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Details of the "posterior abdominal brush" and other scent organs of quadrifine noctuids with special reference to Hypeninae and Herminiinae (Lepidoptera: Noctuidae)

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Abstract

The "posterior abdominal brush" (pab), a scent organ frequently found in numerous quadrifine noctuids, is described and figured with details of its morphology and function. As an example, the brush organs of *Phyllodes eyndhovii* VOLLENHOVEN, 1858 and *Eudocima salaminia* (CRAMER, 1777) are presented in detail. A "fan"- mechanism of the abdominal brush is described. Scent disseminating organs in general are discussed with regard to the subfamilies Hypeninae and Herminiinae.

Zusammenfassung

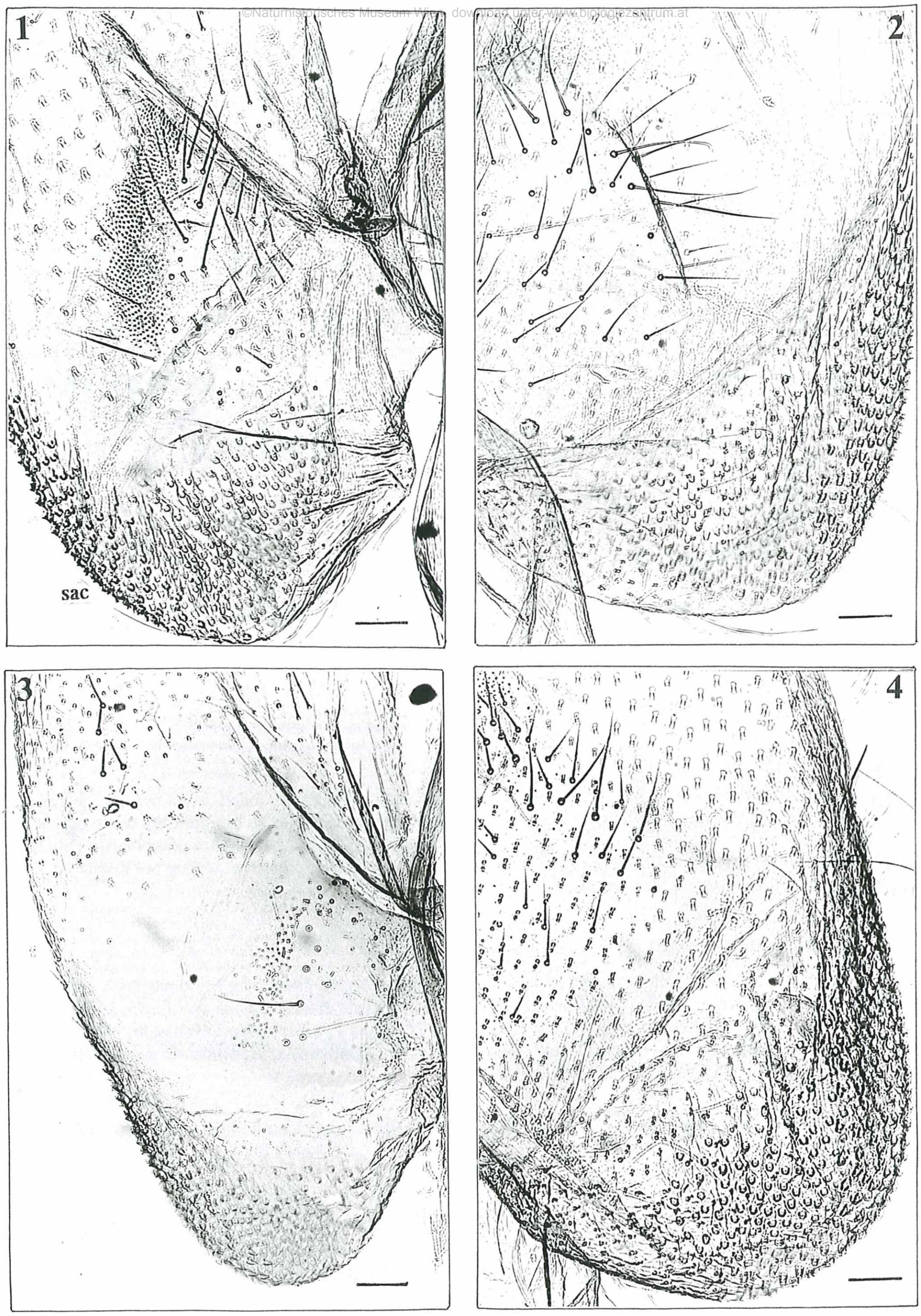
Der "posterior abdominal brush" (pab), ein Duftschuppenorgan, das häufig bei quadrifinen Noctuiden gefunden wird, wird beschrieben und detailliert abgebildet. Als Beispiele dienen das pab von *Phyllodes eyndhovii* VOLLENHOVEN, 1858 und *Eudocima salaminia* (CRAMER, 1777). Ein "Fächer"-Mechanismus des pab, der der Ausstülpung der langen Duftschuppen dient, wird vorgestellt. Duftstoffverbreitende Organe werden im allgemeinen an Hand der Unterfamilien Hypeninae und Herminiinae diskutiert.

Key words: brush organs, Calpinae, Herminiinae, Hypeninae, morphology, Noctuidae, *Phyllodes*, posterior abdominal brush, scent organs.

Introduction

The **posterior abdominal brush (pab)** is a scent organ of males of different groups of Lepidoptera, situated on the sternite of the 8th abdominal segment. It is frequently found in different genera of quadrifine noctuids. Form and shape of the pab are varying. In some groups of noctuids it is typical on the genus level in some genera it is according to the species level.

To answer questions about homology and analogy it is necessary to know details about structure and morphology, histology and lineages within a monophyletic unit. The tendency to build groups of



Figs. 1-4 Sacculi of species of the genus *Dichromia* GUENÉE, 1854 (Scale = 0.1 mm): **Fig. 1**: *D.* (*Camhypena*) *mesomelaena* (HAMPSON, 1902) (Bioco), Noctuidae BM gen.sl. 15288.- **Fig. 2**: *D.* (*Ametropalpis*) *nasuta* MABILLE, 1884 (Madagascar), Noctuidae BM gen.sl. 15193.- **Fig. 3**: [*Hypena*] *aroa* BETHUNE-BAKER, 1908, holotype [type status not yet verified] (New Guinea), Noctuidae BM gen.sl. 16021.- **Fig. 4**: *D.* (*Ametropalpis*) *leucozona* HAMPSON, 1910 (West Africa), Noctuidae BM gen.sl. 15288.

hair-like scales being inserted in skinny, pocket like folds and standing on sockets seems to be widespread in Lepidoptera, particularly in noctuids.

The pab is a concealed scent organ and belongs to a sort of "coremata" This group of scent organs is characterized by the presence of a membranous area which is more or less eversible and tubular. This area wears numerous long, hair-like scales. The whole organ is concealed and situated on the ventral surface of the 8th abdominal segment. During the resting behaviour the "pocket" which contains the pab is hidden between the 8th and 7th sternite, both forming a telescope-like tube.

McColl (1969) (cited after Scoble 1992: 161 ff.) defines six types of scent disseminating organs: 1. Single, isolated scent scales. Each is combined with a glandular cell of the hypodermis. The scales often are aberrant, e.g. frayed at the distal tip. This type is confined to wings, the scent-scales normally are covered by normal cells. 2. Aggregations of glandular cells and bundles of scales forming discrete patches. This type is frequently found on wings, but also on legs and abdomina. 3. Scent organs with groups of glandular cells and hair-like scales but hidden and concealed by skinny pockets or folds. Cuticular folds of the wing or tubular pockets of the intersegmental membrane of the abdomen as well as skinny parts of the genitalia corpus can hide these types of scent organs. Type 4.–6. organs are of increased complexity. The glandular cells are more or less separated from the brush organ, the brush or "pencil" – organ does not come into contact with the scent producing areas continously.

Aim of this paper is to clarify how the complex bundle of scales can be spread out precisely and how the microstructure of the scales contributes to the function of the organ. A short survey of the most frequently found scent organs in Hypeninae and Herminiinae is given.

Material and methods

Three different methods have been used to carry out the present study:

1. Traditional light optic methods. Dried abdomina of noctuids have been mazerated in KOH, cleaned and stained with Chlorazol Black. As embedding medium Euparal was used. The pictures have been carried out with an Olympus stereomicroscope SZX12.

2. In situ preparations of conventionally dried abdomina have been made by using micro tools and an Olympus stereomicroscope SZX12.

3. The SEM study was carried out with conventionally dried specimens (alcohol, aceton 99,9 %, cooled), coated with gold, on a Jeol 6000/400.

The scent disseminating structures of quadrifine noctuids

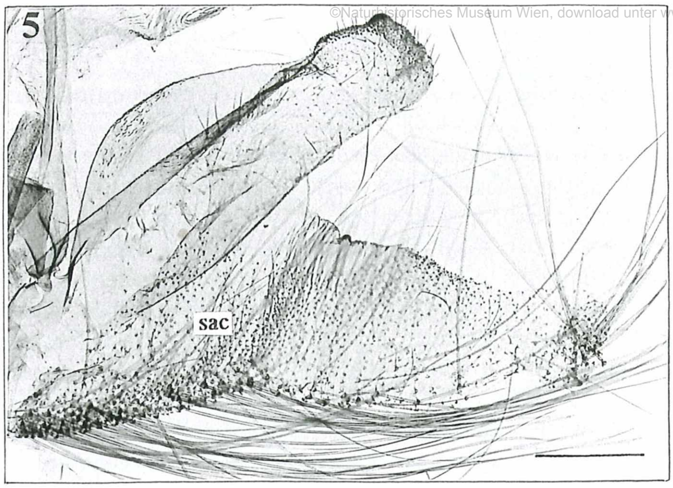
Scent disseminating organs are frequently found in Noctuidae. Coremata are more or less eversible scent organs, skinny and sometimes tubular, covered with hair-like scales (Janse 1932). They mainly occur in Noctuidae, Arctiidae and Geometridae. Typical coremata are long, eversible tubes situated on parts of the male genitalia. The basic typology of a skinny area with long, hair-like scales, concealed and hidden between abdominal segments or in folds or pockets is found on different parts of the lepidopteran body. The length of the eversible tube and the size of the brush vary significantly.

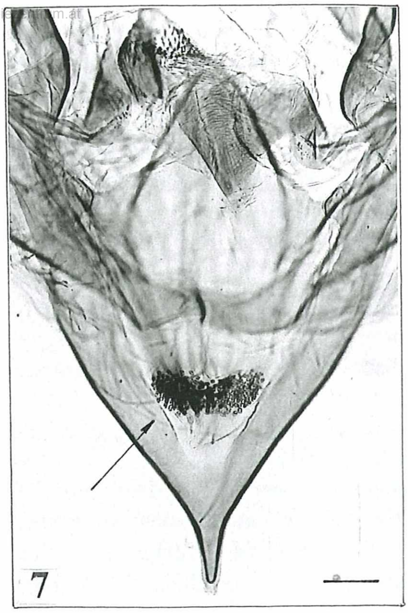
We focus on quadrifine noctuids, mainly Calpinae, Catocalinae, Hypeninae and Herminiinae. The following parts of the body can exhibit scent organs:

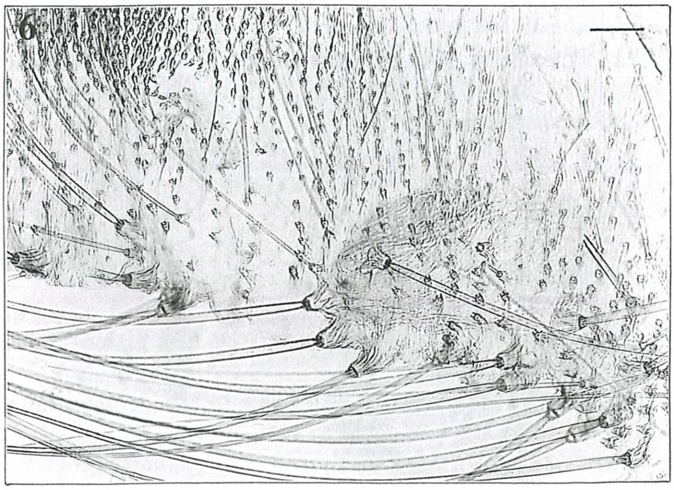
1. The 8th sternite. This is the typical pab (posterior abdominal brush; Birch 1970, 1972).

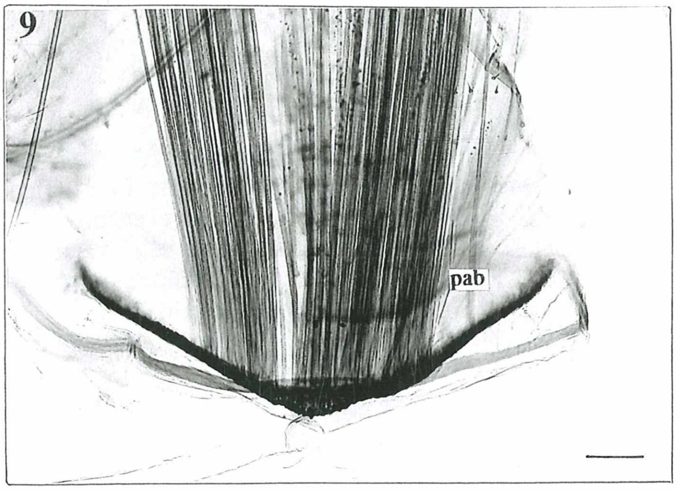
2. The ventral surface of the vinculum/saccus.

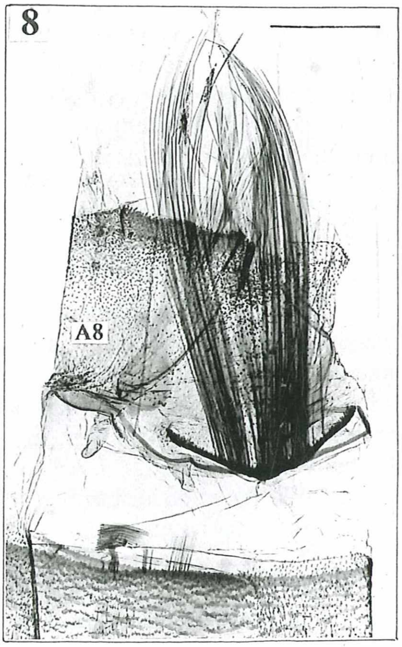
3. The base of the sacculus. This area is known to wear the most voluminous and longest tubes which – in some cases - can be everted to a remarkable length. Some of the tubes exceed the total length of the genitalia corpus. In the Hypeninae some groups tend to enlarge the sacculus. The genus *Dichromia* Guenée, 1854 for example extends the sacculus proximally (valves like "elephant-ears"). Figs. 1-4 illustrate some examples of this feature. This flabby sack is not really eversible, as it is found in the tubular sacculus type of the genus *Catada* Walker, [1859] 1858 (Figs. 5-6). All *Catada* species exhibit long, flabby sacculi, which are eversible and exceed the length of the valves significantly. Especially the ventral surface of the sacculus tube is covered with long, strong hair-like scales sitting on sockets (Fig. 6).











Figs. 5-9:

Fig. 5: *Catada phaeopasta* HAMPSON, 1909, ♂-holotype. Sacculus coremata (sac); Noctuidae BM gen.sl. 16508. Scale = 0.5 mm.- **Fig. 6**: *Catada charalis* SWINHOE, 1900,♂-lectotype. Sacculus coremata, scales on sockets; Noctuidae BM gen.sl. 16504. Scale = 0.1 mm.- **Fig. 7**: [*Oglasa*] *plagiata* GAEDE, 1939, ♂-holotype. Brush organ on vinculum; Noctuidae BM gen.sl. 610. Scale = 0.1 mm.- **Fig. 8**: dto.- 8th abdominal segment (A8) with posterior abdominal brush (pab). Scale = 0.5 mm.- **Fig. 9**: dto.- posterior abdominal brush (pab). Scale = 0.1 mm.

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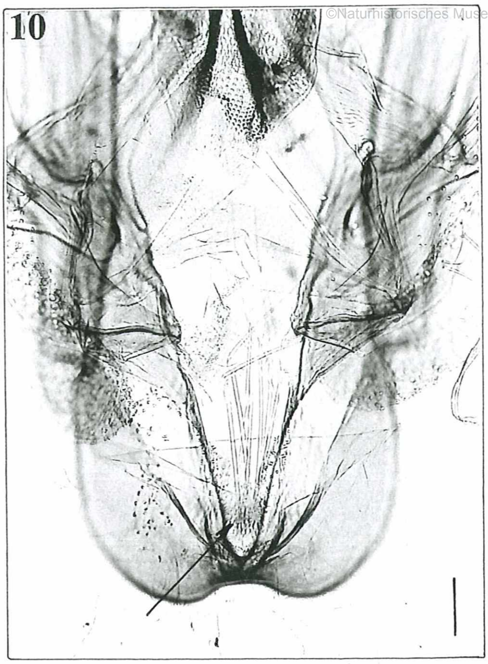

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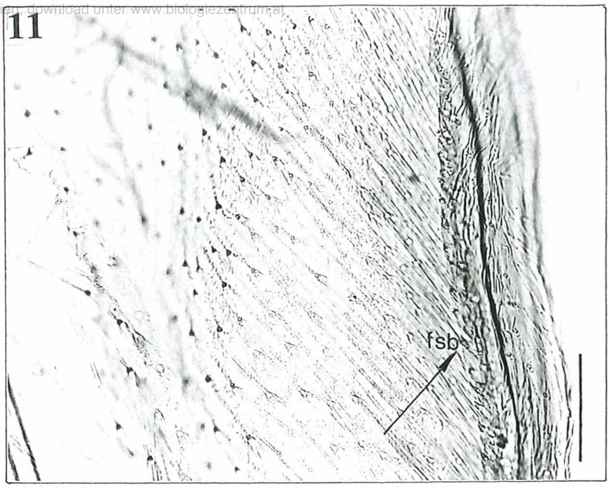

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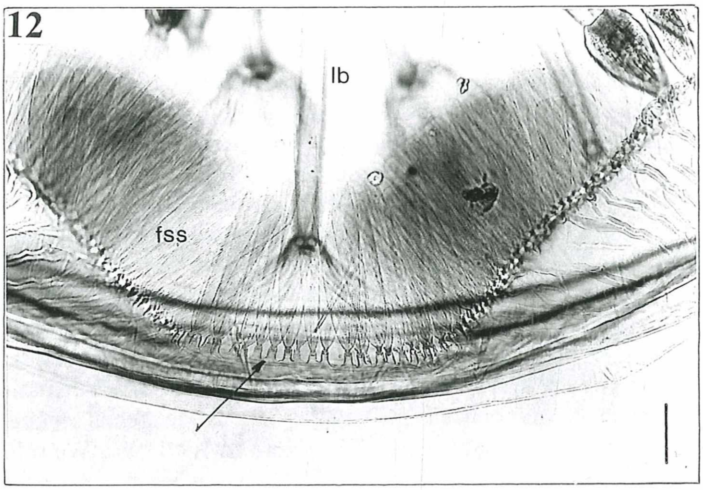

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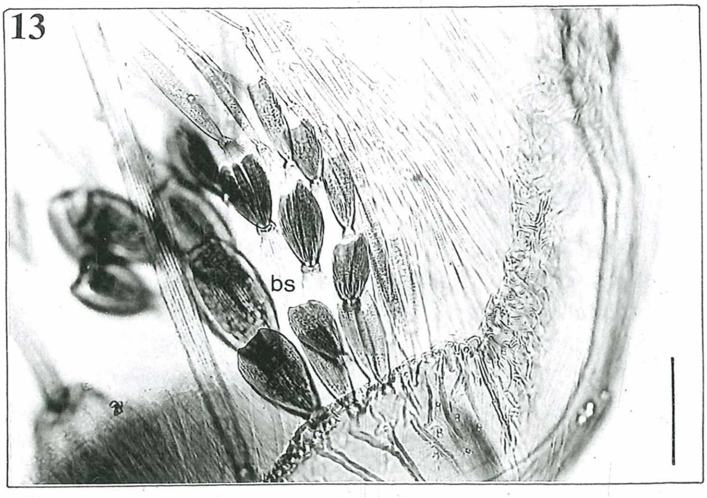

Figs. 10-13 Brush organs of *Nolasena ferrifervens* WALKER, [1858] 1857, Noctuidae BM gen. sl. 16434 ♂ (scale = 0.1 mm):

Fig. 10: Brush organ on saccus, ventral view.- **Fig. 11**: Brush organ on 8th abdominal sternite; fan of small bristles (fsb) along margin.- **Fig. 12**: Lace of scale fan on cephal margin of 8th sternite (fss = fan of small scales, lb = long bristles).- **Fig. 13**: Broad scales with sockets (bs) on both sides of the long bristles. Possible system of glandular tubes on the bottom of the picture visible.

Even the primitive members of the genus, like *Catada phaeopasta* HAMPSON, 1909 (which clearly represents the plesiomorphic state of the group) realize a fully tubular sacculus.

4. The margins of the valves especially in the Hypeninae s.str. wear similar structures of fan-folded, skinny laces. The hair-like scales are inserted on sockets. This is a sort of generalized scent organ, difficult to observe but obviously frequently found in Hypeninae genitalia.

5. Big tufts and pencils of hair-like scales are often found on the ventral or lateral base of the tegumen. These organs are symmetrical and sometimes enlarge the tegumen to a pad-like structure.

6. The labial palps. Especially in the Herminiinae the labial palps can wear tufts of hairs. These can be concealed or permanently exposed.

7. On the wings. Scent organs can occur on the forewings as well as on the hindwings, on the upper- and underside. The scent organs sometimes are open areas of aberrant scales, sometimes wing-folds with bundles of scales inside. These folds can be discrete or very broad, influencing the wing venation or even the shape of the wing.

8. Scent organs also can occur on the forelegs. Tuft organs of different prominence can occur nearly on all parts of the legs, from the coxae to the tarsi.

The "posterior abdominal brush" and other scent organs in the Hypeninae

The type genus of the Hypeninae, the genus *Hypena* SCHRANK, 1802 is poor in posterior abdominal brushes. These organs are not well developed in this genus. Interestingly closely related genera exhibit a wide variety of posterior abdominal brush organs although the variety of other secondary scent organs is not so wide than in the subfamily Herminiinae. The genus *Hypena* is a multidimensional system of lineages (LÖDL 1994a, 1995), like a radiating pencil of rays with a well defined and well structured centre. This centre is a bundle of clearly differentiated but more or less uniform species. On the other hand the rays which radiate in different directions are of remarkable amplitude and range. That is the reason why attempts to split this mega-genus are not very fruitful. *Dichromia* GUENÉE, 1854 was recognized as a sibling genus to *Hypena* (LÖDL 1994b). In the course of conducting a survey of the species range of *Dichromia* the author has certain doubt about the monophyly of the genus now. The genus is mainly based on the striking feature of "elephant-ear"-like valves. This feature is defined by a widely extended sacculus which is a curious sort of scent organ (Figs. 1-4). These coremata are flabby sacs, protruding proximally and wearing a bundle of long hair-like scales. Similar but quite bigger coremata on the sacculus are found in the genus *Catada* WALKER, [1859] 1858 (LÖDL 1999b, 2000) (Figs. 5-6). As in the flabby pockets of the posterior abdominal brushes the scales of these "mega-tufts" are standing on sockets (Fig. 6). These coremata are eversible to a remarkable length and exceed the length of the valves. Due to other unique features the systematic position of the genus *Catada* remains unclear. Sacculus coremata are found as an analogous concept also in the catocaline genus *Achaea* HÜBNER, [1823] 1816 and the chloephorine genus *Chandica* MOORE, 1888 (HOLLOWAY 1998). We refer back to the genus *Dichromia*: The main question which has to be answered is wether the extended sacculus is a monophyletic feature or not. The sacculus coremata could also be secondary features which appeared independently during evolution and now mark etxreme forms of quite different *Hypena* lineages. To our present knowledge we divide the genus *Dichromia* into three subgenera which resemble each other in the male genitalia but are strikingly different in external appearance. The subgenera are *Dichromia* GUENÉE, 1854, *Camhypena* A.E. PROUT, 1927 and *Ametropalpis* MABILLE, 1884. A specialized form of sacculus scent organ is found in the genus *Xoria* NYE, 1975 (LÖDL 1997a). It is distinct, 3d-fold, protruding proximally and extending into the ventral margin of the valve with longitudinal, skinny ribs.

The margins of the valves especially in the Hypeninae s.str. wear similar structures of fan-folded, skinny laces. The hair-like scales are inserted on sockets and stand within a fan-like fold as it is found in the tufts of posterior abdominal brushes and sacculus coremata. This is described as a sort of "generalized scent organ", difficult to observe but obviously frequently found in Hypeninae genitalia (Fig. 14).

Classic posterior abdominal brushes have been observed in the genera *Harita* MOORE, 1882 (LÖDL [1997] 1996) and *Ricla* WALKER, 1869 (LÖDL 1997b). As the genus *Hypena* the African genus *Sarmatia* GUENÉE, 1854 seems to be very poor with posterior abdominal brushes. Posterior abdominal brushes are also found in the genera *Acidon* HAMPSON, 1896 and *Hiaspis* WALKER, [1866] 1865; in *Hiaspis* additionally aberrant brushes on the 2nd abdominal sternite. Additionally in the genus *Hiaspis*

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Fig. 14: *Hypena proboscidalis* LINNAEUS, 1758 ♂; SEM view of fan mechanism on valva, lace of scales with distinct sockets.

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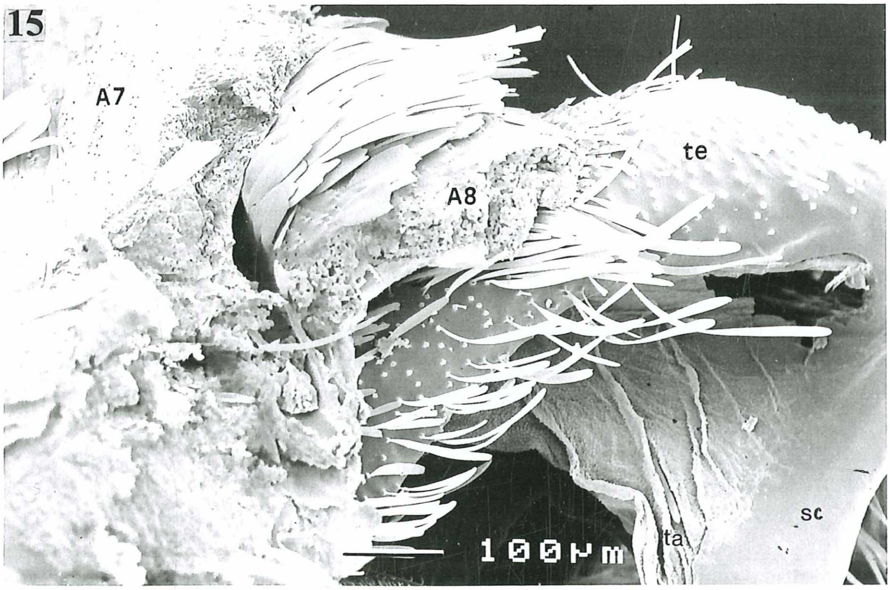

Fig. 15: *H. proboscidalis* ♂; SEM view of telescope mechanism of 8th abdominal segment (A8), dorso-lateral view, genitalia corpus partly exposed (te = tegumen, ta = tuba analis, sc = scaphium).

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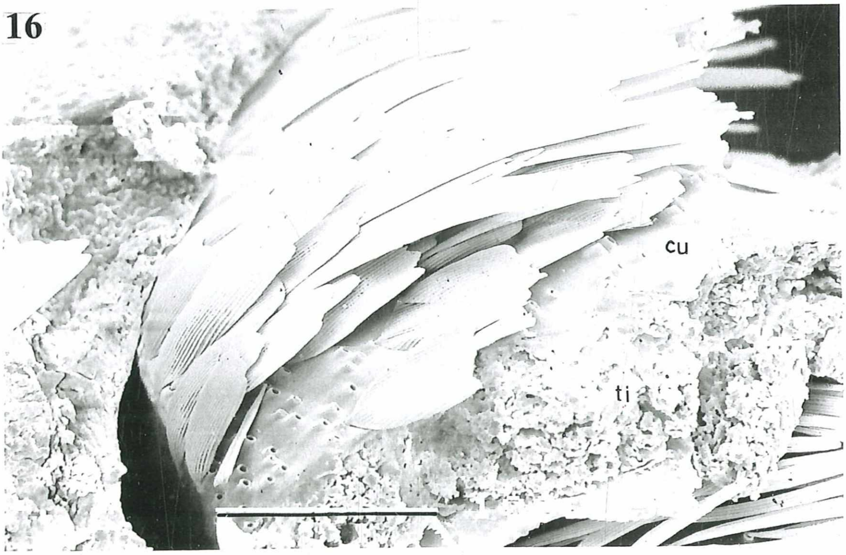

Fig. 16: *H. proboscidalis* ♂; SEM view of telescope mechanism of A8 – details. Cuticula (cu) and subcuticular tissues (ti) exposed.

wide and extensive scent organs on the wings have been observed, characteristic for the species level: *Hiaspis fuscobrunnea* (HAMPSON, 1895) presents a broad scent area under the cell of the forewing. This area is so prominent that the normal run of CuA_2 is influenced and its origin is "pushed" to the distal end of the cell (LÖDL 1998a. fig. 97).

We face a special situation in the genus group *Rhynchina* GUENÉE, 1854. While the posterior abdominal brushes do not play any role in scent dissemination many species exhibit a prominent teguminal pad with big tuft organs. Others, like the type-species *Rhynchina pionealis* GUENÉE, 1854 have enlarged sacculi like *Dichromia* species. The exact systematic position of the *Rhynchina*-group is not yet clear, while we still place the genera *Rhynchina*, *Zekelita* WALKER, 1863 and *Proluta* SAALMÜLLER, 1891 in the Hypeninae, BECK (1996) transferred "*Rhynchodontodes* WARREN, 1913 (which is a synonym of *Zekelita*) to the Catocalinae, tribe Toxocampini. This assumption is based on characters of the larvae (BECK 1999). Clear is, that *Rhynchina* and the allied genera form a monophyletic unit. The species [*Oglasa*] *plagiata* GAEDE, 1939 (which has nothing to do with the genus *Oglasa* WALKER, [1859] 1858) is supposed to belong to this genus group. Prominent scent organs are a massive, deep folded pab (Figs. 8-9) and a well defined area of hair-like scales in the middle of the ventral surface of the vinculum (Fig. 7).

A unique situation was discovered in *Nolasena ferrifervens* WALKER, [1858] 1857 (LÖDL 1999a). This species is traditionally placed in the Calpinae (former Ophiderinae) but it could well be that the species has to be transferred to the Hypeninae, standing there near the genus *Catada*. The vinculum in this species wears a skinny fold in its middle and holds there a tuft of long, hair-like scales (LÖDL 1999a: figs. 19, 21) (Fig. 10). The 8th abdominal segment exhibits some striking features in the male. Tergite 8 is more or less skinny and flabby and shows a longitudinal furrow in the middle. Sternite 8 is very complex (LÖDL 1999a: figs. 7-12) (Figs. 11-13). The major part of sternite 8 is a bowl which is open distally and surrounded by a folded margin (Fig. 11). This margin is roughly skinned (Fig. 11). The bowl is protruding bag-like into the 7th segment and bears several areas of aberrant scales and bristles at its proximal margin (Figs. 12-13). Fine bristles cover both sides of the bowl (fsb = fan of small bristles). In the middle of the proximal margin three distinct, long and fine-pointed bristle-like scales (lb) are found which extend to the end of the abdomen (Fig. 12). The insertion areas of these bristles are surrounded by big, broad scales (bs) (Figs. 13). Another type of smooth and slender scales (fss = fan of small scales) is found as a dense border along the proximal margin (Figs. 12). The fss and the bs are typically stalked standing on distinct sockets. The whole fold is organized as a fan mechanism obviously made for more or less intensive eversion. This border of the fold along the margin of the 8th sternite is densely proliferated by a tubular structure (Figs. 12 and 13 at the bottom). This tubular proliferation is possibly a system of glandular ducts. This is one of the most complex scent organ systems observed in quadrifine noctuids up to the present.

A genus of uncertain placement is *Britha* WALKER, [1866] 1865. This genus occurs with several species in the Indo-Australian and Ethiopian Region and is characterized among other features by asymmetrical male genitalia. An interesting fact is that the type species, *Britha biguttata* WALKER, [1866] 1865, disposes of two striking scent areas on the forewings. One is a large, well defined area along the vein 1A+2A on the upperside. The second is situated at the base of the forewing underside directly under the cell. This scent area is holding extraordinary long hairs. This feature is developed in all taxa which are very near (or synonymous ?) to *B. biguttata*, the other hitherto known species of the genus do not exhibit this character.

The "posterior abdominal brush" and other scent organs in the Herminiinae

The smoothly scaled abdomina of the "true and typical" Herminiinae like the *Herminia* LATREILLE, 1802/*Polypogon* SCHRANK, 1802 – genera complex and *Simplicia* GUENÉE, 1854 are rather poor in striking posterior abdominal brushes. They concentrate on scent organs with tufts of hairs on the male forelegs. A first approach to survey these scent organs typifying the genera was made by OWADA (1987).

Other groups of Herminiinae concentrate on a bundle of different scent organs:

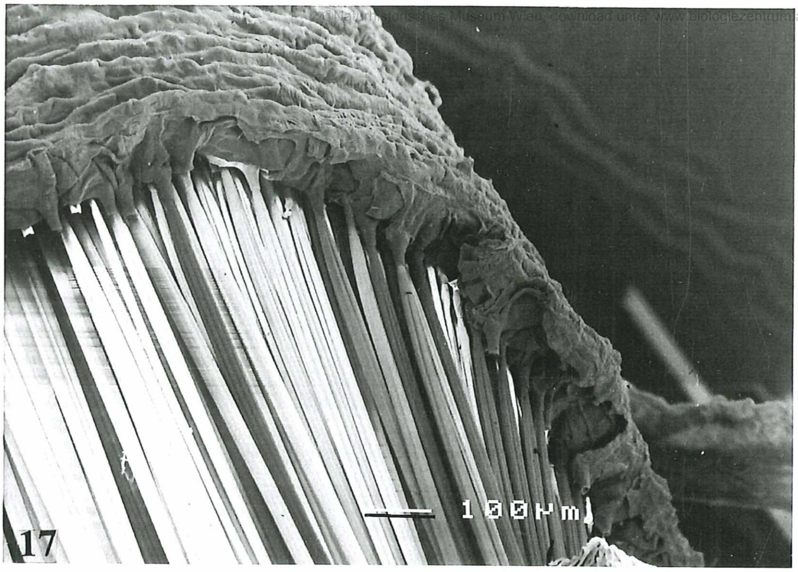

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Fig. 17 *Phyllodes eyndhovii* VOLLENHOVEN, 1858 (Vietnam). SEM-view of pab-pocket. Scale = 0.1 mm.

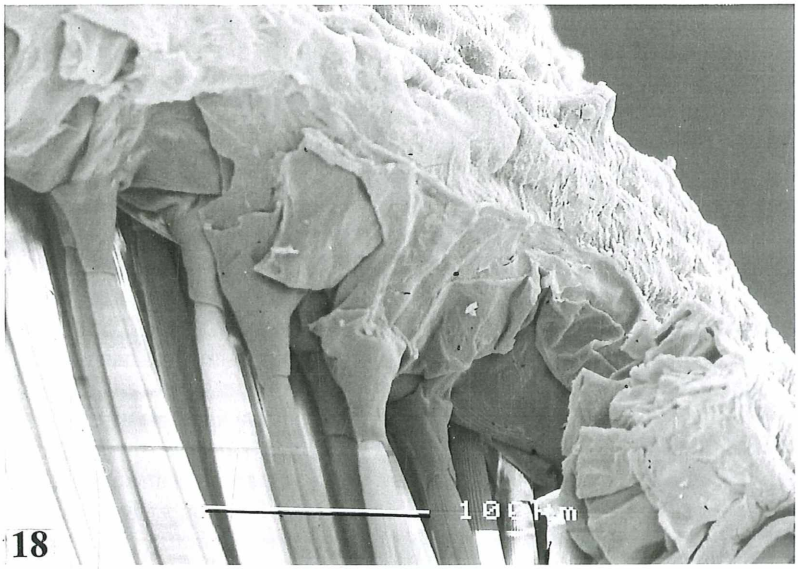

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Fig. 18 *Phyllodes eyndhovii*. SEM-view of pab: fan-mechanism. Scale = 0.1 mm.

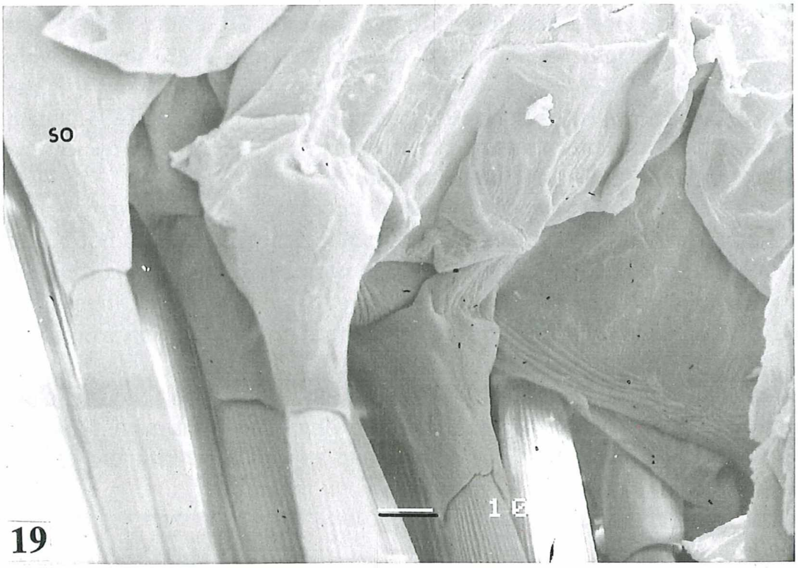

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Fig. 19 *Phyllodes eyndhovii*. SEM-view of pab: fan-mechanism. Details of scale base; scale socket (so). Scale = 0.01 mm.

1. Scent organs of the male forelegs (as in the typical "*Herminias*" are also found in a wide variety of genera. *Adrapsa* WALKER, [1859] 1858, *Bocana* WALKER, [1859] and *Edessena* WALKER, [1859] 1858 have just forelegs fringed with long hair-like scales. A similar situation is present in *Hydrillodes* GUENÉE, 1854 which is a very difficult group in regard to its systematic position. Many genera with five-segmented, three-segmented and one-segmented tarsi exhibit complex tufts of hairs on their forelegs. A very informative table about the Asian groups is found in OWADA (1987: 12, table 1).

Some tropical groups seem to have very complex tuft systems on their forelegs, most genera and species have not yet been examined. Interesting findings can be awaited in the *Naarda* WALKER,1866 and *Gynaephila* STAUDINGER, 1892 – group. These genera most likely belong to the *Idia* HÜBNER, [1813] group of genera. Our newest findings lead to the opinion that [*Hypena*] *fusculalis* SAALMÜLLER, 1880 ([*Hypena*] *fuscomaculalis* SAALMÜLLER, 1880 sensu LÖDL 1996) (LÖDL 1996, 1999c) belongs to that genus group. Obviously [*H.*] *fusculalis* is a very robust species of unclear genus occuring in the Madagascan tropics and exhibiting big and broadened forelegs, covered with fringes and tufts of long hair-like scales. These legs resemble those of bees.

2. Scent organs on the labial palps are frequently found in tropical groups, sometimes tufts of hairs are sitting on palps having a spectacular form and length. The labial palps of the genus *Cidariplura* BUTLER, 1879 extend backwards to the 3rd abdominal tergite. So does *Insolentipalpus* BETHUNE-BAKER, 1908, a widely unknown genus from New Guinea. Massive and densely covered palps are also found in *Cristatopalpus* BETHUNE-BAKER, 1908 (LÖDL 1998b). The genus *Lascoria* WALKER, 1859 (occuring in the Nearctic and Neotropical Region) shows also long and complex labial palps, covered with bundles of hair-like scales. A similar situation is found in the genera *Mastigophorus* POEY, 1832 and *Palthis* HÜBNER, [1825] 1816. There are no detailed investigations of these fantastic and striking structures which are found within these American genera. A good example is the totally uninvestigated genus *Mamerthes* DRUCE, 1891 which shows in the male massive and impressive structures on the long, back curved palpi. The longest labial palps can be found in species like [*Catadoides*] *longipalpis* (SWINHOE, 1903) which exceed significantly the length of the forewing and wear complex tuft structures on the third joint. The tufts of hairs can be exposed (*Bertula* WALKER, [1859] 1858 or *Adrapsa*) or partly or completely concealed (*Hadennia* MOORE, [1885] 1884-1887 or *Trotosema* BUTLER, 1879).

3. Scent organs are also frequently found on the wings. In Asian species costal folds on the undersides of the forewings are common, especially in the "primitive" forms like *Adrapsa*, *Bocana*, *Edessena* and similar groups, like *Cristatopalpus* with big, hairy areas on the underside of the costal margin of the forewing (LÖDL 1998b). On the upperside scent organs are found in the curious genus *Hydrillodes* GUENÉE, 1854. The systematic position is unclear. OWADA (1987) referred in detail to the taxonomic problems of this group. However, the author of this paper believes that *Hydrillodes* species clearly belong to the Noctuidae and are just a remarkable lineage with aberrant male genitalia and scent organs as costal folds on the uppersides of the forewings. Tropical taxa of the South East Asian and Australian as well as the Neotropical realm express an impressive and massive system of different scent structures. Ludicrous and unique features are usual and frequently found, the Hypeninae and the Herminiinae of the tropics realize a wide range of different scent organ systems. So on the wings scent organs– especially of the costal area and the split outer margins of the forewings – are impressively realized in the American *Lascoria*. *Sitophora* GUENÉE, 1854 seems to be near *Hydrillodes* and – if not synonymous – represents this genus in the Neotropics. The Neotropic genus *Argania* DRUCE, 1891, which presumably belongs to the *Renia*–complex exhibits massive scent organs on the costal area of the forewing, partly resulting in an impressive curvature of the costal margin.

In the Indo-Australian Region the genera and species of New Guinea realize the most remarkable scent structures on the wings. The investigation of these complex morphological features has not begun yet. The evolutive aspect is also very interesting – in many genera the most extreme forms, regarding the scent areas, wing shapes and shapes of antennae and labial palps, are always found on New Guinea. The New Guinea genus *Cheillophota* BETHUNE-BAKER, 1908 exhibits scent areas on both the forewings and the hindwings. On the forewings the venation and the complete zone of the inner margin is aberrant. A similar case is the gigantic Herminiinae *Piratisca minax* (BETHUNE-BAKER, 1908), also found in New Guinea. A massive scent area is found in the centre of the male forewing. The Malaysian *Mosopia megaspila* WALKER, [1866] 1865 realizes prominent folds on the forewings as well as striking tuft organs on the labial palps.

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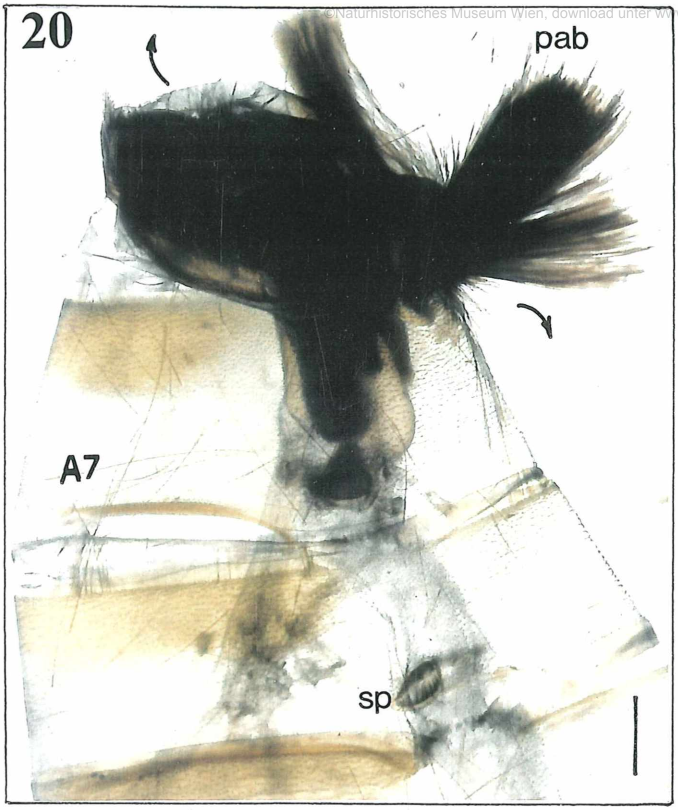

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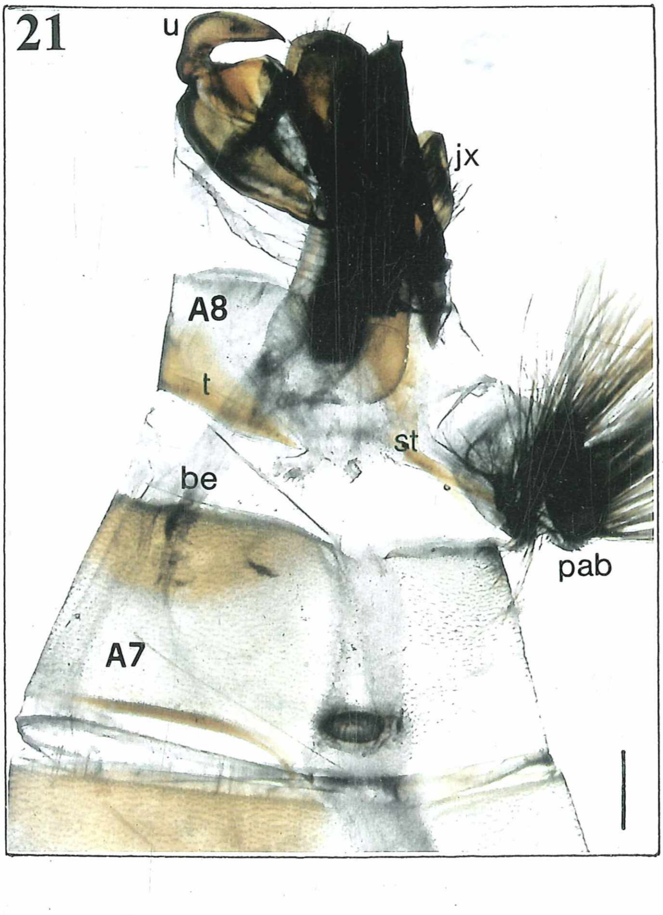

Figs. 20-21 *Eudocima salaminia* (CRAMER, 1777) ♂ (scale = 1 mm):

Light microscope study of telescope mechanism of abdomen, lateral view. Arrows indicate the protruding direction of pab and the corpus genitalis (**A7**, **A8** = 7th and 8th abdominal segment; **be** = bulbus ejaculatorius; **jx** = juxta; **pab** = posterior abdominal brush; **sp** = spiracle; **st** = sternite; **t** = tergite).

4. Very interesting are scent structures on the vinculum. These structures can be easily overlooked during routine preparation. These structures are very well developed in the genera *Bocana*, *Hadennia* and *Paracolax* HÜBNER, [1825] 1816 (OWADA 1987).

5. Posterior abdominal brushes are also found in Herminiinae. A special situation is found in the monophyletic genera complex *Mecistoptera* HAMPSON, 1893 (LÖDL 1997c) and *Perciana* WALKER, 1865 (LÖDL 1999d). Traditionally treated as "Ophiderinae" (= Calpinae) or Hypeninae the author was convinced for a while that both genera could be the missing link between the *Hypena* – and the *Rhynchina*-complex within the Hypeninae. There are some doubts about this hypothesis. A strong argument is the prespiracular hood which is found in both species. It could well be that we have Hypeninae-like Herminiinae, similar to the Neotropical *Dogniades* SCHAUS, 1916 which also exhibits a Hypeninae outfit. *Mecistoptera* and *Perciana* have posterior abdominal brushes. *Mecistoptera* additionally has tufts on the ventral surface of the tegumen (LÖDL 1997c: fig. 12). The pab of *Perciana* is consisting of a more or less simple fold with the normal set of hair-like scales situated on the proximal margin of the 8th sternite. Beside this two further, symmetrical pads of tufts are present on the distal margin of the same sternite. So these can be interpreted as additional scent disseminating accessoires, lying directly beneath a weakly sclerotized distal margin.

Morphological findings

1. The details of the structure of the abdominal brush organ exhibit a fan-mechanism. The hair-like scales are stalked and fitted into a socket (BIRCH 1970) (Figs. 17-19). Every single hair-like scale is not only inserted in a socket. The sockets are standing on skinny folds which aggregate side by side to a well ordered fan mechanism. This seems to give the guarantee for a delicate and precise display of the brush when the muscle is everting the skinny tube and the brush organ itself. This fan mechanism is also realized in a generalized type of scent disseminating structure of *Hypena* and *Dichromia* species. As discussed above, the margins of the valves wear a lace of scales with sockets (Fig. 14).

2. The brush organ itself lies in a pocket. These pockets are of different shape and size (Figs. 22-25) and can be easily extracted during preparation under dry, in situ conditions. This is shown with the two Calpinae *Phyllodes eyndhovii* VOLLENHOVEN, 1858 (Figs. 22-23) and *Eudocima salaminia* (CRAMER, 1777) (Figs. 24-25). These illustrations give the interior dorsal as well as the interior ventral view. BIRCH (1970: 286) considered these cuticular folds as being essential for the development of the secretion and retaining the scent from evaporation. Our findings varify the fact that the folds are well defined pockets with a rough cuticula with well developed tissues. Although the findings of BIRCH (1970) are mainly carried out with the complex trifine pockets on abdominal segments 2-4 of *Phlogophora meticulosa* (LINNAEUS, 1758) the situation in the pab seems to be similar. Of course the complexity is not so high, the pocket itself does not protrude in the abdominal lumen thus far. In the abdominal brush organs of segment 2 the pocket extends into the abdominal lumen to segment 4. Nine muscles and a lever-hinge-system help to protrude the brush organ. The 8th sternite of the quadrifine pab seems to operate similarily as a lever as can be seen in the everted position of fig. 21.

3. The brush organs of the terminal abdominal segments are hidden between the segment shields under resting conditions. The segments stick together exhibiting a telescope mechanism. This mechanism is demonstrated in figs. 15-16 with the tergite situation. The scales, as in the ventral condition with the posterior brush organ, are dragged in when the abdomen is contracted. The telescope mechanism is also demonstrated in figs. 20-21 in the species *Eudocima salaminia*. First the compact tuft is protruded (fig. 20) and then – continously - the whole pocket gets evaginated and displays the total brush system (fig. 21).

Figs. 22-25 Isolated pockets of the posterior abdominal brushes (pab) of two male Calpinae species from Vietnam (scale = 1 mm) (next page / nächste Seite):

Fig.22: *Phyllodes eyndhovii*, pocket from interio-dorsal view.- **Fig. 23**: dto.- Interio-ventral view.
Fig. 24: *Eudocima salaminia*, pocket from interio-dorsal view.- **Fig. 25**: dto.- Interio-ventral view.


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The original position of the pab is demonstrated with figs. 26-32. Figs. 26-29 are dealing with *Phyllodes eyndhovii*, figs. 30-32 with *Eudocima salaminia*. Cuticula and subcuticula were removed continously. The cuticula of the abdominal segments was brushed carefully to remove all scales. The valves and other parts of the genitalia tract were also cleaned. Fig. 28 demonstrates clearly how deep the pocket of the pab is hidden between the telescope system of the segments. The arrow marks the entrance where the pab is found, covered by sternite 7.

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Figs. 26-32 In situ status of the posterior abdominal brush (pab) of two male Calpinae species from Vietnam (scale = 1 mm) (next page / nächste Seite):

Fig. 26 *Phyllodes eyndhovii*, abdomen, lateral view, primary status.- **Fig. 27**: dto.- Scales of 7th segment removed.- **Fig. 28**: dto.- Scales of distal end of abdomen and of valva removed (st = sternite, t = tergite, v = valva).- **Fig. 29**: dto.- Cuticula of 7th segment removed, pab partly exposed.- **Fig. 30**: *Eudocima salaminia*, abdomen, lateral view, primary status.- **Fig. 31**: dto.- Scales of 6th and 7th segment removed.- **Fig. 32**: dto.- Cuticula of 6th and 7th segment removed, pab partly exposed.


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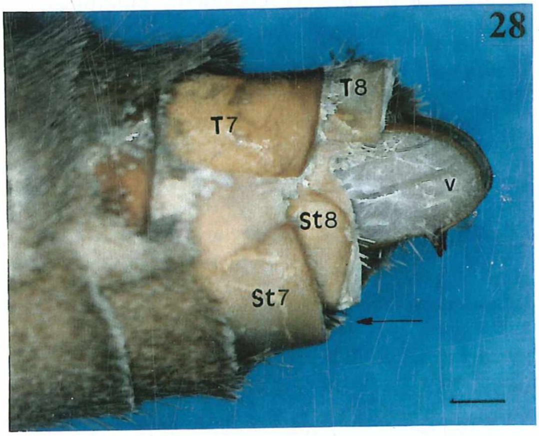
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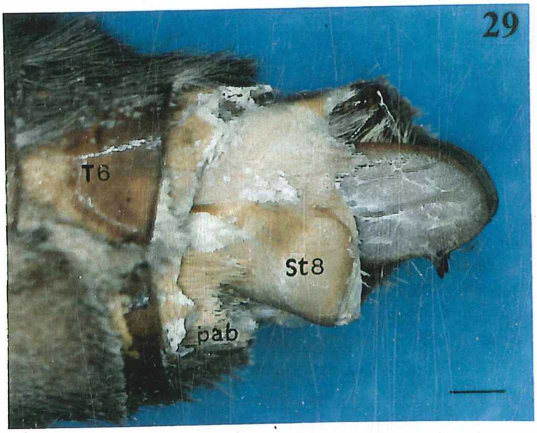
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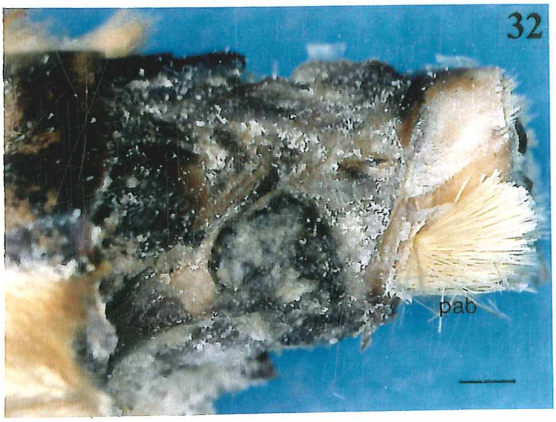
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