

## 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 2.2 : The populations of the central Azores islands of Terceira, São Jorge and Pico

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<i>borgesii</i> :				<i>barbara</i> :			
ex habitat		reared		ex habitat		reared	
♂♂	♀♀	♂♂	♀♀	♂♂	♀♀	♂♂	♀♀
42.6	46.2	D.40.5	D.45.4	37.2	40.3	D.41.0	D.47.7
37.7	47.2	D.41.7	D.45.9	38.8	43.6	D.38.9	D.49.1
39.8	47.4	D.39.6	D.45.1	37.3	43.1	D.43.2	D.46.9
40.4	48.3	D.40.6	D.47.3	38.4	43.8	D.42.6	D.46.8
42.5	44.9	D.39.0	D.46.0	38.9		D.40.7	D.46.6
42.8	46.3	P.40.2	P.49.9	39.8		D.39.9	D.48.5
41.9		P.42.3	P.49.6	39.9		D.42.4	P.48.0
40			P.49.7	38			
40.4			P.50.0	38.2			
41.7			P.49.1	38.4			
41.8				37.1			
39.3				39.4			
				39.6			
<b>40.91</b>	<b>46.72</b>	<b>40.56</b>	<b>47.80</b>	<b>38.54</b>	<b>42.70</b>	<b>41.24</b>	<b>47.66</b>
n = 12	n = 6	n = 7	n = 10	n = 13	n = 4	n = 7	n = 7

TABLE 2 : wingspan in mm of wild caught and reared ♂♂ and ♀♀ originating from the Terceira localities of Alagadiços, ssp. *borgesii*, and Santa Bárbara, ssp. *barbara*. [bold figures = mean wingspan, D.= reared by D.J., P. = reared by P.R., n. = number of specimens measured in each group.]

Table by P. RUSSELL.

#### Relative sizes of the wild caught and reared imagines

The maximum expanse of the forewings of both sexes of some wild caught and reared butterflies originating from both localities on Terceira were

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measured by P.R., using vernier callipers to the nearest 0.1 mm. The results are shown in table 2, from which it can be seen that the ♀♀ are always larger than the ♂♂, both in the wild and when reared. Also both sexes of *borgesii* have similar wingspans whether they originated from the wild or were reared, whereas those of *barbara* are larger when reared by nearly 3 mm in ♂♂ and almost 5 mm in ♀♀. Also it can be seen that, when reared, the mean wingspans of both the ♂♂ and ♀♀ of *borgesii* and *barbara* differed by less than 1 mm. Hence when food availability and time to consume it are similar, as they are when reared in parallel, the imagines of the two taxa reach the same size. The larger size of *borgesii* ♀♀ over *barbara* ♀♀ in the wild is mirrored by their egg production. From the list of the numbers of ova produced (cf. RUSSELL *et al.*, 2005, p. 11), it can be seen that the groups of 3 and 2 *borgesii* ♀♀ laid 150 and 134 ova, whereas the 4 ♀♀ and 3 ♀♀ from Santa Bárbara laid only 125 and 107, respectively. The average number of eggs laid per ♀ was hence approximately 57 for *borgesii* and 33 for *barbara*.

#### Wing colouration of the reared imagines

Altogether nearly 200 imagines resulted from the batches of *azorina* group larvae reared during 2002/03. A selection of those relating to the central

→  
→

PLATES 7-10 : the upper and undersides of reared and wild caught specimens of *H. azorina* from Terceira, São Jorge, Pico and Faial. The dates shown are those of the days of emergence of the reared individuals and the capture of wild caught specimens. It can be seen that, in contrast to the series from Alacadiços (Terceira), São Jorge and Pico, the wild caught specimens from Santa Bárbara (Terceira) and Faial are distinctly smaller than the individuals which resulted from rearing.

All material P.R. *leg.* Photographs taken, edited and prepared by M. GASCOIGNE-PEES.



PLATE 7 : imagines of taxon *barbara* from **Terceira**, Serra Santa Bárbara, 1000 m ; sex and dates of emergence or capture of reared (shaded) or wild caught (unshaded) specimens, respectively, indicating their rearer or captor.

♂	7.6.03 DJ	♂	3.6.03 DJ	♂	3.6.03 DJ	♂	29.5.03 DJ
♂	20.7.01 PR	♂	20.7.01 PR	♂	21.7.02 PR	♂	20.7.01 PR
♀	2.5.03 PR	♀	31.5.03 DJ	♀	1.6.03 DJ	♀	5.6.03 DJ
♀	20.7.01 PR	♀	20.7.01 PR	♀	20.7.01 PR	♀	31.5.03 PR



PLATE 8 : imagines of taxon *borgesii* from **Terceira**, Alagadiços, 600-645 m ; sex and dates of emergence or capture of reared (shaded) or wild caught (unshaded) specimens, respectively, indicating their rearer or captor.

♂ 12.6.03 PR	♂ 9.6.03 PR	♂ 16.6.03 DJ	♂ 17.6.03 DJ	♂ 16.6.03 DJ
♂ 21.7.01 PR	♂ 21.7.01 PR	♂ 21.7.02 PR	♂ 20.7.01 PR	♂ 21.7.01 PR
♀ 27.6.03 PR	♀ 15.6.03 PR	♀ 13.6.03 DJ	♀ 13.6.03 DJ	♀ 16.6.03 PR
♀ 21.7.01 PR	♀ 21.7.01 PR	♀ 21.7.01 PR	♀ 20.7.02 PR	♀ 21.7.01 PR

group islands can be seen from plates 7, 8, 9 and 10, which give an idea of the variability of upper and underside wing pattern and colouration. D. JUTZELER, who had not seen these butterflies in the wild, was surprised by the immense variability of the underside patterns of the emerging imagines. It should be born in mind that these were the offspring of only a few individual ♀♀ and therefore represented only a small fraction of the variation found in nature. He also noted that the butterflies never opened their wings if they were frightened, nor for warming up after they had been cooled in a refrigerator. When placed in sunlight, they assumed a slanting position, holding their closed wings at right angles to the sun, therefore D.J. was only able to photograph the undersides of the living butterflies. It was noted that the two second brood *barbara* ♀♀ differed from the remaining adults in that the marginal zones on both their fore- and hindwings were of an ochre shade with the black and brown scales being very much reduced (*cf.* RUSSELL *et al.*, 2004-7, part 1.2, fig. 5 on the cover and part 2.1, pl. 2, fig. 9).

P.R. prepared the reared butterflies for photographing both sides in order to compare them with each other and with wild caught examples from the same island. Since there is much published work on the wing patterns and colours in *azorina s.l.*, only those features relevant to a possible taxonomic separation will be pointed out.

**Plates 7 and 8** show a comparison of males and females of reared and wild caught individuals from Santa Bárbara and Alagadiços (both located on Terceira), respectively. It exemplifies the size difference in both sexes between reared and wild specimens of *barbara*, which is not paralleled in *borgesi*, as noted from table 2. It also shows the marked similarity in upper and underside wing pattern and colour and also the wingspan between the two taxa when reared. In order to see whether it was possible to separate the **reared** imagines (wild ones being easily separable just by size difference) from the two localities on Terceira, by an examination of their wing morphology alone, a test was devised. A series of 13 ♂♂ (7 *borgesi* and 6 *barbara*) and 11 ♀♀ (6 *borgesi* and 5 *barbara*) were mixed up. P.R. and three other entomologists, who are familiar with European *Hipparchia* species, then attempted to separate them into two groups. Assuming that the first male and first female were positioned to form the starting point, there were 22 specimens remaining to be separated into the two taxa. The four put into the correct group 10, 13, 12 and 13 specimens, none of the results being statistically better than 50/50. Interestingly, only one specimen was diagnosed correctly by all four people, 8 were put into the proper series by three, 5 by two, 7 by one person and 1 specimen was never

placed into its right group by any of the entomologists. The results of this test indicate very strongly that these two taxa, when reared in parallel, cannot be separated by their size, wing colour or pattern. The obvious differences between the wild populations from Santa Bárbara and Alagadiços must result from the influence of their very different environments (*cf.* habitats on Terceira in part 2.1).

**Plate 9** shows a series of reared and wild caught specimens of *jorgense* from the two localities sampled on São Jorge. A difference in size between reared and wild caught butterflies is not evident and the wing patterns of the reared and wild ♂♂ and ♀♀ are similar and they cannot be separated according to their locality of origin. The fact that the wild imagines from the two locations on this island are similarly sized, unlike those from Terceira, is almost certainly due to the similarity of their habitats: wet grassy slopes with less than 150 m of vertical separation between them. The lack of size difference between reared and wild caught individuals is probably indicative of the two populations being well suited to their environment and the larvae are able to consume the optimum amount of food during their lifetime.

**Plate 10** depicts a series of reared and wild ♂♂ and ♀♀ from the islands of Pico and Faial. A small difference in size can be noted between the reared and wild specimens from Faial, once again almost certainly due to the exposure of their natural habitat at 1000 m on Cabeço Gordo, with its lower temperature and adverse weather, resulting in reduced larval feeding time. No differences could be found between the reared adults from Faial and Pico.

The majority of the 'distinctive characters' of the imagines from São Jorge, described by OEHMIG (1983, p. 145/6) for the separation of ssp. *jorgense*, appeared far less obvious when the reared individuals were examined and compared with those of the nominal ssp. from Faial. From an examination of plates 9 and 10 it can be seen that there is little differentiation of the colour of the discal area of the forewings, in either ♂♂ or ♀♀, of the reared individuals from São Jorge, Pico or Faial. The pale, almost white, zig-zag band on the hindwing undersides of reared ♂♂ from São Jorge appears to be slightly broader and its edges better defined than on those from Pico and Faial; this feature was not apparent in ♀♀. However, there would appear to be a small but constant difference in wing morphology between the reared specimens of *jorgense* and those of typical *azorina*.

### Evaluation of the results

The different characters observed by rearing the butterflies from the four central group islands show somewhat conflicting results and do not at first

glance permit a definite answer as to their taxonomic status. To assist in this evaluation, each of the characters where differences were found between populations was weighted according to its apparent usefulness in the present and other taxonomic studies, therefore giving an indication of the strength of its bearing on the present taxonomic problem.

**Ovum** : the ova of all the central island *azorina* are similar in size, shape, colouring and spotting. However, they do vary in the number of longitudinal ribs, with *borgesi* having the least (average 19.7) and *azorina* from Faial having the most (average 24.2). It should be noted that the eggs of *H. miguelensis* differed in colour and had an average number of ribs of 25.2 (part 1.2, p. 293). We consider that the form of the ova is of high significance in this particular taxonomic evaluation.

**Hairiness of the larvae** : From the SEM photographs (plates 5 and 6), it can be seen that the larvae from all the populations of the central Azores islands (including *borgesi*) have long hairs covering their body and these are attached on broad bases. The caterpillars of *miguelensis*, however, exhibit short hairs attached on fine bases. This feature appears to be very constant and consequently it is considered to be a feature of high taxonomic value.

**Genitalia** : it was observed from the genitalia preparations of ♂♂ as well as ♀♀ (plates 11 & 12) that there were no differences between those of any of the populations, neither did they differ from those of Faial (part 1.2, pl. 8 and 9). The fact that the central island populations all had similar genitalia and that these differed in certain aspects from those of *H. miguelensis* (part 1.2, as above) is indicative of this character being of high taxonomic significance.

**Oviposition** : ♀♀ capable of attaching some of their eggs to a substrate were found only in the two populations from Terceira ; ♀♀ from the remaining islands were unable to affix their ova. This feature would tend to indicate that these two series from Terceira should be closely related but separated from those of the other islands in the group. There are, however, other examples of species in which the success of attaching their eggs varies with location. For example those of *Hipparchia neomiris* occurring on the Teghime pass in Corsica are able to adhere their ova to grass stems, whereas ♀♀ from the Sardinian Gennargentu massif are unable to attach their eggs (observation by D.J. in LAFRANCHIS, 2000 : 341). Imagines of these two populations do not show any perceptible morphological differences. Further examples of egg-laying behaviour varying with locality can be found in *Erebia styx* (JUTZELER *et al.*, 2001 : 178, 182) and *Hyponephele lycaon* (HESSELBARTH *et al.*, 1995 :

vol. 2 : 838). Hence we conclude that ovipositing behaviour may not be a criterion of substantive taxonomic relevance.

**Shade of forewing underside** : some adults of ssp. *borgesi* from Terceira had fox-coloured forewing undersides rather similar to those of *H. miguelensis* from São Miguel (part 1.2, pl. 7, figs 11 & 14), possibly indicating the close relationship between these two taxa suggested by TENNENT & BIVAR DE SOUSA (2003). In reality, however, the shade of the forewing undersides and wing colouration in general is so variable that its taxonomic value in the resolution of these central island populations must be considered to be of little systematic significance.

**Shade of the larvae** : very dusky adult larvae were seen among the series from Pico and São Jorge, Serra do Topo. If the average brightness of larvae was considered to be a distinctive criterion, one would presume a close relationship between these two populations, whereas the population of the Pico do Areeiro on São Jorge would be classified as a different taxon. However, the examinations of the complex of *Hipparchia fagi*, *alcyone* and *genava* by D.J. (in prep.) have shown that different larval hues can be due to local or individual variation within the same population. Differences of larval shades and brightness may therefore be considered as a factor of very low taxonomic importance.

### Conclusions on the taxonomy of the central island populations

Corresponding to the relatively short distances between the islands of the central Azores, it can be seen that there was a high degree of similarity between the early stages, the wing patterns of the adults resulting from this rearing programme and their genitalia. However, the ranking of the above criteria provides a basis for an evaluation of the taxonomic level to which the different populations of the central Azores islands should be ascribed.

It has been seen that the ova of all the populations are similar in colour to one another but dissimilar to those of *miguelensis*. The eggs of the central island group taxa do vary in their average numbers of ribs, with *borgesi* having the lowest number. However, *miguelensis* has a mean rib number greater than that of any of the central island taxa. Both factors indicate that *borgesi* should not be separated specifically from the remaining central island taxa. The similarity of the larval hairs of the populations on Faial, Pico, São Jorge and Terceira and their dissimilarity from those of *miguelensis* larvae lead to the same conclusion, as do the differences in both ♂ and ♀ genitalia between the central islands' populations and those of São Miguel. From



PLATE 9 : imagines of taxon *jorgense* from **São Jorge** ; figs 1-10 : Pico do Areiro/P. da Esperança, 860 m, or Pico do Carvão (4,5,9), 800 m (central part of island) ; figs 11-20 : Serra do Topo, 720 m (eastern part) ; sex and dates of emergence or capture of reared (shaded) or wild caught (unshaded) specimens, with their rearer or captor.

♂ 19.5.03 DJ	♂ 18.6.03 PR	♂ 21.6.03 PR	♂ 23.7.97 PR	♂ 23.7.97 PR
♀ 17.6.03 DJ	♀ 11.6.03 DJ	♀ 22.6.03 PR	♀ 20.7.01 PR	♀ 20.7.01 PR
♂ 1.6.03 DJ	♂ 1.6.03 DJ	♂ 31.5.03 DJ	♂ 23.7.97 PR	♂ 23.7.02 PR
♀ 15.6.03 DJ	♀ 14.6.03 DJ	♀ 17.6.03 DJ	♀ 24.7.02 PR	♀ 24.7.02 PR



PLATE 10 : figs 1-10 : imagines of taxon *picoensis* from **Pico**, Cabeco Escalvado, 875-900 m ; figs 11-20 : adults of taxon *azorina* from Faial, Gabeco Gordo, 1000-1030 m ; sex and dates of emergence or capture of reared (shaded) or wild caught (unshaded) specimens, respectively, indicating their rearer or captor.

♂ 19.6.03 PR	♂ 20.6.03 PR	♂ 22.6.03 PR	♂ 24.7.01 PR	♂ 26.7.02 PR
♀ 21.6.03 PR	♀ 24.6.03 PR	♀ 26.6.03 PR	♀ 31.7.97 PR	♀ 25.7.01 PR
♂ 15.6.03 PR	♂ 12.6.03 PR	♂ 20.6.03 PR	♂ 28.7.01 PR	♂ 28.7.01 PR
♀ 6.7.03 PR	♀ 17.6.03 DJ	♀ 27.6.03 PR	♀ 28.7.01 PR	♀ 1.8.97 PR



Fig. 1: *picoensis*  
Pico, Cabeço Escalvado, 900 m

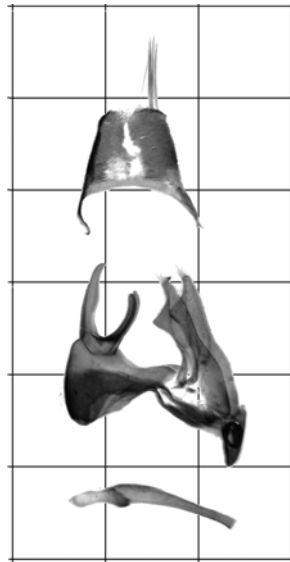


Fig. 2: *picoensis*  
Pico, Cabeço Escalvado, 900 m

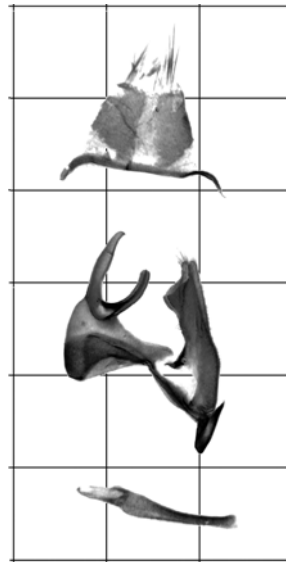


Fig. 3: *picoensis*  
Pico, Cabeço Razo, 900 m

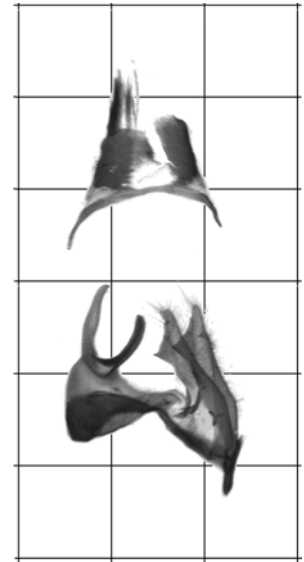


Fig. 4: *picoensis*  
Pico, Cabeço Escalvado, 875 m

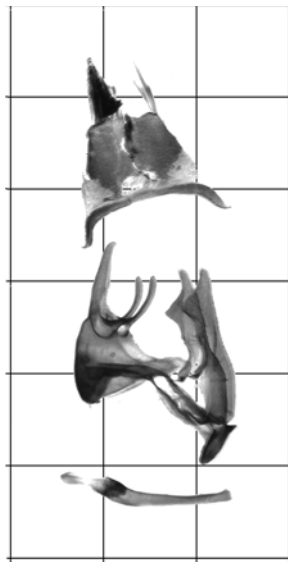


Fig. 5: *jorgense*  
São Jorge, Pico do Areiro, 860 m

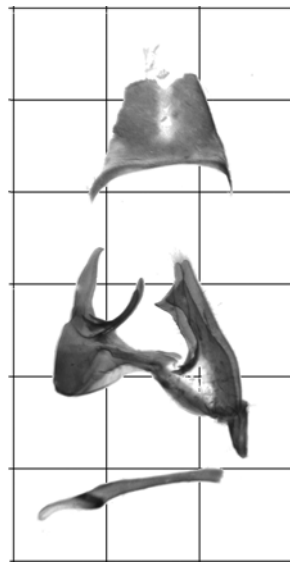


Fig. 6: *jorgense*  
São Jorge, Serra do Topo, 720 m

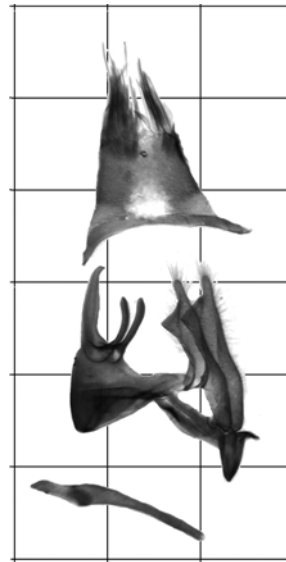


Fig. 7: *jorgense*  
São Jorge, Serra do Topo, 720 m

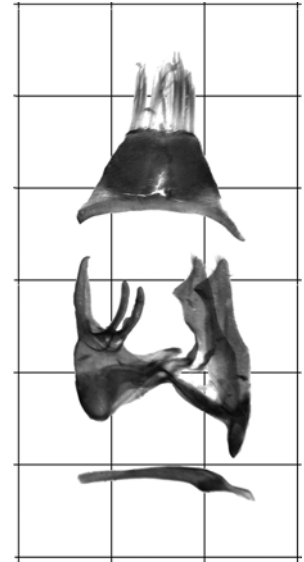


Fig. 8: *jorgense*  
São Jorge, Pico do Carvao, 800 m

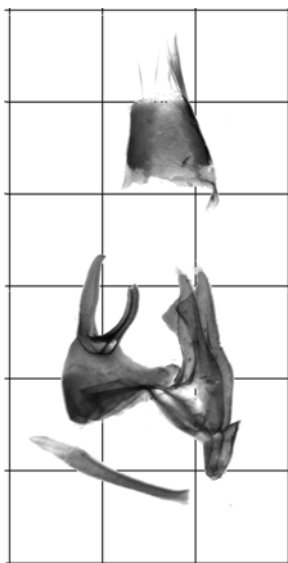


Fig. 9: *barbara*  
Terceira, S. de Sta Barbara, 1000 m

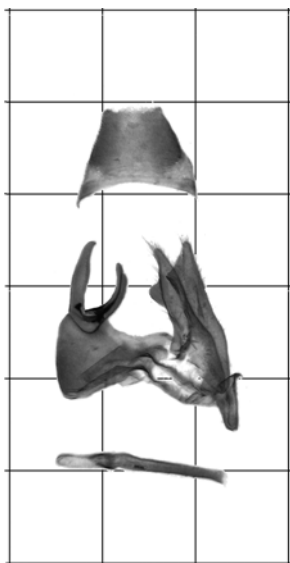


Fig. 10: *barbara*  
Terceira, S. de Sta Barbara, 1000 m

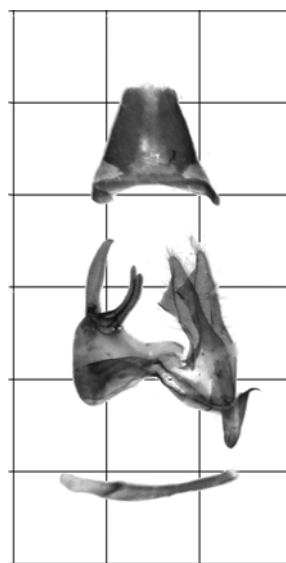


Fig. 11: *borgesii*  
Terceira, Alacadiços, 650 m

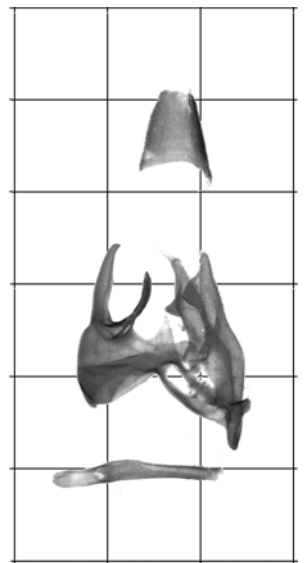


Fig. 12: *borgesii*  
Terceira, Alacadiços, 650 m



PLATES 11, 12 : ♂ and ♀ genitalia of the *azorina*-group taxa from the central Azores islands : figs 1-4 : from Pico ; figs 5-8 : from São Jorge (5 : Pico do Areeiro, 6-8 : Serra do Topo) ; figs 9-12 : Terceira (9 : Santa Bárbara ; 10-12 : Alagadiços).

♂ **genitalia** : in contrast to the large variation in wing pattern exhibited by all the *azorina* populations and unlike the inconsistency of the genital armatures of some conspecific individuals, the ♂ genitalia of all the five populations examined from Pico, São Jorge and Terceira were remarkably constant in both size and shape. ♀ **genitalia** : the ♀ genitalia of the above populations were also very similar to each other.

Both ♂ and ♀ genitalia of these colonies exhibited a high degree of similarity to those examined from Faial (the other central group island) see part 1.2 of this study (RUSSELL *et al.*, 2004).

All material P.R. *leg.* Preparations, graphics and legends by G. VOLPE.

these three important taxonomic criteria we conclude that **all** the *Hipparchia* populations of the central islands should be considered belonging to a **single species** : *H. azorina*.

The ability of ♀♀ to attach their ova is unique (among the central island populations) to the ♀♀ from Terceira and may be indicative that a taxonomic separation of the Terceira populations from those of the remaining central islands is required but only at a **subspecific** level. The preponderance of imagines having a fox coloured forewing underside supports such a theory.

The small but constant differences in wing colour and shade of the adults between both

♀♀ genitalia of *Hipparchia azorina*

Scale: +——+ 1 mm

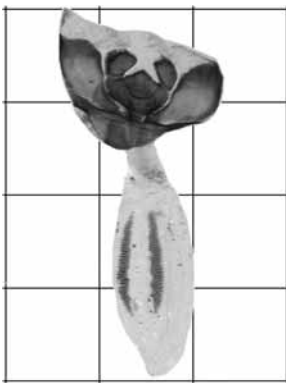


Fig. 1: *picoensis*  
Pico, Cabeço Escalvado, 875 m

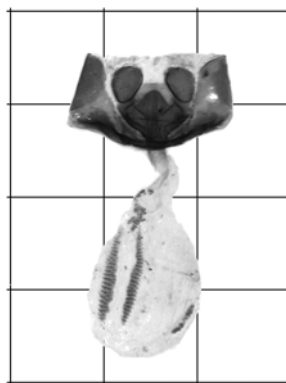


Fig. 2: *picoensis*  
Pico, Cabeço Escalvado, 875 m

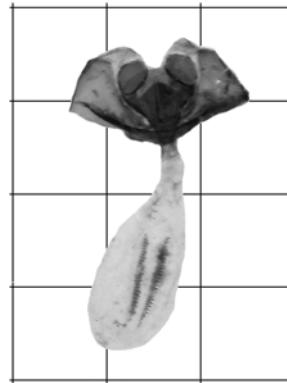


Fig. 3: *picoensis*  
Pico, Cabeço Escalvado, 875 m

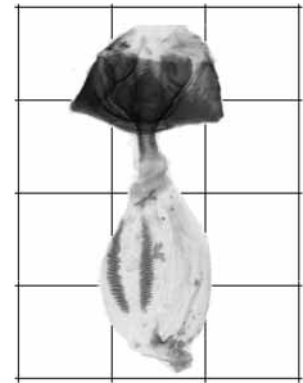


Fig. 4: *picoensis*  
Pico, Cabeço Escalvado, 875 m

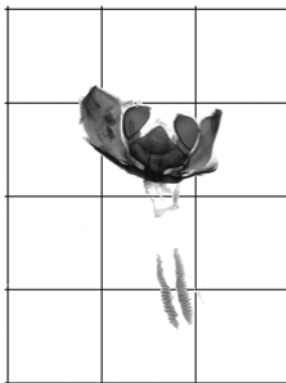


Fig. 5: *jorgense*  
São Jorge, Pico do Areeiro, 860 m

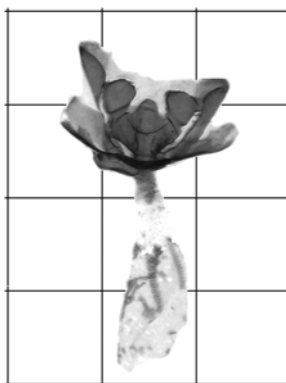


Fig. 6: *jorgense*  
São Jorge, Serra do Topo, 720 m

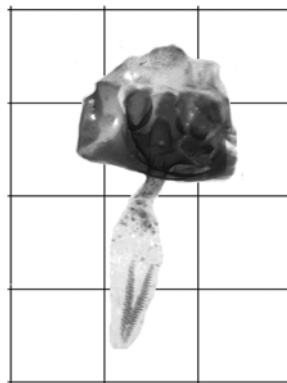


Fig. 7: *jorgense*  
São Jorge, Serra do Topo, 720 m

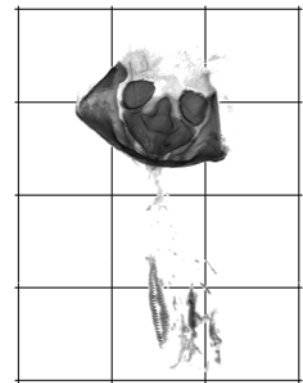


Fig. 8: *jorgense*  
São Jorge, Serra do Topo, 720 m

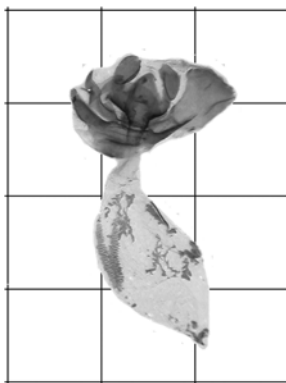


Fig. 9: *barbara*  
Terceira, Santa Barbara, 1020 m

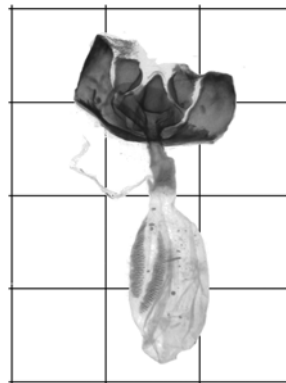


Fig. 10: *borgesi*  
Terceira, Alacadiços, 620 m

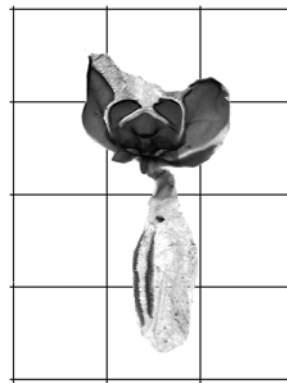


Fig. 11: *borgesi*  
Terceira, Alacadiços, 620 m

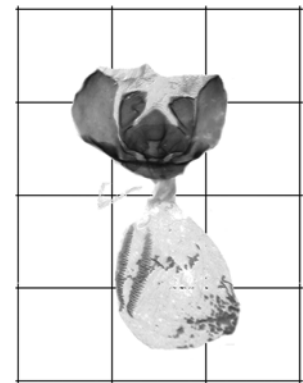


Fig. 12: *borgesi*  
Terceira, Alacadiços, 620 m

populations on São Jorge and those of Terceira, Pico and Faial give grounds for their separation but again restricted to **subspecific** level. The differences in androchionial scales found by OEHMIG (1983) supports their separation from the other central island populations.

The results of this second rearing program confirm our previous conclusion, drawn in part 1 of this study, that *H. miguelensis* from São Miguel at the eastern end of the archipelago should be classified as a species distinct from *H. azorina*, which is found throughout the central island group. We could find no evidence to support the view of Tennent and BIVAR DE SOUSA (2003) that *borgesi* should be considered as a subspecies of *miguelensis*. The authors' conclusions concerning the systematics of this whole Azorean *Hipparchia* complex will be given at the end of the final part of this study, which will involve a comparison between the populations of Flores and Corvo, at the western end of the archipelago, and their relationship to both *Hipparchia azorina* and *H. miguelensis*.

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