ON THE MORPHOLOGY OF BASAL HINDWING RECTO BLACK SCALES IN SOME PAPILIONIDAE (LEPIDOPTERA: RHOPALOCERA)

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Introduction

ONE OF THE principal characters used in taxonomic studies on butterflies is the morphology of the male genital apparatus. It is highly conserved within species, and therefore its anatomical investigation normally leads to a correct identification of a given specimen with regard to its specific status. Nonetheless, sibling species can frequently only be discerned from each other by considering long series of each taxon, taking into account a variety of geographical, ecological and morphological features, particularly concerning the morphology and biology of immature stages. With regard to adult and preserved specimens, as mostly found in collections, however, nothing but the genital apparatus and the outer appearance can be subjected to comparative investigations since geographical and ecological information upon preserved specimens are normally kept to the minimum and the larval stages are often not known. Most recently, the senior author of the given paper found that the morphology of homologous scales (Squamulae) in the sibling species *Pieris rapae* Linnaeus and *P. napi* Linnaeus, all taken on the same occasion in south-western Germany, obviously varied according to their shape (Anken, 1995). The noted differences between the scale morphology were therefore regarded as a species-distinctive feature, both species being discernible from each other by the shape of scales rather than by the morphology of the genital apparatus.

The present study was undertaken in order to add some information to the question, to what extent homologous scales differ in more or less closely related non-sibling species. Therefore, some species of several genera of Papilionidae were squamologically investigated.

Material and methods

The following species (males only) were investigated: *Papilio machaon* Linnaeus (Germany), *Iphiclides podalirius* Linnaeus (Italy), *I. feisthamelii* Duponchel (Portugal), *Zerynthia polyxena* Denis & Schiffermüller (Yugoslavia), *Z. rumina* Linnaeus (Portugal), *Parnassius mnemosyne* Linnaeus (Switzerland), *P. apollo* Linnaeus (Switzerland).

The protocol to take scales follows Anken (*op. cit.*). In brief, the black scales to be investigated were taken from the basal recto hindwing surfaces by a moistened brush. After having been transferred to microscopical slides, they were allowed to dry and were subsequently coverslipped using Hydromatrix (wasserlösliches Einschlussmittel, Micro-Tech-Lab, Graz, Austria). Before being used for another specimen, the brush was carefully cleaned. From each species, at least three individuals were squamologically

analysed. Therefore, at least thirty individual scales per individual were drawn using a camera lucida (Zeiss, Oberkochen, Germany) equipped binocular light microscope (Standard 14, Zeiss) at a magnification of 400x. The drawn series-images (called SI in the following) were coded, compared to each other and any observations were noted. The coding was employed in order to prevent the experimenter knowing the specific name of an SI, which might unwillingly have lead to biased results. The observations having been done, the results obtained were attributed to the respective species. The SIs in the figures of the given study comprise randomly-chosen scales of randomly-chosen individuals of each species. In the course of extensive preliminary examinations, it had been found out that such short SIs are satisfactorily suited for demonstrating the general morphological appearance of the scales of a given species.

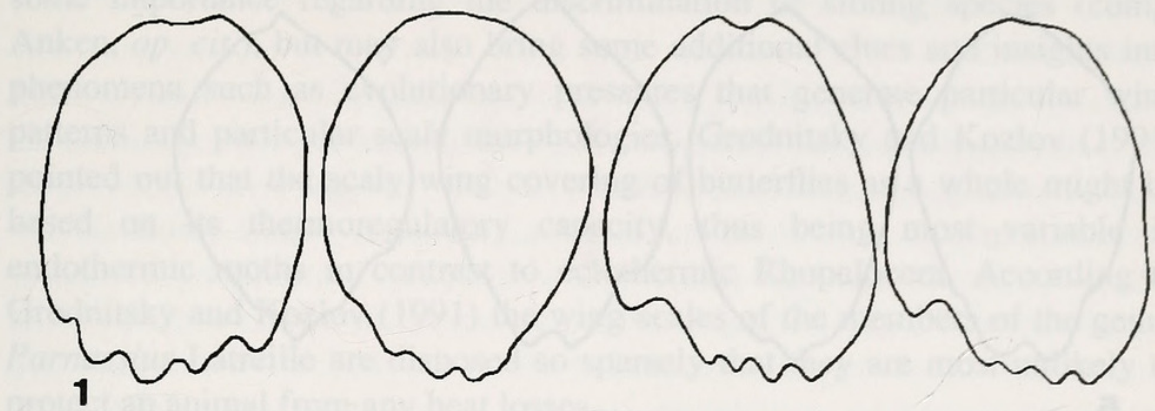
Results

Representive SIs of homologous basal hindwing recto black scales of the species investigated are given in Figs. 1-7. All scales analysed reveal an apical field with more or less pronounced protrusions (processi), which vary among the same individual and from species to species. As can be taken from Fig. 1, *Papilio machaon* had broad scales with a narrow apical field in its rostrocaudal extension, revealing several, but not well-pronounced protrusions. Homologous scales in *Iphiclides* spp. (Figs. 2 and 3) differ strikingly from the ones of *P. machaon* in being considerably narrower, especially in *I. feisthamelii* (Fig. 3). The apical protrusions in this species are as little pronounced as they are in *P. machaon,* therewith differing from the process of *I. podalirius* (Fig. 2). Homologous scales of *Zerynthia polyxena* (Fig. 4) somewhat resemble the ones of *P. machaon* in outer shape, but are smaller and differ in having a triangle-like apical field that is also found in *Z. rumina* (Fig. 5). The latter scales clearly differ from those of *Z. polyxena* in their more rhomboid-like silhouette. The scimitar-like processi in *Parnassius mnemosyne* (Fig. 6) rule out any misidentification as do the extremely large scales of *P. apollo* (Fig. 7).

Discussion

It is obvious, that a microscopical investigation on wing scales of European Papilionidae is merely academic, since these species can be easily discriminated from each other by outer appearance.

Nevertheless, it is intriguing, that they are discernible from each other by the shape of scales. Moreover, the grade of similarity regarding scales reflects the grade of similarity concerning the outer appearance and the systematical positions. Both *Zerynthia* spp. analysed can be readily discerned by scale features but they both remarkably differ from the representatives of the other genera, as do the Apollos and the Scarce Swallowtails. An investigation of scales may therefore not only be one of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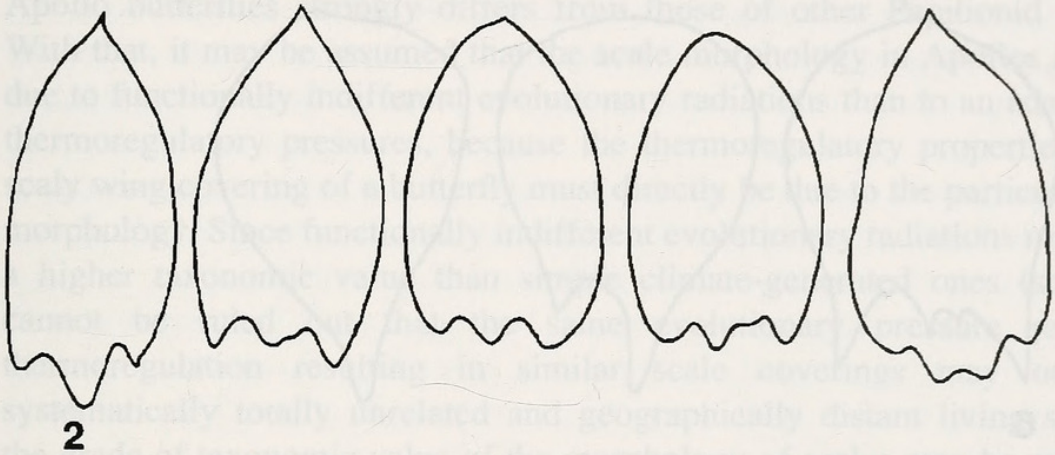
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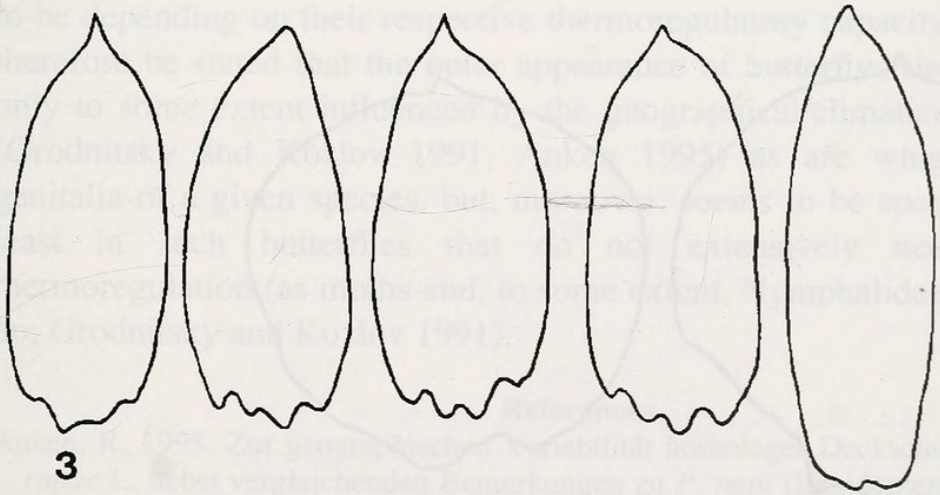
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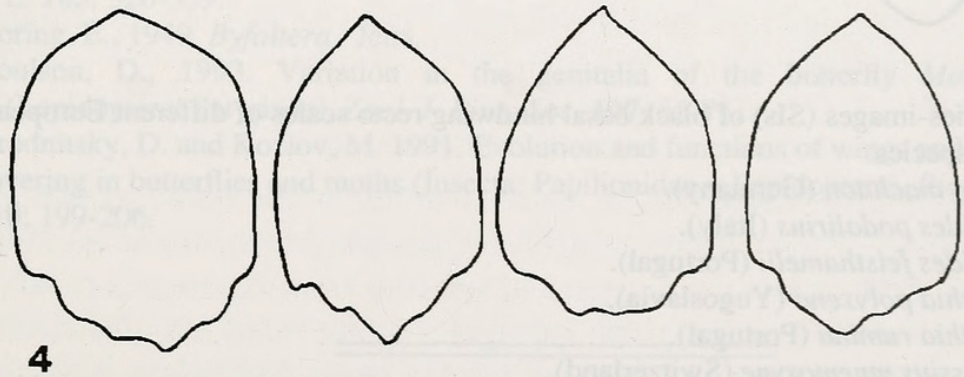
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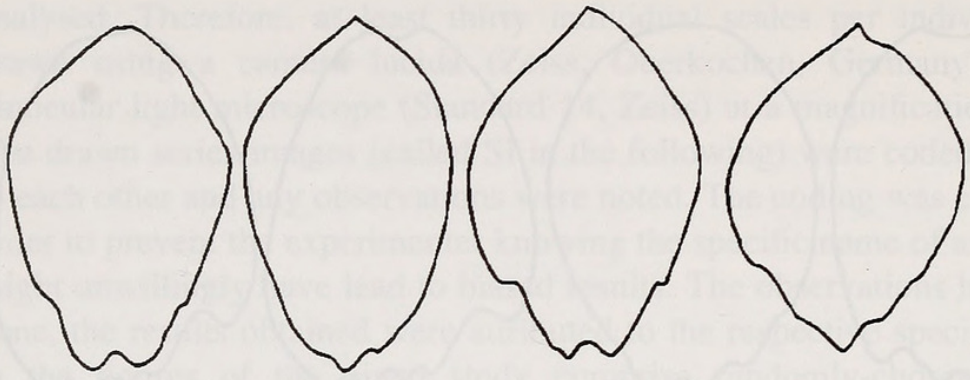

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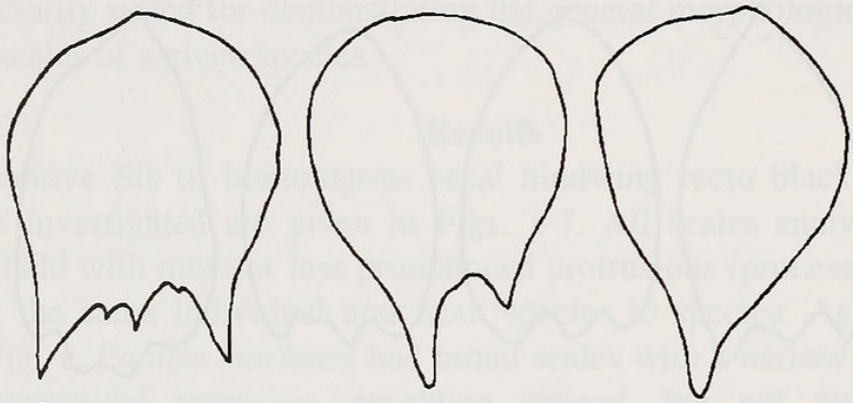

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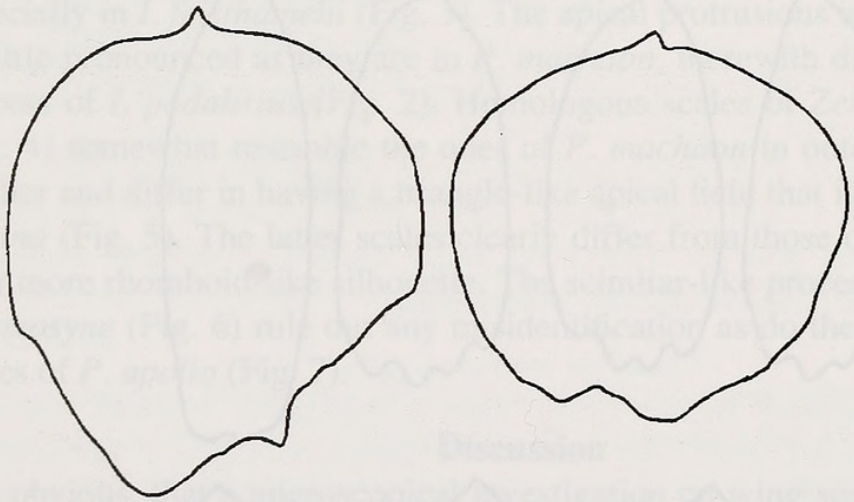

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Figs. 1-7: Series-images (SIs) of black basal hindwing recto scales of different European Papilionidae species.
Fig. 1. *Papilio machaon* (Germany).
Fig. 2. *Iphiclides podalirius* (Italy).
Fig. 3. *Iphiclides feisthamelii* (Portugal).
Fig. 4. *Zerynthia polyxena* (Yugoslavia).
Fig. 5. *Zerynthia rumina* (Portugal).
Fig. 6. *Parnassius mnemosyne* (Switzerland).
Fig. 7. *Parnassius apollo* (Switzerland).
Magnification: x400.

some importance regarding the discrimination of sibling species (comp. Anken, *op. cit.*), but may also bring some additional clues and insights into phenomena such as evolutionary pressures that generate particular wing patterns and particular scale morphologies. Grodnitsky and Kozlov (1991) pointed out that the scaly wing covering of butterflies as a whole might be based on its thermoregulatory capacity, thus being most variable in endothermic moths in contrast to ectothermic Rhopalocera. According to Grodnitsky and Kozlov (1991) the wing scales of the members of the genus *Parnassius* Latreille are disposed so sparsely that they are most unlikely to protect an animal from any heat losses.

The given study indicates that the particular morphology of scales of Apollo butterflies strongly differs from those of other Papilionid species. With that, it may be assumed that the scale morphology in Apollos is rather due to functionally indifferent evolutionary radiations than to an adaption to thermoregulatory pressures, because the thermoregulatory properties of the scaly wing covering of a butterfly must directly be due to the particular scale morphology. Since functionally indifferent evolutionary radiations may be of a higher taxonomic value than simple climate-generated ones (so far, it cannot be ruled out that the same evolutionary pressure regarding thermoregulation resulting in similar scale coverings may occur in systematically totally unrelated and geographically distant living species), the grade of taxonomic value of the morphology of scales may be presumed to be depending on their respective thermoregulatory capacity. So far, it can therefore be stated that the outer appearance of butterfly wing scales is not only to some extent influenced by the geographical/climatical environment (Grodnitsky and Kozlov 1991, Anken 1995) as are wing patterns and genitalia of a given species, but, moreover, seems to be species-specific, at least in such butterflies that do not extensively need scales for thermoregulation (as moths and, to some extent, Nymphalidae and Satyridae do; Grodnitsky and Kozlov 1991).

References

Anken, R, 1995. Zur geographischen Variabilität homologer Deckschuppen von *Pieris rapae* L. nebst vergleichenden Bemerkungen zu *P. napi* (Lepidoptera: Pieridae). *Ent. Z.* **105**: 326-339.

Doring, E., 1949. *Byfaltera.* Jena.

Goulson, D., 1993. Variation in the genitalia of the butterfly *Maniola jurtina* (Lepidoptera: Satyrinae). *Zool. J. Linn. Soc.* **107**: 65-71.

Grodnitsky, D. and Kozlov, M. 1991. Evolution and functions of wings and their scale covering in butterflies and moths (Insecta: Papilionidae = Lepidoptera). *Biol. Zent. bl.* **110**: 199-206.