

The use of the pre-imaginal stages of the Macaronesian *Hipparchia* species in the clarification of the numbers and ranks of the taxa present in Madeira and the Azores archipelago (*Lepidoptera* : *Nymphalidae*, *Satyrinae*)

Part 3 : The populations of the western Azores islands of Flores and Corvo and general conclusions

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Summary

The final part of this study deals primarily with a taxonomic assessment of those populations of the *azorina* group inhabiting the westernmost Azores islands of Flores and Corvo. For this purpose, their pre-imaginal stages were reared to adult butterflies by D.J. They shared several common features which contrasted with those found in the populations of the central Azores islands : their larvae had shorter and less dense hairs, their imagines had smaller genitalia, the bright spots in the basal area of hindwing undersides were enlarged to whitish zigzag bands in many specimens (particularly those from Corvo) and androchonical scales were absent. For these reasons, the populations of Flores and Corvo are separated from all those present on the other Azores islands as a species, whose appropriate name is *H. occidentalis* BIVAR DE SOUSA 1982. Due to their smaller adult wingspan, individuals from Corvo have been separated as ssp. *minima* by BIVAR DE SOUSA 1985 but, when reared under similar conditions, this difference was not apparent and therefore size was of no taxonomic value. However, because of differences in ovipositing and wing morphology, this separation is maintained. A penultimate chapter deals with the conclusions reached from this extensive study of Macaronesian *Hipparchia* populations, giving a detailed assessment of the taxonomic value of our observations, comparing them with those of earlier workers and finally suggesting a taxonomic arrangement. In a concluding section, based on four visits to Madeira and six to the Azores archipelago between 1993 and 2004, P.R. discusses critically the threat assessments and conservation measures ascribed by previous authors to the *Hipparchia* species inhabiting these islands.

Résumé

Cette dernière partie de notre étude traite essentiellement de l'appréciation taxonomique des populations du groupe d'*azorina* qui peuplent Flores et Corvo, îles les plus occidentales des Açores. Dans ce but, D.J. les éleva de l'oeuf à l'imago. Elles présentent plusieurs caractéristiques communes contrastant avec celles notées chez les populations des îles des Açores centrales : les chenilles ont les poils plus courts et moins denses, les imagos ont des armatures génitales plus petites, les taches claires dans l'aire basale au revers des ailes postérieures sont élargies en une bande blanchâtre en zigzag chez maints individus (en particulier ceux de Corvo) et les écailles androconiales sont absentes. Pour ces raisons, on a séparé les populations de Flores et Corvo de celles des autres îles des Açores comme une entité spécifique dont le nom correct est *H. occidentalis* BIVAR DE SOUSA 1982. En raison de l'envergure moindre des imagos, BIVAR DE SOUSA 1985 avait séparé les individus de Corvo comme ssp. *minima*. Cependant, dans des conditions d'élevage similaires, cette différence ne s'est pas manifestée et, pour cette raison, la taille fut considérée comme critère sans valeur taxonomique. On a cependant maintenu cette séparation à cause de différences dans la ponte et la morphologie alaire. Un avant-dernier chapitre traite des conclusions tirées de l'étude étendue des populations macaronésiennes d'*Hipparchia* : on y donne une appréciation détaillée de la valeur taxonomique de toutes les observations, on les compare avec celles des auteurs précédents et on propose un modèle de classification. Dans une section finale, P.R. discute d'une manière critique les appréciations des auteurs précédents sur les dangers menaçant les espèces d'*Hipparchia* peuplant ces îles et sur les mesures de conservation proposées, en se basant sur ses quatre visites à Madère et ses six visites aux Açores entre 1993 et 2004.

Riassunto

La parte finale di questo studio tratta essenzialmente della valutazione tassonomica di quelle popolazioni del gruppo *azorina* che abitano Flores e Corvo, le isole più occidentali delle Azzorre. A tal fine D.J. le alleva dall'uovo all'imagine. Esse presentano alcune caratteristiche comuni che contrastano con quelle trovate nelle popolazioni delle Azzorre centrali : le larve sono più corte e meno ricoperte di peli, le loro imagini hanno genitali più piccoli, in molti individui (in particolare quelli di Corvo) le macchie chiare nell'area basale della pagina inferiore

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Errata : Part 2.1, head of page 8 : 'plates 5 and 6' should read 'plates 3 and 4'.

delle ali posteriori sono allargate in una banda biancastra a zigzag e le squame androconiali sono assenti. Per queste ragioni, le popolazioni di Flores e di Corvo sono separate da tutte quelle presenti nelle Isole Azzorre come specie, il cui nome appropriato è *H. occidentalis* BIVAR DE SOUSA 1982. Per l'apertura alare più piccola delle immagini, BIVAR DE SOUSA 1985 aveva separato gli individui di Corvo come *ssp. minima*, ma quando allevate in condizioni similari questa differenza non si è più manifestata, alla taglia non è stato più dato un valore tassonomico. Comunque, a causa delle differenze nella ovoposizione e nella morfologia delle ali, questa separazione è mantenuta. Un penultimo capitolo si occupa delle conclusioni ottenute da questo studio estensivo delle popolazioni macaronesiane di *Hipparchia* dando una dettagliata valutazione del valore tassonomico delle nostre osservazioni, paragonandole con quelle di studiosi precedenti e in fine proponendo un modello di classificazione. In una sezione finale, sulla base di quattro visite a Madeira e sei nell'Arcipelago delle Azzorre, tra il 1993 e il 2004, P.R. discute in maniera critica le valutazioni degli autori precedenti sui pericoli che minacciano le specie di *Hipparchia* che popolano queste isole e sulle misure di conservazione proposte.

Zusammenfassung

Im letzten Teil dieser Studie steht die taxonomische Beurteilung der auf den westlichsten Azoreninseln Flores und Corvo lebenden Populationen der *azorina*-Gruppe im Mittelpunkt. D.J. züchtete sie zu diesem Zweck vom Ei bis zum Falter. Es wurden mehrere Merkmale gefunden, in denen sie übereinstimmen und worin sie sich von den Populationen der zentralen Azoreninseln unterscheiden: Ihre Raupen haben eine kürzere und weniger dichte Behaarung, die Falter haben kleinere Genitalarmaturen, die weissen Flecke im Wurzelbereich der Hinterflügelunterseite sind bei manchen Exemplaren zu weissen Zickzackbinden erweitert (insbesondere bei Faltern aus Corvo) und die ♂♂ haben keine Androkonienschuppen. Daher werden die Populationen der Inseln Flores und Corvo von jenen der übrigen Azoreninseln als eine Art abgegrenzt, deren richtiger Name *H. occidentalis* BIVAR DE SOUSA 1982 lautet. Dieser Autor trennte die Falter der Insel Corvo wegen ihrer geringen Flügelspannweite als *ssp. minima* ab. Bei Zucht unter denselben Bedingungen zeigte sich dieser Unterschied nicht mehr, so dass der Grösse keine taxonomische Bedeutung beigemessen wird. Diese Unterteilung wurde jedoch wegen Unterschieden im Eiablageverhalten und in der Flügelmorphologie beibehalten. In einem vorletzten Kapitel wird gezeigt, welche Schlüsse sich aus der umfangreichen Studie über makaronesische *Hipparchia*-Populationen ergeben, indem die vorliegenden Beobachtungen nach ihrer taxonomischen Bedeutung beurteilt und mit jenen früherer Bearbeiter verglichen werden und ein Modell zur Klassierung vorgeschlagen wird. Unter Berufung auf seine vier Besuche der Insel Madeira und seiner sechs Besuche der Azoren im Zeitraum von 1993 bis 2004 bezieht P.R. in einem abschliessenden Kapitel kritisch Stellung zur Beurteilung der Gefährdungssituation dieser *Hipparchia*-Arten aus der Sicht der vorigen Autoren und den Massnahmen, die diese zu ihrem Schutz vorschlagen.

Resumir

A parte final deste estudo pretende avaliar o estatuto taxonómico das populações do grupo *azorina* que ocorrem nas ilhas mais ocidentais dos Açores, Flores e Corvo. Para atingir este objectivo os estádios imaturos foram criados por D.J. em

condições laboratoriais até atingirem o estado adulto. Estes partilharam várias características comuns que contrastam com as populações das ilhas do grupo Central: as suas larvas possuem pelos mais curtos e menos densos: os imagos possuem genitálias mais pequenas: particularmente em alguns exemplares da ilha do Corvo as manchas claras na área basal da parte ventral das asas posteriores ampliam-se em manchas esbranquiçadas em zig-zag: as escamas androconiais estão ausentes. Por todas essas razões as populações das Flores e Corvo são bem diferenciadas em relação às presentes nas outras ilhas, pelo que devem ter o estatuto de espécie, cujo nome apropriado será *H. occidentalis* BIVAR DE SOUSA 1982. Devido ao pequeno tamanho das asas, os indivíduos do Corvo foram separados na *ssp. minima* por BIVAR DE SOUSA 1985, mas quando criados nas mesmas condições a diferença no tamanho das asas não foi aparente, pelo que o tamanho das asas não possui valor taxonómico. No entanto, devido a diferenças na oviposição e morfologia das asas esta separação é mantida. O penúltimo capítulo lida com as conclusões obtidas a partir deste estudo alargado sobre as populações de *Hipparchia* da Macaronésia, apresentando uma avaliação detalhada do valor das nossas observações, comparando-as com as de outros autores e finalmente propondo um novo arranjo taxonómico. Numa secção de conclusões, baseada em quatro visitas à Madeira e seis aos Açores entre 1993 e 2004, P.R. discute de forma crítica as ameaças e as medidas de conservação propostas pelos autores anteriores para as populações de *Hipparchia* destas ilhas.

Introduction

Parts 1.1, 1.2, 2.1, 2.2 of this study (see RUSSELL *et al.*, 2004-7) dealt with an examination of the early stages, genitalia and imagines of the populations of *Hipparchia maderensis* and *H. azorina s.l.* occupying the islands of Madeira, São Miguel and the central islands of the Azores archipelago. In this final part the populations inhabiting the two western Azores islands of Flores and Corvo are treated in a similar manner. In 1982, BIVAR DE SOUSA described *ssp. occidentalis* from Flores and three years later *ssp. minima* from the neighbouring island of Corvo: the latter name refers to the small size of the individuals present on this island. To investigate the taxonomic rank appropriate for these two western populations of *azorina*, parallel rearing of the two taxa was necessary. Both of them are distributed more or less continuously around the slopes of the volcanic craters down to 600 m on Flores and to 400 m on Corvo. P. RUSSELL collected the rearing material from Flores near Pedrinha at 725 m and from Corvo on the slopes of Lomba Redonda at 420-460 m in August 2003 and 2004, the second visit being necessitated by the death of the majority of the larvae from Corvo during the winter of 2003/4. As a precaution, P.R. sent only about half of the ova that were obtained in 2004 immediately to D.J. The remainder of the ova were reared by P.R. and sent to Switzerland in the spring.

The second rearing attempt in 2004/5 was successful, allowing D.J. to illustrate all the early stages from both island populations. D.J. sent all the reared butterflies to P.R. for him to measure their wingspans. Guido VOLPE received from P.R. imagines of both sexes from both islands for preparation and examination of their genitalia.

Some of the pictures of the early stages of taxon *occidentalis* from Flores were photographed during the period of 2002/3. At that time, larvae from Flores were reared in parallel with those originating from both São Miguel and the central Azores Islands but publishing was kept in reserve for the present article.

The habitat of taxon *occidentalis* on Flores

The island of Flores is approximately oval in shape, being roughly 16½ km in length by 12 km wide, with its long axis aligning N/S. It is rugged with high cliffs particularly on the north and west sides: on the west side, many waterfalls cascade from 400 m to sea level and, after heavy rain, these can be particularly spectacular. The central area contains many calderas, their rims ranging in height from the 511 m high Pico da Casinda to the highest peak on the island, Moro Alto at 914 m: some calderas contain deep lakes, such as Caldiera Funda, others are almost dry, like Caldiera Branca. The butterflies can be found on sloping ground at elevations from about 500 to 900 m above sea level, however most of the time conditions in this area are most unsuitable for studying butterflies: low cloud with mist or heavier rain. The sun often shines in the mornings, particularly on the East side at sea level, where Santa Cruz das Flores with its two tourist hotels is situated and from where it is not possible to see the higher ground. Following a ½ hr. car journey the clouds are often already beginning to shroud the habitats by 9 o'clock in the morning before the temperature has reached a level at which the butterflies begin to fly: it would then rain for the remainder of the day. P.R. has made four excursions to Flores between 1999 and 2004 totalling some 19 days and on only 2 of those did the sun shine throughout the day on the higher ground. In 2003 and 2004, the conditions were particularly difficult with the slopes being covered in cloud almost continuously. After some searching it was discovered that the slopes above the southern town of Lajes das Flores were often just on the edge of the mist and occasionally this would clear enough for the sun to make brief appearances for some 15-20 minutes, usually around the middle of the day when the sun had warmed the lower slopes creating an updraft to remove the mist, however the windy

conditions, which were created by this updraft, also provided difficult conditions to collect the butterflies, which when they took flight were quickly blown out of sight. The slopes above Pedrinha at c.725 m proved to be the best area, due to their proximity to a road they could be visited frequently during the day to see whether conditions allowed the butterflies to take to the wing, and it was from this location that ♀♀ specimens of the taxon *occidentalis* were collected to obtain ova. The ♀♀ oviposited very readily in the netted pots containing *Festuca jubata* when placed in the hotel garden down at sea level in the more or less continuous sunshine.

The habitat of taxon *minima* on Corvo

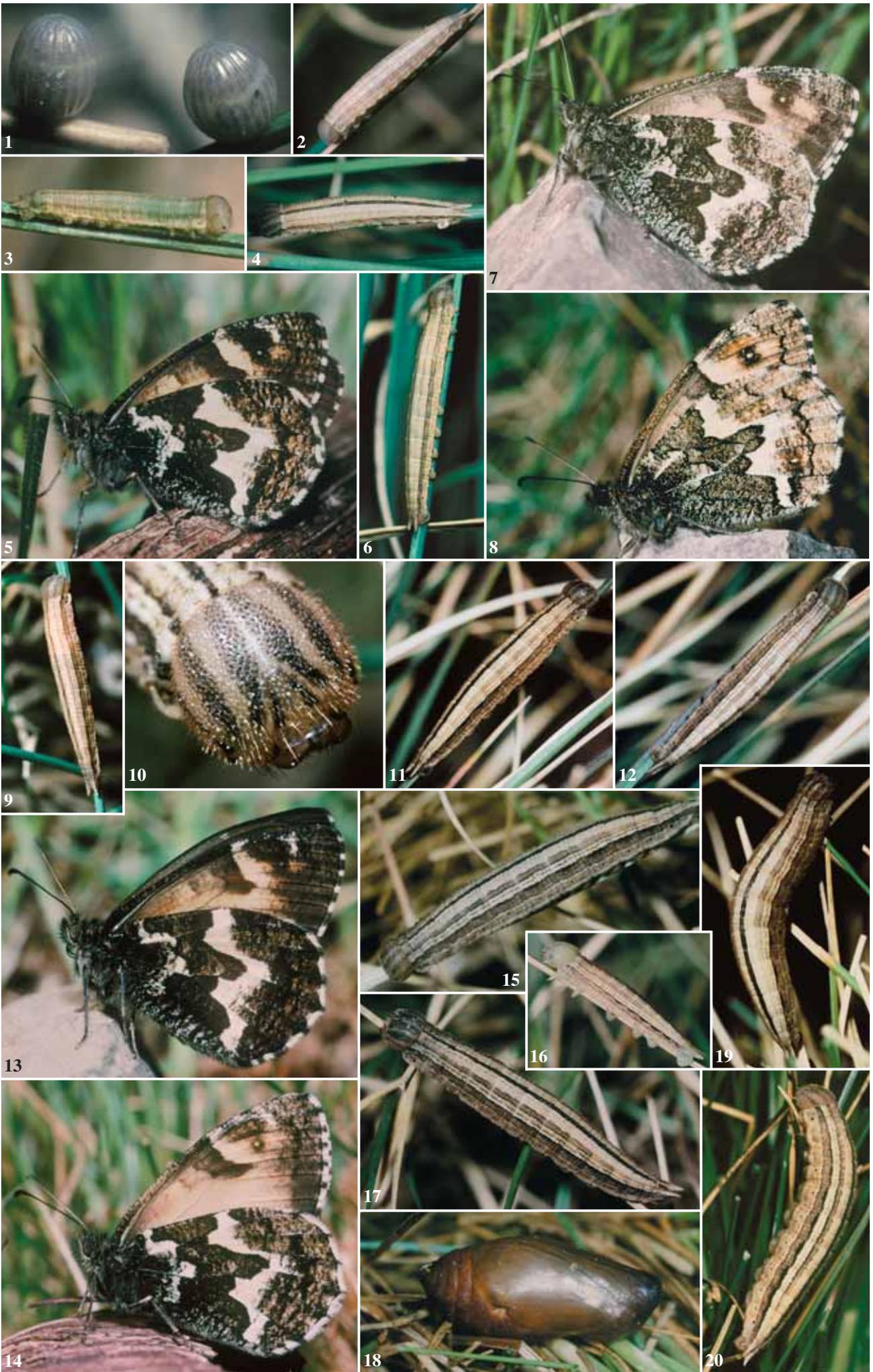
The island of Corvo, lying some 7 km off the NE coast of Flores, is shaped like a comma and is c. 6½ km from N. to S. and a little over 4 km wide. It consists of a single extinct volcanic collapsed cone with a deep crater, having a flat bottom, containing a small lake. Villa Nova, the only settlement, lies at the southern tip of the island adjacent to the airstrip. The *Hipparchia* are found on some of the damper western slopes where *Festuca jubata* is abundant between approx. 400 and 600 m. The conditions on Corvo are even worse for studying butterflies than on Flores: the sun often shines for a short time early in the morning, allowing the butterflies to take to the wing, but by the time the upper slopes of the caldera are reached, requiring a walk of some 1½ hours, it is often already windy and they are shrouded in mist or low cloud. The butterflies do continue to fly in the rain for approximately 30-45 minutes, depending on the heaviness

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PLATE 1 : *Hipparchia occidentalis* from Flores, Moro Alto and Pedrinha : 1 : ova attached to grass ; 2,4,6 : larvae in stage L3 with different colouring ; 3 : L1 after the first alimentionation ; 5,13,14 : ♂♂ varying in their underside wing patterns ; 7,8 : ♀♀, *idem* ; 9,11,12 : caterpillars in stage L4 ; 10 : head of a fully fed larva ; 15,17,19,20 : caterpillars (L5) with different shading ; 16 : freshly moulted L4 larva ; 18 : chrysalis.

PLATE 2 : *Hipparchia occidentalis minima* from Corvo, Lomba Redonda : 1 : ova lying on the ground ; 2,4 : freshly hatched L1 larvae ; 3,9,10 : larvae in stage L3 with different colouring ; 5,7,8 : ♀♀ varying in their underside pattern ; 6,11,12 : larvae in stage L4 ; 13 : chrysalis ; 14,15 : ♂♂, with differing undersides ; 16 : head of fully grown larva ; 17-19 : L5 larvae ; 20 : reared ♀ ovipositing between the stems of potted fescue grass.

Photographs of plates 1 and 2 : D. JUTZELER





of the rainfall, but once ones net is soaking wet it becomes almost impossible to take them as they fly low to the ground for short distances and then disappear into the lea side of clumps of grass seeking shelter. In both 2003 and 2004, it had been intended to allow 5 days on Corvo, however this was cut to 3 days on each occasion because of mechanical problems with the plane and secondly strong wind from the SW prevented the plane from landing on the island. Due to poor weather conditions, it was on only one morning in 2003 and one period of about two hours during one afternoon in 2004 that it was possible to collect the butterflies needed for this study. They were taken between 420 and 460 m on the slopes of a small ridge leading up to Lomba Redonda, which being some 150m below the rim of the crater, was a little less windy. When disturbed from their sheltering places, usually a grass tussock, the butterflies were often blown over this ridge and quickly settled in its lea.

Climatic aspects

The two westernmost Azores islands have a considerably higher rainfall than the central or eastern island groups and, even in the summer months, the higher regions of the islands are shrouded in cloud with either drizzle or heavier bursts of rain for most of the day. MADEIROS (1987) gives the following information concerning the climate on Corvo : the prevailing winds are westerly, with the NW and SW being the most common. The annual mean temperature is 17.6°C, with a maximum mean daily recording of 22.7°C in August and a minimum of 14.1°C, which can occur during February or March. The maximum and minimum daily averages recorded oscillate between 20.2° and 25.2° in August and between 12.0° and 15.9° in March. All these readings were taken at sea level : the temperature decreases 0.6°C with each 100 m increase in altitude. Very similar temperature regimes would be applicable to all the islands in the Azores archipelago, since they are situated at almost the same degree of latitude. We can conclude from these data that the larvae of the entire *azorina* complex should hardly be exposed to frosty temperatures in their natural habitats during the cold season.

Methodology

Details of the rearing methods can be found in part 1.1 (p. 200, 201) of this study. As a consequence of the failed rearing during 2003/4, D.J. used anew the winter garden of his mother's house for hibernating *azorina* larvae during the winter 2004/5.

Rearing reports

Ssp. *occidentalis*, rearing 2002/3 : on 30.VII.02 P. RUSSELL collected ♀♀ on Mt Moro Alto at 700 m for ovipositing. On 6.VIII. D.J. received a batch of ova which had been deposited on 30. and 31.VII. and a second one on 8.VIII. with eggs that had been laid from 1.-3.VIII. 6.X. : many larvae were in stage L2 and some in L3 : 3.XI. : many are in L3 and some in L4 : 30.XI. : 1 L2, 8 L3, 64 L4. On 1.III.03 94 larvae were visible : 14 L3, 80 L4. Of these larvae, more than 50% were lost. By 17.III. 28 were visible : 25 L4 and 3 L5 : on 5.IV. : 6 L4, 24 L5 and 10.IV. : 3 L4, 24 L5. By 26.IV. L5-larvae, pre-pupae and chrysalides were present and on 10.V. only a few larvae still appeared to be feeding, the majority having pupated. The pupae took up a vertical or horizontal position at the base of the grass like those of all the other series of the *azorina* group. Emergence : 9 ♂♂ from 16.V.-7.VI. and 11 ♀♀ from 12.V.-13.VI.

Ssp. *occidentalis*, rearing 2003/4 : on 12.VIII.03 P.R. collected ♀♀ 1 km N. of Pedrinha at 700 m. On 22.VIII., D.J. received some 30 eggs laid 16-18.VIII. The resulting larvae all died (see below).

Ssp. *occidentalis*, rearing 2004/5 : on 7.VIII.04 P.R. took 3 ♀♀ near Pedrinha (700 m). The ova deposited on 7/8.VIII. arrived at D.J.'s home on 12.VIII. On 23.X. 54 larvae were visible : 27 L2, 27 L3. On 24.XI. the pot containing the larvae was transferred into the winter garden for hibernation. 5.III. : 4 L3, 7 L4. 18.III. : 1 L3, 7 L4, 1 L5. 27.III. : 3 L5, 5 L4. The anterior half of an L4-larva was observed on the ground. Woodlice that co-existed in the pot could have killed these individuals and they were removed. 12.IV. : 7 L5. 8.V. : 2 pre-pupae and at least 3 pupae could be found. **Larvae overwintered in England by P.R.** : on 18.III. 15 L3-larvae arrived at D.J.'s home. 19.IV. : 12 L4, 3 L5 : 8.V. : 13 L5 visible. Emergence : 5 ♂♂ from 28.V.-8.VI. and 13 ♀♀ from 23.V.-26.VI.

Ssp. *minima*, rearing 2003/4 : 13.VIII. capture of ♀♀ on slopes of Lomba Redonda at 420-460 m, two batches of ova were deposited from 16.-18.VIII.03 arriving in Effretikon on 20.VIII. and 22.VIII. On 18.X. : the caterpillars were in the phases L1 and L2. 23.II. : 4 L2, 26 L3, 2 L4. 14.IV. : 9 L3, 16 L4. 4.V. : 8 L3, 12 L4, 1 L5. By 15.V. all the larvae had died.

Ssp. *minima*, rearing 2004/5 : on 3.VIII. P. RUSSELL collected 4 ♀♀ depositing 61 ova on the next day. They arrived in Effretikon on 9.VIII.04. 13.VIII. : hatching of a first larva. 23.X. : 17 L2, 5 L3. 21.XI. : the pots containing the caterpillars were transferred into the winter garden. 5.III. :

4 L3, 4 L4. 18.III. : 9 L4. 27.III. : 8 L4. 12.IV. : 1 L4, 5 L5. 24.IV. : 7 L5. 8.V. : 3 L5, 1 pre-pupa, 1 chrysalis. **Larvae overwintered in England by P.R.** : On 18.III. D.J. received 1 L2 and 12 L3-larvae. 18.IV. : 7 L3, 3 L4, 1 L5. 24.IV. : 9 L5. Emergence : 6 ♂♂ from 15.V.-25.VI. and 5 ♀♀ from 5.VI.-23.VI.

Possible reasons for the differing successes of the larval rearing in 2002/3 and 2003/4

The results from the 8 batches of larvae reared in 2002/3 were most satisfactory. This was probably due to the exceptionally warm and sunny autumn of 2002 and the particular care by D.J. to keep the temperature oscillations to a minimum and avoid temperatures below zero during winter, mimicking the conditions in the Azores. The spring of 2003 was exceptionally warm in April and this accelerated larval development. The emergence periods of *occidentalis* in two different years illustrates this : in 2003 20 imagos emerged from 12.V.-13.VI., whereas the 18 individuals in 2005 enclosed almost 2 weeks later, from 25.V.-26.VI. The intense sunshine on D.J.'s balcony and the lack of regular mist and drizzle were apparently not disadvantageous to larval development.

Although only two *azorina* batches from the western islands were reared in 2003/4, a further 12 pots of *H. wyssii* larvae needed more specialised care. Thus the failure of the larvae in the spring was probably due to insufficient attention during the spring.

Many of the 2004/5 series of *occidentalis* and *minima* larvae reared by D.J. were almost certainly eaten by woodlice during the hibernation in his mother's winter garden.

Description of the pre-imaginal stages

Ssp. occidentalis : Ovum : high of 1-1.2 mm (mainly 1.1 mm), oval in shape, brilliant yellowish-grey chorion with brownish dots. The numbers of longitudinal ribs of 20 eggs counted from Moro Alto were as follows : 3 had 20, 2 had 21, 9 had 22, 1 had 23 and 5 had 24 ribs (average 22.15). Of 28 eggs counted from Pedrinha, 3 had 21, 8 had 22, 6 had 23, 3 had 24, 7 had 25, 1 had 26 (average 23.21). **Larva : L3** : many larvae are brownish in shade, dorsal line marked, dotted or sometimes absent. **L4** : individuals with marked dorsal line were more frequent than those with incomplete or absent line. **L5** : the shading varies between beige and brown, many individuals with contrasty colouring. The dorsal line is always marked. Body and head are covered with short hairs. Width of lar-

val head : L2 : 0.8-1 : L3 : 1.3-1.9 : L4 : 2.0-2.8 : L5 : 3.0-3.7 mm. The fully grown larvae reached 32 mm in length. **Pupa** : the lengths of those chrysalides measured varied from 13-16.5 mm.

Ssp. minima : Ovum : 0.9-1.1 mm in height (mainly 1 mm). Yellowish shaded at first, later covered with brownish dots. Of 23 eggs inspected in 2003, 1 had 19, 3 had 20, 7 had 21, 9 had 22, 2 had 23, 1 had 25 longitudinal ribs (average : 21.52) and of 20 eggs examined in 2004, 1 had 20, 5 had 21, 3 had 22, 5 had 23, 4 had 25, 2 had 26 ribs (average : 22.9). **Larva : L3** : most of L3 larvae were light with slight shading, only a minority of individuals showed a dotted or marked dorsal line. **L4** : mainly light in colour with slight or marked dorsal line. **L5** : variable in colouring but individuals with light shading are predominant. Body and head are covered with relatively short hairs. Width of larval head : L2 : 0.8-0.9 ; L3 : 1.2-1.9 ; L4 : 2.1-2.8 ; L5 : 2.9-3.5 mm. Length of the fully grown larva up to 32 mm. **Pupa** : similar to those of *occidentalis*.

Comparison of pre-imaginal stages

Oviposition : During the years of 2002, 03 and 04, P. RUSSELL analysed 8 cages containing *occidentalis* ♀♀ and 4 containing *minima* ♀♀, counting the number of ova successfully attached (to either grass stems, cage netting or wires) in each case and expressing this as a percentage of the total number of eggs laid with the following results : *occidentalis* : 83%, 57%, 16%, 63%, 90%, 21%, 96% and 34% attached ; *minima* : none of the ova were attached, all falling onto the soil. A similar result was recorded among the populations of the central Azores islands where ♀♀ of both Terceira populations (*barbara*, *borgesii*) attached the majority of their eggs, those of all the remaining islands failed to attach any at all (see part 2.1, table p. 11).

Size, sculpture and colour of ova : the ova of *minima* were a little smaller than those of *occidentalis*. This difference in size can not be considered to be a distinctive feature because the egg size also varies within the same range among central Azores populations. The slightly smaller average number of ribs found in the Corvo eggs is again not significant. The ova of *occidentalis* and *minima* show no remarkable difference in colouring and are similar to those produced by the populations of central Azores.

Colouring of the larva : *occidentalis* larvae were darker with more contrast than the lighter-coloured ones of *minima*. Such differences with regard to the average shade of the larvae occur also among the populations of the central Azores : the

Comparison of adult butterflies

caterpillars from Flores and Corvo do not exhibit any particular variations that did not occur among the larvae of the central island populations.

Hairyness of larvae : the hairs on the head and cremaster of *occidentalis* and *minima* larvae are similar to one another in length and density but shorter and less dense than those found on the larvae of all the central island populations.

Pupae : the pupae of both *occidentalis* and *minima* were inseparable in size and colour.

Size : BIVAR DE SOUSA (1985) obviously adopted the name *minima* to describe those *azorina* from Corvo because of their smaller size compared with those from Flores. P. RUSSELL confirmed that this was in fact the case by measuring the wingspans of wild caught ♂♂ and ♀♀ from both island populations (table 1), from which it can be seen that the mean wingspans of Corvo ♂♂ and ♀♀ were smaller by 2.7 and 3.8 mm, respectively, than those from Flores. However, when the reared material from both islands was measured and compared, it was discovered that this difference was no longer apparent : in fact the reared ♂♂ and ♀♀ from Corvo were on average slightly larger than those from Flores by 0.7 and 1.1 mm, respectively. That this latter difference is not significant can be seen from an inspection of their size ranges : Flores 33.2 – 40.5 and 38.4 – 47.2 mm in ♂♂ and ♀♀, encompassing those from Corvo of 34.1 – 39.3 and 40.9 – 46.2 mm, respectively.

These results indicate that the smaller size of individuals inhabiting Corvo is not determined genetically but rather by harsher environmental conditions curtailing the development of their larvae. A sample of both wild caught and reared imagines from both islands are illustrated in plate 3, from which the size differences and similarities described above can be seen clearly.

Wing colour patterns : From this plate it can also be seen that the colour and patterns of both the uppersides and undersides of the wings in both ♂♂ and ♀♀ from Flores and Corvo are very similar, whether they are caught in the wild or reared. However, the proximal white zigzag markings on the underside hindwings are particularly well developed in some specimens, for example in figs 1, 3 and 4 (♂♂ from Flores), figs 7-10 and 17-20 (♂♂ and ♀♀ from Corvo, respectively) and also in many of the freshly emerged specimens figured in plates 1 and 2. Further examination, with respect to this feature, of all the material available to P.R. from both islands indicated that it varied in intensity both within and between populations on Flores, being particularly strongly marked in individuals of both sexes from the Moro Alto and Caldiera Rasa but only very weakly so in those from Pedrinha. However, this white zigzag feature was well marked in individuals from both the populations, for which material was available, in Corvo : Lomba Redonda on the west side and Junco Queimada on the east side of the crater rim.

Androchionial scales : another feature common to the ♂♂ of all the *azorina* populations examined from both Flores (OEHMIG, 1983) and Corvo is the

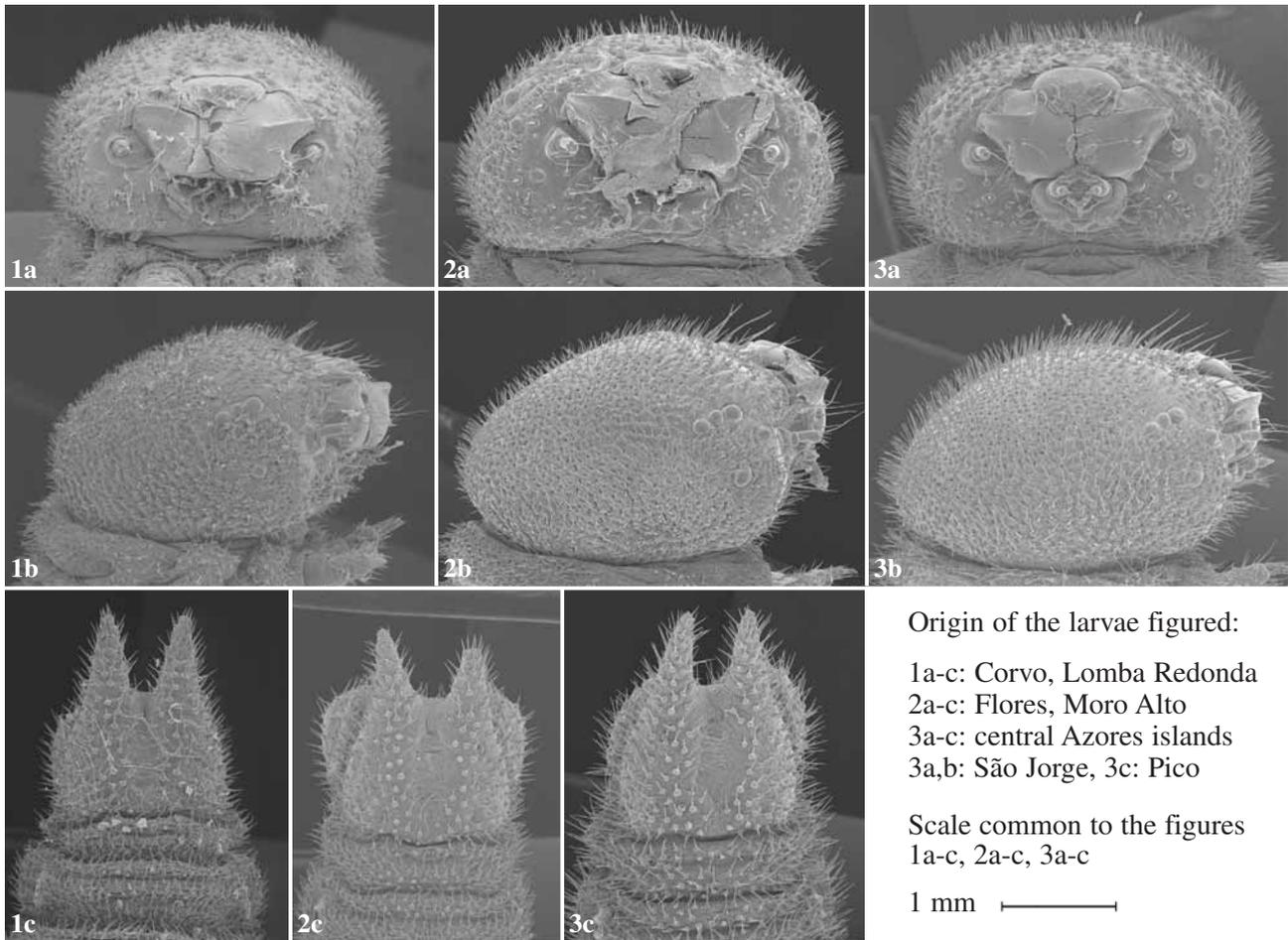
FLORES				CORVO			
Wild		Reared		Wild		Reared	
♂♂	♀♀	♂♂	♀♀	♂♂	♀♀	♂♂	♀♀
38.7	44.1	39.6	44.5	33.3	38.8	39.3	40.9
36.9	43.8	40.5	44.6	32.1	38.9	37.2	46.2
38.3	40.4	39.8	46.7	32.3	37.4	34.1	46.1
39.5	44.5	39.2	45.3	33.0	38.2	38.9	41.9
37.9	44.4	39.5	47.2	35.5	39.8	37.1	44.5
40.8	46.6	33.2	42.2	34.2	36.3	37.4	
38.5	45.2	35.4	41.4	34.4	36.9	38.1	
37.3	41.7	34.1	41.6	32.8	44.0		
38.5	40.8	34.9	41.3	35.5	44.8		
38.1	40.1	34.6	43.4	32.4	43.1		
35.9	40.5	33.6	41.8	34.3			
34.5	47.9	37.1	40.2	37.5			
35.7	46.9	36.7	42.5	39.0			
37.2	44.1	36.3	43.2	37.3			
36.4	43.4	33.7	39.9	38.0			
35.3		37.0	38.4				
36.3		36.8	42.1				
		36.6	42.8				
		37.9	41.3				
		37.8	43.9				
		35.8	41.9				
		36.0	44.9				
		37.9	41.6				
		37.3	44.1				
		36.8	40.5				
			43.7				
			41.9				
			41.9				
			43.7				
			44.9				
			42.2				
			43.8				
			44.3				
n = 17	n = 15	n = 25	n = 33	n = 15	n = 10	n = 7	n = 5
34.5	40.1	33.2	38.4	32.1	36.3	34.1	40.9
40.8	47.9	40.5	47.2	39.0	44.8	39.3	46.2
37.4	43.6	36.7	42.8	34.7	39.8	37.4	43.9

TABLE 1 : wingspan in mm of wild caught and reared ♂♂ and ♀♀ originating from Flores and Corvo. [Bold figures : minimum and maximum wingspans measured (upper and middle lines, respectively) and mean wingspan (bottom line, shaded) : n = number of specimens measured in each group.]



PLATE 3 : figs 1-5 : imagines of taxon *occidentalis* from Flores, Pedrinha 725 m ; figs 6-10, 16-20 : imagines of taxon *minima* from Corvo, Lomba Redonda 440 m ; sex and dates of capture or emergence of wild caught or reared specimens (shaded), respectively, indicating their captor or rearer.

♂	8.8.04 PR	♂	8.8.04 PR	♂	21.6.05 PR	♂	8.6.05 DJ
♂	14.8.03 PR	♂	15.5.05 PR	♂	25.6.05 DJ	♂	13.6.05 PR
♀	8.7.04 PR	♀	16.7.05 PR	♀	28.5.05 DJ	♀	2.7.05 PR
♀	3.8.03 PR	♀	14.8.03 PR	♀	16.6.05 PR	♀	16.6.03 PR
♂	7.7.05 PR	♂	5.6.05 PR				



Origin of the larvae figured:

1a-c: Corvo, Lomba Redonda

2a-c: Flores, Moro Alto

3a-c: central Azores islands

3a,b: São Jorge, 3c: Pico

Scale common to the figures

1a-c, 2a-c, 3a-c

1 mm —————

Figs : 1/2/3a-c : head in ventral (a) and lateral view (b) and abdomen in dorsal view (c) of adult larvae of *minima*, *occidentalis* and *azorina* from the islands of Corvo (1), Flores (2), São Jorge and Pico (3), respectively. The hairs of the larvae from the two western Azores islands (1 and 2) are on average shorter and less dense than those of the larvae of central island populations (3).

Photographs by scanning electron microscope : Urs JAUCH

complete absence of androchional scales on the forewings (plate 3). This feature is shared by the majority but not all of the specimens examined from the two populations on Terceira (the taxa *barbara* and *borgesii*): the presence of androchional scales can be seen in figs. 1 and 5 in plate 7 (*barbara*) and figs. 3 and 8 in plate 8 (*borgesii*) of part 2.2, in the remainder of the figured ♂♂ from the Terceira populations they appear to be absent in both, wild caught and reared specimens.

Genital armatures: the genitalia of the two westernmost populations of the *azorina*-group are distinguishable from those of the central Azores island populations by their small size, thus making their preparation more difficult. To illustrate this numerically in ♂♂, the distance between the top of the uncus and the “back” border of the tegumen was measured in some of the photographed preparations of genitalia of wild caught specimens originating from both the two western islands (see plate 4) and the central Azores islands (see part 2.2, figures pl. 11); the measurements were made using the millimetre scale netting visible beneath the gen-

italia. The ranges of measurements and their means were as follows: 1.54–1.62 mm (mean 1.6 mm) for six specimens from Flores: 1.56–1.65 mm (mean 1.59 mm) for four specimens from Corvo: 1.67–1.83 mm (mean: 1.74 mm) for the twelve specimens originating from the central Azores islands. From these measurements it can be seen that the mean distance extending from the top of the uncus to the back border of the tegumen is very similar in specimens from Flores and Corvo but some 9% greater in specimens from the central Azores islands. No significant differences in ♀ genitalia were found between specimens from Flores, Corvo or the central island populations.

Conclusions reached from this study

Undoubtedly an examination of the early stages of the Macaronesian *Hipparchia* species has been of assistance in establishing their taxonomic status. In order to study the early stages it was necessary to rear the butterflies in parallel under ‘laboratory’ conditions and an examination of the resulting

♂♂ genitalia of *Hipparchia occidentalis*

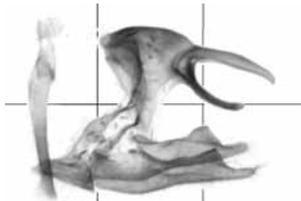


Fig. 1: Flores (902).

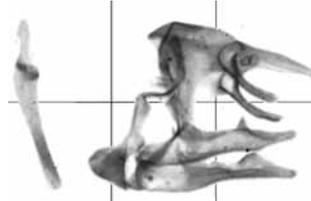


Fig. 2: Flores (904).

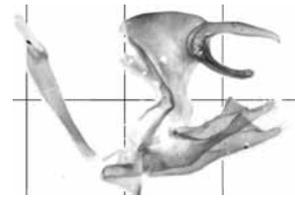


Fig. 3: Flores (905).

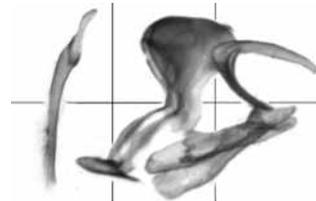


Fig. 4: Flores (906).

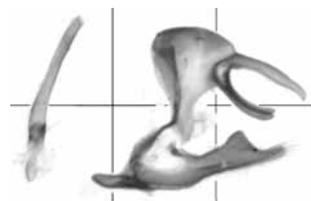


Fig. 5: Flores (908).

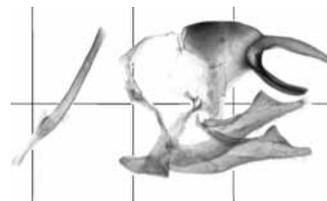


Fig. 6: Corvo (1281).

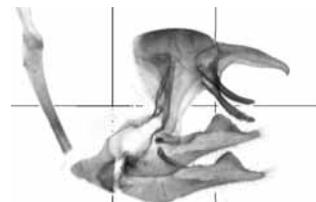


Fig. 7: Corvo (1283).



Fig. 8: Corvo (1284).

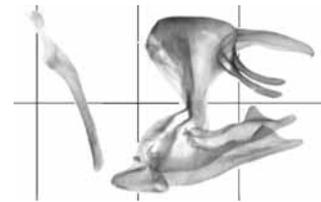


Fig. 9: Corvo (1285).

♀♀ genitalia of *Hipparchia occidentalis*



Fig. 10: Corvo (1287).

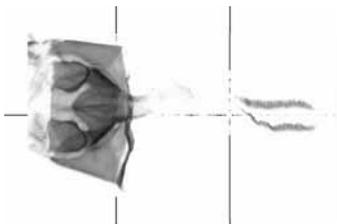


Fig. 11: Corvo (1288).



Fig. 12: Corvo (1289).



Fig. 13: Corvo (1290).

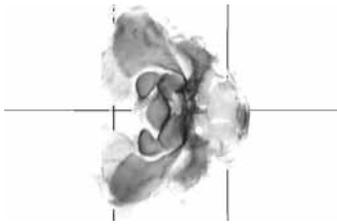


Fig. 14: Flores (1279).

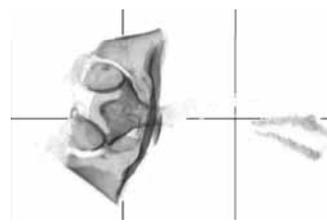


Fig. 15: Flores (1277).

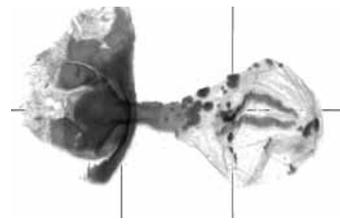


Fig. 16: Flores (910).

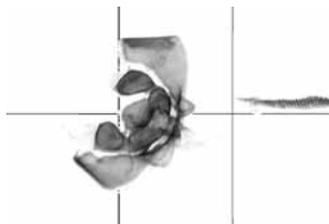


Fig. 17: Flores (1278).

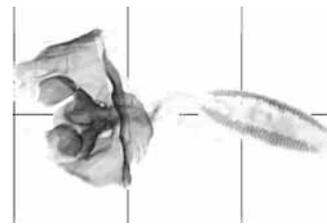


Fig. 18: Flores (1280).

PLATE 4 : genital armatures of both sexes of wild caught individuals (all *leg.* P. RUSSELL) of the taxa *occidentalis* from Flores (1,5 km N. of Pedrinha, 720 m, 12.VIII.03) and *minima* from Corvo (Lomba Redonda, 420-460 m, 13/14.VIII.03).

Scale : sides of the squares = 1 mm.

Preparation, photographs and layout by G. VOLPE

imagines has proved also to be of considerable value in assessing whether or not certain island populations deserve to be separated, be it at specific or sub specific level.

H. maderensis has been considered to be a subspecies of *H. algerica* by KUDRNA (1977), of *H. aristaeus* by TOLMAN (1997) and by other authors as a separate species (e.g. OLIVIER & COUTSIS, 1997 and MEYER, 2003). Although the ovum of *maderensis* was of similar size to those of S. European *semele*, it had a more pronounced chorion structure. The larva of *maderensis* was rather similar to that of *semele* from Southern England having a light brown head, as distinct from those of the S. European *semelelaristaeus* group which have contrasting darker heads. The most striking feature, which set *maderensis* larvae apart from all the others of the *semelelaristaeus* group, was the extreme slenderness of their pointed anal extremities and the prominent processes on their mandibulae. For these reasons together with the more pronounced chorion structure of its ovum we have concluded that the taxon *maderensis* should be given specific status.

H. miguelensis was sunk in synonymy under *H. azorina* by KUDRNA (1977), treated as a semi-species of the superspecies *H. azorina* by OLIVIER & COUTSIS (1997) and MEYER (2003), given subspecific status by LE CERF (1935), accepted as a full species by OEHMIG (1983) and TOLMAN (1997) and further divided into the two subspecies *miguelensis s.s.* and *borgesii* by TENNENT & BÍVAR DE SOUSA (2003). This study has shown that the populations of *miguelensis* on São Miguel can almost invariably be separated from *H. maderensis* by their wing patterns alone, e.g. the absence of orange triangles on the upperside of the hindwings, especially in the ♀♀, the larger brighter yellow markings on the their forewings and the presence of a slimmer but well defined white zigzag marking on the discal area of the underside of their hindwings in both sexes (part 1.1, pl. 7, p. 299/300). However, some of the wing characters chosen as definitive by OLIVIER and COUTSIS (1997), e.g. shape of the forewing apex and its outer margin are not supported by this study. These authors stated (p. 235/6) that the forewing apex was distinctly pointed and the outer margin convex in *miguelensis* whereas in *maderensis* the opposite was the case. From an examination of the *miguelensis* specimens represented in plate 7 of part 2.2 as figs 9 (♂) and 14 (♀) and of those of *maderensis* shown by figs 17 (♂) and 20 (♀) it can be seen that, in these specimens, the complete reverse is true : these characters are thus not absolutely definitive and as has been stated previously wing shapes, patterns and

colours are so variable as to make a definitive identification almost impossible. However, several characters in the preimaginal stages of *miguelensis* from São Miguel differ significantly from those of the *azorina* group populations occupying the central islands of the archipelago. **The ovum** in *miguelensis* from São Miguel is taller, has more ribs and the chorion is a yellowish white with no coloured ornamentation (part 1.1, p. 296, figs 12a,b), whereas those of the *azorina* group occupying the central and western islands are more squat, have on average fewer ribs and the chorion is beige-grey in colour and covered with violet spots. OEHMIG (1983, p. 151, table 1) suggested that the number of micropyles differed significantly between *miguelensis*, *azorina* from Faial and *occidentalis* from Flores (named by OEHMIG as *caldeirensis* - a junior subjective synonym of *occidentalis*), being 3, 4 and 2, respectively. Using the SEM photographs (plate 4), D.J. counted the micropyles of 5 ova of *H. miguelensis* from São Miguel, 4 of *azorina* from Faial, 1 of *barbara* from Terceira and 5 of *occidentalis* from Flores. All of these taxa had ova with a variable number of micropyles (legend of plate 5). In *occidentalis*, some of the micropyles were rudimentary (*i.e.* not open). Therefore we have to conclude that micropyles do not represent a definitive character. **The larvae** of *miguelensis* from São Miguel have almost invariably a bright ground colour with only a slightly contrasting pattern and never having light yellowish white sub-dorsal lines on a dusky ground, which are found in the *azorina* group populations from the central islands. Also the larva of *miguelensis* is densely covered in short hairs, whereas those of *azorina* from the central island group are more sparsely covered in longer hairs with broader bases. We consider that these differences in both ova and larvae suggest that the taxon *miguelensis* from São Miguel warrants separation at species level (*).

The taxon *borgesii* was described by TENNENT & BÍVAR DE SOUSA (2003) as new subspecies of *H. miguelensis* from the island of Terceira, based mainly on the work of FUJACO (2000), who carried

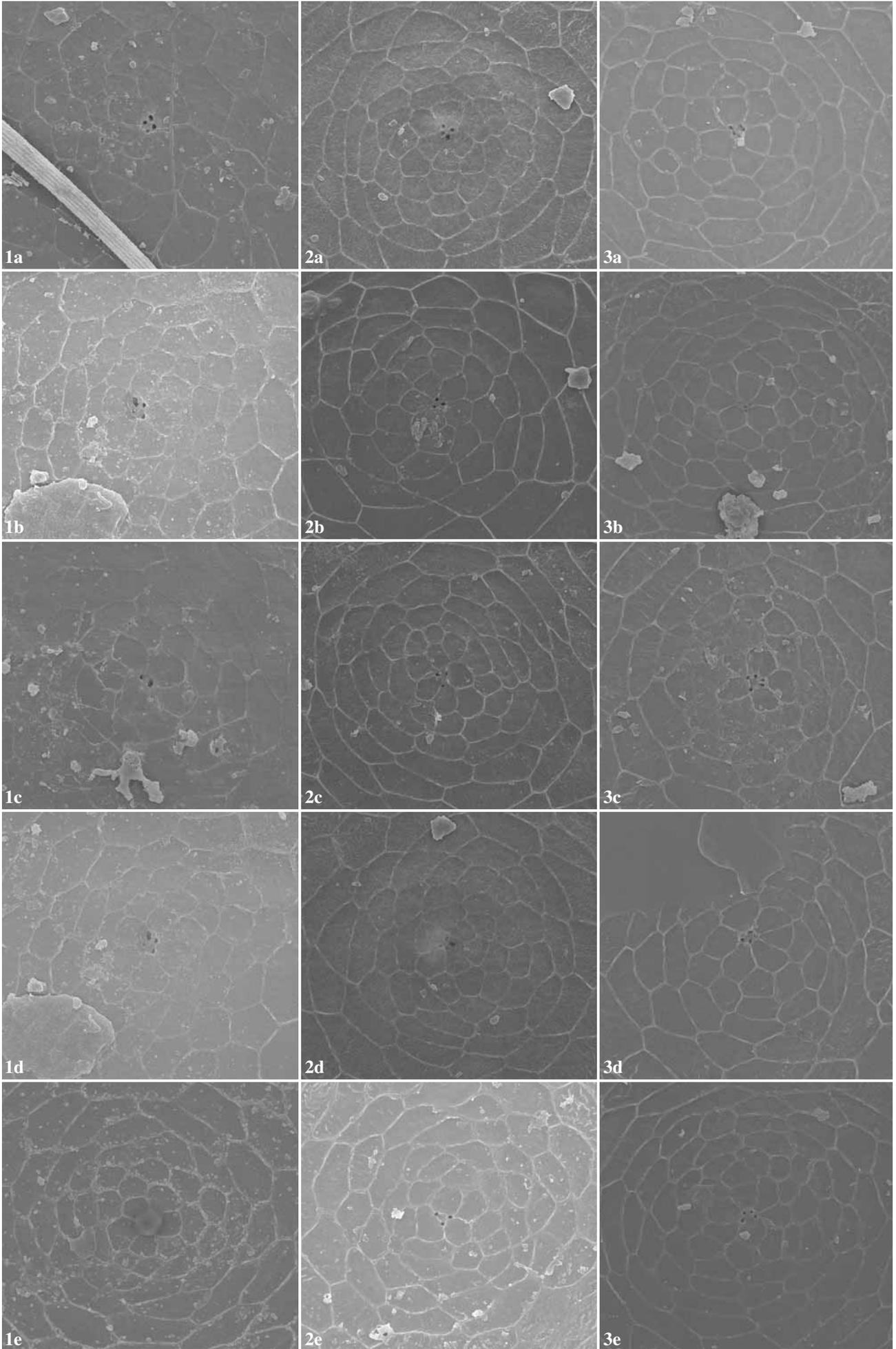
(*) FUCHS (1999) reared in parallel livestock from São Jorge and São Miguel. In June 1995, he placed a fresh ♀ *H. azorina jorgense* with a two day old ♂ *H. miguelensis* in a netted cage in a sunny window and observed copulation. 30 ova were produced by the ♀ during the following days and reared to imagines. Some butterflies emerged in October/November and the others in May/June 1996. The resulting hybrid imagines were of transitional appearance but tended more towards *jorgense*. When these hybrids were caged in a similar manner, no copulation was observed, from which this author concluded that *H. azorina* and *H. miguelensis* were different species.

Magnification common to all of the figures: 500 x

São Miguel (1a-e)

Faial (2a-d), Terceira (2e)

Flores (3a-e)



out mitochondrial DNA analysis on samples of all the island populations of *H. azorina s.l.*, including the newly discovered population near Pico Alto on Terceira (subsequently named *borgesi*). His results indicated that this population was genetically allied to *H. migueleensis* as opposed to its geographically nearest neighbour on Terceira, the taxon *barbara*. TENNENT & BIVAR DE SOUSA (2003) were unable to find any constant differences in wing shape, colouring or pattern between the taxa *borgesi* and *barbara*: the only difference found was one of size. It was established that this apparent difference disappeared when the two taxa were reared in parallel (part 2.2, table 2, pl. 7,8).

No differences were found in the early stages of these taxa, both being related to the other central island populations, their ova, larval hair density and length all being similar. It was also noted that none the ♀♀ from São Miguel nor those from all the central island populations were able to affix their ova, **except** those from the two Terceira populations (part 2.1, p. 11). Neither ♂ nor ♀ genitalia of *borgesi* exhibited any differences from those of the other central island populations but were different from those of *migueleensis* from São Miguel (part 1.2, pl. 8,9 and part 2.2 pl. 11,12). Thus all our results are clearly at odds with those of TENNENT & BIVAR DE SOUSA (2003) and, although we are unable to comment on the results of FUJACO (2000), we find ourselves with no option but to sink *H. migueleensis borgesi* TENNENT & BIVAR DE SOUSA (2003) in synonymy with *H. azorina barbara* BIVAR DE SOUSA (1985).

The origin of the type specimen of *H. azorina* STRECKER 1899 is given simply as 'Azores' with no island name indicated. For figures of the Holotype see OLIVIER & COUTSIS (1997 : 168) or TENNENT & BIVAR DE SOUSA (2003 : 15). The type locality has been ascribed by different authors to two of the central group islands : Pico, suggested by OEHMIG (1983 : 139), based on wing characteristics, and Faial suggested by BIVAR DE SOUSA (1982 : 207), based on the fact that in the late 19th century, Horta harbour on Faial was used extensively, in preference to Pico, by ships crossing the Atlantic, making

it far more likely that the specimen originated from Faial. Since we have been unable to find any distinctive characters to differentiate between the populations of these two islands, we accept that, although its origin will most probably never be defined, it is most likely to have come from Faial and this has formed the basis of the nomenclature used in the study.

All the **central island populations** have **ova** of a very similar size, their average heights varying between 0.9 and 1.1 mm, with taxon *barbara* being the smallest and similarly sculptured, having an mean number of ribs between 19.7 in *borgesi* and 24.2 in *azorina s.s.* They were consistently smaller and had, on average, fewer ribs than that of *H. migueleensis*, which was also of a different colour (part 1.2, figs 11a,b and 14a,b ; part 2.1, p. 7-14). The **larvae** of all the central island populations were very variable in colour but were all fairly similar, being less densely covered in long hairs with broad bases compared with the caterpillars of *migueleensis* (part 2.1 pl. 5, 6). The similarity of the early stages of all the central island populations warrants the taxa *azorina s.s.*, *picoensis*, *jorgense* and *barbara* being grouped as a single species, under the name *H. azorina*. The imagines from **Pico** are almost identical in size, wing colour and pattern and no differences were found in the genitalia of both ♂♂ and ♀♀, consequently we suggest that there is no justification for the subspecific division of the population on Pico and follow OLIVIER & COUTSIS (1997) in considering the taxon *picoensis* as a junior synonym of *H. azorina*. In contrast the imagines from **São Jorge** do exhibit some distinctive wing pattern and colouration : the yellow circles surrounding the two dark ocelli, which are invariably present on the upperside of the forewings, are brighter in tone. Also the pale zigzag markings on both the uppersides (yellowish in colour) and undersides (white in colour) of the hindwings are somewhat wider, more conspicuous and more clearly demarcated from both the distal and especially the proximal darker areas of the wing in both reared and wild caught butterflies from both populations on São Jorge. Also the androchional scales of the ♂ butterflies from São Jorge differed from those of the other central island populations (OEHMIG, 1983). We follow MEYER (1991) and TOLMAN (1997) in accepting the taxon *jorgense* as a subspecies of *H. azorina*. In contrast, OLIVIER & COUTSIS (1997) sunk it in synonymy with the taxon *occidentalis*, basing this on similarities of wing colour, the lack of a conspicuous sex brand and having fewer androchional scales than typical *azorina*. MEYER (2003) followed OLIVIER & COUTSIS (1997) without further elucidation.

←

PLATE 5 : micropylar area of 15 ova belonging to 4 different populations of the *azorina* complex. The number of micropyles for each ovum, rudimentary micropyles in parenthesis, was as follows :

column 1 : *migueleensis*, São Miguel 4/4/2/4/0 micropyles :

column 2 : *azorina*, Faial : 4/3/3/4 : Terceira, Santa Bárbara : 3 micropyles :

column 3 : *occidentalis*, Flores : 5/2(2)/5/3(2)/4 micropyles. Photographs by SEM : Urs JAUCH

The two populations on **Terceira** have been grouped under the taxon *barbara* and it is considered that, since their ova and larvae are similar to those of the other central island populations, they must be placed under *H. azorina*. However, since Terceira ♂♂ have very few if any androchonia scales and their ♀♀ are able to adhere a large proportion of their ova to a substrate (part 2.1, p. 11), differing in this respect from all other central island populations, we consider that the populations from Terceira should be given subspecific status under the name *H. azorina barbara*. This again follows MEYER (1991) and TOLMAN (1997) but not OLIVIER & COUTSIS (1997), who sunk the taxon *barbara* (the only population known from Terceira at that time) in synonymy, again with *occidentalis* for the same reasons as for *jorgense*; MEYER (2003) also followed this taxonomic grouping without comment.

The populations inhabiting the **western islands** of Flores and Corvo have several features in common and also exhibit features which distinguish them from those of the central group: firstly their larvae are more densely covered with shorter hairs with finer bases (part 2.1, figs. 3,4), in this respect being similar to those from São Miguel, secondly the complete absence of a sex brand and androchonia scales in the ♂♂ and, thirdly, a marked tendency towards an underside hindwing pattern which differs from those imagines of the central island populations. It has been demonstrated that there is a tendency towards the presence of a clearly demarcated white zigzag band in the proximal area of the hindwing underside in some, but not all, populations on Flores and in both populations studied on Corvo. Since the genitalia in both ♂♂ and ♀♀ of *occidentalis* and *minima* are much smaller relative to the size of their imagines than those of any of the other *Hipparchia* populations under consideration and the larvae of both taxa differ from those of all the central island populations in the same manner as those of *H. miguelensis* then they must be considered to have the same taxonomic status. Therefore we propose to follow MEYER (1991) and TOLMAN (1997) in giving specific status to these populations under the name *H. occidentalis*, which predates the name *caldeirensis* OEHMIG, 1983, which was used erroneously by TOLMAN (1997). It has been shown that the smaller size of the imagines from Corvo evident in the wild is negated by rearing them under less harsh conditions. However, the fact that they are unable to attach their ova and have a greater tendency, especially when fresh, to have a bright white proximal zigzag mark on their underside hindwing, makes them different enough from the population on Flores to retain their subspecific status, *H. occidentalis minima*.

A summary of the taxonomy of the Macaronesian *Hipparchia* species from Madeira and the Azores, together with their distributions is given below:

Hipparchia maderensis BETHUNE-BAKER 1891, restricted to Madeira.

Hipparchia miguelensis LE CERF 1935, restricted to São Miguel.

Hipparchia azorina comprising three ssp.:

- *azorina* STRECKER 1899, inhabiting both Faial and Pico;

- *jorgense* OEHMIG 1983, restricted to São Jorge;

- *barbara* BIVAR DE SOUSA 1985, restricted to Terceira and comprising all known populations known from this island.

Hipparchia occidentalis comprising two ssp.:

- *occidentalis* BIVAR DE SOUSA 1982, restricted to Flores;

- *minima* BIVAR DE SOUSA 1985, restricted to Corvo.

Conservation of *Hipparchia* sp. in Madeira and the Azores Archipelago

Much has been published recently on the need for conservation of Western Palaearctic butterflies. VAN SWAY and WARREN (1999) published the Red Data Book of European Butterflies, in which all four *Hipparchia* sp. under consideration are listed (p. 31: table 4) under the highest category of: 'Species of global conservation concern' (SPEC 1). All the information provided on these species is referenced to MEYER (1993) and it seems clear from an examination of the content that no other entomologist has been involved in the compilation of the data. The 'status' of these species is given a 'trend class' (pp. 197-200) as follows: *H. maderensis* as 'decrease of 15-25%' and the three Azorean species as 'decrease 25-50%'. These decreases were not mentioned by MEYER (1993), who visited Madeira twice: in May 1989 and July 1991 and made a single visit to the Azores in July/August 1990. Therefore, he will probably not have observed each of these species more than once (it would have been extremely unusual for *H. maderensis* to have been flying in May), making it difficult for him to have made such a diagnosis.

More recently VAN SWAAY and WARREN (2006) mapped (p. 8, fig. 2) 431 prime butterfly areas of Europe (PBAs), which included 8 sites in the Azores and 1 in Madeira: the overall abundance trends of the 34 'target species' in the PBAs were also reported (p. 9, table 2). The four *Hipparchia* species under investigation were included and it can be seen that for both *H. azorina* and *H. occidentalis* their 'status' is 'unknown', whereas those for *H. maderensis* and *H. miguelensis* are given as 'stable'. These abundance trends do not seem to equate to the data given in their Red Data Book of 1999. Has the status of these two endemic butterflies really changed so dramatically since 1999?

VAN SWAAY *et al.* (2006) gave a list (p. 193, table 5) of numbers of species threatened in each CORINE biotope [for details of CORINE biotopes see MOSS *et al.* (1991)] but the 3 Azorean *Hipparchia* species have been specifically excluded, without reason being given, but the authors do say that they "...are mentioned for agricultural land and artificial landscapes...". The most probable reason for their exclusion would seem to be that neither 'agricultural land' nor 'artificial landscapes' feature in their list of biotopes given in the aforementioned table. Most unfortunately, for the purpose of this discussion, Portugal (and hence the Azores ?) was not one of the countries selected for the calculation of trends of specialist butterflies. However, from appendix 1 (pp. 198-207) it can be seen that all populations of the 3 Azorean *Hipparchia* sp. occupy 'heath and scrub' and 'mesophile grasslands' and *H. maderensis*, a combination of 'dry siliceous grasslands, coniferous, mixed and evergreen broadleaved woodlands and volcanic features'; this latter habitat class was not included for the Azorean species, whose habitat is typified by this feature.

We have already questioned whether or not the population status of *Hipparchia maderensis* and *H. miguelensis* improved significantly between 1999 and 2006. The fact that the status of the other two Azorean species was given as 'unknown' might appear at first site to be worrying. However, since the data upon which the previous apparent dramatic decline of all four species given by VAN SWAAY and WARREN (1999) was based, appears to be completely lacking, then the category 'unknown' very aptly sums up the published knowledge of the *Hipparchia* populations on Madeira and the Azores. P.R. has visited the Macaronesian islands during the flight period of the *Hipparchia* sp. on many occasions (Madeira : 4 times between 1993 and 2003 ; Azores : 6 times between 1997 and 2004) and consequently has gained at least some insight into the fluctuations of the populations of the species under consideration.

Dealing first with *H. maderensis* where the habitats on Madeira consist primarily of open grassland with very little scrub and clearings in the forests (part 1.1 : p. 201 ; pl. 1, fig 11 and pl. 4, fig. 15) with an altitude range of between *c.* 800 and 1700 m. Many of the areas concerned are currently unused and thus unmanaged, *e.g.* the many hectares of open grass-land, encompassing Campo Piqueno, Lombo do Mouro and Paul da Serra, form an ideal habitat, where the grass grows well in the spring (at larval feeding time) but dries out completely in the summer, nectar is provided by brambles (*Rubus* sp.), which are common around

the perimeter of the habitat. The population just in this one area probably contains hundreds of thousands of individuals. For example, it was not possible to walk along the verge of the road which runs through the northern part of the habitat, without clouds of butterflies rising from the dry grass and many were killed on the road, as they basked on the tarmac warmed by the early morning sunshine. Another strong population is situated in a similar habitat lying to the south of Pico do Areeiro, in which the Parque Ecológico da Madeira is situated. Although the park area is to some extent 'managed' (*e.g.* the original road through it has been closed to the public for some years now), little is done to 'conserve' it and the whole area surrounding the park appears very similar and contains a huge population of *maderensis*. It is the smaller populations in the scattered forest clearings, which are liable to disturbance from forestry activity (felling and replanting). However, as soon as suitable conditions return, *maderensis* can easily recolonise from the surrounding populations. We consider it most unlikely that numbers of *H. maderensis* declined by 15-25% in the years prior to 1999 ; there was no reason for such a decline as its habitats remained virtually untouched. Neither do we think that it is particularly vulnerable, other than from further volcanic activity : its main population centres are most unsuitable for any activity which might disturb them (*e.g.* agriculture, forestry or urbanisation), the future upgrading of roads for tourism, even through their main habitats is unlikely to have any major impact.

On the Azores the habitats of all three species of *Hipparchia* are very similar to one another, being very wet mesophile grasslands on a base of peat and they could almost be considered as 'bogs', being shrouded in mist or low cloud for much of the time, even in the summer. The populations of *H. miguelensis* on São Miguel, the driest of the islands, are distributed on the higher ground throughout the island (habitat descriptions see part 1.1, pl. 1, fig. 9 and p. 208). In general terms the populations are more dense at higher altitudes in the more open, wetter areas with little scrub and no trees but near to the precipitous rims of craters, where the ♀♀ prefer to oviposit into their host-plant, *Festuca jubata*. Many of the areas inhabited

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PLATE 6 : 1 : São Miguel : Sete Cidades, Lagoa Azul and L. Verde from the crater rim ; 2 : Flores : Caldeira Comprida below Pico dos Sete Pés ; 3 : Corvo : the western slopes of Caldeirão in the mist ; 4 : Terceira : the invasive Ginger plant *Hedychium gardnerianum* (Zingiberaceae).

Photographs : John TENNENT



by *miguelensis* are utilised for grazing dairy cattle but their influence on the population seems to be minimal ; however the population in the well forested Serra da Trocqueira is much more restricted and this habitat now appears rather unsuitable. We suggest that the overall number of individuals has not radically altered during recent years but consider that forestation on a large scale could cause a decline in numbers : even so the species would certainly survive around the crater rims where tree planting is impractical. Urbanisation and tourism are hardly a threat. Although a hotel was built above Sete Cidades, it is currently unused. On a clear day the view of the lakes is stunning (pl. 5, fig. 1) but who wants to spend their holiday at a hotel, which is usually enveloped in mist ? We dispute the figure of a 25-50% decline in the past and consider that the population is currently stable and not endangered.

The habitats of *H. azorina* on the central group islands have been described previously (parts 1.1, 2.1 & 2.2 of this article) but a brief comment about possible threats to the populations on each island will be given. As has been stated the population on **Faial** is restricted to the rim of the single crater, with the majority of the population on the south side around Cabeço Gordo ; here the site is often shared with grazing dairy cattle, which tend to keep away from the wetter areas preferred by the ♀♀. Tourists come up to view the crater from the SE, using the only tarmac road reaching the rim : a small tunnel has been constructed for people to reach the edge of the crater just beneath its rim and, if they are lucky, they see the small lakes and cones at the bottom. However, usually the whole area is shrouded in mist and almost nothing can be seen. Very occasionally, when weather permits, some tourists may walk around the rim using the track but any disturbance to the butterfly habitat is minimal. On **Pico** the butterfly population is far more spread out and occupies most of the higher ground along the central spine to the east of Ponta do Pico. Although the island is circumnavigated by a tarmac road with a connecting road across the middle, the only way to reach the bulk of the habitat is by a volcanic ash track, along which cattle are driven from one area of pasture to another. Once again the cattle tend to avoid the steep slopes and wetter areas with standing water favoured by the butterflies. Tourists very rarely reach this area and pose no threat. The only problem for the butterflies is that the resident Wagtail, *Motacilla cinerea patriciae* VAURIE, 1957 (endemic ssp.) has learnt that the most productive way to hunt for food is by following a browsing cow, which will often flush butterflies from the grass, the Wagtails immediately give

chase and are usually successful ! P.R. found by chance two nests very close to *H. azorina* populations and it is thought that this Wagtail is probably the only regular predator of adult butterflies.

On **São Jorge** the situation is similar with the butterfly populations occupying the higher ground along the central chain of extinct volcanoes, with grazing cattle sharing their habitat, and the main centres of human habitation along the coastal strip. Once again tourism is not a problem, the area is totally unsuitable for urbanisation and forestry activity is not evident. On **Terceira** the two centres of population of *H. azorina* are separated by a narrow strip of unsuitable habitat. The lower and middle more sheltered slopes of Serra de Santa Bárbara are forested but the top most area around the old Wireless Telegraph station, occupied by the butterflies, is very probably unsuitable due to the high winds, which are almost invariably present. The occasional tourist braves the elements and admires the view, if there is any, and there rarely is ! The population of Serra Lapaçal around Pico Alto and Alagadiços is only accessible via ash roads and tourists have no reason to visit this area, although they do come to the bottom of the track to view the fumaroles. The whole area is most unsuitable for urbanisation. Aforestation appears to be the only potential problem in the Serra Lapaçal, the area near Alagadiços has already been planted but the growth of the saplings has been very slow (Paulo BORGES, pers. com.) and it is possible that this will deter future planting in this area. We dispute the 25-50% decline in the past and consider that the butterfly population is stable and thriving in suitable habitat.

The western islands of Flores and Corvo are by far the wetter of the Azores islands and thus the habitat of *H. occidentalis* are found at a much lower altitude than on the other islands. On **Flores**, in 1999 the butterflies could be found down to c. 350 m along the main road above Santa Cruz das Flores, particularly in cuttings through small hills where the stems of *F. jubata* growing on the steep banks hung down covered in moisture : such places of course resemble the sides of craters, their natural habitat. However, in 2002 following an extremely dry spring when almost no rain fell in April or May, no imagines were found at these lower elevations, they were only to be found above 700 m around Moro Alto and Sete Pés (pl. 5, fig. 2), where even the normally wet and spongy Sphagnum moss had become brittle and crumbly. We suspect that the larvae can not tolerate such dry conditions and desiccated before they were fully fed and ready to pupate. This catastrophic (for the *occidentalis* population on Flores at least) meteor-

logical event far outweighed any potential dangers to the species from human activity. In fact a new ash road was been constructed near Moro Alto in 2002/3 but its use seems to be restricted to the driving of cattle and it has had no visible effect on the butterfly population. Normal levels of rainfall returned during the Springs of 2003 and 2004 and, although during P.R.'s visits in August of those years the weather was still inclement enough to prevent any observations in the central region, *occidentalis* was found down to at least 550 m on the slopes of Pedrinha in the south of the island : thus it would appear that the butterfly was beginning to recolonise those areas from which it had been lost due to the drought.

The drought was not so evident on **Corvo** (pl. 5, fig.3), the wettest of all the islands, and *occidentalis* was found down to 400 m on the western slopes of the Caldiera in August 2002 (TENNETT, pers. com.), 2003 and 2004. Once again the habitat is shared with grazing cattle but they appear to have little influence on the numbers of butterflies present. There is no forestry activity on the island, very little tourist interest (except for scuba diving) and urbanisation is very unlikely to impinge on the habitat. We consider it most unlikely that the populations on Flores and Corvo had declined by 25-50%, prior to 1999, it was thriving even at low levels : however, we do concede that the population on Flores could well have been depleted by 50% in 2002 due to the drought but this, of course, was not due to any human activity and no amount of 'conservation' could have averted this disaster. The population was recovering in 2003/4 and thus can be said to be currently 'increasing', admittedly from a reduced level.

As far as the three *Hipparchia* species which occupy the Azores archipelago are concerned, it is considered that numbers have not declined over the past 10 years as a result of any human activity. The only observed population decline, that of *occidentalis* in Flores, has been the result of meteorological conditions and here the population appears to be recovering. As for the need for conservation, it would seem most unlikely that urbanisation or tourism will pose any threat in the foreseeable future. Very few people would want to live in or even visit such inhospitable places. The grazing of dairy cattle to produce milk for cheese and butter production is the main agricultural activity ; the cattle are generally milked 'on site' by using mobile milking machinery, which avoids the necessity to move herds over long distances for milking. On Corvo, the use of a three legged milking stool is still much in evidence, however, it is suspected that this may now be short-lived ! Both the physical and

chemical results of grazing by cattle, *i.e.* the eating of the host-plant and over nitrification of the soil, respectively, could obviously have an effect on larval and pupal survival rates but, since the plants upon which the larvae feed and pupate tend to be those on precipitous ground, this is unlikely to have much of an effect on the population, even in the long term. Another activity which could pose a threat is forestry. On Flores and Corvo there is almost no forestry. On Faial, Pico, São Jorge and the Serra de Santa Bárbara area of Terceira the habitat is totally unsuitable and there are almost no naturally occurring trees on the upper boggy areas, which form the main habitats of *azorina*. In Serra Labaçal the population has so far remained unaffected by tree planting. However, there is no doubt that if the habitats of the butterfly were to be forested, their numbers would decline dramatically as the trees matured, as appears to have happened in Serra da Troqueira, where the butterflies are found only at low density compared to the unplanted areas nearby.

There are two invasive plants, which have become naturalized in the Azores and are causing a problem to the endemic flora : *Pittisporum undulatum* VENT. (originating in S.E. Australia), which is found throughout Madeira and the Azores, and *Hedychium gardnerianum* SHEPPARD ex KERGAWLER (originating in the Himalayas), found in Madeira and all of the Azores except Corvo (SJÖGREN, 1984). The former species is very resistant to salt winds and was introduced long ago, probably for the protection of Orange groves : it is found especially on larva flows below 500 m and therefore should not directly effect the populations of *Hipparchia* sp., except possibly on Flores and Corvo, where the butterflies may occur below this level. However, *H. gardnerianum* (pl. 5, fig. 4), which was introduced as an ornamental garden plant in the middle of the 19th century, is having a very serious impact on the Azorean laurel forest : where it has been cut down regeneration is completely checked (SJÖGREN, 1984). It has become well established, particularly on São Miguel, in the laurel-juniper forests, and it is found up to 700 m on Faial and about 850 m on Pico (P.R., pers. obs.), very close to those areas occupied by *H. azorina*. This plant's sheer height (up to 2 m) and bulk (dense foliage with leaves up to 30 cm in length) enables it to smother *Festuca jubata*, *Leontodon* sp., and *Tolpis azorica* (NUTT.) P. SILVA (the flowers of the latter two species are used extensively as nectar sources by butterflies of both sexes). Unfortunately, once this plant has become established it is almost impossible to eradicate, because of its rhizomatous perennial habit. However, although it is found on larva slopes, particularly

along the edges of streams (SJÖGREN, 1984), the plant appears to find it more difficult to invade the very steep precipitous sides of the calderas on the Azores and also the drier grassland areas on Madeira and thus it should not pose too much of a threat to the *Hipparchia* sp. under consideration.

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Livres lus

Ahmet BAYTAS, 2007, A Field Guide to the Butterflies of Turkey, NTV Yayinlari, Istanbul : 218 pp., 88 pl. coul. ISBN 978-975-6690-79-6.

Disponible chez les libraires par correspondance NHBS et Pemberley (UK), Vermandel (NL) et Insecta (Erich Bauer-D).

Voilà enfin un guide de terrain sur les Rhopalocères de Turquie. D'un format très pratique (14 × 21 cm), léger, il présente 344 espèces soit l'essentiel de la faune rhopalocérique turque. Les 756 photos en couleurs de papillons vivants, de très bonne qualité, en constituent l'atout majeur. De nombreux photographes ont d'ailleurs complété la riche photothèque personnelle de l'auteur.

Les textes sont courts et insistent sur les critères de détermination mais indiquent également l'époque de vol, la répartition en Turquie, les habitats et les plantes-hôtes des chenilles. La mise en page et le style sont très clairs et efficaces, rappelant les guides nord-américains que l'auteur, né et élevé en Turquie, a eu l'occasion d'utiliser depuis qu'il vit aux Etats-Unis. Il s'agit d'un ouvrage résolument moderne qui encouragera les jeunes

naturalistes turcs et contribuera certainement à la reconnaissance de la richesse et de la fragilité de l'exceptionnel patrimoine naturel de la Turquie, d'autant qu'une édition en turc est prévue.

Comme le reconnaît l'auteur, la détermination de certains papillons vivants est très difficile, parfois même impossible, chez les *Agrodiaetus* et les *Pyrgus* en particuliers. Il n'en reste pas moins vrai que la grande majorité des papillons (Rhopalocères mais aussi macro-Hétérocères) peuvent être identifiés sur le terrain pour peu que l'on dispose d'un livre conçu à cet effet comme celui que nous propose Ahmet Baytas. Bravo donc à l'auteur et à l'éditeur, auxquels nous souhaitons un succès très mérité.

Tristan LAFRANCHIS

Papillons d'Europe, par Tristan LAFRANCHIS, 2007, édité par Diatheo, 35 rue Broca F-75005 Paris. ISBN 978-2-9521620-1-2.

Prix : 30 euros (port en sus : 6 euros pour la France et l'Europe). Pour le commander merci de contacter l'e-mail : lafranchis@yahoo.fr

Après le succès de *Butterflies of Europe* et sa traduction en polonais, *Papillons d'Europe* est sorti en français il y a quelques mois. Un livre pour identifier de manière rigoureuse tous les papillons de jour volant en Europe, y compris les espèces décrites ou reconnues très récemment (*Agrodiaetus orphicus*, *A. eleniae*, *Melitaea ogygia*) qui sont toutes illustrées par plusieurs photographies en couleurs.

Autres nouveautés par rapport à l'édition anglaise : une liste de plantes-hôtes de 14 pages illustrée de photos de chenilles et plus de 400 nouvelles photos.

Ce guide de terrain est construit sur une succession de clés de détermination illustrées par 1400 photos en couleurs de papillons vivants, sur lesquelles des flèches pointent les critères utiles pour l'identification. Pour chaque espèce, texte, photos et carte de répartition sont présentés sur la même double-page. Les cartes de répartition sont précises et bénéficient des données les plus récentes.

De format réduit (13 × 19 cm, 380 pages, 600 grammes, couverture souple), ce livre est destiné à devenir le compagnon fidèle de vos excursions et voyages.

Quelques extraits de critiques :

“Nous regrettons de ne pas avoir disposé d'un tel livre lorsque nous commençons à nous intéresser aux papillons.”

Ronny LEESTMANS, *Linneana Belgica*

“Ce parfait guide d'identification se place en tête de liste des outils de terrain.”

Hervé GUYOT, *Insectes*

“L'ouvrage est d'une efficacité redoutable !”

Bruno GILARD, *www.tela-insecta.org*

“Je n'ai aucune hésitation à recommander ce livre, un ouvrage de première classe (...) C'est aussi le fruit d'une grande expérience et je vais m'en servir énormément.”

Rob PARKER, *Journal of Entomology and Natural History*

“Pour le tester, 12 passionnés l'ont utilisé dans les Pyrénées. Leur verdict est clair, c'est devenu leur livre de prédilection.”

Nick BOWLES, *Atropos*



1a



1b



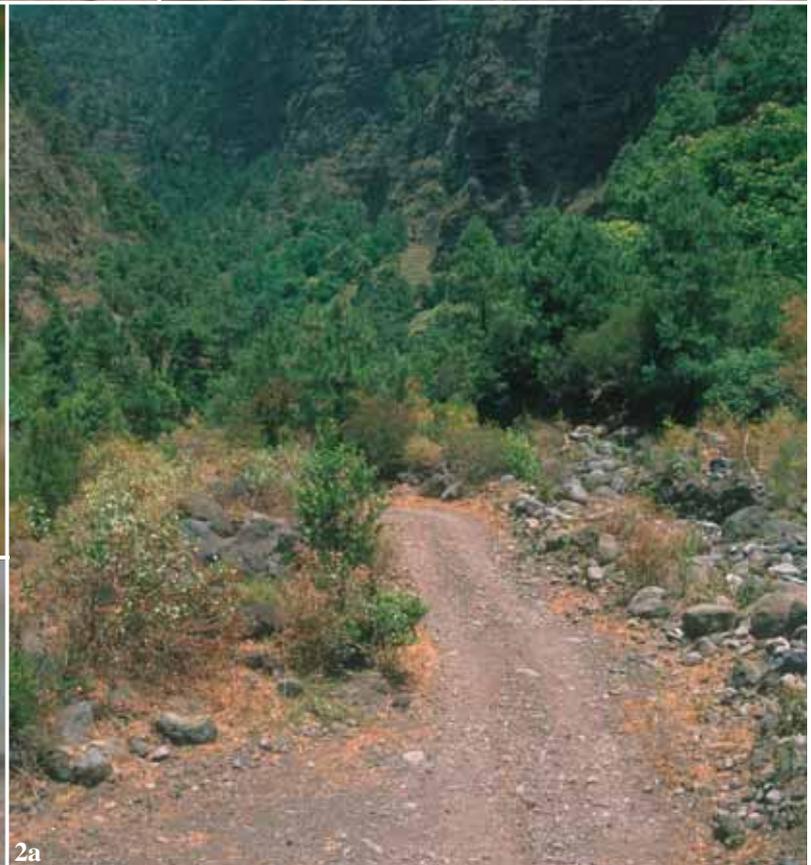
2b



3a



3b



2a

Hipparchia bacchus (1a,b), *tilosi* (2a,b) et *gomera* (3a,b) en comparaison : 1a : El Hierro, vignoble au pied des falaises au N.E. de Frontera à env. 250 m d'alt., biotope typique d'*Hipparchia bacchus*, 1b : ♀ élevée d'*Hipparchia bacchus*, 2a : La Palma, Barranco de la Madera, 600-650 m d'alt., habitat d'*Hipparchia tilosi* : 2b : ♂ élevé d'*H. tilosi*, 3a : ♂ élevé d'*Hipparchia gomera*, 3b : chrysalide d'*H. gomera* avec pruinosité forte. Photos : John TENNENT (1a,2a) et D. JUTZELER (reste)