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The modification of the "posterior notal wing process" of the forewing in the family Noctuidae and its importance for taxonomy (Insecta, Lepidoptera)

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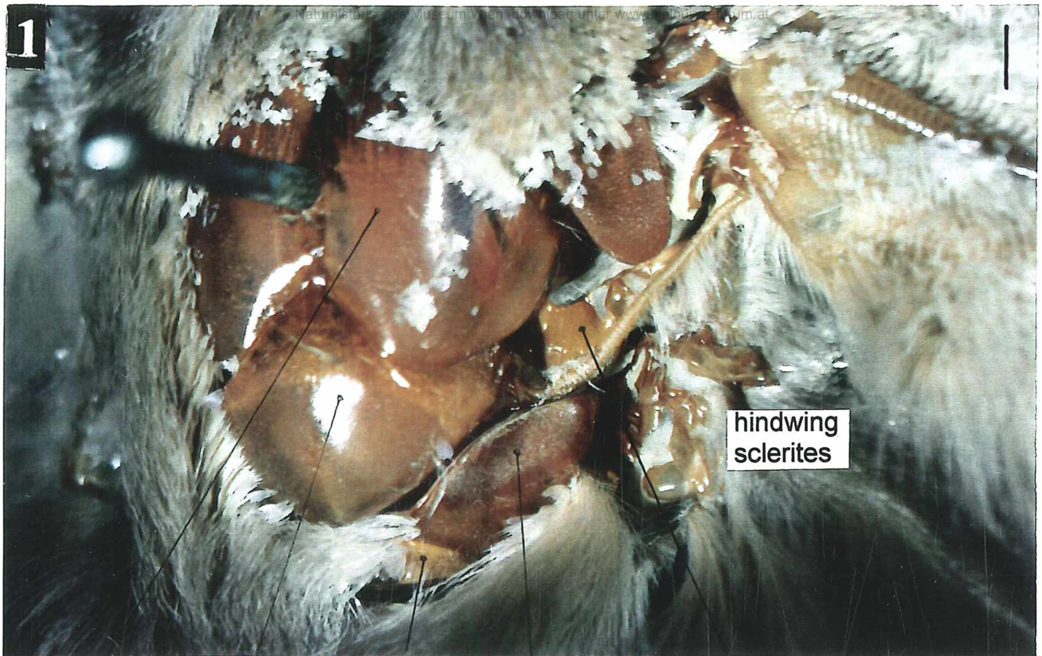
Abstract

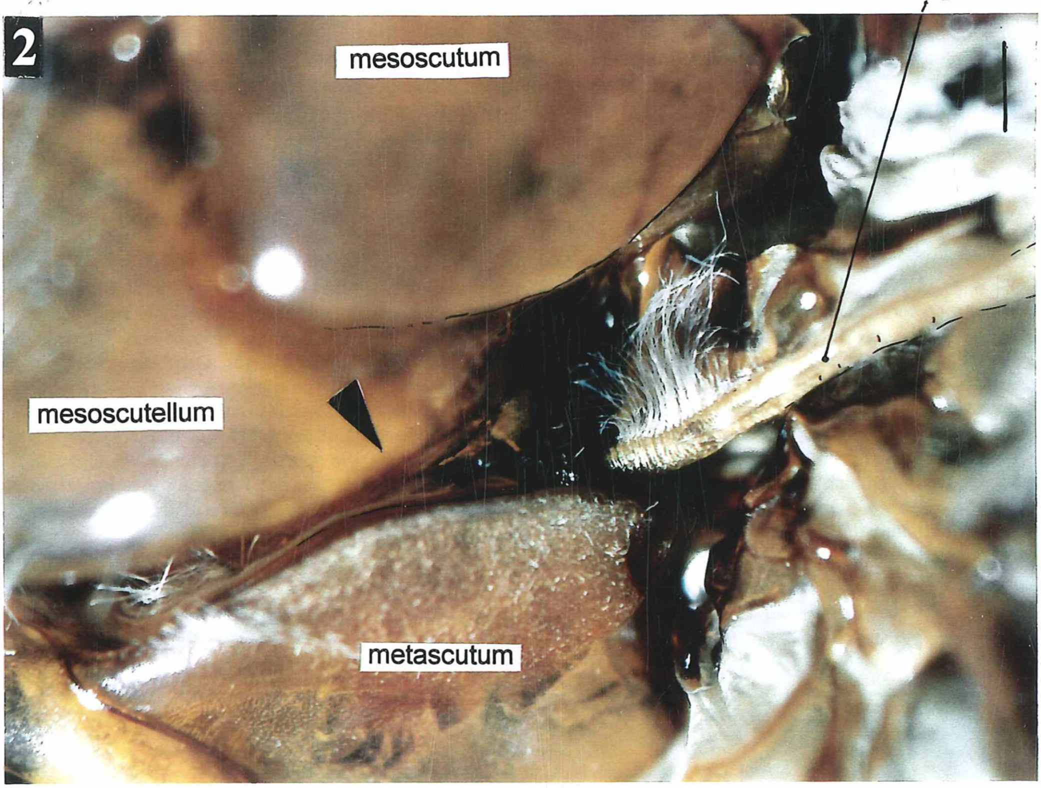
A comparative morphological study of the wing base sclerites in the family Noctuidae resulted in recognizing remarkable differences in the posterior notal wing process. The morphology of the wing base and its sclerites was investigated with representatives of the Noctuidae subfamilies Calpinae, Catocalinae, Cocytiinae, Hypeninae, Herminiinae and Plusiinae using light microscopic methods. The composition of the complex system of notal processes, axillary sclerites and median plates was investigated briefly. Particular attention was paid to the morphological differences in the posterior notal wing process which turned out to be of taxonomic importance on specific as well as on higher taxonomic level. Taxonomic important features are found particularly in the lateral branch of the posterior notal wing process, its proportion within the central membrane and the proportion of the basal plate with its bending cuticle on the base of the posterior notal wing process. The variability of the posterior notal wing process is illustrated. A first step is made into the morphometric analysis of taxonmoic valuable and morphologically stable characters on the posterior notal wing process.

Zusammenfassung

Die vergleichende Morphologie der Flügelbasen und ihrer Sklerite innerhalb der Familie Noctuidae ergibt merkbare Unterschiede besonders in der Ausgestaltung des "posterior notal wing process" Die vorliegende Arbeit untersucht die Flügelbasen mit ihren Skleriten innerhalb der Familie Noctuidae anhand von Arten der Unterfamilien Calpinae, Catocalinae, Cocytiinae, Hypeninae, Herminiinae und Plusiinae. Die Untersuchungen wurden mit lichtoptischen Mitteln durchgeführt. Die Zusammensetzung des komplizierten Systems an "notal processes", "axillary sclerites" und "median plates" wurde untersucht. Besonderes Augenmerk wurde dem "posterior notal wing process" gewidmet. Erstmals wurde nachgewiesen, daß dieser Merkmale trägt, die auf spezifischem aber auch auf höherem taxonomischem Niveau von Relevanz sein können. Taxonomisch bedeutende Merkmale finden sich am "lateral branch" des "posterior notal wing process", in der Proportion des Prozessus innerhalb der zentralen Membran und der Proportion der "basal plate" mit ihrer "bending cuticle" an der Basis des "posterior notal wing process" Die Variationsbreite ist illustriert. Ein erster Schritt zur morphometrischen Analyse des "posterior notal wing process" wurde gemacht.

Key words: comparative morphology, morphometry, Lepidoptera, morphology, Noctuidae, posterior notal wing process, pterothorax, wing base, wing sclerites, taxonomy.


1
hindwing sclerites
mesoscutum
mesoscutellum
metascutellum
metascutum
posterior notal wing process


axillary cord
2
mesoscutum
mesoscutellum
metascutum

Figs. 1-2 Dorsal view of the pterothorax and the wing sclerites (previous page / vorige Seite):

Fig. 1: *Phyllodes verhuellii* VOLLENHOVEN, 1858 (Java, NHMW), pterothorax and wing base partly descaled, tegula in situ – this is the ideal condition of routine investigation. Scale = 1 mm.
Fig. 2: *Phyllodes conspicillator* (CRAMER, 1777) (Sulawesi, NHMW), base of the posterior notal wing process reaching the pterothorax; the fusion of the basal sclerotization of the axillary cord with the mesoscutellum is marked by an arrowhead. Scale = 0.5 mm.

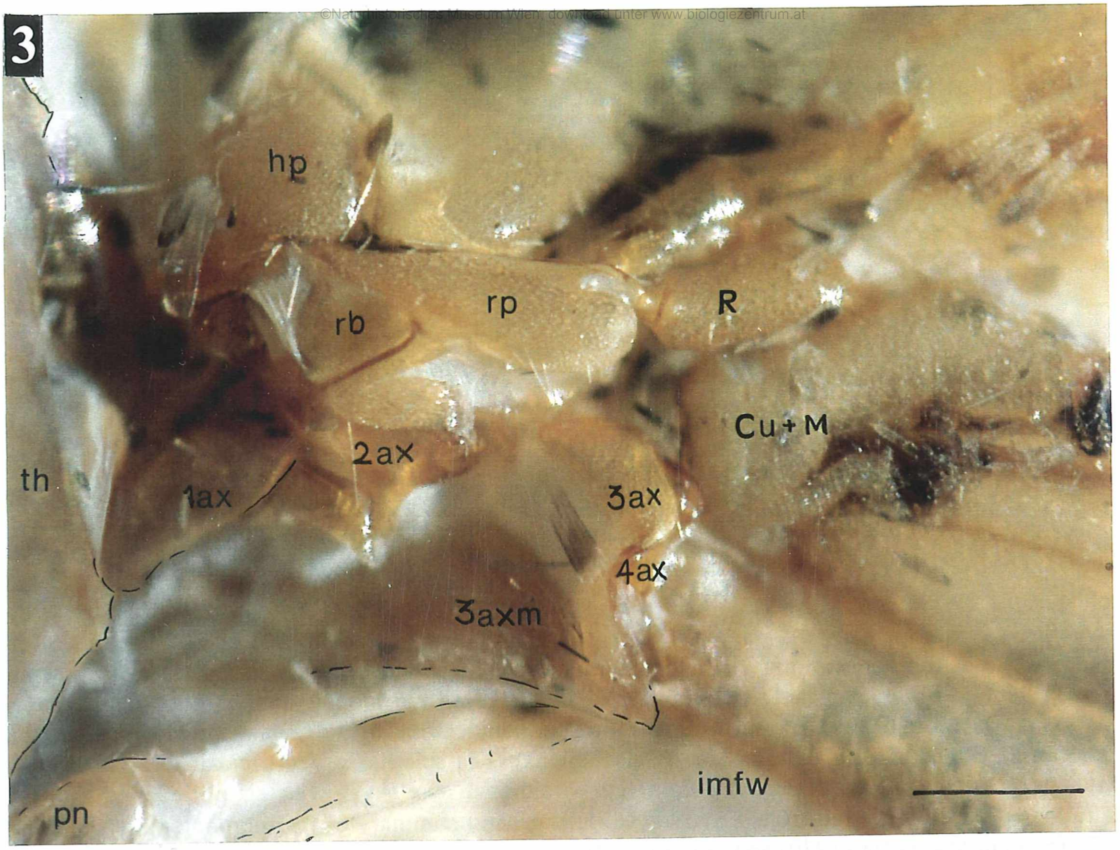
Introduction

The wing base of Lepidoptera is characterized by a complex system of sclerites and membranes which connects the wings with the corresponding parts of the meso- and metathorax. This system of sclerites has two duties: First the up-and-down movement of the wings during the flight, and second an anterior-posterior movement, responsible for the different resting positions and the wing folding. A basic work on the morphology of the sclerite arrangement of the Lepidoptera has been published by SHARPLIN (1963 b, c). This paper was a consequent attempt to standardize the terminology of the wing sclerites and a valuable contribution to the understanding of the different movements of the wings made possible by the complex articulation of the wings at the thorax. Additionally SHARPLIN (1963a, 1964a) contributed to the knowledge of the wing folding of Lepidoptera and the function of the bending cuticle of the wing base. DAVIS (1986) investigated the wing base of the primitive monotrysian family Palephatidae. ADAMSKI & BROWN (1989) are also dealing with Microlepidoptera: they give a detailed survey on the sclerite arrangement of the Blastobasidae (Gelechioidea). The sclerites of Tortricidae are discussed in ADAMSKI & PETERS (1982). Useful information – although explained with simplified and reduced illustrations - can be gathered from EATON (1988). A general summary of the morphology of the wing base is found in MATSUDA (1970) and SCOBLE (1992).

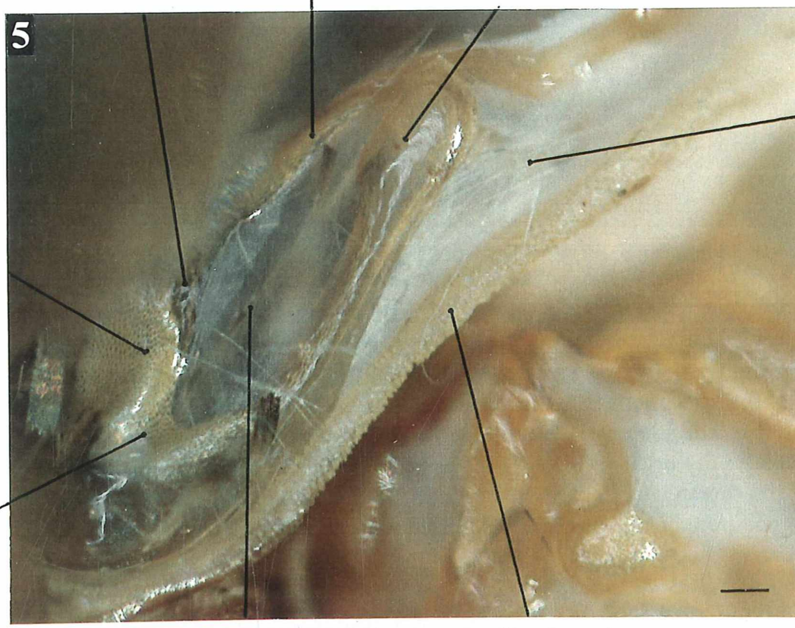
Aim of this paper is to demonstrate the taxonomic importance of the posterior notal wing process. Taxonomic important features have been found particularly in the lateral branch of the posterior notal wing process, in its proportion within the central membrane and in the proportion of the basal plate with its bending cuticle on the base of the posterior notal wing process. This is an additional attempt to clarify the taxonomic possibilities which are opened up by studying the complex system of articulating sclerites of the wing base of lepidopterous insects. An exact taxonomic cataloguing of the different morphology of the posterior notal wing process is reserved to later papers. A first contribution to the taxonomic significance of the wing base structures was published by SHARPLIN (1964b). This paper deals with the taxonomic value of the wing base features on a very generalized level and does not go into details of the lower classificatory levels. Although much information is available so far on the lateral condition of the pterothorax (BROCK 1971) further studies are needed to clarify the fusion of the notal wing processes with the meso- and metathorax in detail. Detailed studies within the family Noctuidae are still missing.

Figs. 3-4 Survey of the right forewing sclerites anterior of the posterior notal wing process (dorsal view) (scale = 0.5 mm) (next page / nächste Seite):

Fig. 3: *Catocala nupta* (LINNAEUS, 1767) (Austria inferior, NHMW). Note: The membrane of the third axillary sclerite (3axm) exhibits a coriaceous sector near the third axillary sclerite and fuses proximally with the anterior membrane of the posterior notal wing process.
Fig. 4: *Catocala fraxini* (LINNAEUS, 1758) (Austria inferior, NHMW).
Abbreviations: 1ax, 2ax, 3ax, 4ax = First to fourth axillary sclerite; 3axm = membrane of third axillary sclerite, 1mp = first median plate; Cu+M = basal plate of cubital and median veins; hp = humeral plate; imfw = inner margin of forewing; pn = posterior notal wing process, R = basal plate of radial veins; rb = radial bridge; rp = radial plate; Sc = basal plate of subcosta; th = thorax.


3
hp
rp
rb
R
Cu+M
th
2ax
1ax
3ax
4ax
3axm
imfw
pn


4
Sc
hp
R
rp
rb
Cu+M
1mp
3ax
2ax
1ax
4ax


5
anterior branch
longitudinal suture
lateral branch of posterior notal wing process
distal posterior membrane
bending cuticle
basal plate
proximal posterior membrane
axillary cord


6
anterior membrane
1ax
2ax
3axm
3ax
lace of hair-like scales
axillary cord
hindwing sclerites

Figs. 5-6 Morphology of the posterior notal wing process (previous page / vorige Seite):

Fig. 5: *Catocala nupta* (LINNAEUS, 1767) (Austria inferior, NHMW). Scale = 0.1 mm.- **Fig. 6**: *Catocala fraxini* (LINNAEUS, 1758) (Austria inferior, NHMW). Scale = 0.5 mm. Note the lace of hair-like scales covering the fold between the axillary cord and the anterior branch of the pn. This is the normal condition without descaling.

Material and method

The results of this paper have been obtained with light optic methods. Dried specimens have been cleaned step by step, the photographic documentation was done with an Olympus stereomicroscope SZX12. Although the wing position in set specimens is artificial, the position of the posterior notal wing process is documented in this arrangement. This allows a better comparison, the major part of specimens is mounted for collections.

Cleaning of the specimens is done carefully by using very small brushes or distinct bristles. With reasonable practice it is not necessary to remove the tegula to investigate the posterior wing sclerites of the forewing. Especially the posterior notal wing process can be observed directly. Cleaning is necessary along the sides of the thorax and along the axillary cord which normally bears a lace of long, hair-like scales which cover completely the whole complex of membranes and sclerotized branches of the posterior notal wing process.

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

List of species investigated:

Catocalinae:
Catocala fraxini (LINNAEUS, 1758)
Catocala nupta (LINNAEUS, 1767)
Catocala sponsa (LINNAEUS, 1767)

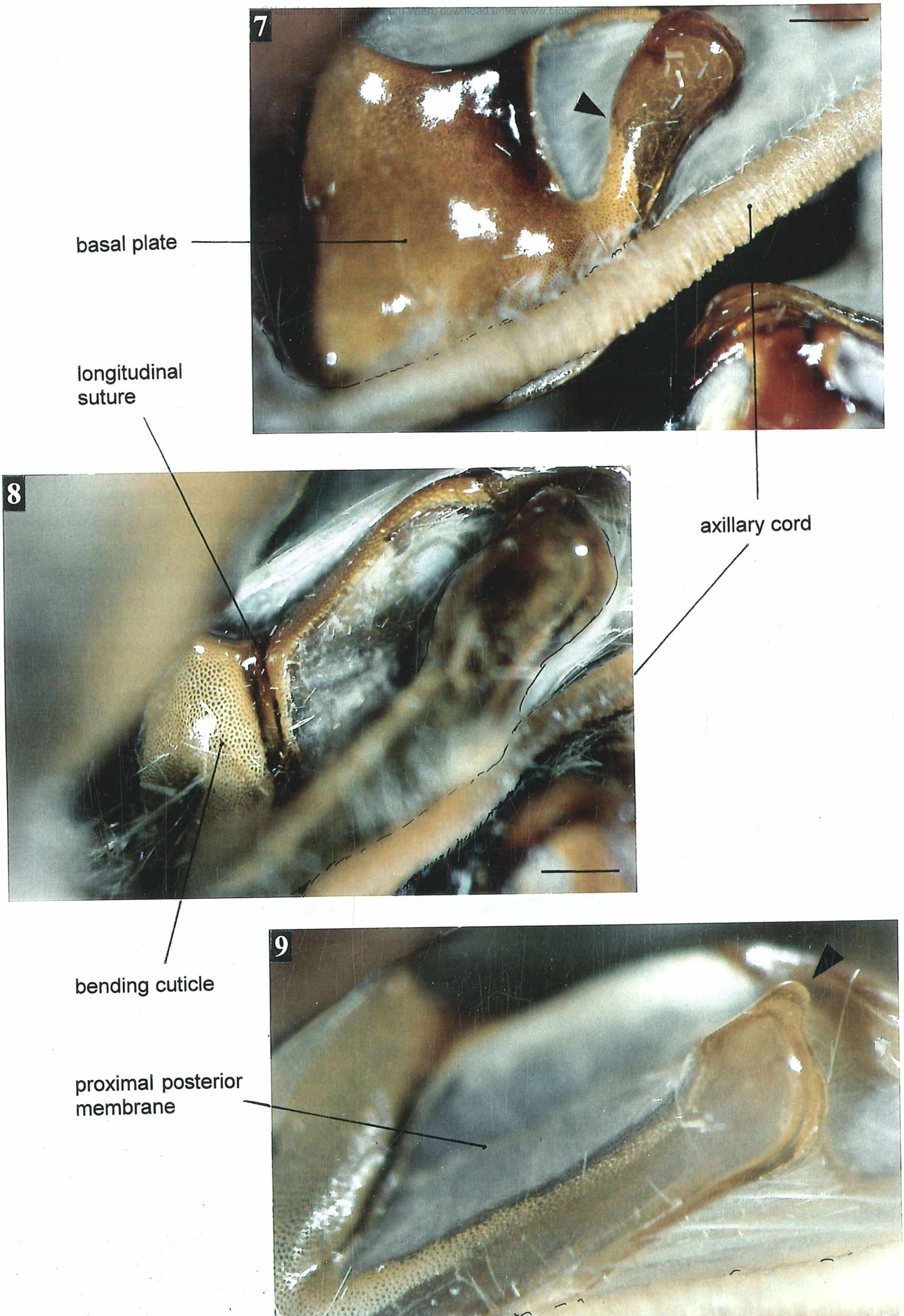
Calpinae:
Calesia dasypterus (KOLLAR, 1844)
Eudocima salaminia (CRAMER, 1777)
Phyllodes conspicillator (CRAMER, 1777)
Phyllodes eyndhovii VOLLENHOVEN, 1858
Phyllodes roseigera BUTLER, 1883
Phyllodes verhuellii VOLLENHOVEN, 1858
Ericeia inangulata (GUENÉE, 1852)
Thyas honesta HÜBNER, [1824]
Thyas juno (DALMAN, 1823)

Cocytiinae:
Cocytia durvillii BOISDUVAL, 1828 s.l.

Hypeninae:
Hypena proboscidalis (LINNAEUS, 1758)
Rhynchina lignicolor (HAMPSON, 1898)

Herminiinae:
Simplicia rectalis (EVERSMANN, 1842)
Edessena gentiusalis WALKER, [1859] 1858

Plusiinae:
Autographa gamma (LINNAEUS, 1758)


7
basal plate
longitudinal
suture
8
axillary cord
bending cuticle
9
proximal posterior
membrane

Figs. 7-9 Extension of the bending cuticle in the posterior notal wing process (previous page / vorige Seite):

Fig. 7: *Phyllodes roseigera* BUTLER, 1883 (Andaman Islands, NHMW). The arrowhead indicates the boundary of bending cuticle and homogeneous sclerotization on the lateral branch. Typical for *Phyllodes*-species is the broad basal plate. Scale = 0.25 mm.
Fig. 8: *Thyas honesta* HÜBNER, [1824] (NHMW). Note the very prominent longitudinal suture. Scale = 0.25 mm.
Fig. 9: *Thyas juno* (DALMAN, 1823) (Ussuri region, NHMW). The arrowhead indicates a specific terminal process on the lateral branch.

The wing base of the forewing

The wing base of the forewing consists of a complex system of sclerites, ligaments and sclerotized plates connecting the wings with the mesothorax. Bending cuticles, membraneous areas and ribbed cords (like the axillary cord) guarantee a wide range of movements which are necessary for flying and folding the wings. Although the concept of the wing bases of the Ditrysia is "surprisingly constant" (SHARPLIN 1963b) many morphological details seem to be uninvestigated. The present paper deals with the posterior notal wing process (or postnotal wing process as termed by some authors). It can be shown that the posterior notal wing process is a complex system of bending cuticles, sclerotizations and ligaments allowing a wide variety of movements and moreover exhibits a selection of morphological features which are of taxonomic importance.

First a general survey of the wing base of the forewing and its structures is given. The following areas can be differentiated (Figs. 1-4):

1. The notal processes:

Three notal wing processes can be distinguished: the **anterior notal wing process**, the **median notal wing process** and the **posterior notal wing process**. These notal wing "processes" are connective membranes incorporating several more or less sclerotized branches and connecting the axillary sclerites and the wing membrane with the wing bearing parts of the mesothorax. The anterior and the median notal wing process in Noctuidae are not very prominent. The first is a small ligament connecting the scutum with the costal plate system. The median notal wing process arises also from the scutum and connects to the first axillary sclerite (ax1). The posterior notal wing process is an elongated and more or less folded ligament system with sclerotized parts. It arises from the subalare and articulates with the third axillary sclerite system (ax3 and ax4) and with the inner margin of the forewing membrane.

2. The plates:

There is a **posterior plate system** and a **median plate system**. The prominent humeral plate is situated between the anterior notal wing process and the costal vein. There are also the radial plate and bridge system which is a basal extension of the radial vein. This posterior plate system represents the basal condition of the wing venation. The median plates can be found between the second and third axillary sclerites and are sometimes difficult to locate between the strongly sclerotized axillary sclerites. Additionally there seem to occur certain fusions between the sclerotized plate structures and the sclerotized sclerites which causes special difficulties in the 3ax/4ax-system.

3. The axillary sclerites:

Lepidoptera have three (sometimes four) axillary sclerites. These axillary sclerites are the central articulation system of different joints connected by membranes and fixed to the thorax with ligaments. The first axillary sclerite (1ax) is fused with the scutum by the membraneous median notal wing process. The second axillary sclerite (2ax) is a prominent joint extending through the surface of the wing. The dorsal part of this sclerite is connected with the radial plate system, the ventral part is connected with the subalare by membranes. The third axillary sclerite (3ax) is connected with the posterior notal wing process and with the median plate system. In higher Ditrysia the third axillary sclerite is divided into a distal (and from dorsal view very narrow) part and a proximal part. The distal part forms the fourth axillary sclerite (4ax). There seems to be considerable confusion about the exact definition of the 4ax if one compares a selection of papers. This may be due to the complex, three-dimensional situation which is additionally complicated by the membrane and muscle situation between the mesothorax and the axillary sclerites. First investigations made obvious that the exact composition of the 4ax and its implementation in the membraneous connection anterior of the posterior notal wing process remain somewhat obscure and have to be a focus for further studies. The 3ax clearly extends posteriorly and normally forms an edge where the pleurodorsal muscle for wing-folding inserts. This broad muscle is covered by the membrane of the 3ax and hides the view of the exact position of the 4ax.

The lateral condition of the pterothorax will need further attention in the future. The subalare seems to keep several highly important, taxonomic characters. Moreover in this sector the mesothoracal homologue of the metathoracal tympanal area is found (YACK, SCUDDER & FULLARD 1999). So the question remains whether the ligament system of the wing sclerites and the attachment sites of the subalare region and the meso- and metathoracic links are more than a membraneous connection or not. It may well be that a more complex system of proprioreceptive or possibly sound sensitive functions will come to light than has been assumed so far. A detailed analysis of the neuronal set of the complete ligament and membrane system of the wing hinge would be highly required.

The posterior notal wing process (pn) of the forewing

Morphological condition illustrated in figs. 1-2, 5-6, morphometric condition shown in fig. 27.

Our investigations made clear that the posterior notal wing process is a complex system of ligaments and sclerotizations linking the sides of the thorax and the axillary sclerite system. Detailed observation made the following sections obvious:

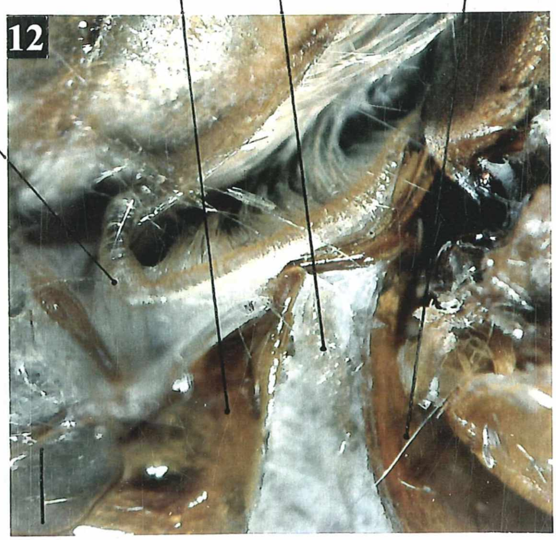
1. Basal plate (Figs. 5, 7-9, 27):
The basal plate of the pn mainly consists of bending cuticle (SHARPLIN 1963a). This flexible cuticle guarantees a better bending condition of the wing base and is found on several, especially exposed sites of the wing hinge. Normal cuticle is not in the position to stand the same extent of torsion as the bending cuticle is. All sites which are subject to distortion or bending movements have a specialized mesocuticle, consisting of distinct cones or pegs. These structures project down through the endocuticle. So the cuticle shows a continous exocuticle and a divided mesocuticle. This mesocuticle is responsible for a more or less high degree of bending possibilities. Arrowhead 1 in fig. 27 indicates the indent of the bending cuticle area on the posterior margin of the basal plate. This indent can range from very deep (and forming a "Z" together with the bending cuticle line along the lateral branch) to absent. Members of the genus *Phyllodes* BOISDUVAL, 1832 e.g. have very broad basal plates, with a dark amber colour and no striking indent of the bending cuticle area. Arrowhead 2 in fig. 27 marks the anterior margin of the basal plate and the origin of the anterior branch. This area can wear different types of extensions and enlargements (e.g. *Eudocima salaminia* (CRAMER, 1777)).

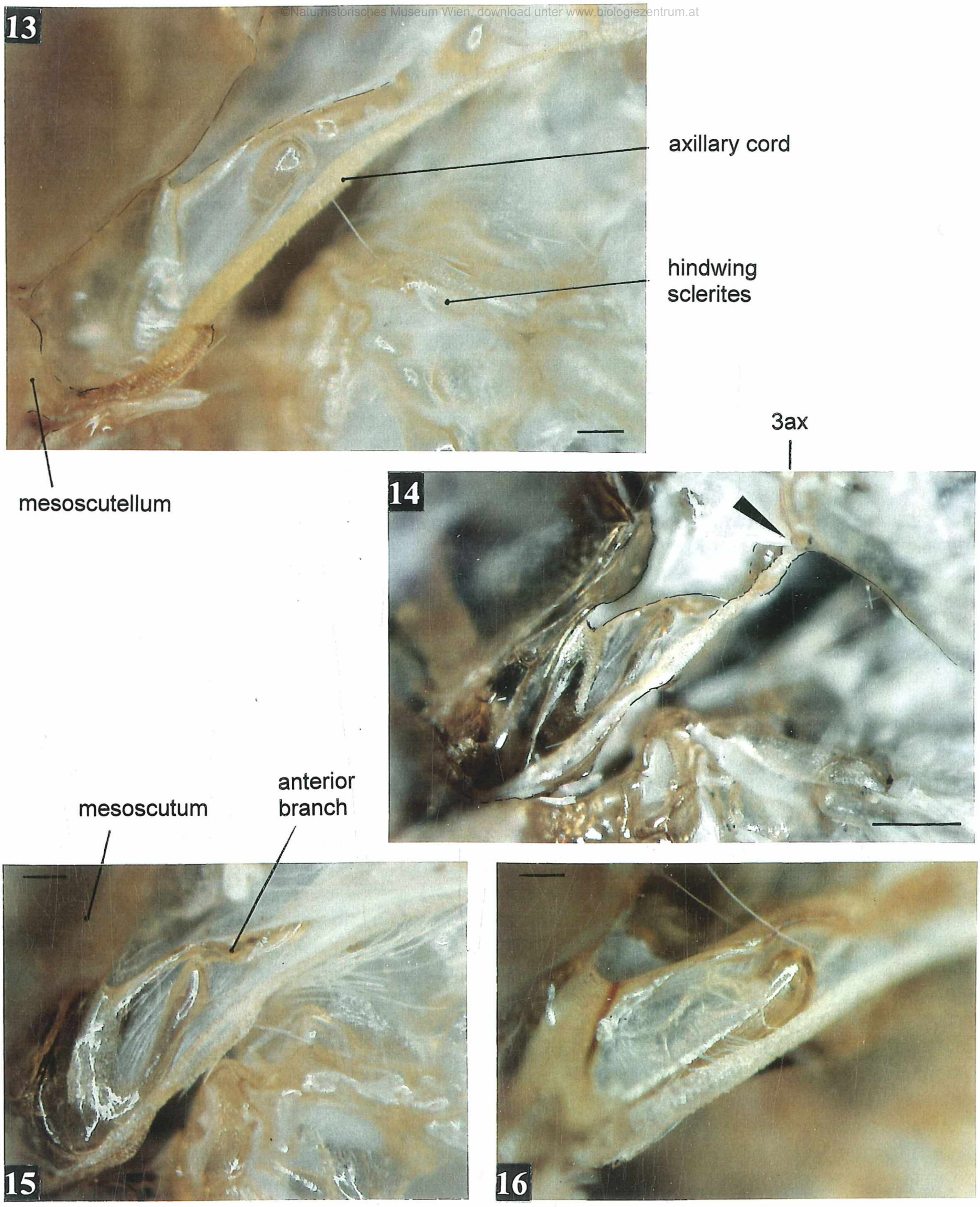
Figs. 10-12 Lateral view of the pterothorax of *Phyllodes eyndhovii* VOLLENHOVEN, 1858 (Vietnam, NHMW) with wings folded up artificially (scale = 0.5 mm) (next page / nächste Seite):

Fig. 10: Survey of the wing hinge forewing/hindwing, focus on the subalare sector.
Fig. 11: Details of the axillary cord and the distal portion of the posterior membrane folded artificially. On the left side the ventral portion of the axillary branch of the pn is visible. The hindwing is not removed.
Fig. 12: Focus on the posterior sector of the mesothorax namely the posterior region of the subalare. This sector is the mesothoracal homologue of the metathoracal tympanal area (YACK, SCUDDER & FULLARD 1999). This is the condition with removed hindwing. The artificial bending of the axillary cord shows its enormous flexibility. On the left side the fusion of the axillary cord with the inner margin of the forewing is visible.


10
forewing
frenulum
subcosta
humeral plate
of hindwing
hindwing
basalare pad
metepisternum
mesepimeron
subalare


11
axillary branch
humeral plate
of hindwing
distal posterior
membrane
axillary cord


12
subalare-
mesepimeron-
membrane
subalare
mesepimeron



Figs. 13-16 Posterior notal wing processes of selected species of Hypeninae and Herminiinae:

Fig. 13: *Hypena proboscidalis* (LINNAEUS, 1758) (Spain, NHMW). The fusion of the axillary cord with the mesoscutellum is visible in the left bottom corner. Scale = 0.1 mm.
Fig. 14: *Rhynchina lignicolor* (HAMPSON, 1898) (Nepal, NHMW). An arrowhead marks the fusion of the axillary cord with the inner margin of the forewing. Scale = 0.25 mm.
Fig. 15: *Simplicia rectalis* (EVERSMANN, 1842) (Hungary, Balaton, NHMW). Scale = 0.1 mm.
Fig. 16: *Edessena gentiusalis* WALKER, [1859] 1858 (China, NHMW). Scale = 0.1 mm.

2. Longitudinal suture (Figs. 5, 7-9):

The longitudinal suture originates on the distal "shoulder" of the basal plate and runs longitudinally to the posterior end of the indent filled with the proximal posterior membrane. The extension, length and width at the "shoulder" are quite different. The longitudinal suture divides the base of the pn and marks the incision of basal plate and anterior branch.

3. Anterior branch (Figs. 5, 15)

The anterior branch is the anteriormost sclerotization of the pn. It is embedded in the anterior membrane (or membrane of the third axillary sclerite (3axm)) and originates at the "shoulder" of the basal plate. The anterior branch extends distally, exhibits several typical torsions and then bends ventrally. Normally there is no connection of the distal knob of the lateral branch with the anterior branch. In some cases the anterior branch shows a certain loop and torsion at the point where the lateral branch incises the posterior membrane (Fig. 22). In some cases the distal knob of the lateral branch reaches this sclerotized loop of the anterior branch and shows some corium-like connections.

4. Lateral branch (sometimes called lateral process) (Figs. 5-6, 7-9):

The lateral branch is the central part of the pn, consisting of a strong, sclerotized arm originating from the posteriolateral edge of the basal plate. The bending cuticle can protrude more or less into the corpus of the lateral branch (arrowhead in fig. 7). The area with the bending cuticle is confined to the base and proximal side of the lateral branch (Fig. 9). The extension of the bending cuticle is of taxonomic importance. Also of taxonomic importance are form, shape and the proportion of the lateral branch. The lateral branch can be slim and slender (as it is found in several *Thyas* HÜBNER, [1824] (Calpinae) species; figs. 8, 21, 23) or broad and bulky. Members of the genera *Phyllodes* (Figs. 17-19) or *Eudocima* BILLBERG, 1820 (Fig. 20) have thick and knob-like lateral branches. A very interesting morphological feature is situated at the distal end of the lateral branch: in some Calpinae species the distal end forms a terminal tooth or process (Figs. 21, 23).

5. "Axillary branch" (most likely the ventro-proximal portion of the 4ax)

Although there are some serious doubts about the origin of this (partly) sclerotized portion situated ventrodistal from the anterior branch in the middle of the posterior membrane of the pn, we can say that it is most likely not a "true" part of the pn-complex. There is no exact data about this sclerite in literature although the main opinion (SHARPLIN 1963b, MATSUDA 1970) prefers the theory of a derivate of the 3ax/4ax complex. We call this sclerite here "axillary branch" and find a very complex three-dimensional structure. On top of all this structure is completely hidden by the posteriormost extension of the 3ax which bears the insertion of one of the pleurodorsal folding muscles. The third axillary membrane (= anterior membrane; figs. 3, 6) incorporates this muscle fascicle (Fig. 3) and hides the "axillary branch" completely. Due to our findings this "axillary branch" has no sclerotized connection with the anterior branch although it follows the direction of the anterior branch discretely. Normally the ventrodistal portion of the "axillary branch" is enlarged like a knob and shows a structure like a perforated buckle. This sclerite-arm runs consequently to the 4ax system and so far it is not clear if it links to the latter completely and exclusively or if it has some secondary connection with the 3ax-system. The dorsodistal portion of the "axillary branches" investigated for this paper (different *Catocala* SCHRANK, 1802 species) exhibited a complex enlargement of different degree of sclerotization at its dorsodistal end. The different sclerotization and a certain cover of ligament make the decision difficult whether it is a "true" and direct part of the 4ax or not. Considerable troubles in the interpretation of this part of sclerites may have occured in literature by taking Rhopalocera into consideration (MATSUDA 1970). Rhopalocera have a quite different wing-folding system and this might be responsible for the difficulties in comparing the sclerite and plate system.

6. Anterior membrane (connected with the membrane of the 3ax) (Figs. 3, 6)

The big central membrane can be divided into several "zones" Although the membrane is one continous ligament area we decided to differentiate several areas which allow a more detailed handling of the morphological particulars.

The first area is the area near at the 3ax. This is the membrane of the third axillary sclerite (3axm) and runs from the posterior portion of the 3ax proximally and forms a thick margin at the posterior extension of this sclerite. More proximally it fuses with the anterior branch. Underneath this 3axm a robust and flat pleurodorsal muscle forms its fascicles and makes the ligament darker in colour (best visible in figs. 3, 6).

The second, very weak area is recognizable under the anterior portion of the 3ax and reaches the first median plate and the 2ax.

Thirdly, the same membrane connects 1ax and 2ax on the ventral side of their posterior processes and runs along the 1ax and the median notal wing process to the mesothorax.

The last area is the posteriormost one, it is the proximal portion called here the anterior membrane of the pn and accompanies the anterior margin of the basal plate. This is also a very weak and skinny membrane.

7. Posterior membrane (with distal and proximal sector) (Figs. 5, 9, 10-12):

The posterior membrane is lying posteriorly of the anterior branch and can be divided into a **proximal posterior membrane** and a **distal posterior membrane**. The first forms a loop within the indent of the basal plate and the lateral branch. This loop can be wide open (*Edessena gentiusalis* WALKER, [1859] 1858, fig. 16) or nearly closed (*Calesia dasypterus* (KOLLAR, 1844), fig. 22). This condition has to be investigated very carefully. The bending and torsion facilities of the pn allow a wide range of opened or closed "fold"-situations which can result in a hidden lateral branch or an (artificially) widened pn. It is best to observe several specimens of one species to realize the "normal" condition of the pn, however the situation found on set specimens in Museum's collections is always somewhat artificial because of the unnatural position of the forewing in relation to the pterothorax. The investigation of the bulky terminal portion of the lateral branch from a dorsoanterior view has proved a reliable method to recognize the extension of the loop of the proximal posterior membrane. We also omit specimens which have obviously distorted or overtasked wing hinges. If the axillary cord is in a good condition and the sclerite system (1ax-4ax) does not exhibit typically broken areas, the specimen can be taken into consideration.

8. Axillary cord (Figs. 2, 5-7, 10-13):

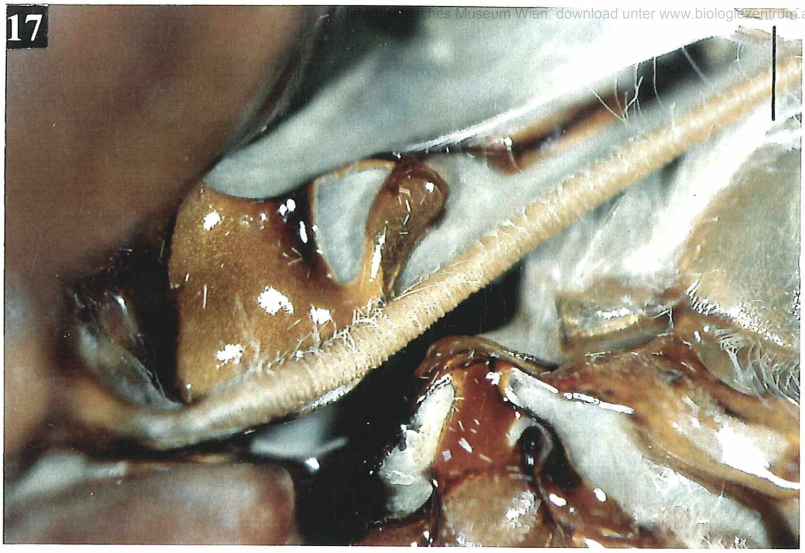
One of the most impressive features connected with the pn is the axillary cord. The axillary cord is a tubular cord forming the posteriormost boundary of the wing-hinge-system. This cord bears a lot of interesting details. First it is a highly specialized organ coping with the mechanical demands of this complex wing-operating device. A detailed investigation on the axillary cord as part of the "bending system" of the pn is in preparation (LÖDL, in press). The axillary cord normally wears a lace of hair-like scales which occasionally cover the complete axillary cord (a condition frequently found in *Catocala*-species, fig. 6 shows the condition of a partly descaled pn). The genus *Rhynchina* GUENÉE, 1854 e.g. does not have such an intensive hair-lace (*Rhynchina lignicolor* (HAMPSON, 1898, fig. 14).

Conclusions

1. The posterior notal wing process in Noctuidae turned out to wear several features of lower classificatory value. It is shown that the taxonomic importance is confined to generic, sometimes to specific level. The taxonomic impact is quite different from taxa to taxa.

2. The important features are mainly found in the following particulars (Fig. 27): The extension of the basal plate, the indent of the bending cuticle on the basal plate, the depth of the indent of the proximal anterior membrane, the form and torsion of the anterior branch and the form and shape of the lateral branch.

3. Taxonomic important morphometric relations (Fig. 27) are found in the width of the basal plate (wbp) in relation to the depth of the indent of the proximal anterior membrane (im), in the width of the lateral branch in the distal fourth (wlb) in relation to the length of the lateral branch (llb) and in the dimension of the bending cuticle on the lateral branch (lbc) in relation to the length of the lateral branch (llb). Figs. 28-30 give a first impression of some morphometric results. Fig. 28 gives a boxplot of the measurements im, lbc, llb, wbp and wlb in the Calpinae-species *Thyas juno* and some *Phyllodes*-species. It is shown that the bending cuticle on the lateral branch is very short in *Phyllodes* but extending distally in *Thyas juno*. On the other hand the basal plate is much broader in *Phyllodes* and the lateral branch is much longer in *Thyas juno*.



Figs. 17-19 Posterior notal wing processes of selected species of *Phyllodes* BOISDUVAL, 1832. Typical are the broad basal plates. Scale = 0.5 mm.

Fig. 17: *P. roseigera* BUTLER, 1883 (Andaman Islands, NHMW).
Fig. 18: *P. verhuellii* VOLLENHOVEN, 1858 (Java, NHMW)

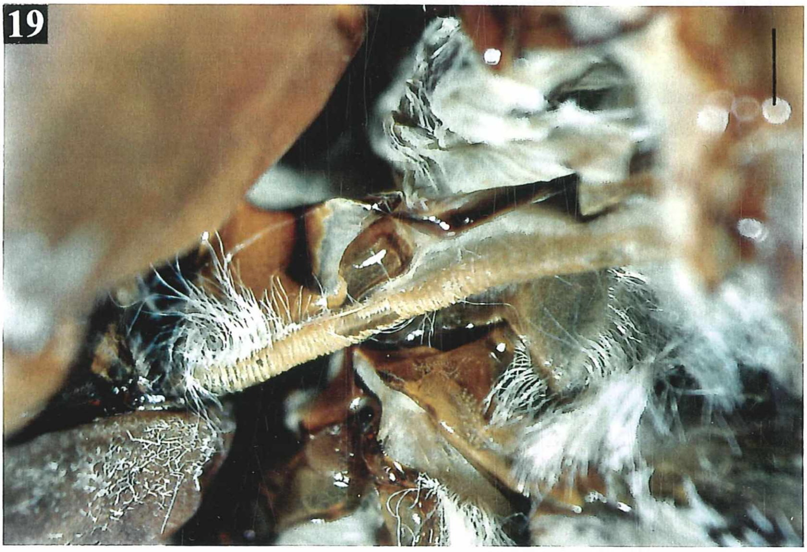
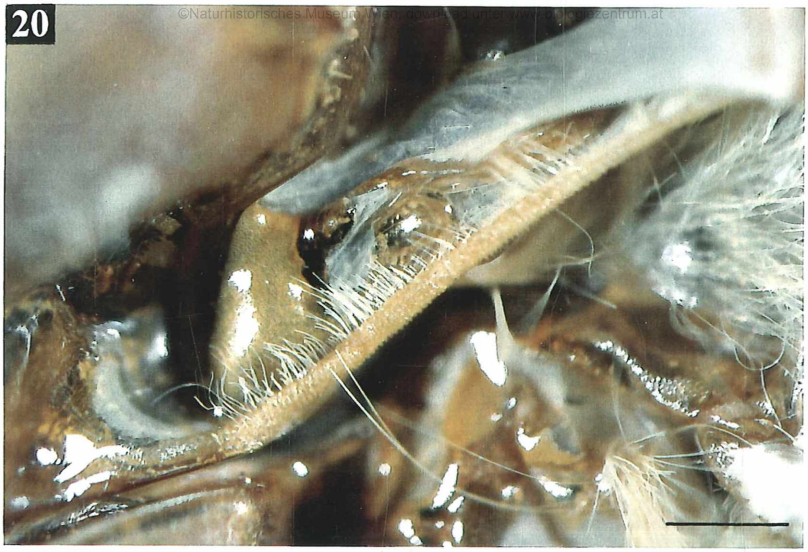


Fig. 19: *P. conspicillator* (CRAMER, 1777) (Sulawesi, NHMW)



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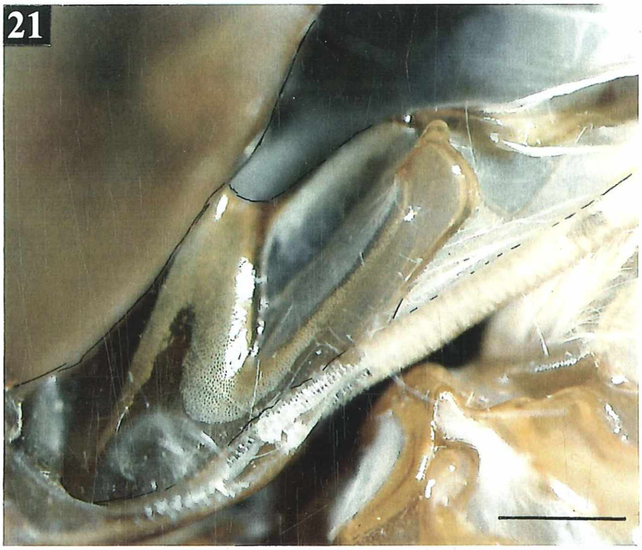

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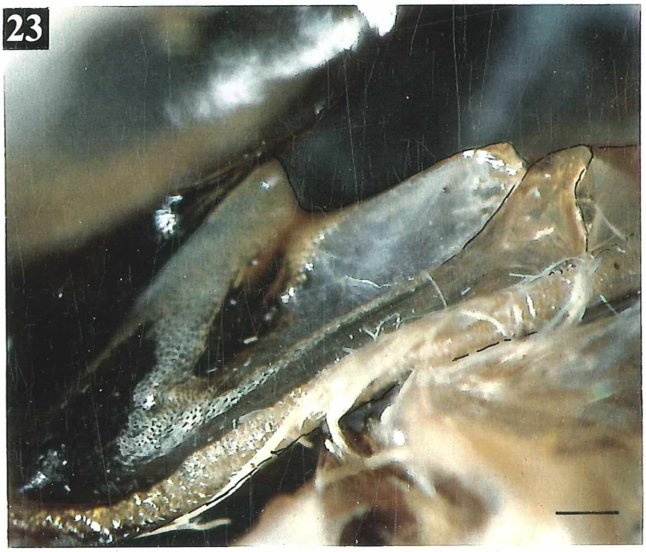

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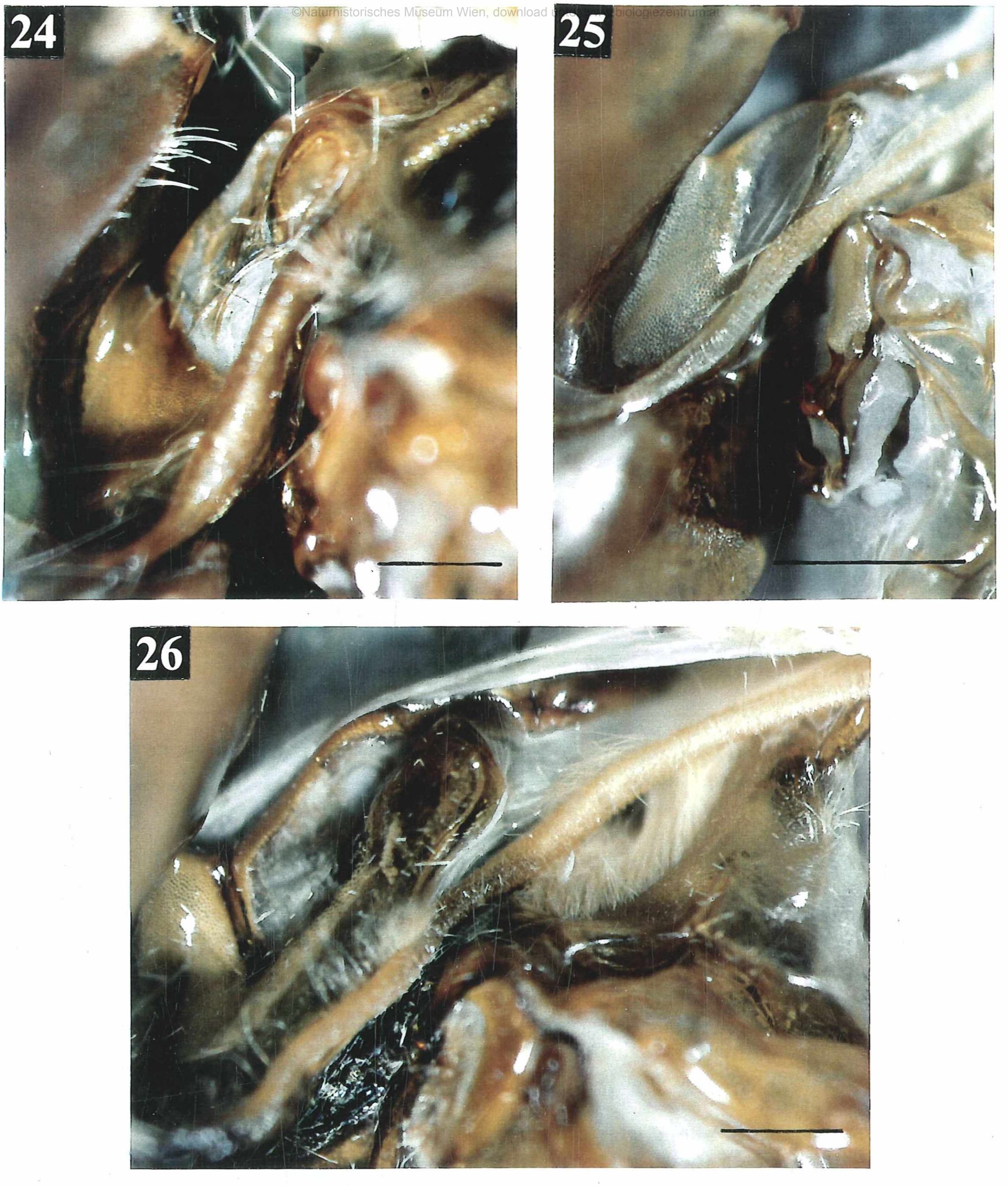
Figs. 20-23 Posterior notal wing processes of selected species of Calpinae (previous page / vorige Seite):

Fig. 20: *Eudocima salaminia* (CRAMER, 1777) (Samoa, NHMW). Typical features are the distal enlargement of the anterior margin of the basal plate and a bulky, knob-like lateral branch. Scale = 0.5 mm.
Fig. 21: *Thyas juno* (DALMAN, 1823) (Ussuri region, NHMW), exhibits the "Z-type" of the bending cuticle sector on basal plate and lateral branch and a knob-like terminal process of the lateral branch. Scale = 0.5 mm.
Fig. 22: *Calesia dasypterus* (KOLLAR, 1844) (India, Darjeeling, NHMW), shows a very broad lateral branch and an excessively bended anterior branch. Scale = 0.5 mm.
Fig. 23: *Ericeia inangulata* (GUENÉE, 1852) (Samoa, NHMW), shows the "Z-type" of the bending cuticle and a long lateral branch with a finger-like terminal process. Scale = 0.1 mm.



Figs. 24-26 Posterior notal wing processes of selected species of different noctuid subfamilies (scale = 0.5 mm):

Fig. 24: *Cocytia durvillii* BOISDUVAL, 1828 (s.l.) (Cocytiinae).
Fig. 25: *Autographa gamma* (LINNAEUS, 1758) (Plusiinae) (Austria inferior, NHMW).
Fig. 26: *Thyas honesta* HÜBNER, [1824] (NHMW).

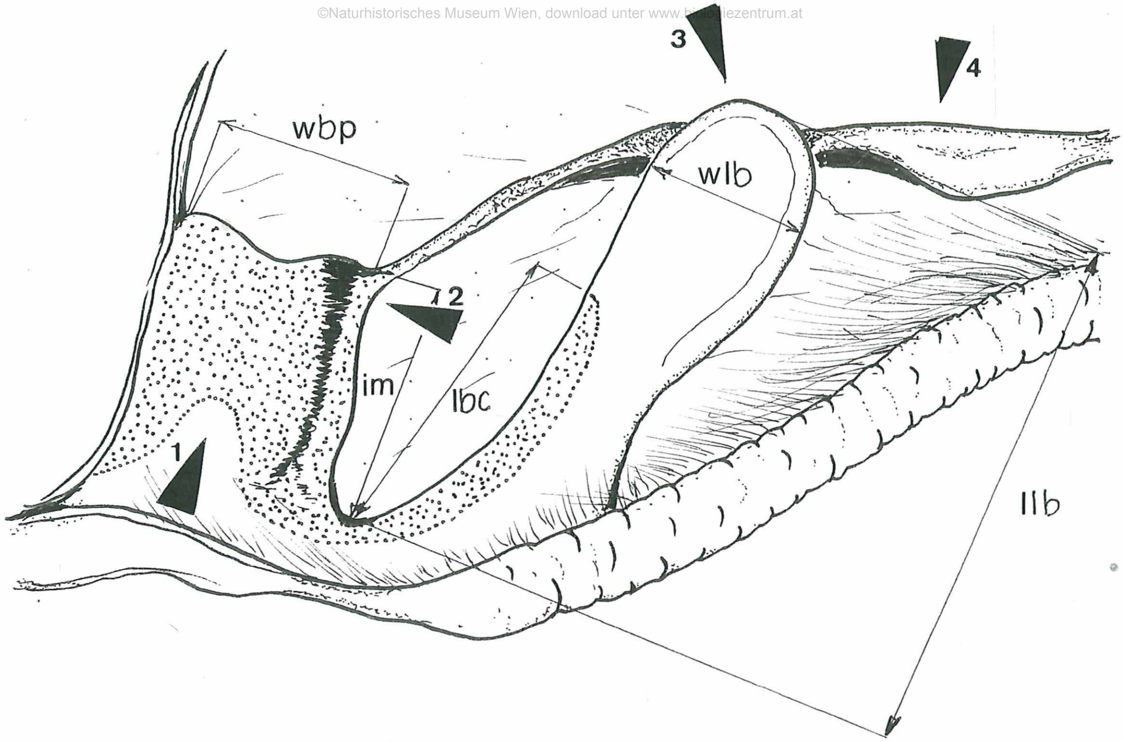
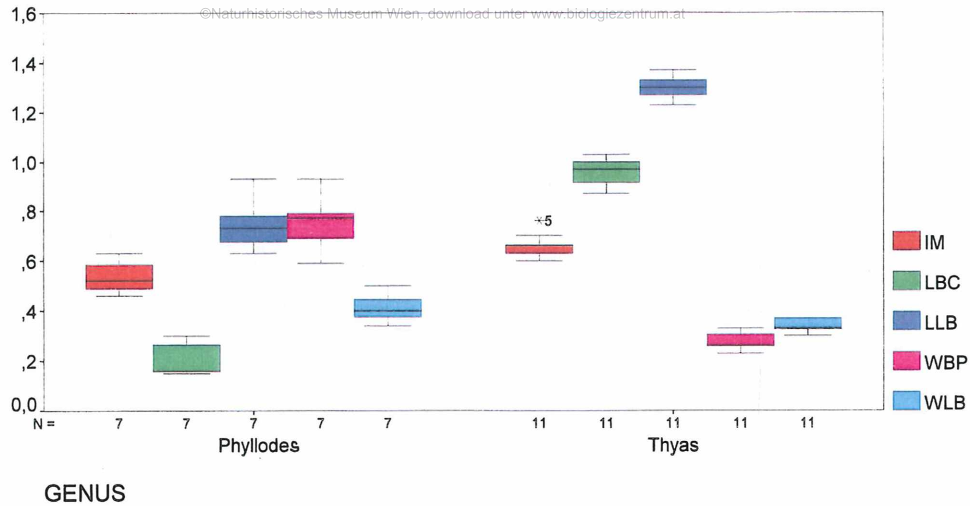


Fig. 27 Diagrammatic view of a posterior notal wing process of a noctuid moth to illustrate characters of diagnostic importance and the measurements for morphometric analyses.

Arrowheads 1-4:
Arrowhead 1 indicates the indent of the bending cuticle area on the posterior margin of the basal plate. This indent can range from very deep (and forming a "Z" together with the bending cuticle line along the lateral branch) to absent.
Arrowhead 2 marks the anterior margin of the basal plate and the origin of the anterior branch. This area can wear different types of extensions and enlargements.
Arrowhead 3 focusses on the terminal region of the lateral branch. The "head" of the lateral branch can wear different types of processes.
Arrowhead 4 reveals the different outline of the margin of the anterior branch. There can occur soft bendings or remarkable grooves and indents.

Measurements of the posterior notal wing process:
wbp (width of basal plate on the anterior margin): This measurement characterizes the width of the anterior margin of the basal plate from the mesothorax to the knee where the anterior branch originates. This "shoulder" can be very narrow or broad.
im (length of the indent of the proximal portion of the posterior membrane): This indent can vary from short to extremely long.
lbc (length of bending cuticle portion along the lateral branch): The bending cuticle can run along the proximal margin of the lateral branch far distally or can end on the base of the indent of the membrane.
wlb (width of the lateral branch at the distal fourth): This measurement indicates the enlargement of the lateral branch at its distal portion.
llb (length of the lateral branch): Measured from the distal end to the posteriormost end of the indent of the posterior membrane is an important feature for the proportion of the lateral branch.

28



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Phyllodes
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IM
LBC
LLB
WBP
WLB
GENUS

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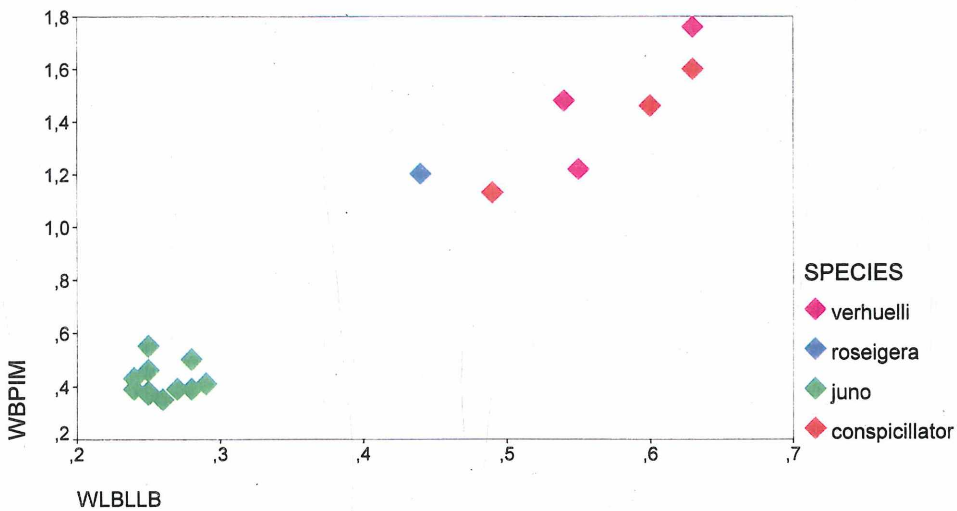

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WBPIM
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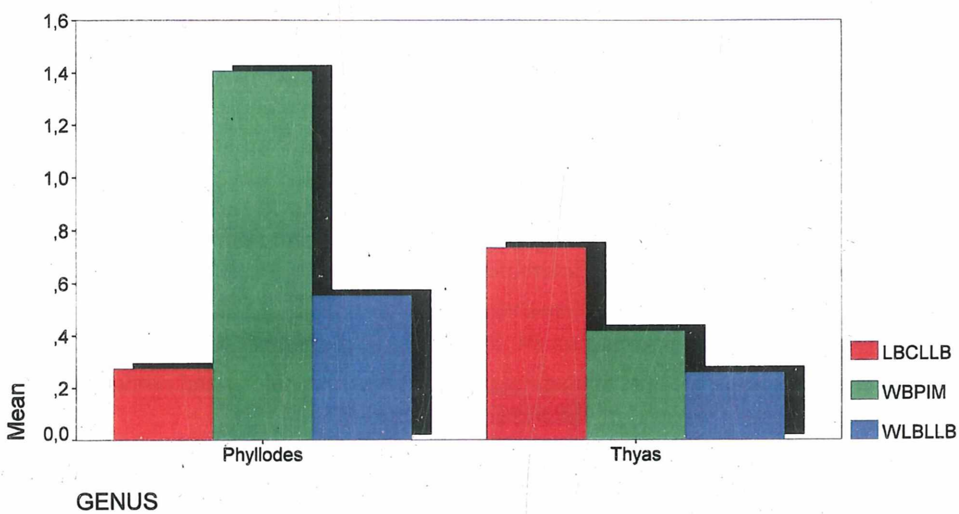
WLBLLB
SPECIES
verhuelli
roseigera
juno
conspicillator

30



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Mean
Phyllodes
Thyas
GENUS
LBCLLB
WBPIM
WLBLLB

Figs. 28-30 Graphic interpretation of different pn-features and relations (previous page / vorige Seite):

Fig. 28: Boxplot of the measurements im, lbc, llb, wbp and wlb in the Calpinae-species *Thyas juno* and some *Phyllodes*-species (*P. conspicillator*, *P. roseigera*, *P. verhuelli*). Abbreviations: **im** = depth of the indent of the proximal anterior membrane; **lbc** = extension of the bending cuticle on the lateral branch; **llb** = length of the lateral branch; **wbp** = width of the basal plate; **wlb** = width of the lateral branch in the distal fourth.
Fig. 29: Scatterplot of the two relations wbp/im and wlb/llb. The figures of three *Phyllodes*-species and *Thyas juno* are plotted and the separation is demonstrated.
Fig. 30: Bar-diagram of the mean calculation of the three relations lbc/llb, wbp/im and wlb/llb in *Thyas juno* and the three *Phyllodes*-species.
Interpretation in the text.

Fig. 29 is a scatterplot of the two relations wbp/im and wlb/llb. The figures of three *Phyllodes*-species and *Thyas juno* are plotted and a stringent separation is visible.

Fig. 30 shows the mean calculation of the three relations lbc/llb, wbp/im and wlb/llb in *Thyas juno* and the three *Phyllodes*-species. It is obvious that in *Phyllodes* a very broad basal plate and a very short bending cuticle area on the lateral branch is found, while in *Thyas juno* exhibits a long and slender lateral branch.

Further studies are needed for interpreting the origin and detailed morphological structure of the "axillary branch" Although this sclerite is most likely a derivate of the 3ax/4ax system many questions are unsolved.

A focus on the pterothorax from its lateral condition will be needed. The subalare region seems to have several highly important, taxonomic features. For instance: The anterior, tooth-like pronge of the subalare sclerite needs further attention, the proportion and curvature of the subalare itself will be interesting and the extension of the subalare-mesepimeron-membrane is also important. Moreover – as mentioned above - in the posterior sector of the subalare the mesothoracal homologue of the metathoracal tympanal organ is found (YACK, SCUDDER & FULLARD 1999). So a detailed study of the ligament system of the wing sclerites and the attachment sites of the subalare region and the meso- and metathoracic links will be highly appreciated. Especially proprioreceptive functions will probably come to light.

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Literature

ADAMSKI, D. & BROWN, R. L. 1989: Morphology and Systematics of North American Blastobasidae [Lepidoptera: Gelechioidea]. – Mississippi Agricultural and Forestry Experiment Station Technical Bulletin 165, Mississippi Entomological Museum No. 1: i-iii, 1-70.

ADAMSKI, D. & PETERS, T. M. 1982: Axillary structure of the Tortricidae (Lepidoptera). – Proceedings of the Entomological Society, Washington 84: 397-401.

BROCK, J.P. 1971: A contribution towards an understanding of the morphology and phylogeny of the Ditrysian Lepidoptera. – Journal of Natural History 5: 29-102.

DAVIS, D.R. 1986: A New Family of Monotrysian Moths from Austral South America (Lepidoptera: Palaephatidae), with a phylogenetic Review of the Monotrysia. - Smithsonian Contributions to

Zoology, no. 434, Smithsonian Institution Press, Washington: i-iv, 202 pp.

EATON, J.L. 1988: Lepidopteran Anatomy. – In: SCHAEFER, C.W. (ed.): Wiley-Interscience Series in Insect Morphology. John Wiley & Sons, New York, i-xiii, 257 pp.

LÖDL, M., in press: The "axillary cord" – one of the three bending systems of the "posterior notal wing process" of the forewing in the family Noctuidae (Lepidoptera). – Quadrifina 4 (in preparation).

MATSUDA, R. 1970: Morphology and Evolution of the Insect Thorax. – Memoirs of the Entomological Society of Canada 76: 1-431.

SCOBLE, M.J. 1992: The Lepidoptera: Form, Function and Diversity. - Natural History Museum Publications. Oxford University Press: i-xi, 404 pp.

SHARPLIN, J. 1963a: A Flexible Cuticle in the Wing Bases of Lepidoptera. - The Canadian Entomologist 95(1): 96-100.

SHARPLIN, J. 1963b: Wing Base Structure in Lepidoptera. I. Fore Wing Base. - The Canadian Entomologist 95(10): 1024-1050.

SHARPLIN, J. 1963c: Wing Base Structure in Lepidoptera. II. Hind Wing Base. - The Canadian Entomologist 95(11): 1121-1145.

SHARPLIN, J. 1964a: Wing Folding in Lepidoptera. - The Canadian Entomologist 96: 148-149.

SHARPLIN, J. 1964b: Wing Base Structure in Lepidoptera. III. Taxonomic characters. – Canadian Entomologist 96: 943-949.

YACK, J.E., SCUDDER, G.G.E. & FULLARD, J.H. 1999: Evolution of the metathoracic tympanal ear and its mesothoracic homologue in the Macrolepidoptera (Insecta).- Zoomorphology 119 (2): 93-103.

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