Morphology and chaetotaxy of the first instar larvae of six species of the *Satyrus* (s.l.) series (Lepidoptera: Nymphalidae)

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ABSTRACT. The morphology and chaetotaxy of the first instar larvae of six species belonging to the genera *Hipparchia*, *Kanetisa* and *Chazara* are described. Specific characters are stated, drawn mainly from size, setal length and morphology, and the shape of the suranal plate. Several characters, other than chaetotaxy, that are of potential use in nymphalid systematics are discussed. The larval chaetotaxy is briefly compared with that of both heliconiine and danaine first instar larvae.

Introduction

Recently, Kitching (1985) and DeVries *et al.* (1985) demonstrated the usefulness of egg, larval and pupal morphological characters in cladistic analyses of the Nymphalidae; suggesting that analyses based on data gathered from thorough examination of the early stages will, together with adult data, resolve many of the difficulties associated with nymphalid phylogeny (DeVries *et al.*, 1985).

As adequate samples of immature stages are rarely found in collections, this kind of work has until now been restricted to a small number of genera and species. Obviously, the number and type of characters selected will be greatly influenced by the characteristics of the species chosen or which are available. As the number of available morphological characters can be substantially increased, more detailed knowledge of the early stages of the infra-familiar taxa in the Nymphalidae is needed in order to highlight useful characters for the final synthesis of the higher classification.

Although several descriptions of newly hatched satyrine larvae can be found scattered in the literature (e.g. Aussem & Hesselbarth, 1980; Comstock, 1961; de Lesse, 1954; Roos, 1981; Scudder, 1873; Tutt, 1896), none of them is sufficiently detailed to allow comparison with the published chaetotactic descriptions of the Heliconiinae (Fleming, 1960) or Danainae (Kitching, 1984).

This paper is devoted to describing the morphology and chaetotaxy of the first instar larvae of six species of Satyrinae belonging to the 'Satyrus series' (Miller, 1968).

Materials and Methods

Material was obtained from eggs laid in the laboratory by either field-caught or laboratory-reared females. The generic nomenclature follows de Lesse (1951), while specific names within the genus *Hipparchia* Fab. are those employed by Kudrna (1977). Dates refer to the date of hatching of the larvae, and localities to the sites where females were taken (all sample sites are in peninsular Spain). The species examined were:


*Hipparchia* (*Neohipparchia*) *statilinus"


Twenty individuals of each species were examined, ten of which were selected for measurements. The larvae were cleared in 10% KOH or lactic acid and transferred to glycerol temporary mounts. They were examined in several orientations and the head and mouthparts were detached when necessary for close observation. Skin mounts, following the method described by Mukerji & Singh (1951), were used only with _H. _fidia because of its larger size. Drawings and measurements were made with a light microscope (100-1000×) and the aid of a grid system and a camera lucida. The setal homologies were established using Hinton's 1946 paper, and a comparison with Kitching (1984).

Results

A remarkable similarity was found between all six species. I will thus provide a general description, followed by a short diagnosis for each of the species.

Head

Head hypognathous, rounded, as in Fig. 1. Diameter of ocellus II 1.4-1.6× the diameter of ocelli I and III. No definite horns or tubercles. Surface of the head capsule rugose, consisting of an intricate design of low blunt ridges enclosing more or less rounded fossulae. Setae short, blunt at their tips and more or less curved, but those on the frons, labrum and mouthparts, together with SO1 and SO3, are acute.

Chaetotaxy of the head capsule

The arrangement of cephalic setae and punctures (sensilla) is somewhat unusual, due to the atypical location of some of the setae and punctures and the presence of one additional seta on each genu. The homologies stated (Figs. 1-3, 8) are those that appeared to be most likely using Hinton's (1946) criteria. Under this interpretation, one head sensilla that is generally found in lepidopterous larvae (Va) was not observed. However, some of the sensilla and minute setae (V1, Pa) were identified only after close examination at 400-1000×, due to their small size and the irregular shape of the head surface and Va might have been overlooked.

Setae: F1; C1, C2; AF1, AF2; A1, A2, A3, O1, O2, O3; SO1, SO2, SO3; L1; P1, P2; V1, V2, V3; G1; unhomologized seta (?). 

Sensilla: Fa; AFa; Aa; Oa; Ob; SOa, SOb and two small elliptic sensilla here termed SOy anterior and near the postgenal edge; La; Pa; Pb; Ga; Va apparently absent.

The frontal setae and punctures are near to the anterior margin of the frons, Fa almost in a line with the clypeal setae. Posterior setae and punctures arranged in a transverse row. V1 and V2 very close to the occipital foramen. SO1 smaller than SO3, near the base of the antennal socket. L1 and L2 near the posterior margin of the head. Puncture Aa remarkably above the socket of A2. Unhomologized seta (?) about halfway between AF2 and L1, near the centre of the trapezoid figure drawn by the sockets of AF2, P2, L1 and A3.

_Labrum, mandibles and spinneret_

_Labrum_ as in Fig. 4. Labral notch shallow labral spine plate (see DeVries et al., 1985) present, small. Epipharynx with three small muscle scars or punctures on each side, arranged in straight line. Of the three epipharyngeal setae that are usual among lepidopterous larvae, two are placed near the anterior margin on each side, the third is poorly developed, and was clearly seen only in one specimen of _K. _circe.

_Mandibles_ (Figs. 5-7) with two primary setae on the outer surface. Cutting edge with several small teeth, one of which (near the dorsal part of the cutting edge) always projects relative to the others.

The spinneret is very poorly developed. The fusuliger consists of two narrow sclerites, and the fusulus is represented only by a short unsclerotized lobe (see Fig. 10).
Body

Dorsum subcylindrical, venter depressed. Width of the body progressively decreasing from the thorax to the end of the abdomen. Typical structure of a lepidopterous larva, with three pairs of thoracic legs and five prolegs on abdominal segments 3–6 and 10. The segments are externally subdivided by transverse folds parallel to the intersegmental sutures giving the appearance of subsegments (four in the mesothorax and metathorax, six in the abdominal segments).
The anterior ventral margin of each segment is slightly displaced cephalad in respect to dorsum, but the microscopic (proprioceptor) setae (MV) can be used to identify the limits between two consecutive segments.

Cuticular surface regularly covered by small rounded granules (5–10 μm in *H. fidia*). There are no definite well-sclerotized plates except the prothoracic shield, tenth abdominal segment proleg shield, and suranal plate. Setae arising from short chalazae (Fig. 13). Only primary setae present. Body setae directed backwards (especially dorsals), except on the prothorax.

Spiracles protruding from the cuticle (Fig. 12).

**Prothorax**

Prothoracic shield consisting of two small moderately sclerotized plates, one on each side of the dorsum. Legs with primary setae only (Fig. 11), tarsal setae lanceolate, tarsal claw simple.

Prothoracic gland on the midventral line, just ahead of coxae. It may appear either protruded or invaginated in cleared specimens, resembling a short cuticular coecum, with its outer distal surface covered by minute spines.

Chaetotaxy as in Fig. 9. Each prothoracic plate bears four setae (XD1, XD2, D1, D2) on
FIG. 10. Labium of the first instar larva of *Chazara briseis* (ventral view) showing the unsclerotized fusulus and poorly developed fusuliger.

FIG. 11. Outer view of the prothoracic leg of *Hipparchia fidia*.

FIG. 12. Spiracle of *H. fidia*. Scale lines=50 μm.

the anterior margin, and a socket. XD1 and XD2 longer than D1 and D2; SD1 and SD2 very close at their bases, SD1 ventral to SD2, hairlike (Fig. 13c). MV2 and MV3 besides the ventral prothoracic gland, anterior to coxae.

Mesothorax and metathorax

D1 and D2 arranged in a vertical row. SD1 and SD2 equal in size and placed at a same level, and it is thus not possible to identify either of

them precisely. The rest of the setae are as in the above mentioned figure.

All thoracic setae are blunt (Fig. 13), except for the ventrals (V1), which are shorter and acutely pointed, the microscopic setae (propiceptors) and prothoracic SD1.

**Abdominal segments 1–8**

Prolegs on segments 3–6 with a single row of crochets arranged in an homoedous meso-series on a straight or evenly curved line.

**Chaetotaxy.** D1 level with D2 on meso- and metathorax, on the first fold of the segment. D2 on the fourth fold, SD1 on the second. SD2 very small, anterior and slightly dorsal to the spiracle, similar to the microscopic setae MD1 and MV3. SV1, SV2 and V1, almost in a vertical line with L1 except on the proleg bearing segments, where SV1 and SV2 are on the outer surface of the proleg, and V1 on the inner one.

Subventrals and ventrals acute, except those on abdominal segments 1 and 2, where only V1 of this form.

**Abdominal segment 9**

Resembling abdominal segment 8 except for the lack of spiracles and the setae SD2, L2 and SV2.

**Abdominal segment 10**

Suranal plate (epiproct, Figs. 14–19) characteristically bilobed at its distal end, each lobe bearing the setae L1 (distal) and D2 (inner and proximal). SD1 on the side of the plate, D1 level with dorsals of the ninth segment. The length of the dorsal setae increases to the last abdominal segment, those on the epiproct being longer than any other D setae.

**Chaetotaxy, of the proleg, paraproct and ven...**
ter. Paraprocts and subparaprocts (P1, SP1); subventral (SV), ventral (V1); five proleg shield setae (PL) and two punctures, PLA on the outer face of the proleg, and PLB on the inner surface. The nomenclature here employed follows Kitching (1984). The PL setae, however, cannot be compared with those of Danaus larvae, due to their different relative positions and their subequal size, except PL1, which is likely associated to PLA.

Colour of the newly hatched larvae

Head light brown. Ocelli black. Body, ground colour light brown or yellowish grey, with longitudinal brown or reddish brown lines. One middorsal line and, on each side, one subdorsal line enclosing seta D2 and the mesothorax and metathorax and running just beneath D2 on the abdomen. A wider lateral band enclosing both SD setae (meso/metathorax) and SD1 on the abdomen. A subventral band beneath the subspiracular fold, which is somewhat paler than the ground colour; and a thin, not always well marked line, limiting the subspiracular fold dorsally.

Spiracles dark brown. Setae pale, almost unpigmented. Sockets dark brown or blackish, resembling small black spots.

Specific characters

Some measurements were found to be useful for specific identification. Those selected here for descriptions can in most cases be made on the dorsal view of a same specimen. Six measurements refer to the suranal plate (Figs. 14–19), for its shape does not substantially change during the first instar (see Table 1). The most useful relative values between pairs of measurements, setal lengths, or intersetal distances, are stated in Table 2. Total length refers to preserved

<table>
<thead>
<tr>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>V</th>
<th>VI</th>
<th>VII</th>
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<td>140-170</td>
<td>90-140</td>
<td>390-450</td>
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<td>50-70</td>
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TABLE 1. Intersetal distances and setal lengths (range, mean±SD). I–VI, measurements on the suranal plate. I=distance between D2–D2 at their bases; II =L1–L1; III=SD1–SD1; IV=D1–D1; V=length of the distal lobes of the suranal plate (equal to the depth of the notch, measured from its bottom to the medium point between L1–L1 bases); VI=maximum length of the suranal plate, excluding setae. VII=length of seta P1 on the head; VIII=same of seta D1 on the abdominal segment 4. IX=same of L1 on the suranal plate. Sample size, n=10 for each species. All measurements in μm.

<table>
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<tr>
<th>II/III</th>
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<th>IV/V</th>
<th>V/I</th>
<th>NC4</th>
<th>NC10</th>
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</tr>
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<td>0.7–0.9</td>
<td>1.3–1.8</td>
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<td>1.3–1.9</td>
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<td>0.3–0.7</td>
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TABLE 2. Relative value of five pairs of measurements (see Table 1), and number of crochets on the prolegs (NC4=number of crochets on the proleg on the abdominal segment 4, NC10=same for abdominal segment 10).
newly hatched larvae only (mean values are not given, since body length depended largely on the degree of distension reached by the larvae when killed).

**Hipparchia hermione**

Length 3.0–3.5 mm, head capsule width 0.72–0.77 mm (mean=0.74, SD=0.02). Setae on the dorsum of the head and body distinctly blunt at their ends. Length of distal lobes of the suranal plate smaller than the distance between both D2 setae on the same segment. Dorsal setae curved. Setal socket D2 anterior to setal socket L1 (abdominal segment 10).

**Hipparchia fidia**

Length 3.3–3.5 mm. Head capsule width 0.78–0.85 mm (mean=0.82, SD=0.03). Resembling the former species, but suranal plate with distal lobes well marked and longer than in **H. hermione** (1.0–1.4× the distance between setae D2 on abdominal segment 10). Dorsal setae on abdominal segment 4 longer than those in **H. hermione** (compare also II, III, V, VI and VIII from Table 1).

**Hipparchia statilinus**

Length 2.5–3.5 mm. Head capsule width 0.50–0.54 mm (mean=0.51, SD=0.01) Distinctly smaller than the former, setae shorter.

**Hipparchia semele**

Length 2.4–3.0 mm. Head capsule width 0.55–0.59 mm (mean=0.57, SD=0.02). Similar in size to **H. statilinus**, but differs because of the smaller suranal plate, shorter dorsal setae on abdominal segment 4, and the relative length of the distal epiproctal lobes, which are shorter in **H. semele**.

**Kanetisa circe**

Length 3.0–3.3 mm, head capsule width 0.59–0.62 mm (mean=0.60, SD=0.01). Setae clearly more slender than in **Hipparchia** and **Chazara**, dorsal abdominal setae with the tips directed backwards, almost parallel to body surface (Fig. 13: b, i). Distance D2–D2 on abd 10 clearly smaller than distance L1–L1 on the same segment.

Similar to **H. statilinus** and **H. semele**. It can be separated from the former by the length of the epiproctal lobes when compared with the distance D2–D2, the total length of the suranal plate, and the length of setae; and from **H. semele** because of the relative length of epiproctal seta L1. D2 and L1 are placed at a same level in **Chazara**, whereas D2 is at least slightly anterior to L1 in the two other genera.

**Discussion**

As might be expected from the uniform adult structural plan of **Satyrus s.l.**, there is a remarkable similarity among their first instar larvae, each of the six species slightly differing from the others. As far as they are known at present, the first instar larvae of **Oeneis**, **Pseudochazara**, and to some extent **Erebia**, could prove to be very close to the above-described pattern (compare e.g. Aussem & Hesselbarth, 1980; de Lesse, 1954; Scudder, 1873).

Some of the above-described characters are of special interest, such as the head chaetotaxy (with the addition of one supernumerary pair of setae), the shape of the setae and head and the lack of a well-developed spinneret (according with my own observations, the spinneret is always well developed in the last instar larvae). The general appearance of the labrum fits well with that of **Antirrhea** (see the figure in DeVries et al., 1985).

One of the characters, ocellus II distinctly larger than ocellus III, seems to be distinctive for at least one part of the Satyrinace.

It was surprising to note that one character thought to be found in its apomorphic state in the Satyrinace, Morphinae, Charaxinae, and Apatura, i.e. mandibles in an evenly curved cutting edge (DeVries et al., 1985; see also Dias, 1979, for Brassolinace) is not found in the first instar larvae of **Hipparchia** and allied species. Furthermore, the newly hatched larva of **Hipparchia**, **Kanetisa** and **Chazara** show toothed, though modified, mandibles, resembling the plesiomorphic state of the character. It is important to note, however, that DeVries et al. examined only last instar larvae, while the shovel-shaped mandibles described by Aussem (1980) in the fully grown larvae of **Hipparchia**, **Kanetisa** and **Chazara** are also absent in the first
instar. In *Hipparchia fidia*, the curved cutting edge appears only after the first moult, and the shovel-like expansion only in the third larval instar (García-Barros, unpubl. observations).

The peculiar shape of the suranal plate, which was formerly believed to be characteristic for the Satyrinae, was also recorded by Müller (1886) not only in the satyrine genus *Taygetis*, but also in the first instar of the genus *Prepona* (Charaxinae). On the other hand, a bilobed suranal plate is lacking in the first instar larvae of *Lasionmatia, Maniola* and *Pyronia* (belonging to Miller's (1968) *Lethini* and *Maniolini*), while intermediate shapes are found in the palaeartic satyrids *Melanargia* and *Coenonympha* (García-Barros, unpubl.).

Two other structures, though not frequently mentioned in larval descriptions, are likely to be widespread in most ditrysian Lepidoptera. One is the modified hair-like seta SD1 on the prothorax, which probably serves sensory functions (cf. Tautz & Markl, 1978); it was also found in the first instar larva of *Hesperia* (Scott, 1975). The second feature is the ventral prothoracic gland, well known in several notodontids where it is related with defensive behaviour, but is also present in *Noctuidae, Nymphalidae* (s.l.) or *Pieridae* (see examples in Peterson, 1948).

A brief comparison of the chaetotaxy with those of the first instar larvae of *Danaus*, *Tirumala* and *Heliconiinae*, described by Kitching (1984) and Fleming (1960), is useful to highlight some of the main differences. The head chaetotaxy of *Hipparchia* and allied species differs in several respects from these two subfamilies, not only in the addition of one setae on each side, but also in the displacement of several of the setae (P2, L1, V2, V3, O3) towards the postero-ventral margin of the head. However, the body chaetotaxy of the *Satyrus* group appears to be more conservative than that of either the Danainae or the Heliconiinae. Each half of the prothoracic shield bears four setae in *Satyrus* s.l., with D1 on the anterior margin of the plate (as in the Argynnini: Gerasimov fide Hinton, 1946), while the prothoracic shield of both danaine and heliconine larvae bear only three setae. In the Danainae, there are two SD2 setae on the abdominal segments: the microscopic MSD2, antero-dorsal to the spiracle (abdominal segments 1–8), and the long SD2, dorsal to SD1 on the abdominal segments 1–9. *Satyrus* s.l. bear only a microscopic SD2 (thus equivalent to MSD2 in Kitching, 1984), and only one long subdorsal seta SD1 on these segments. The fact that two long tactile SD setae are found on the abdominal segments of danaine larvae reinforces the suggestion made by Hinton (1946: 30) that the microscopic SD2 is not the homotype of the thoracic SD2. The Danaina do differ also in the absence of SV2 on abdominal segments 1, 7 and 8, and of both SV setae on abdominal segment 9. Regarding *Heliconius* and allied species, there is also a trend towards the reduction in the number of SV setae (SV2 missing on the abdominal segments 1, 7 and 8 in *H.melpomene*). V1 is absent on the thorax and the abdominal segments 6–9, and D1 on abdominal segment 10 is borne on a single pinaculum, isolated from the rest of the suranal shield.

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**References**


DeVries, P.J., Kitching, I.J. & Vane-Wright, R.I. (1985) The systematic position of *Antirhea* and *Caerois*, with comments on the classification of the Nymphalidae (Lepidoptera). *Systematic Entomology, 10*, 11–32.


Hinton, H.E. (1946) On the homology and nomenclature of the setae of lepidopterous larvae, with some notes on the phylogeny of the Lepidoptera. *Trans-


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