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*PAPILIO SAHARAE* OBERTHÜR, 1879 (*Lepidoptera Papilionidae*)  
ON THE HYBLEAN PLATEAU, SICILY: CASE OF A RELICT  
POPULATION DUE TO CLIMATE-DRIVEN PHENOMENA?

SUMMARY

A female specimen, likely of *Papilio saharae*, is reported from Giarratana in Sicily, some 30 km away (linear distance) from Lentini, where the first recorded specimen was taken in 1978 (MOONEN, 2012). Both localities, Lentini and Giarratana, lie on the Hyblean Plateau. Conventional morphometric examination appears to indicate that the species is *Papilio saharae*, subject to the limitations described below.

*Keywords:* ecological refugia, vicariance, dispersal, glacials, interglacials, geographical isolation

RIASSUNTO

*Papilio saharae* Oberthür, 1879 (*Lepidoptera Papilionidae*) nell'Altopiano Ibleo (Sicilia): caso di popolazione relictta dovuto a fenomeni climatici? A Giarratana (Sicilia) è stato raccolto un esemplare femmina, verosimilmente appartenente alla specie *Papilio saharae*; la località dista c. 30 km da Lentini, ove è stato raccolto il primo esemplare nel 1978 (MOONEN, 2012). Entrambe le località si trovano nell'altopiano Ibleo. L'esame morfometrico convenzionale indicherebbe appunto che la specie è *P. saharae*, con il minimo dubbio dovuto a limitazioni sotto riportate.

*Parole-chiave:* rifugi ecologici, vicarianza, dispersione, glaciali, interglaciali, isolamento geografico

INTRODUCTION

*Papilio saharae* was initially treated by OBERTHÜR (1879) as a variety of *Papilio machaon* – [*Papilio machaon* var. *saharae* Oberthür 1879, Etud. Ent., 4:

68, TL: Laghouat (Algeria)]. Subsequently, OBERTHÜR (1888) described *P. machaon hospitonoides* from a larva, which, it transpires, was that of *P. sabarae* (PITTAWAY *et al.*, 1994). While some authors continued to treat it as a subspecies, or lower, of *Papilio machaon* Linnaeus, 1758 (SEITZ, 1908; TURATI, 1924; PELLECCIA *et al.*, 2002), other workers, including some with extensive field and taxonomic experience of north African and Middle Eastern butterfly fauna, consider it a distinct species (PITTAWAY, 1985; LARSEN, 1990; PITTAWAY *et al.*, 1994; TENNENT, 1996; TOLMAN & LEWINGTON, 1998; TARRIER & DELACRE, 2008; TSHIKOLOVETS, 2011; LERAUT, 2016). This separation is based upon a variety of different morphometric characters (HIGGINS & RILEY, 1978; PITTAWAY, 1985; LARSEN, 1990; PIERRON, 1990; PITTAWAY *et al.*, 1994; TENNENT, 1996; TOLMAN & LEWINGTON, 1998; MOONEN, 2012), as well as on fairly disparate habitat and biotope preferences (LARSEN, 1983; 1990; CLARKE & LARSEN, 1986), and “*some evidence of interspecific sterility*” in the Maghreb (CLARKE & SHEPPARD, 1956; LARSEN, 1990). On the basis of what appears to be discernible morphological evidence, the author of the present work also subscribes to the notion of heterospecificity, that is, of two distinct taxa, even if there remains much scope, taxonomically (morphometric and molecular), to further examine the biogeography of the *P. machaon*-complex within the central Mediterranean region and the Maghreb.

#### RANGE

The species' known global range extends from Morocco to the Arabian Peninsula, including Yemen (PITTAWAY, 1985; LARSEN, 1990; PITTAWAY *et al.*, 1994) and Oman, where two specimens were recorded, respectively from Wadi Tiwi in Sharqiya [larva collected on March 1<sup>st</sup> 1990, from which a male eventually emerged], and from Wadi Abyad in Batinah [a female taken fifteen days later] (pers. comm. Ebejer, 2018). The nominotypical *P. sabarae sabarae* is present along the northern fringes of the Sahara from Morocco, continuing eastward across the Maghreb and into Egypt where it is known from Siwa oasis, and from various locations within the eastern desert between the Nile and Suez on the Red Sea. Within the Levant, it extends across parts of the Sinai Peninsula, the Negev and southern Jordan, and into the northern Hejaz. Although *P. sabarae sabarae* largely occurs in hyper-arid locations within the geographical range described, the species has also been recorded from arid environments nearer the Mediterranean coast, such as Sallum in Egypt (LARSEN, 1990), on the Libyan coast at Tripoli, Barca and Benghazi (CLARKE & SHEPPARD, 1956; SEYER, 1974), and in Tunisia at Gabès and Gafsa (PIERRON, 1990). In April 2007, the present author also took a female at El Khouala (remote village near

Hachichina, on the Gulf of Gabès, the environment of which can best be described as eremic coastal steppe). The subspecies *P. saharae rathjensi* occurs in the Asir region of Saudi Arabia and in Yemen, typically in mesic habitats within *djebel* environments - rocky uplands and montane zones (LARSEN, 1983, 1984, 1990; PITTAWAY, 1985; MEERMAN & BOOMSMA, 1986).

Prior to the present record, a male was taken in Lentini, Sicily (also on the Hyblean Plateau), on 20<sup>th</sup> September 1978 by H. van Oorschot and came to light, by chance rather than intention, during curation of the Palaearctic Papilionidae collections at the Zoological Museum in Amsterdam (MOONEN, 2012). Consequent to this initial record, LERAUT (2016) claims to have discovered several specimens of the species from Sicily in the collections of the natural history museum of Paris, but affords no further detail on field data or determination methods. Additionally, LERAUT (2016), proposes (based on Internet material) that *Papilio machaon* from the Maltese Islands be referred to as *P. saharae melitensis* Eller, 1936, **stat. rev.**; however, he provides no basis for this assertion.

#### DIAGNOSTICS

The species has been raised to specific rank on the basis of a number of fairly constant diagnostic characters, notably but not exclusively: the number of antennal segments [30-31 for *saharae*; 33-36 for *machaon*]; the size and shape of the hindwing anal fold, rendering the red anal eyespot smaller, often less rounded and somewhat ovoid in *saharae*; and, the size of the harpe (male genitalia) and the number of teeth on it [short harpe with 7-10 teeth in *saharae*; long harpe with 12-24 teeth in *machaon*]. Various other morphological diagnostic features have been proposed, such as overall size (wingspan and forewing length), larval colour patterns, and, coloration and markings (wings and abdomen), and tail length of the imago. Habitat-type preferences and flight period have also been cited as a means of distinguishing one species from another (LARSEN, 1990; PITTAWAY *et al.*, 1994; TENNENT, 1996; TOLMAN & LEWINGTON, 1998; MOONEN, 2012), although it transpires that both species are capable of producing a number of generations, however, with *P. saharae* being more reliant on annual rainfall patterns (PITTAWAY *et al.*, 1994).

#### MATERIAL, METHODS AND RESULTS

The specimen in question was taken in flight at Giarratana, Sicily, by means of a kite-net.

*Papilio sabarae sabarae* Oberthür 1879

**ITALY:** SICILY, Giarratana [37°02'24.94"N, 14°47'42.54"E], at 473 m amsl, 31.v.2018, 1 ♀ (taken in flight at 13:20 hrs. GMT+2).

**Diagnosis:** Antennal segments: 31; FW length: 43 mm; HW vannal (anal) fold fairly compressed, with red ovoid ocellus or eyespot (tornal area) dimensions: 4.25 mm x 3.0 mm; smattering of yellow scales over the dark markings of the FW basal and postbasal region, and of the HW basal and inner margin areas, rendering them seemingly lighter in colour.



Fig. 1 — *Papilio sabarae sabarae* Oberthür, female. Italia, Sicilia, Giarratana. 31.v.2018. leg. L.F. Cassar (Photo credit: G. Bonetti).

In addition to the Giarratana specimen, material examined for comparative purposes comprised a (dry set) series in the author's collections of: *Papilio sabarae sabarae* specimens collected from Morocco, Algeria and Tunisia; and, *Papilio machaon* specimens from Malta (*P. m. melitensis*), Sicily (*P. m. sphyrus*), Morocco (*P. m. mauretunica*), Lebanon (*P. m. syriacus*), and, Sardinia and central Italy (*P. m. emisphyrus*). Also examined were examples

of *Papilio hospiton* (author's collection and from the Museo di Scienze Naturali Belvi).

Morphometric analysis, involving conventional measurement, was employed, supplemented by stereoscopic microscopy. A total of 46 (dry) specimens were examined, consisting of the above-listed taxa, the main purpose being to establish whether antennal segment number and forewing length were discernible characters in distinguishing between *P. machaon* and *P. saharae*. The following results were obtained:

Table 1

*A comparison of antennal segments and forewing length (range and average) between species, results of which are quite similar to those obtained by PITTAWAY et al. (1994). Limitations include the disparate number of individuals examined from each species and unequal assortment of males and females*

Species	Locality	Antennal segments (average number)	FW length range (mm)	FW length average (mm)	Specimens examined
<i>Papilio saharae saharae</i>	Morocco, Algeria, Tunisia	30.5	32-44	35.57	8
<i>Papilio machaon melitensis</i>	Malta	33.89	34-45.5	40.07	18
<i>Papilio machaon sphyrus</i>	Sicily	33.4	36-45.5	41.8	5
<i>Papilio machaon mauretana</i>	Morocco	34	38-39	38.5	1
<i>Papilio machaon syriacus</i>	Lebanon	32.25	44.5-45	44.75	2
<i>Papilio machaon emisphyrus</i>	Sardinia, Tuscany	33.25	35-43	39.33	6
<i>Papilio hospiton</i>	Sardinia and Corsica	30.83	31.5-36	33.92	6

## DISCUSSION AND CONCLUSIONS

Apart from the fairly discernable differences between some of the larval instars of *P. machaon* and *P. saharae* (MEERMAN & BOOMSMA, 1986; PITTAWAY *et al.*, 1994; TOLMAN & LEWINGTON, 1998), it does not seem possible to rely on wing markings for identification, given considerable variability in colour patterns and marking combinations (particularly in *P. machaon*), which are known to vary seasonally, geographically, as well as within broods (intra-generational morphological variation). Generally, this variability also applies to wingspan size, even if *P. saharae* is commonly portrayed as the smaller of the two species. TSHIKOLOVETS (2011), however, suggests that the two species fall within the same wingspan size range; it may be worth noting that wingspan measurements can be misleading since specimen spreading style varies according to individual preferences. PITTAWAY *et al.* (1994) further claim that

it is virtually impossible to separate the two species with the naked eye, which renders the likelihood of *P. sabarae*'s presence being overlooked (in peripheral locations where the two species may be sympatric – see below) not too farfetched. Moreover, there appears to be no single character by which to make a fail-safe determination to separate *P. machaon* from *P. sabarae* adult forms (TENNENT, 1996).

Environmental conditions, shaped by both biotic and abiotic factors – including landscape structure (particularly the extent of fragmentation), topography and altitude, habitat gradient, type and seasonality, water balance and degree of aridity, as well as the species' nutrition regime at larval stage – may also have a bearing on morphological variation. Larval host-plants across its established range include *Deverra chloranthus*, *D. scoparia*, *D. tortuosa*, *Seseli varium*, *Ferula communis*, *Ferula sinaica*, *Pycnocyla glauca* and *P. tomentosa* (OBERTHÜR, 1915; FAROULT, 1917; BENYAMINI, 1984; PITTAWAY, 1985; PIERRON, 1990; TSHIKOLOVETS, 2011). Of these food-plant species, however, only *Ferula communis* occurs in Sicily; the other species, with the exception of *S. varium* (which occurs in the NE of Italy and eastwards to Anatolia), typically occur in Saharan or Arabian arid and hyper-arid environments. LARSEN (1990) further suggests that the larva may also feed on *Haplophyllum* sp., some species of which occur in the Mediterranean; in addition, other closely related Rutaceae occur in Sicily, such as *Ruta chalepensis*, on which the larvae of *P. machaon* regularly feed. Moreover, one finds other umbellifers (family Apiaceae) in Sicily such as *Thapsia garganica* and *Cachrys ferulago*, which are superficially similar to *Ferula (pers. comm.* Lanfranco, 2018), and which, therefore, may potentially serve as host-plants for *P. sabarae* larvae.

From their respective larval food-plants and the plant species' corresponding habitats, it is evident that *P. sabarae* and *P. machaon*, in general, occupy appreciably different biotopes, even climatically. In effect, the Köppen classification system (FAO, 1997) clearly demonstrates that the geographical locations in which the two species occur, fall within two distinct climate zones, respectively 'dry' for *sabarae* and 'temperate' for *machaon*. However, the two species are also known to occur sympatrically in a number of locations, particularly in some parts of the Mediterranean where the two climatic zones tend to grade into one another; this leads one to surmise that *P. sabarae* may be exploiting *ecological refugia* in enclaves harbouring environmentally apposite, albeit fragmented, habitats in Sicily. Such situation may well have come about as a response to changing and fluctuating climatic conditions, which would have triggered a southward retreat with the onset of the glacials, with a possible scenario of relict populations left stranded within climatically suitable ecological niches. This was probably the case of

*Papilio hospiton* on Corsica and Sardinia, which, according to PITTAWAY *et al.* (1994), may well have speciated from an isolated *P. saharae* population. Similarly, *Papilio saharae rathjensi* in Arabia, was left stranded in mesic mountainous environments of the Asir region consequent to climatic change, in this case, the present interglacial (PITTAWAY, 1993). Although it is not the scope of this present communication to delve into speciation time-frames, it may be plausible to suggest that a geographically isolated *Papilio saharae* population in Sicily could well have adapted to a variable semi-arid to arid climatic regime typical of the Mediterranean biome and thus survived the fluctuating conditions of the glacials and interglacials of the Quaternary Period (encompassing both the Pleistocene geological epoch and current Holocene interglacial). Whether or not such population remained completely isolated or whether influxes of the species from northern Africa reinforced population numbers on the Mediterranean's largest island during postglacial dispersal (potentially rendering it a 'secondary contact zone'), remains to be seen.

The central Mediterranean, inclusive of the Pelagian Block on the the Siculo-Tunisian sill, was exposed to a complexity of dynamic and multifarious processes during the Quaternary Period's glacial and interglacial episodes, which have had a profound influence on patterns of vicariance and dispersal that subsequently shaped the region's biogeography. Whatever the actual status of *Papilio saharae* in the central Mediterranean, it is evident that more work is necessary, both in the field and in the laboratory, amongst other things, to enable more definitive identification of the species. This is especially critical given that, in some instances, adult individuals of both *P. machaon* and *P. saharae* tend to bear rather similar morphological characters, which can make determination somewhat challenging.

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