SECTION B

AN ATTEMPT AT BIOLOGICAL CONTROL OF CALLOSObRUCHUS ANALIS USING DINARMUS BASALIS.
CHAPTER III.
MORPHOLOGY OF DINARMUS BASALIS (EXCLUDING ABDOMEN AND OVIPOSITOR).

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CHAPTER III.
MORPHOLOGY OF DINARMUS BASALIS (EXCLUDING ABDOMEN AND OVIPOSITOR).

Introduction:

Dinarmus basalis remains uninvestigated from standpoint of morphology. Infact there are only a few studies on general morphology of chalcidoids, e.g. James (1926), Guido Grandi (1929), Alam (1961). Tiegs (1922), discussing metamorphosis of insects, has recorded his observations on morphology of Nasonia.

In view of paucity of information on chalcidoid structure, a morphological study of Dinarmus basalis has been undertaken, with special emphasis on mouth-parts and ovipositor apparatus.

Material and Methods:

Dinarmus basalis adults, taken from laboratory cultures, have been studied using conventional microscopes.

Observations and Discussion:

(a) Body size.

Among adults of Dinarmus basalis large or normal sized adults and diminutive or under-sized adults may be made out. When bruchid larvae, with
parasitoid larvae feeding on them, were removed from seeds, and the latter were allowed to develop in petri-dishes, it was noted that a *D. basalis* larva, feeding on a young bruchid larva (2nd/3rd instar), would pupate early, form a diminutive pupa, and subsequently a diminutive adult. From such observations it has been inferred that *D. basalis* individuals, developing on early bruchid larvae (2nd or 3rd instars), develop into diminutive adults, while those feeding on later host larvae grow to become normal sized adults.

For study of body size adults were removed from the same culture, and were divided into two categories, viz. 'normal' and 'diminutive', on basis of general visual impression. Then the individuals of the two categories were examined for body length under a binocular dissecting microscope, with an oculometer disc inserted in one of the eye-pieces. Results, obtained this way, are shown in Table 1.

The difference in body length between 'normal' and 'diminutive' adults of the same sex is statistically significant. (p in % for
difference between the columns 1 and 2 in Table 1, and also that for the difference between the columns 3 and 4, by t-test is < 0.1).

Another inference is that males are smaller than females. (p in % for difference between columns 1 and 3 in Table 1, and also for that between columns 2 and 4 is < 0.1 by t-test.)

In this context it may be noted that in two other species of Dinarnus, viz. D. ivorensis and D. steffani also males are smaller than females (Rasplus, 1986). According to Assem et al (1984) in the pteromalid Anisopteromalus calandrae the size of the host determines the eventual size of the parasitoid adult. Further these authors have pointed out presence of large and small males and females. They say, ".... differences between small and large sons are probably less than between small and large daughters". In the present material however this is not the situation. \( \frac{n}{d} \) for males of D. basalis is 1.32, while for females it is 1.28, where 'n' is \( \bar{x} \) of body length in 'normal' males/females, and 'd' is the corresponding value for 'diminutive' males/females.
(b) **Dimorphism in body colouration**:

Body colouration shows sexual dimorphism in *D. basalis*. Female of this species is shiny black, except in antennae and legs, which are brown, and in the compound eyes, which are red in colour. Male is similarly coloured, except that the abdomen is lightly sclerotized and is translucent cream coloured with dark brown patches (fig. 3, 4 of the next chapter). The author of these lines has not come across an earlier published account of such a dimorphism in this species.

(c) **Head capsule**.

Head of *D. basalis* is rounded, anteroposteriorly compressed, a little narrowed on the ventral side, hypognathous, hard, black and almost uniformly covered with velvety pubescence (fig. 1).

Compound eyes are not so large, leaving large genal areas on sides. Ocelli are prominent on the dorsal side, and form an anteroposteriorly depressed triangle (fig. 2). On the frons there are a pair of shallow and vertical longitudinal grooves (fig. 1). They are obviously meant to accommodote scapes of the antennae.
Sutures are mostly only faintly indicated on the surface. At the first sight the head looks almost sutureless. The epicranial suture is mostly obliterated, and it is only faintly indicated behind the anterior median ocellus for a short distance. The occipital suture is well marked (fig. 3 and 4), and separates a depressed and concave occipital region of the head capsule. The ocular suture is fairly well marked, and completely surrounds each compound eye at its corneal periphery. The epistomal suture, separating the clypeal area from the rest of the head surface, is only faintly indicated (fig. 1). The clypeus is somewhat triangular. A separate labrum seems to be lacking from outside, but, when mandibles are removed, a crease or a low ridge, running close to the lower margin of the head capsule on the inner face of the anterior wall of the capsule indicates presence of a narrow labrum (fig. 4).

The head capsule does not differ any considerably in the two sexes. The only difference noted is in size. This difference, however is corresponding to the body size.
(d) **Antennae.**

As is expected in a chalcidoid, the antennae are elbowed or geniculate and clubbed (fig. 5, A, B). Scape is long and two jointed. It rises vertically from the antennal socket, and mostly remains accommodated in the shallow longitudinal trough on the frons. The pedicel is followed by ring joints, 2 in male and 3 in female. The club is three jointed. It is little thicker in female than in male. The greatest thickness of the club for six different females (\( \bar{x} \pm s.e. \)) was found to be 0.095 - 0.097 mm, and for six different males 0.078 - 0.081 mm. The means of the two ranges differ significantly, as \( p(\%) < 0.1 \) by \( t \)-test. (Different parts of antennae have been named following Imms, 1963.)

Thus the antennae of *D. basalis* show dimorphism, which is quite common among Hymenoptera (Imms, 1963).

According to Rasplus (1986) *D. basalis* is characterised by the antennal ring joint number 3 being obviously longer than the first
two. This situation is clearly seen in female
of *D. basalis*, while in *male*, as noted earlier, the
third joint is long and is almost equal to the
subsequent flagellar joints. Rasplus, however
does not mention this feature of sexual dimorphism
in antennal morphology.

(e) **Mandibles.**

Mandibles of *D. basalis* have a typical
chewing biting form, with four fairly tall and well
defined teeth (fig. 6, A, B). They are well exposed
in an anterior view of the head, due to presence of
a narrow labrum. A special feature of the mandible
is that on its antero-outer surface there are long
hairs. Another special feature is presence of three
well defined longitudinal grooves on its posterior
or adoral surface, extending distally so as to
almost reach the teeth (fig. 6 B, and fig. 7, A, B).

In another member of Parasitica,
*Stenobracon deesae* (Alam, 1961) the apex of the
mandible is pointed, and has "very few teeth....
in the incisor area". In contrast in the present
material there are four high and well defined
teeth. Such toothed incisor margin is obviously
not for feeding, as the adult parasite either
does not feed, or feeds entirely on liquid nourishment. Keeping in view the biology of the species, it may be inferred safely that the mandibular teeth in D. basalis are meant for cutting an emergence hole in the roof of the bruchid cavity.

The two special features of mandibles, viz. the long hairs on the antero-outer surface and presence of longitudinal grooves on the adoral surface, seem to be related to mode of feeding. The setae are presumably sensory, and help in grasping the outer end of the feeding tube correctly for feeding between mandibles and the maxillolabial complex, and the grooves, it seems, help flow of liquid nourishment upward.

As far as the author of these lines is aware, there is no previous description of such mandibular grooves in a hymenopteran.

(f) Maxillolabial complex.

Maxillae and labium in this insect are well interconnected to form a complex organ, the maxillolabial complex (fig. 8). (It may also be
called labiomaxillary complex, but Alam, 1961, Fox and Fox, 1964 and Snodgrass, 1935 have referred to it as maxillolabial complex, which term is perhaps to be preferred as it follows the natural sequence of appendages.) Labium has become reduced, and does not articulate directly with the cranium. It forms sclerotic connections with the maxillae, and maxillae form articulations with the cranium at the posterior tentorial pits.

The cardo of maxilla is elongated, triangular and forms a suspensorium for the maxillolabial complex. The upper (or proximal) end of the suspensorium, as pointed out above, articulates with the cranium at the posterior tentorial pit of its side. The stipes is elongated oval in shape. Its outer edges are produced into a membranous flap, which is continuous distally with the membranous and trough-like galeae. Infact the membranes are taller, and, becoming folded over the stipes, form a deeper longitudinal trough than what appears from the figure. Lacinia is triangular and setose. Maxillary palp is four segmented and well developed.
The basal part of the labium is a broad oval and a well sclerotized plate. It seems to be soft along the median line, as in a dissected out labiomaxillary complex the plate readily folds along this line. The basal plate is not differentiated into pre- and post-labium. Within it arising on either side of the median line are muscle fibres, which extending obliquely outward find attachment on peripheral parts of the plate. The fibres obviously represent the median labial muscles. As both the origin as well as insertion of the muscles are within the basal plate, the plate seems to represent both the pre- as well as the post-labium. Labial palps are considerably smaller than maxillary palps, and are three jointed. Ligula is membranous and oval; it is nearly transparent and difficult to make out in an unstained balsam whole mount. There are sclerotic extensions from the basal labial plate to the membranous flaps arising from the stipes. There are two such sclerotic bridges on each side, one arising from about middle of the length of the basal plate, and the other from a distal part of the plate and extending close to the base of the galea of its side.
The maxillolabial complex makes the food ingestion apparatus of this insect well suited to its mode of feeding. As is obvious from the figure of the complex, it forms a semi-funnel hanging down from a point close behind the mouth. Presence of mandibles in front converts the semi-funnel into a near complete funnel. The funnel is meant for being applied to the upper end of the feeding tube. As the membranes, arising from the outer edges of the stipes, are taller than what is shown in the figure, the semi-funnel, formed by the maxillolabial complex, is more of a funnel than what is suggested by the figure.

As has been pointed out by Snodgrass (1935), the union of maxillae with labium is a fundamental characteristic of larval as well as adult Hymenoptera. From the account of saw-fly mouth-parts (Imms, 1963; Fox and Fox, 1964), and from that of the mouth-parts of a braconid (Alam, 1961) it may be inferred that reduction of the basal part of the labium, so that there is loss of direct articulation between the labial
base and the cranium, may be expected in fairly widely different groups of Hymenoptera.

Several points of similarity between mouth-parts of *D. basalis* and those of *Stenobracon deesae* (Alam, 1961) may be made out. Besides the above pointed similarity in compounding of maxillae and labium into a maxillolabial complex, it is notable that in both there is no direct sclerotic articulation between labial base and cranium. In both the insects the cardo is narrow proximally and becomes gradually broadened distally, and an outer part of the cardo is thicker and more sclerotized than inner portions. In both the forms the labium ends distally in a median ligula or tongue. But at the same time a number of differences between the two forms may be pointed out. In *D. basalis* there are sclerotic bridges between the basal plate of the labium and the stipes, but in *S. deesae* there are only areas of arthrodial membrane separating the two, and there are no sclerotic connections. In *D. basalis* an outer part of the stipes is membranous, whereas in *S. deesae* an inner portion has become membranous.
In the former, as noted above, the membranous outer part of the stipes continues into galea. The corresponding part of stipes in *S. deesae*, forming a sclerotized carina, is also 'united' with the galea, this being again a point of similarity. Alam (1961) is of the opinion that prementum constitutes the whole of the basal part of the labium. But origin of median muscles of the labium in *D. basalis* suggests that the labial base in this form includes prelabium as well as the postlabium.

Though Alam (1961) does not find any sclerotic connection between the labium and maxillae, Duncan (1939) pointed out presence of a small sclerite in his material connecting the labial base with a distal part of the maxillary stipes. He named the sclerite the 'labiomaxillary jugum'.

(g) Thorax

Thorax of *D. basalis* is in general similar to that of *Stenobracon deesae* (Alam, 1961).

The pronotum is a collar-like sclerite in front of the mesonotum, and has become closely associated with the 'pterothorax', while the
propleura and the prosternum are membrane separated from the pronotum, and constitute propectus, which is a suspensorium for the forelegs and a support for the head.

Mesonotum is large, and covers about two third of the thorax (fig. 9 and 10). The scutum of mesonotum is large, convex and with lateral parapsidal sutures, and also with lateral axillae or triangles (i.e. inner and outer triangles). The mesoscutellum is also large and convex, but a little smaller than the scutum, and with narrowing on sides. The mesopleura are large and slanting towards the median line, as they extend downward from the side of the mesonotum. The pleura have become fused with the mesonotum to form mesoprectus (fig. 10).

Mesopleuron and lateral part of the pronotum on each side present depressions to accommodate the femora of mid- and fore-legs (fig. 10). Hind femora are accommodated in lateral depressions between thorax and gaster.

The mesonotum is a narrow strip, inserted between mesonotum and propodeum (fig. 9 and 10). Metapleura are considerably separated
from the metanotum, and are located on sides of
the propodeum (fig. 10). Ventroposteriorly they
extend upto origin of hind coxae. The metasternum
is a small sclerite between the hind coxae.

The propodeum, though it has its origin
in the abdomen, is well integrated into the thorax.
It presents a short peg-like posterior bulging
(fig. 9 and 10). Short and narrow petiole joins
the under-surface of the peg. The first gastric
segment presents a socket-like depression to
accomodate the propodeal peg as well as the petiole
(fig. 11).

(h) Formation of the adult thorax.

Tiegs (1922), describing development
of the pteromalid Nasonia, says, "The general shape
assumed by the abdomen is ovoidal; but in this the
first two segments do not cooperate; on the other
hand, a remarkable migration takes place here, and
the whole of the first abdominal segment, and the
upper half of the second, become merged in with the
thoracic segments to form the middle region of the
insect, the hymenopteran "alitrunk", while the
lower part of the second abdominal segment forms
the petiole, which in the adult wasp connects the abdomen with the alitrunk, and articulates with the upper part of the second segment, with which, therefore, it always remains in a fairly close intimacy." Thus according to him the first abdominal segment and also upper or anterior part of the second abdominal segment become incorporated in the thorax. This is how the observations of Tiegs (1922) have been quoted and interpreted by Matsuda (1976). The common situation in Hymenoptera is, however different. It is only the first abdominal segment, which becomes incorporated into the thorax, and the second abdominal segment wholly or partly gets constricted into the petiole. Incorporation of only one abdominal segment in the thorax is suggested by Heslop-Harrison's figures (1985) of the prepupal stage of Apis. That in Parasitica there is a similar situation may be inferred from Alam (1961).

In D. basalis the thorax includes only one sclerite, in addition to the usual structure of the thorax, viz. propodeum. The petiole is a well defined narrow structure with an arthrodial membrane
at either end. In young pupa the first and the second abdominal segments have become a little narrowed, and obviously separated from the differentiating gaster (fig. 9 of Ch. VII). At this stage the first and the second abdominal segments are obviously narrower than the third segment, but when the abdomen is separated from the thorax the former is seen to continue into the latter fairly broadly. Later the first abdominal segment or the propodeum forms a backward, broad, peg-like evagination, while the second segment becomes narrowed into a petiole. This change becomes obvious when the adult cuticle has darkened, and has become withdrawn from the pupal cuticle. (This happens about four days after start of the pupal life.) Thus present observations do not agree with those of Tiegs (1922) in this respect.

It may be inferred from the present study of a pteromalid that the constitution of the functional thorax is much the same as in other higher/ clistogastrous Hymenoptera.

The complex articulation between petiole and propodeum, including a pair of propodeal teeth and a process on the antecosta of petiole,
found in higher Hymenoptera (Matsuda, 1976), is lacking in *D. basalis*. On the other hand there is ball-and-socket type of articulation due to propodeum forming a rounded and peg-like bulging, fitting into a socket-like depression on the first segment of the gaster. Obviously this is to permit rotational movements, which are a part of ovipositional movements (vide infra).

(i) **Wing venation.**

Venation is greatly reduced and typical of chalcidoids (fig. 12). As is expected in *Dinarmus basalis* (Rasplus, 1986), the stigmal vein and the marginal vein are equally long, and the post-marginal is longer than marginal. (Veins have been named following Borror et al, 1976).

**References**:


<table>
<thead>
<tr>
<th></th>
<th>Normal (1)</th>
<th>Diminutive (2)</th>
<th>Normal (3)</th>
<th>Diminutive (4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>2.75 - 2.12 mm</td>
<td>2.14 - 1.69 mm</td>
<td>2.80 mm</td>
<td>2.22 mm</td>
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<tr>
<td>Male</td>
<td>1.69 - 1.4 mm</td>
<td>2.2 mm</td>
<td>2.43 mm</td>
<td>1.78 mm</td>
</tr>
</tbody>
</table>

N.B. - X for 13 individuals in (1) and (2). 15 males in (3) and (4).

*Body length in normal and diminutive adults of Dinarmus basalis.*

Table 1
Key to lettering of figures:

ABD  - abdomen.
AS   - antennal socket.
AXMS - axilla of mesoscutum.
CA   - cardo.
CE   - compound eye.
CL   - club.
CLY  - clypeus.
DFL  - depression for femur of fore-leg.
DMSP - depression in mesopleuron to accommodate femur of meso-thoracic leg.
DO   - dorsal ocelli.
ES   - epicranial suture.
PCS  - frontoclypeal suture.
FL   - flagellum.
FMG  - foramen magnum.
FU   - funicle.
GA   - galea.
GAS  - gaster.
GLM  - gap occupied by the maxillolabial complex.
H    - head.
ITM  - inner triangle of mesoscutum.
LA   - labrum.
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>LDA</td>
<td>longitudinal depression to accommodate scapes of the antennae.</td>
</tr>
<tr>
<td>LGR</td>
<td>longitudinal grooves on the adoral surface of mandible.</td>
</tr>
<tr>
<td>LI</td>
<td>ligula.</td>
</tr>
<tr>
<td>LP</td>
<td>labial palp.</td>
</tr>
<tr>
<td>LS</td>
<td>labial suture.</td>
</tr>
<tr>
<td>MD</td>
<td>mandibles.</td>
</tr>
<tr>
<td>MML</td>
<td>median muscles of the labium.</td>
</tr>
<tr>
<td>MNT</td>
<td>metanotum.</td>
</tr>
<tr>
<td>MPL</td>
<td>metapleuron.</td>
</tr>
<tr>
<td>MSC</td>
<td>mesoscutum.</td>
</tr>
<tr>
<td>MSCL</td>
<td>mesoscutellum.</td>
</tr>
<tr>
<td>MSP</td>
<td>mesopectus (= mesopleuron fused ventrally with mesosternum).</td>
</tr>
<tr>
<td>MV</td>
<td>marginal vein.</td>
</tr>
<tr>
<td>MXP</td>
<td>maxillary palp.</td>
</tr>
<tr>
<td>OCS</td>
<td>occipital suture.</td>
</tr>
<tr>
<td>OFW</td>
<td>origin of fore-wing.</td>
</tr>
<tr>
<td>OHW</td>
<td>origin of hind-wing.</td>
</tr>
<tr>
<td>OMC</td>
<td>origin of metacoxa.</td>
</tr>
<tr>
<td>OS</td>
<td>ocular suture.</td>
</tr>
<tr>
<td>OTM</td>
<td>outer triangle of mesoscutum.</td>
</tr>
<tr>
<td>PC</td>
<td>pedicel.</td>
</tr>
<tr>
<td>PE</td>
<td>petiole.</td>
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<tr>
<td>Abbreviation</td>
<td>Description</td>
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<td>--------------</td>
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<tr>
<td>PMV</td>
<td>post-marginal vein.</td>
</tr>
<tr>
<td>PNT</td>
<td>pronotum.</td>
</tr>
<tr>
<td>PP</td>
<td>peg formed by the propodeum.</td>
</tr>
<tr>
<td>PRO</td>
<td>propodeum.</td>
</tr>
<tr>
<td>PS</td>
<td>parapsidal suture.</td>
</tr>
<tr>
<td>PTA</td>
<td>posterior tentorial arms.</td>
</tr>
<tr>
<td>RS</td>
<td>ring segments.</td>
</tr>
<tr>
<td>SC</td>
<td>scape.</td>
</tr>
<tr>
<td>SCLB</td>
<td>sclerotic bridge between labial base and galea.</td>
</tr>
<tr>
<td>SMV</td>
<td>submarginal vein.</td>
</tr>
<tr>
<td>SO</td>
<td>socket on anterior face of the first gastric segment for receiving the short peg of the propodeum.</td>
</tr>
<tr>
<td>ST</td>
<td>stigma.</td>
</tr>
<tr>
<td>STP</td>
<td>stipes.</td>
</tr>
<tr>
<td>STV</td>
<td>stigmal vein.</td>
</tr>
<tr>
<td>TH</td>
<td>thorax.</td>
</tr>
<tr>
<td>VE</td>
<td>vertex.</td>
</tr>
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