ typical upper- and underside, Boboshtiçë, Albania, 16.vii.2013 (coll. & photograph: SC). **c–d.** ♂ typical upper- and underside, Gjergjeviçë, Albania, 18.vii.2013 (coll. & photograph: MM). **e–f.** ♂ aberration, upper- and underside, Boboshtiçë, Albania, 16.vii.2013 (coll. & photograph:

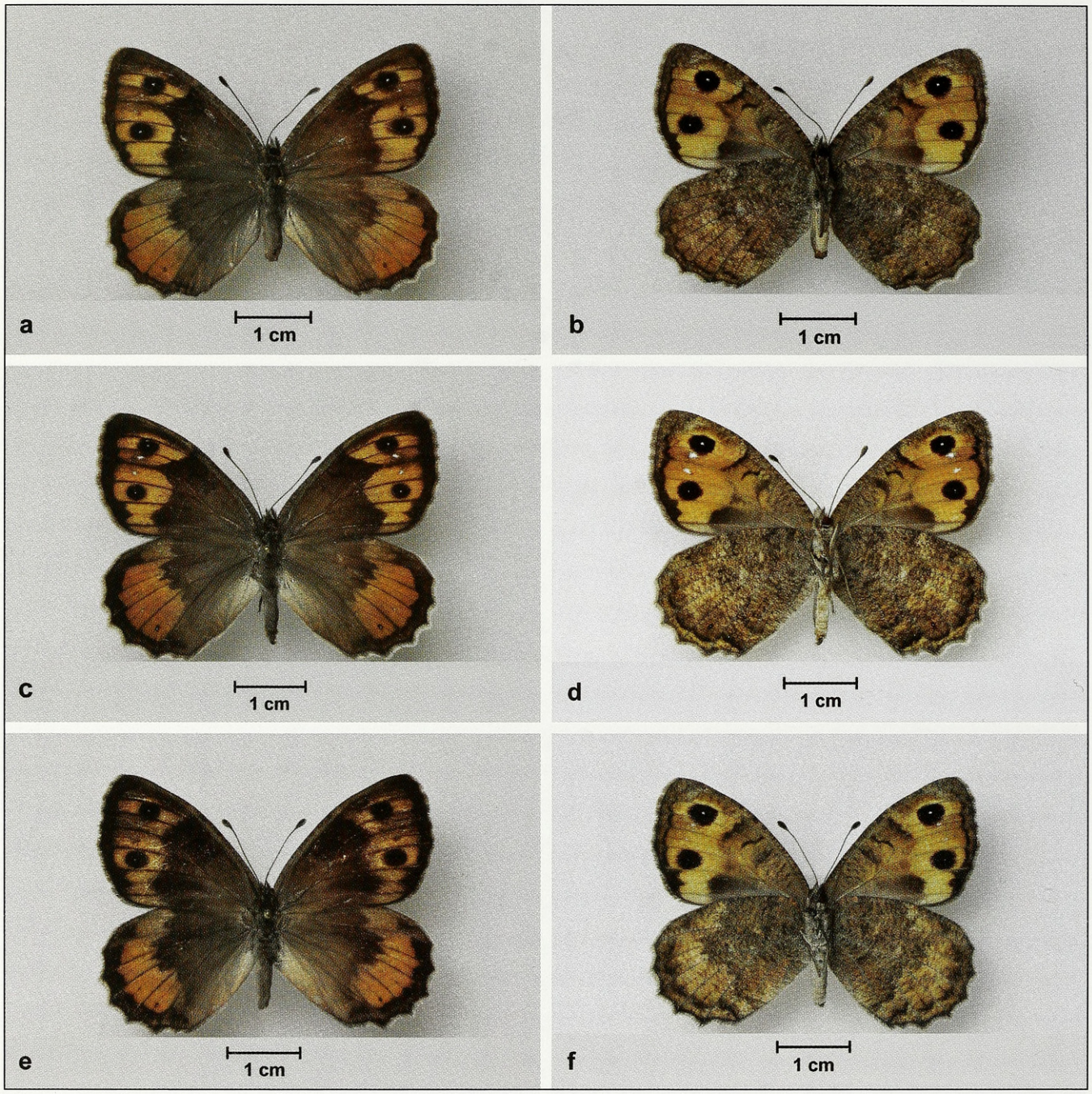

Figure 4. Variability in *P. amymone*. **a–b.** ♀ typical *P. amymone* upper- and underside, Gjergjeviçë, Albania, 18.vii.2013. **c–d.** ♀ typical *P. amymone* upper- and underside, Boboshtiçë, Albania, 16.vii.2013. **e–f.** ♀ dark form upper- and underside, Gjergjeviçë, Albania, 18.vii.2013. (Coll. & photographs: SC).

ments from the two populations can be pooled together for the comparison between Albanian *P. amymone* and *P. mniszechii tisiphone*.

Two *P. amymone* specimens exhibited asymmetry between right and left side. This was the case for one male with one spot in S3-S4 on the left FW UPS and no marking on the right FW. One female had one black ocellus on the left side of the HW UNS and two on the right side.

There seem to be a few marked differences between *P. amymone* from Albania and the original description by Brown (1976). It is clear that the holotype (Fig. 1) is not fresh and probably the paratypes were even more worn. A few butterflies in our study that were less fresh also have a clearer appearance and tend to become more orange in the postdiscal bands of the FW UPS. We

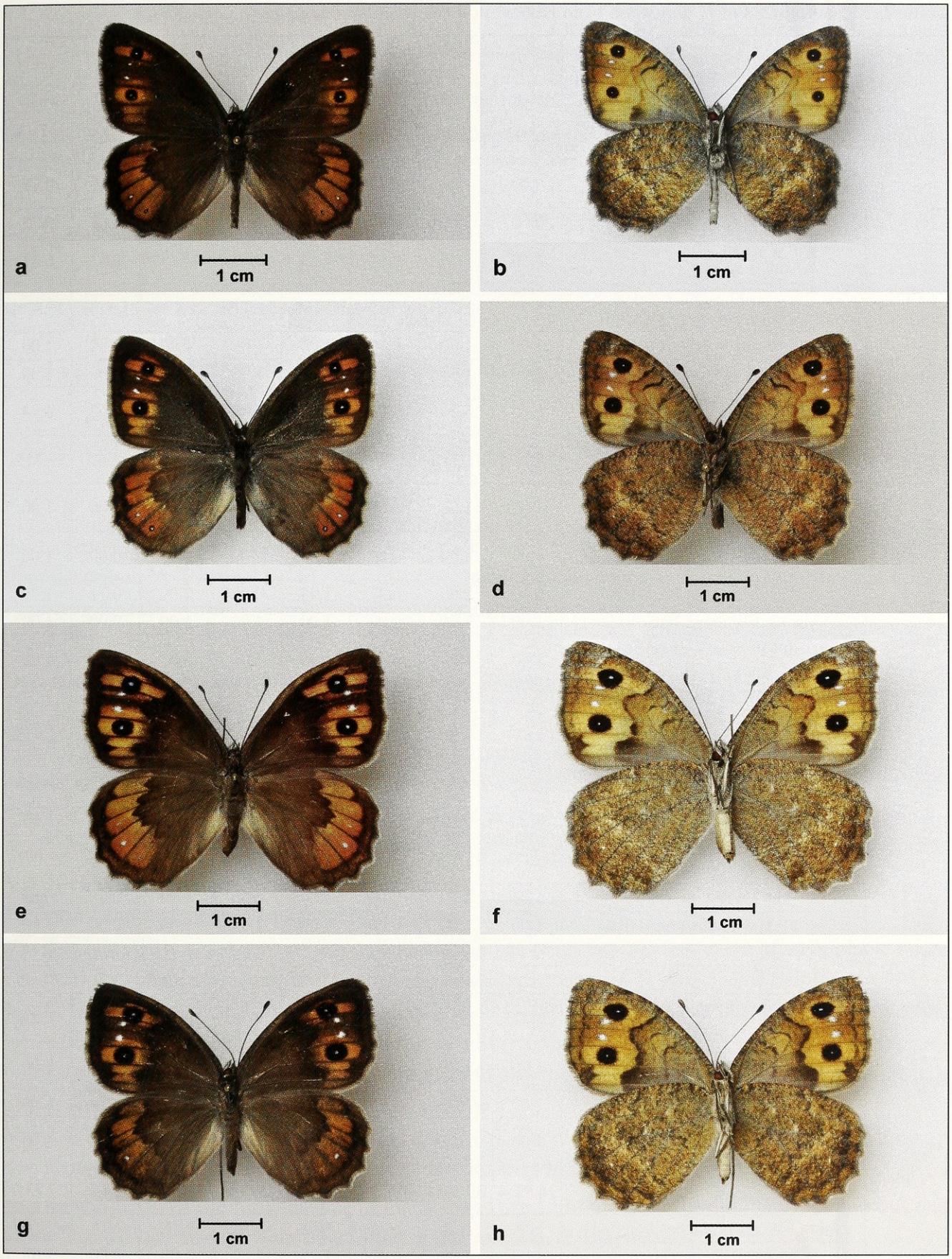

Figure 5. Variability in *P. mniszechii tisiphone*. **a–b.** Typical ♂ upper- and underside, Boboshtiçë, Albania, 16.vii.2013. **c–d.** ♂ typical upper- and underside, Boboshtiçë, Albania, 16.vii.2013. **e–f.** ♀ typical upper- and underside, Boboshtiçë, Albania, 16.vii.2013. **g–h.** ♀ dark form upper- and underside, Boboshtiçë, Albania, 18.vii.2013. (Coll. & photographs: SC).

Table 1. Measurements of *P. amymone* from Boboshtiçë versus *P. amymone* from Gjergjeviçë.

	P. amymone	Males (n=30) Boboshtiçë				Males (n=8) Gjergjeviçë			
		Range (min-max)		SD	Mean	Range (min-max)		SD	Mean
UPS	Var 1: FW length from thorax to apex (mm)	22.00	25.00	0.76	24.08	22.50	24.50	0.65	23.50
	Var 2: FW white pupils in black oc. S2, S5 (N°)	0.00	1.00	0.25	0.93	0.00	1.00	0.35	0.88
	Var 3: FW spots S3, S4 (N°)	0.00	2.00	0.82	0.57	0.00	2.00	0.89	0.75
	Var 4: FW width subm. band oc. S2 (mm)	5.50	7.25	0.44	6.54	5.75	6.75	0.37	6.31
	Var 5: FW width subm. band oc. S2/ FW length (%)	23.40%	30.43%	1.87%	27.18%	24.49%	28.72%	1.52%	26.87%
	Var 6: FW sex brand position (0-1)	1.00	1.00	0.00	1.00	1.00	1.00	0.00	1.00
	Var 7: HW oc. (N°)	1.00	1.00	0.00	1.00	1.00	1.00	0.00	1.00
	Var 8: HW width subm. band vein 3 (mm)	6.00	8.25	0.52	7.28	6.00	7.75	0.62	6.94
	Var 9: HW width subm. band vein 3/ FW length (%)	25.53%	35.23%	2.01%	30.25%	26.09%	32.98%	2.34%	29.51%
UNS	Var 10: FW white pupils in black oc. S2, S5 (N°)	1.00	1.00	0.00	1.00	1.00	1.00	0.00	1.00
	Var 11: FW oc. S5 towards cell paler area (0-1)	1.00	1.00	0.00	1.00	1.00	1.00	0.00	1.00
	Var 12: FW spots in S3, S4 (N°)	0.00	2.00	0.37	1.93	0.00	2.00	0.71	1.75
	Var 13: FW marg. line (0-1)	1.00	1.00	0.00	1.00	1.00	1.00	0.00	1.00
	Var 14: FW basal area cell: black markings (0-1)	1.00	1.00	0.00	1.00	1.00	1.00	0.00	1.00
	Var 15: FW oc. S5 length (mm)	2.50	4.00	0.33	3.04	2.70	3.25	0.20	3.03
	Var 16: FW oc. S5 length/FW length (%)	10.83%	16.33%	1.30%	12.60%	11.74%	14.22%	0.93%	12.91%
	Var 17: FW oc. S5 length/FW centre oc. S5-margin (%)	49.52%	80.00%	8.17%	60.73%	52.17%	65.00%	4.97%	58.58%
	Var 18: FW centre oc. S5-margin (mm)	4.00	5.50	0.36	5.03	5.00	5.75	0.29	5.19
	Var 19: FW centre oc. S5-margin/FW length (%)	16.33%	22.92%	1.58%	20.88%	21.28%	23.96%	0.94%	22.07%
	Var 20: HW oc. (N°)	1.00	1.00	0.00	1.00	0.00	1.00	0.35	0.88
	Var 21: HW median band (0-1)	1.00	1.00	0.00	1.00	1.00	1.00	0.00	1.00
	P. amymone	Females (n=14) Boboshtiçë				Females (n=5) Gjergjeviçë			
		Range (min-max)		SD	Mean	Range (min-max)		SD	Mean
UPS	Var 1: FW length from thorax to apex (mm)	24.00	27.00	0.84	26.14	24.00	26.00	0.71	25.00
	Var 2: FW white pupils in black oc. S2, S5 (N°)	1.00	1.00	0.00	1.00	1.00	1.00	0.00	1.00
	Var 3: FW spots S3, S4 (N°)	1.00	2.00	0.36	1.86	0.00	2.00	0.89	1.40
	Var 4: FW width subm. band oc. S2 (mm)	7.00	8.25	0.41	7.48	6.50	7.50	0.37	6.95
	Var 5: FW width subm. band oc. S2/ FW length (%)	26.92%	32.35%	1.57%	28.63%	25.00%	30.00%	1.79%	27.83%
	Var 6: FW sex brand position (0-1)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Var 7: HW oc. (N°)	1.00	2.00	0.43	1.21	1.00	1.00	0.00	1.00
	Var 8: HW width subm. band vein 3 (mm)	7.00	8.75	0.50	7.86	7.00	8.00	0.55	7.40
	Var 9: HW width subm. band vein 3/ FW length (%)	25.93%	33.33%	1.85%	30.07%	26.92%	32.00%	2.31%	29.62%

UNS	Var 10: FW white pupils in black oc. S2, S5 (N°)	1.00	1.00	0.00	1.00	1.00	1.00	0.00	1.00
	Var 11: FW oc. S5 towards cell paler area (0-1)	1.00	1.00	0.00	1.00	1.00	1.00	0.00	1.00
	Var 12: FW spots in S3, S4 (N°)	2.00	2.00	0.00	2.00	2.00	2.00	0.00	2.00
	Var 13: FW marg. line (0-1)	1.00	1.00	0.00	1.00	1.00	1.00	0.00	1.00
	Var 14: FW basal area cell: black markings (0-1)	1.00	1.00	0.00	1.00	1.00	1.00	0.00	1.00
	Var 15: FW oc. S5 length (mm)	3.00	3.75	0.29	3.35	3.00	4.00	0.44	3.61
	Var 16: FW oc. S5 length/FW length (%)	11.11%	14.42%	1.15%	12.81%	12.00%	16.00%	1.59%	14.43%
	Var 17: FW oc. S5 length/FW centre oc. S5-margin (%)	45.93%	71.43%	8.50%	56.51%	54.55%	66.67%	4.95%	61.02%
	Var 18: FW centre oc. S5-margin (mm)	5.25	6.75	0.49	5.98	5.50	6.25	0.29	5.90
	Var 19: FW centre oc. S5-margin/FW length (%)	19.44%	25.96%	1.92%	22.88%	22.00%	25.00%	1.13%	23.60%
	Var 20: HW oc. (N°)	1.00	2.00	0.51	1.43	1.00	2.00	0.45	1.20
	Var 21: HW median band (0-1)	0.00	1.00	0.52	0.50	1.00	1.00	0.00	1.00

have clearly shown that many characteristics are much more variable within a single population than described by Brown (1976). We presume, until more material becomes available, that Greek *P. amymone* falls within the given range of variability.

Determination keys between *P. amymone* and *P. mniszechii tisiphone*

The maximal range and mean of all variables for the two species are shown in Table 2. An overview of the statistical significance status of all variables is shown in Table 3. Some variables of *P. amymone* and *P. mniszechii tisiphone* did not overlap at all. Some differences are present in both sexes, others are only present in males. Below we list the variables that can be used in distinguishing *P. amymone* and *P. mniszechii tisiphone*.

Var 13: UNS FW submarginal line in both sexes (Figs 6a–b). This line is always sharp in *P. amymone* and diffuse in *P. mniszechii tisiphone*.

Var 14: UNS FW basal area of the cell in both sexes (Figs 6c–d). There are always black linear markings inside this area in *P. amymone* which are absent in *P. mniszechii tisiphone*.

Var 6: UPS FW sex brand position in males (Figs 6e–f). *P. amymone* has a black sex brand over the whole cell and the androconial field is extending to the inner margin of the FW. *P. mniszechii tisiphone* does not have a sex brand in the cell and the androconial field is covering only half of the cell towards the inner margin of the FW.

Var 7: UPS HW number of oc. in males (Figs 6g–h). There is 1 ocellus in *P. amymone* and 2 oc. in *P. mniszechii tisiphone*. Females of the two species have both a range of 1 to 2 oc.

The wingspan of the females was in many cases useful in the field for the identification but one *P. mniszechii tisiphone female* falls in the upper range of *P. amymone*.

Table 2. Measurements of pooled data of *P. amymone* versus *P. mniszechii tisiphone*.

		Males (n=38) *P. amymone*				Males (n=15) *P. mniszechii tisiphone*			
		Range (min-max)		SD	Mean	Range (min-max)		SD	Mean
UPS	Var 1: FW length from thorax to apex (mm)	22.00	25.00	0.77	23.96	24.50	27.00	0.70	26.30
	Var 2: FW white pupils in black oc. S2, S5 (N°)	0.00	1.00	0.27	0.92	1.00	1.00	0.00	1.00
	Var 3: FW spots S3, S4 (N°)	0.00	2.00	0.82	0.61	2.00	2.00	0.00	2.00
	Var 4: FW width subm. band oc. S2 (mm)	5.50	7.25	0.43	6.49	5.00	6.50	0.51	5.85
	Var 5: FW width subm. band oc. S2/ FW length (%)	23.40%	30.43%	1.79%	27.11%	18.87%	25.00%	1.77%	22.24%
	Var 6: FW sex brand position (0-1)	1.00	1.00	0.00	1.00	0.00	0.00	0.00	0.00
	Var 7: HW oc. (N°)	1.00	1.00	0.00	1.00	2.00	2.00	0.00	2.00
	Var 8: HW width subm. band vein 3 (mm)	6.00	7.75	0.55	7.21	5.50	7.50	0.54	6.47
	Var 9: HW width subm. band vein 3/ FW length (%)	25.53%	35.23%	2.07%	30.09%	21.30%	27.78%	1.92%	24.59%
UNS	Var 10: FW white pupils in black oc. S2, S5 (N°)	1.00	1.00	0.00	1.00	1.00	1.00	0.00	1.00
	Var 11: FW oc. S5 towards cell paler area (0-1)	1.00	1.00	0.00	1.00	0.00	1.00	0.26	0.07
	Var 12: FW spots in S3, S4 (N°)	0.00	2.00	0.45	1.89	2.00	2.00	0.00	2.00
	Var 13: FW marg. line (0-1)	1.00	1.00	0.00	1.00	0.00	0.00	0.00	0.00
	Var 14: FW basal area cell: black markings (0-1)	1.00	1.00	0.00	1.00	0.00	0.00	0.00	0.00
	Var 15: FW oc. S5 length (mm)	2.50	4.00	0.30	3.03	2.25	3.25	0.28	2.71
	Var 16: FW oc. S5 length/FW length (%)	10.83%	16.33%	1.23%	12.67%	8.65%	12.50%	0.94%	10.31%
	Var 17: FW oc. S5 length/FW centre oc. S5-margin (%)	49.52%	80.00%	7.60%	60.28%	40.00%	55.00%	5.01%	48.89%
	Var 18: FW centre oc. S5-margin (mm)	4.00	5.75	0.35	5.06	5.00	6.25	0.44	5.57
	Var 19: FW centre oc. S5-margin/FW length (%)	16.33%	23.96%	1.54%	21.13%	18.52%	24.04%	1.64%	21.17%
	Var 20: HW oc. (N°)	0.00	1.00	0.16	0.97	0.00	2.00	0.62	1.67
	Var 21: HW median band (0-1)	1.00	1.00	0.00	1.00	0.00	1.00	0.41	0.80
		Females (n=19) *P. amymone*				Females (n=20) *P. mniszechii tisiphone*			
		Range (min-max)		SD	Mean	Range (min-max)		SD	Mean
UPS	Var 1: FW length from thorax to apex (mm)	24.00	27.00	0.94	25.84	27.00	31.50	1.27	29.43
	Var 2: FW white pupils in black oc. S2, S5 (N°)	1.00	1.00	0.00	1.00	1.00	1.00	0.00	1.00
	Var 3: FW spots S3, S4 (N°)	0.00	2.00	0.56	1.74	2.00	2.00	0.00	2.00
	Var 4: FW width subm. band oc. S2 (mm)	6.50	8.25	0.46	7.34	7.25	10.00	0.63	8.48
	Var 5: FW width subm. band oc. S2/ FW length (%)	25.00%	32.35%	1.62%	28.42%	25.44%	31.75%	1.56%	28.79%
	Var 6: FW sex brand position (0-1)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Var 7: HW oc. (N°)	1.00	2.00	0.37	1.16	1.00	3.00	0.51	1.95
	Var 8: HW width subm. band vein 3 (mm)	7.00	8.75	0.54	7.74	6.00	9.00	0.77	7.41
	Var 9: HW width subm. band vein 3/ FW length (%)	25.93%	33.33%	1.93%	29.95%	20.69%	29.03%	2.12%	25.17%

UNS	Var 10: FW white pupils in black oc. S2, S5 (N°)	1.00	1.00	0.00	1.00	1.00	1.00	0.00	1.00
	Var 11: FW oc. S5 towards cell paler area (0-1)	1.00	1.00	0.00	1.00	0.00	1.00	0.47	0.30
	Var 12: FW spots in S3, S4 (N°)	2.00	2.00	0.00	2.00	2.00	2.00	0.00	2.00
	Var 13: FW marg. line (0-1)	1.00	1.00	0.00	1.00	0.00	0.00	0.00	0.00
	Var 14: FW basal area cell: black markings (0-1)	1.00	1.00	0.00	1.00	0.00	0.00	0.00	0.00
	Var 15: FW oc. S5 length (mm)	3.00	4.00	0.34	3.42	3.25	4.50	0.29	3.85
	Var 16: FW oc. S5 length/FW length (%)	11.11%	16.00%	1.43%	13.24%	10.48%	15.00%	1.11%	13.12%
	Var 17: FW oc. S5 length/FW centre oc. S5-margin (%)	45.93%	71.43%	7.86%	57.70%	41.94%	64.29%	5.32%	54.55%
	Var 18: FW centre oc. S5-margin (mm)	5.25	6.75	0.44	5.96	6.50	8.00	0.40	7.09
	Var 19: FW centre oc. S5-margin/FW length (%)	19.44%	25.96%	1.74%	23.07%	22.22%	25.81%	1.09%	24.10%
	Var 20: HW oc. (N°)	1.00	2.00	0.50	1.37	1.00	3.00	0.60	1.55
	Var 21: HW median band (0-1)	0.00	1.00	0.50	0.63	0.00	1.00	0.51	0.55

Table 3. Overview of the statistical significance of Mann-Whitney U tests of all variables of *P. amymone* versus *P. mniszechii tisiphone*. Males DF = 51, females DF = 37. *P* values below 0.05 are shown in bold.

	Z ♂	p ♂	Z ♀	p ♀
Var 1: FW length from thorax to apex (mm)	-0.873	0.38430	2.694	**0.00714**
Var 2: FW white pupils in black oc. S2, S5 (N°)	-0.838	0.40090	0.195	0.84930
Var 3: FW spots S3, S4 (N°)	-2.890	**0.00386**	0.495	0.62414
Var 4: FW width subm. band oc. S2 (mm)	2.048	**0.04036**	1.889	0.05876
Var 5: FW width subm. band oc. S2/FW length (%)	1.995	**0.04550**	0.265	0.79486
Var 6: FW sex brand position (0-1)	3.994	**0.00006**	N/A	N/A
Var 7: HW oc. (N°)	-1.995	**0.04550**	1.340	0.18024
Var 8: HW width subm. band vein 3 (mm)	0.859	0.38978	0.130	0.89656
Var 9: HW width subm. band vein 3/FW length (%)	1.971	**0.04884**	-1.709	0.08726
Var 10: FW white pupils in black oc. S2, S5 (N°)	0.004	1.00000	0.005	1.00000
Var 11: FW oc. S5 towards cell paler area (0-1)	3.994	**0.00006**	-3.794	**0.00016**
Var 12: FW spots in S3, S4 (N°)	-0.417	0.67448	0.005	1.00000
Var 13: FW marg. line (0-1)	3.994	**0.00006**	-3.794	**0.00016**
Var 14: FW basal area cell: black markings (0-1)	3.994	**0.00006**	-3.794	**0.00016**
Var 15: FW oc. S5 length (mm)	-0.810	0.41794	-0.635	0.52870
Var 16: FW oc. S5 length/FW length (%)	-0.512	0.61006	0.480	0.63122
Var 17: FW oc. S5 length/FW centre oc. S5-margin (%)	-1.466	0.14156	0.405	0.68916
Var 18: FW centre oc. S5-margin (mm)	1.736	0.08186	-0.475	0.63836
Var 19: FW centre oc. S5-margin/FW length (%)	1.757	0.07840	-0.030	0.97606
Var 20: HW oc. (N°)	0.796	0.42372	-0.685	0.49650
Var 21: HW median band (0-1)	2.732	**0.00634**	-0.595	0.55520

Androconial scales of *P. amymone* and *P. mniszechii tisiphone*

The dense sex band in the FW cell makes it difficult to isolate the androconial scales (Fig. 7a) of *P. amymone*. Scales with quite different shapes, sometimes bright silver-grey (Fig. 7b), were found in this area and created confusion. The type of these scales is unclear to the authors.

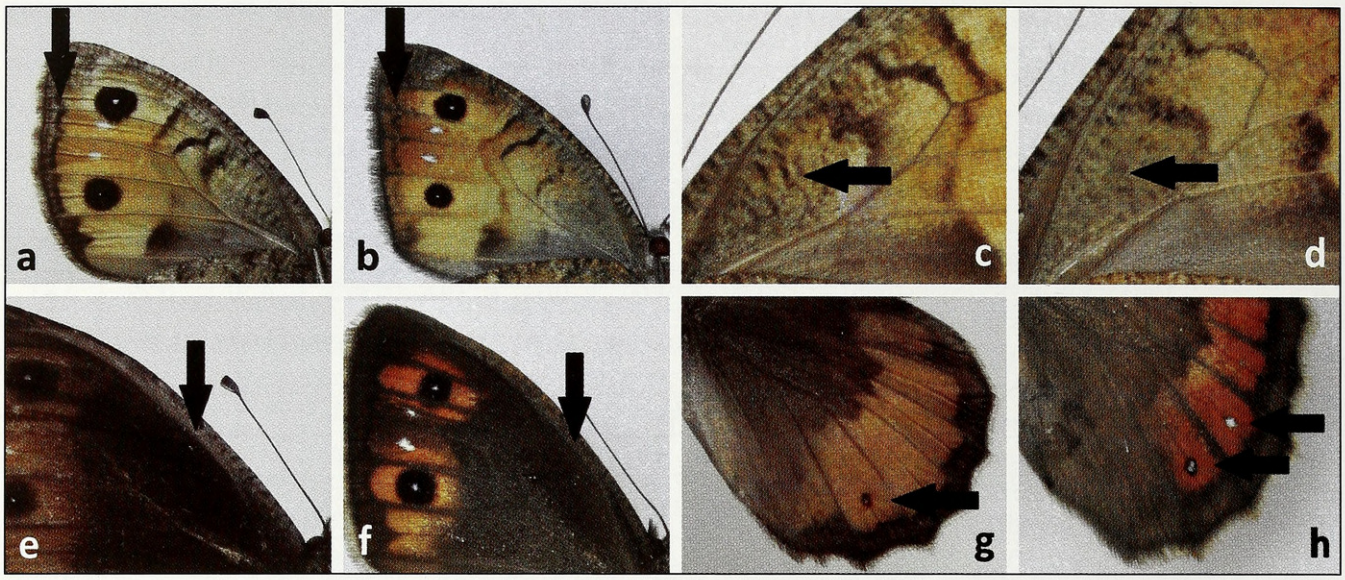

Figure 6. Visualization of the significant difference between *P. amymone* (**a, c, e, g**) and *P. mniszechii tisiphone* (**b, d, f, h**). Var 13 (**a–b**), Var 14 (**c–d**), Var 6 (**e–f**), Var 7 (**g–h**).

According to the criteria of Gross, the androconial scales of *P. amymone* (Fig. 7c) are in general of type 7 (Gross 1978) but few were found where the diameter of the lamina decreased immediately from the basal stalk tasowards the apex. These are more closely resembling a type 6 androconial scale. AL= 0.42 mm, AB= 0.05 mm and A= 8.4. These data are near the values for *P. mamurra* in Wakeham-Dawson and Kudrna (2000). Also the shape of the scales from *P. amymone* falls within the ranges of *P. mamurra* (Wakeham-Dawson and Kudrna 2000; Wakeham-Dawson and Kudrna 2005). The androconia of *P. amymone* are much larger and of a different shape than *P. graeca* (Wakeham-Dawson, 2000). The androconial scales of *P. mniszechii tisiphone* (Fig. 7d) are different in shape, transitional type 5-6 with dimensions: AL= 0.33 mm, AB= 0.027 mm and A= 12.19.

Coverage of historical data and personal observations

Additional field work in other localities of the province of Korçë and in the provinces Kolonjë, Përmet, Tepelenë and Skrapar fill an important gap in the documented distribution of the butterflies from south-eastern Albania. The coverage map (Fig. 8) shows historical data (red dots), the two areas where *P. amymone* was found (blue letters B and G) and all new places that were surveyed by the authors (green dots).

Discussion and conclusion

The discovery of *P. amymone* on a new isolated mountain and the fact that large parts of Albania with similar geological origins still remain unexplored suggest that *P. amymone* might be more widely distributed than previously thought. With further field research on slopes in steep river valleys, not necessarily with ophiolites, the species will undoubtedly be discovered at new sites.

The butterfly probably has a more restricted and fragmented distribution in Greece due to the less frequently present favoured type of geological substrate. This idea is already supported by the almost complete lack of evidence despite the many efforts of numerous lepidopterists since the discovery of the butterfly by Brown (1976). Using geological data, we suggest that the research in

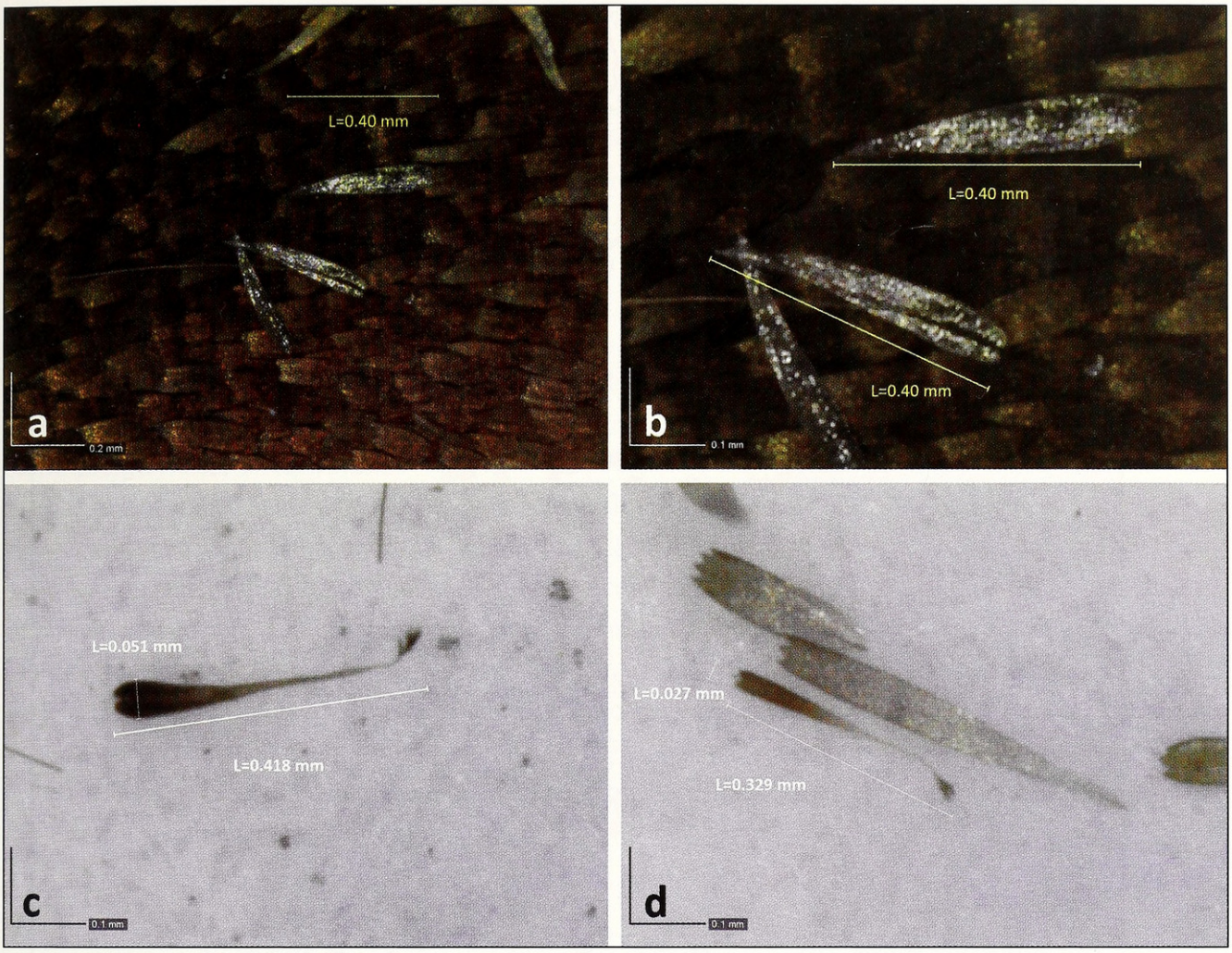

Figure 7. a. UPS FW sex brand of ♂ *P. amymone* (× 250), Boboshtiçë, Albania, 16.vii.2013. **b.** UPS FW scales in sex brand of ♂ *P. amymone* (× 500), Albania, 16.vii.2013. **c.** Androconial scale of ♂ *P. amymone* (× 500), Boboshtiçë, Albania, 16.vii.2013. **d.** Androconial scale of ♂ *P. mniszechii tisiphone* (× 500), Boboshtiçë, Albania, 16.vii.2013. (Coll. & photographs: SC).

Greece should be extended because areas with ophiolite substrate are present over a wider part of continental Greece, whereas they are hardly present near Ioannina. Understanding more fully the habitat requirements of *P. amymone*, it now looks possible to elucidate the mystery of its whereabouts in Greece in order to undertake any conservation measures if needed.

During the examination of the Albanian material it became clear that *P. amymone* is a very variable species and that the original description (Brown 1976) did not cover the whole range of variability, partly because of the very restricted number of studied butterfly vouchers. Pamperis (1997: 348-349, fig. 3.7.10; 2009: 499, fig. 3.5.11) shows figures with characteristic marks on the underside of *P. amymone* in comparison with other Greek species of *Pseudochazara*. The black and white figure of *P. amymone* focuses on a black base of the HW UNS and a pale dentate line in the postdiscal area with more contrast than in other *Pseudochazara* species. This black base is not a striking feature of the Albanian specimens. Darker grey scales in that area are sometimes visible in both *P. amymone* and *P. mniszechii tisiphone*. The dentate line was visually assessed as Var. 21 showing overlap and for both species this variable was sometimes scored as absent. In external

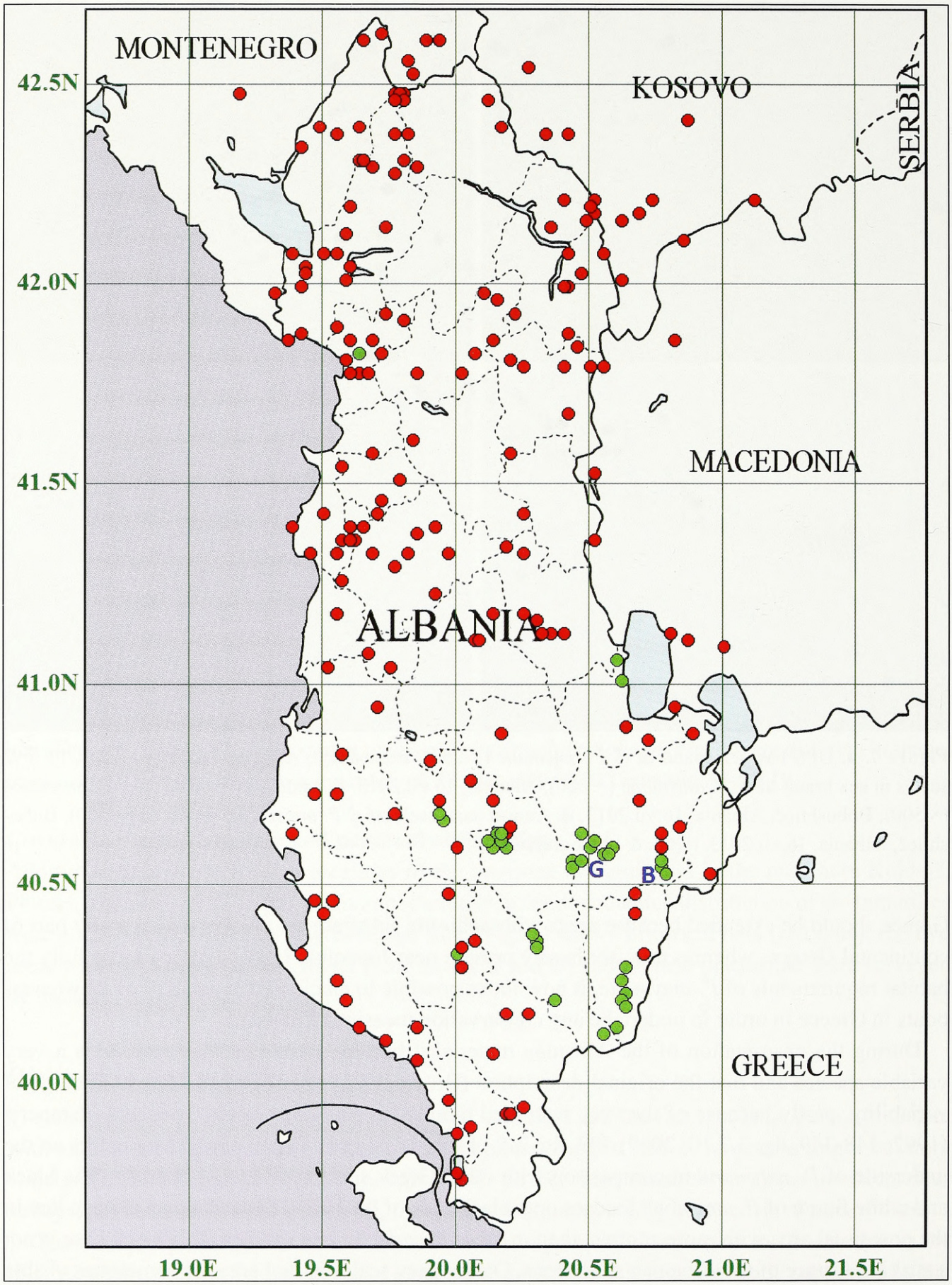

Figure 8. Coverage of historical data and personal observations: map of Albania indicating Papilionoidea observations from literature (●) and from observations by the authors (●). **B:** Boboshtiçë; **G:** Gjergjeviçë: localities of *P. amymone*.

features, Pamperis (1997: 351; 2009: 500) in analogy with Brown (1976), focuses on the orange brown band in the postdiscal area.

The only feature for Greek *P. amymone* that seems different is the presence of the broad and clear orange postdiscal bands. Only for older butterflies from Boboshtiçë and Gjergjeviçë is there a tendency to paler orange postdiscal bands. This potential difference should be documented by studying material from new localities including additional material in this dataset to increase the sample size. Adding material from Greece to get an idea about the full range of the external characters of this taxon seems mandatory. A few other criteria seem specific to *P. amymone* in comparison with *P. mniszechii tisiphone*. It became clear that *P. mniszechii tisiphone* is a very variable species too.

Despite clear differences in the androconial scales, it would be interesting to make an analysis of external characters with the very similar *P. graeca*, a species that has never been found in the same locality with *P. amymone*.

The androconial scale of *P. amymone* falls within the range of the different subspecies of *P. mamurra* and this result supports the treatment by Eckweiler of *P. amymone* as a potential subspecies of *P. mamurra.* Even though androconia have been used as a taxonomic character for distinguishing species of the genus *Pseudochazara*, no comment is given here as independent DNA analysis is ongoing and will be published soon.

We encourage entomologists to visit Albania during different periods of the year to do research not only for *P. amymone* but also to survey large parts of the country that are poorly explored for butterflies. It will certainly help to significantly improve knowledge about the distribution of many taxa in the south-western Balkans.

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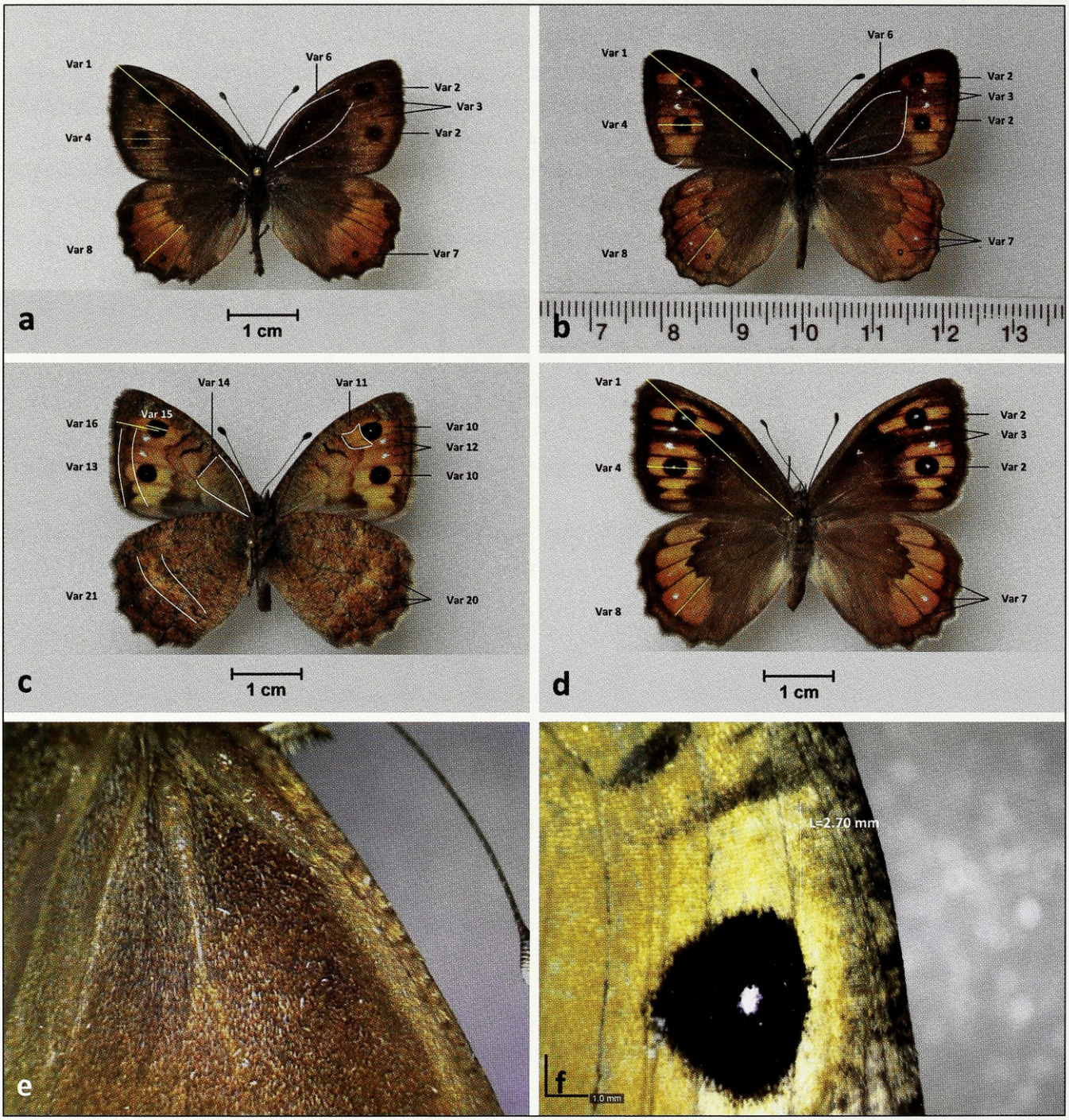
Appendix 1



Variables of *P. amymone* and *P. mniszechii tisiphone*. **a.** UPS variables of ♂ *P. amymone*, Boboshtiçë, Albania, 16.vii.2013. **b.** UPS variables of ♂ *P. mniszechii tisiphone*, Boboshtiçë, Albania, 16.vii.2013. **c.** UNS variables of ♂ *P. mniszechii tisiphone*, Boboshtiçë, Albania, 16.vii.2013. **d.** UPS variables of ♀ *P. mniszechii tisiphone*, Boboshtiçë, Albania, 16.vii.2013. **e.** Sex brand of ♂ *P. amymone* (×30), Boboshtiçë, Albania, 16.vii.2013. **f.** UNS pale area from ocellus in S5 towards cell, *P. amymone* (×32), Boboshtiçë, Albania, 16.vii.2013. (Coll. & photographs: SC).