Throughout the Heteroneura, with such exceptions as the deltoid group and a few others, the strigil remains very much the same, varying only in being a little broader or narrower, more flattened or more rounded, curved or straight. Between the strigil of the Heteroneura and that of the Homoneura, however, the difference is considerable, while the difference between the families of the Homoneura is as great as that between the suborders.

In order to ascertain if any homologous structure was present in related orders, the Trichoptera and Mecoptera were examined. In the Trichoptera, species of the genera *Rhyacophila, Psilochorema, Hydrobiosis, Hydropsyche, Polyplectropus, Triplectides, Notanatolica, Oecetis, Philanisus, Philorheithrus, Pycnocentria, Olinga,* and *Oeconesus;* and, in the Mecoptera, *Choristella, Nannachorista, Harpobittacus, Taeniochorista, Bittacus, Choristella,* and *Merope,* have all yielded negative results, and it seems therefore reasonably certain that the tibial strigil in the Lepidoptera is peculiar to that order.

The families of the Lepidoptera, as far as I have been able to examine them, will now be considered in order, and the modifications of the cleaning-apparatus described.

Suborder HOMONEURA.

Micropterygidae.

Of this, the most primitive family of the Lepidoptera, I have examined *Sabatinca* and *Micropteryx* only. The strigil in these genera (fig. 1) is a simple leaf-shaped structure, lying, both transversely and longitudinally, convexly to the tibia (fig. 2). It is covered with hair on both surfaces, but that on the inner surface is longer, and directed chiefly towards the outer fissure, forming there a marginal fringe. At its attachment to the tibia the strigil is much narrowed, and connects to a circular base by means of a thin membrane which allows of free movement (fig. 3). This method of basal connection seems to point strongly to the strigil being a modified spur. Presumably, after development into a strigil, the structure moved basad or distad in sympathy with the tibial modification or other conditions as the different forms evolved. The base of the strigil is about the middle of the tibia, and its apex rather less than a quarter from the tibial apex. Except for being somewhat swollen round the base of the strigil, the tibia itself is not modified; there is not the flattening beneath, nor the formation of a groove, as occurs in the higher groups.

Mnesarchaeidae.

In *Mnesarchaea* the strigil is very much reduced, being only about four-fifths as long as the tibia is broad (fig. 4). It is clothed with scales similar to those on the tibia itself, and no hair is present. The reduction of the organ in this genus is apparently correlated with the type of antenna, this being filiform and scaled, with a few minute hairs. In *Sabatinca* the better-developed strigil is accompanied by submoniliform antennae which are thickly covered with hair.

Hepialidae.

In the Hepialidae the strigil is not homologous with the structure so far described; it is an outgrowth from the tibial wall instead of a modified spur. The Hepialidae are without tibial spurs, and it seems probable that they were never provided with the strigil as it exists in other Lepidoptera, but evolved a different organ to carry out the same function. At or near the base of and beneath the tibia there is a flap-like structure, covering the lower surface and extending usually about half-way along the segment (fig. 5). There is no indication of a hinge at the base, the strigil passing

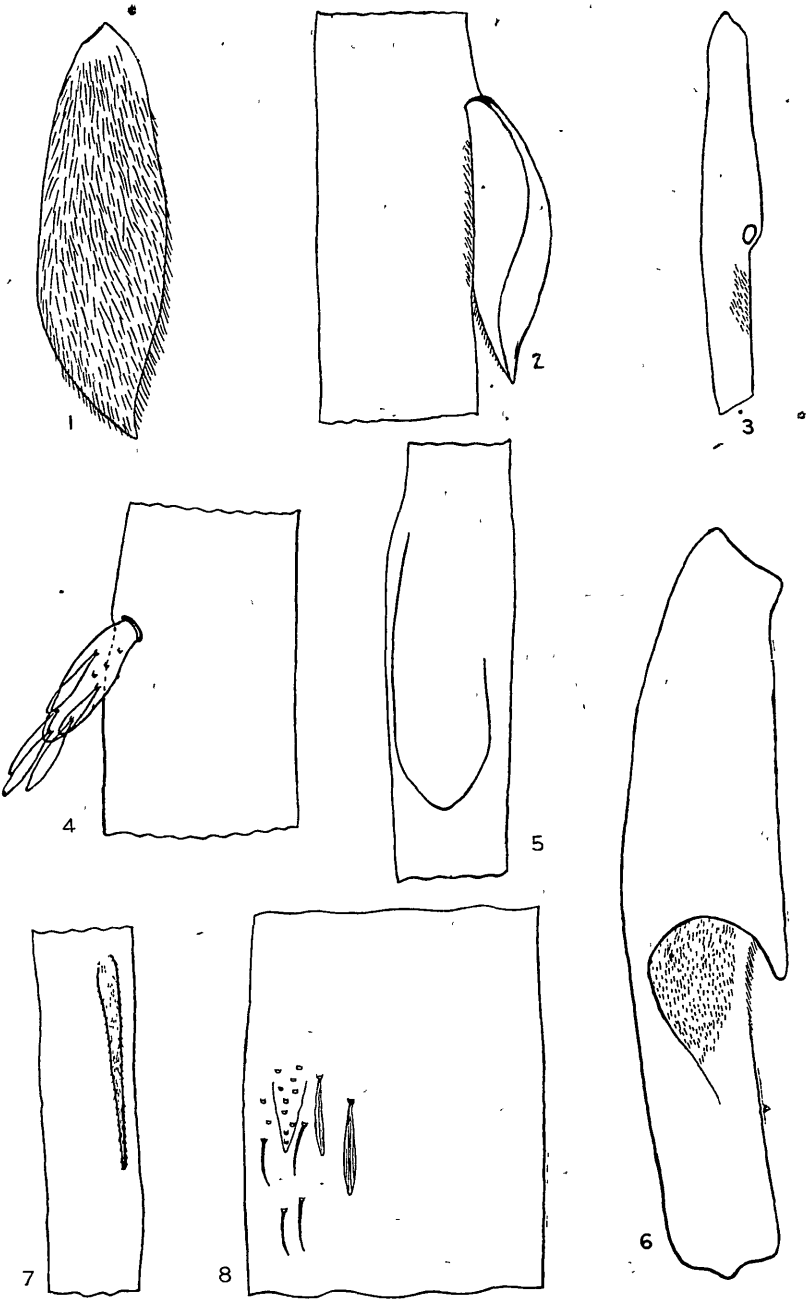

FIG. 1.—*Sabatinca quadrijuga* Meyr. Strigil removed from tibia.
FIG. 2.—*Sabatinca chrysargyra* Meyr. Portion of tibia with strigil attached; view from outer side.
FIG. 3.—*Sabatinca quadrijuga* Meyr. Tibia with strigil removed to show ring-like point of attachment.
FIG. 4.—*Mnesarchaea hamadelpha* Meyr. Portion of tibia with strigil. Some scales are shown and the bases of others indicated.
FIG. 5.—*Charagia virescens* Dbld. Portion of tibia with flap-like strigil.
FIG. 6.—*Porina signata* Walk. Tibia; view of back of strigil.
FIG. 7.—*Oncopera mitocera* Turn. Portion of tibia, showing reduced spine-like strigil.
FIG. 8.—*Fraus* sp. Portion of tibia, showing vestigial strigil with spines and scales.

into the tibia without any modification. The origin of the organ, in this family, was probably a simple notch or ridge on the tibia; this developed into a fold, and thence into a flap, after which, in some instances, it narrowed into a spur-like form. The walls of the strigil are not fused, and can be separated without difficulty. In *Porina* the strigil is strongly concave to the tibia, forming a rounded channel for the reception of the antenna (Plate 18, fig. 3). The outer sinus is not usually produced far back towards the base; in many instances the outer apical margin is broadly excurved, and joins the tibia forward of the apical point (fig. 6). *Porina dinodes* Meyr. differs from most of the other members of the genus in having the strigil lying closer to the tibia, thus forming a sinus which reaches backwards for nearly half the length of the structure. *Perissectis* is similar to *Porina*; *Charagia* and *Trictena* have very simple strigils, merely flaps standing out very slightly from the tibia and quite hidden in the long hair of the limb. The huge Hepialid, *Leto staceyi*, is one of the few species of moth in which I have failed to find a strigil of any sort. The antennae of this species are very short and but slightly hairy, and both tibia and tarsi bear thick spreading tufts of hair on each side; probably these brush-like devices have superseded the strigil as a cleaning-apparatus. In *Fraus croceus* Luc. the strigil has become somewhat spur-like, owing to the outer fissure being carried back as far as the inner, combined with a narrowing of the organ. In *Oncopera* this narrowing is carried to an extreme point, the strigil being reduced to the form of a stout spine. This process, which is covered with minute hairs, springs from about the middle of the tibia and extends to four-fifths (fig. 7). An undetermined species of *Fraus* from Australia is interesting as showing marked sexual differences in the strigil. In the male the organ is of the usual generic type, though rather small, while in the female it is reduced to a mere vestige (fig. 8). The tibia, beneath the strigil, is covered with curved macrotrichia, and these are still present forward of the diminished female organ. It seems probable that these hooks form the essential part of the cleaning-apparatus, that the strigil is now more or less functionless, and is undergoing reduction accordingly.

Suborder HETERONEURA.

In the Heteroneura the typical strigil is a rather flat organ, something like a longitudinally folded leaf. In the lower groups this fold is not central, leaving a considerable portion of the inner part single, but in the higher groups the folding is often complete, and the strigil tends to become irregularly tubular. The structure is more or less convex to the limb, and is clothed on the inner side with short dense hair. It is situated on the lower surface of the tibia, and usually takes an outwardly-oblique course. In most species it occupies the central third of the limb, but may arise from near the base and extend to the apex; in the Pterophoridae, where the tibia is much elongated, the strigil has moved distad to an apical position. The tibia itself is usually flattened beneath, and the hair on that part of its surface covered by the strigil is frequently lengthened and directed obliquely outwards so as to be opposed to the antenna when it is being drawn through. On the outer side of the tibia there is usually a more or less dense brush of hair; this covers the outer fissure of the strigil, and apparently acts as part of the cleaning-apparatus. Beneath the strigil the tibia is often hollowed out so as to form a groove for the reception of the antenna.

TINEOIDEA, TORTRICOIDEA, AND PYRALOIDEA.

These three superfamilies require little comment. The strigil is of the type described under the heading of the suborder, and is remarkably uniform (figs. 9, 10, 11, 12, 13).

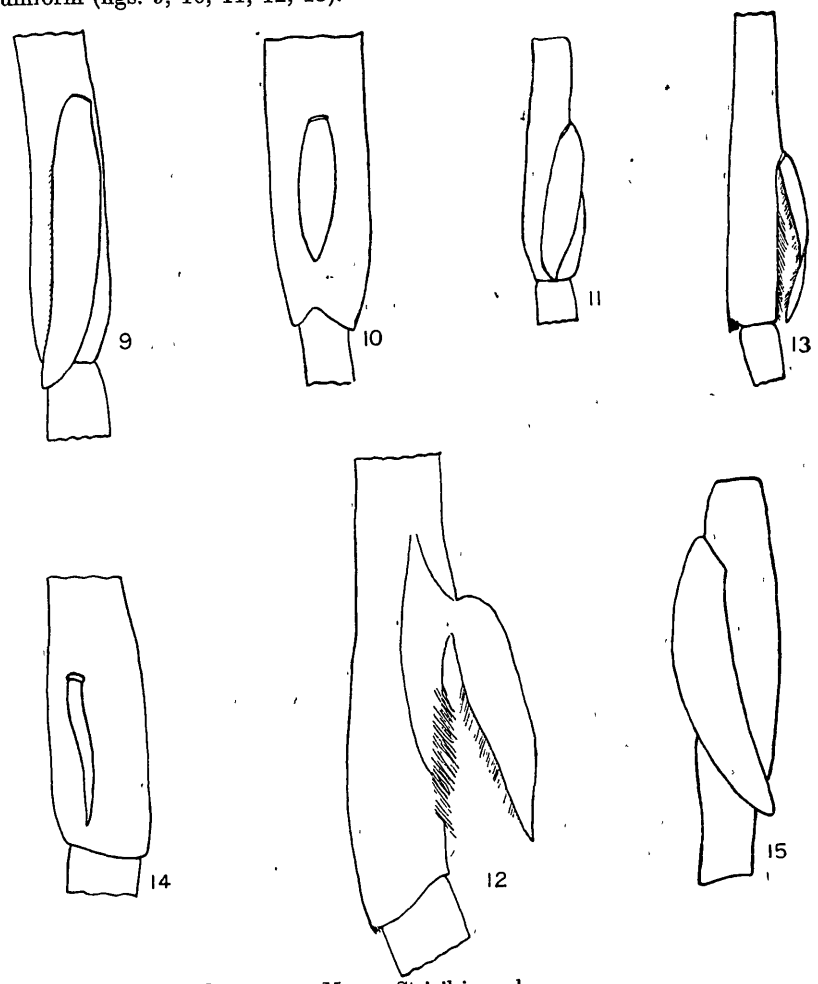

FIG. 9.—*Xysmatodoma saxosa* Meyr. Strigil in male.
FIG. 10.—*Xysmatodoma saxosa* Meyr. Strigil in female.
FIG. 11.—*Crosidosema plebeiana* Zell.
FIG. 12.—*Crambus crenaeus* Meyr. Strigil folded back to show concavity beneath.
FIG. 13.—*Alucita monospilalis* Walk. Tibia, viewed from outer fissure of strigil.
FIG. 14.—*Synemon hesperoides* Feld.
FIG. 15.—*Entometa fervius* Walk.

CASTNIOIDEA.

CASTNIDAE.

In this family only two or three species of *Synemon* have been available for examination. In these the strigil is folded completely round and fused, forming a hollow spur. The structure has the appearance of a much reduced organ, and it is probable that the smoothly jointed and closely scaled antennae are not difficult to keep clean (fig. 14).

ZYGAENOIDEA.

ZYGAENIDAE.

In the small moths of the genus *Pollanisus*, the only species investigated, no strigil is present.

LIMACODIDAE.

Neither sex possesses a strigil. The antennae are comparatively short, but are usually bipectinated in the male, frequently only on the basal portion. All the tibiae, and also the first tarsal segments, are thickly fringed with long hair-scales; on the anterior pair of legs these scale-brushes may carry out the functions of the strigil.

LASIOCAMPOIDEA.

LASIOCAMPIDAE.

The genera *Entometa* and *Porela* have a strong strigil springing from a little below the base of the tibia and extending almost to the apex. It is slightly flattened, curved, and spur-like (fig. 15).

NOCTUOIDEA.

LIPARIDAE.

The Liparidae have the strigil rising above the middle of the tibia. Frequently it springs from just below the base, as in *Laelia*, *Notoloupus*, and *Porthesia*. In some genera—for instance, *Argina* and *Asota*—it is rather short and broad (fig. 16), but in *Porthesia* and its allies the organ is as long as the tibia itself. The sexual difference in this group is also very striking. In the females of *Laelia* and *Porthesia* the strigil is reduced to an apparently functionless vestige, a weak and thin appendage covered with fine hairs (figs. 17, 18). In *Notoloupus australis* Walk. the female is apterous and has lost all trace of the strigil. It need hardly be said that these sexual differences in the strigil are correlated with the condition of the antennae, those of the males being strongly pectinated, while those of the females are shortly pectinated or simple. The male of *Laelia obsoleta* Fabr. has the longest antennal pectinations of any species of the family which I have examined, and the strigil is proportionately longer than in any other.

NOCTUIDAE.

In the Hypeninae and Plusiinae the strigil is usually rather short and broad, the organ springing from a little below the base of the tibia (fig. 19). The antennae in these groups are generally of the simple type, but in the somewhat aberrant *Rhapsa scotosialis* Walk. the antennae of the male are strongly bipectinated, a condition accompanied by a corresponding development of the strigil, which is almost as long as the tibia. In the group of small forms represented by *Eublemma*, *Araeoptera*, and other genera the strigil is of normal shape and size, but in *Tarache nivipicta* Butl the organ has moved distad to the middle of the tibia and is broader than usual, the tibia being also broadened and flattened to accommodate it (fig. 20). In the Melanchrinae a different type of antennal armature is met with. The segments are frequently subdentate, or serrate, and are almost always either ciliated or bear short stiff pectinations. Apparently in order to meet these modifications, the strigil in this group has assumed a special form. The outer margin, instead of being free from base to apex, is attached

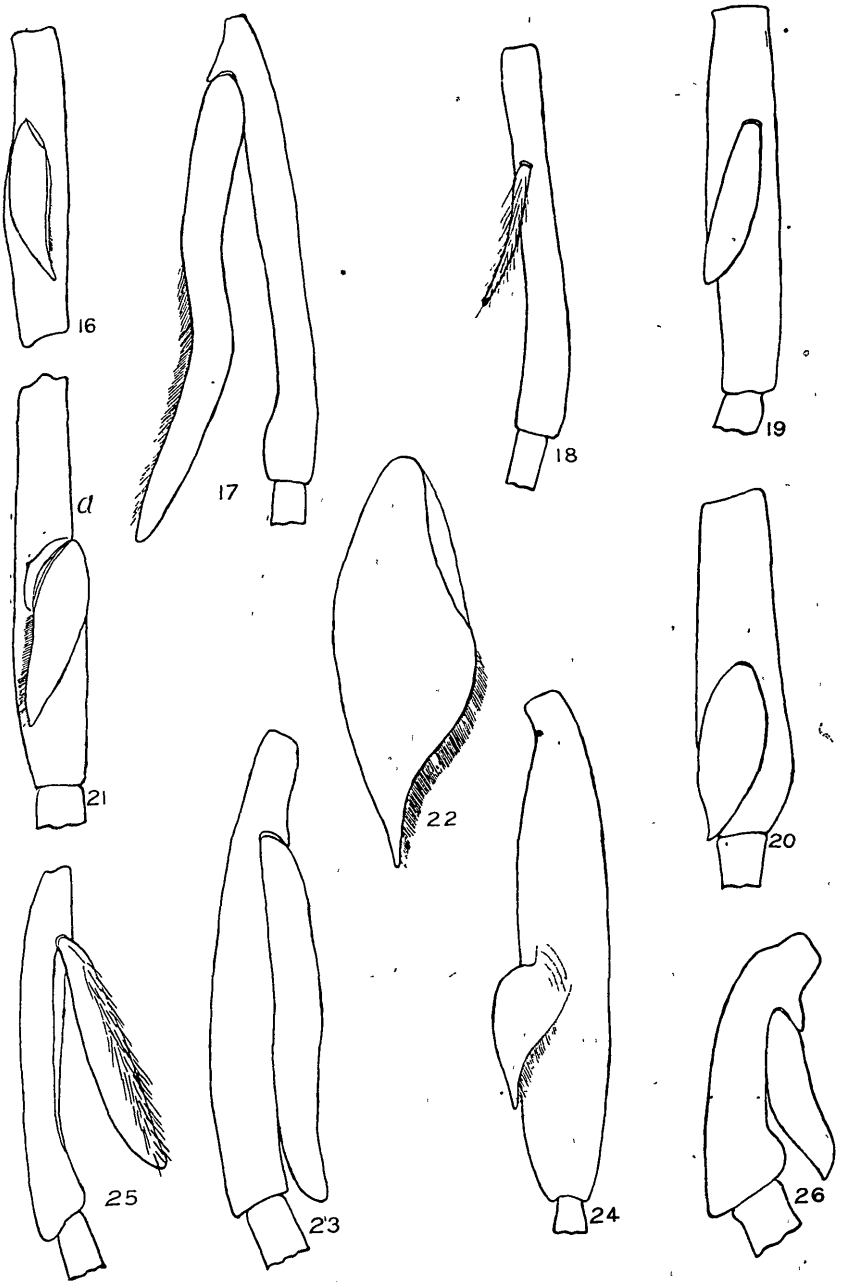

FIG. 16.—*Argina cribraria* Clerck.
FIG. 17.—*Laelia obsoleta* Fabr. Strigil in male.
FIG. 18.—*Laelia obsoleta* Fabr. Strigil in female.
FIG. 19.—*Calpe emarginata* Fabr.
FIG. 20.—*Tarache nivipicta* Butl.
FIG. 21.—*Melanchra agorastis* Meyr. To show (*a*) attaching membrane.
FIG. 22.—*Persectania ewingii* Westw. Detached strigil.
FIG. 23.—*Ichneutica ceraunias* Meyr.
FIG. 24.—*Schistophleps albida* Walk.
FIG. 25.—*Ardices curvata* Don.
FIG. 26.—*Metacrias erichrysa* Meyr.

by a membrane for a third or more of its upper portion to the tibia (figs. 21, 22). The lower part is armed with the usual fringe of hairs, but near its centre it is broadly and deeply convex. The tibia is somewhat flattened, and bears an oblique groove which passes beneath the comb, forming with the convexity of the latter a covered channel through which the antenna can be drawn. Fitting into the convexity of the strigil is a dense bunch of hairs, the whole forming a cleaning-apparatus with comb above and brush below. That this type of strigil is correlated with the usual type of antennal armature in the Melanchrinae seems still more probable when the genus *Ichneutica* is examined (fig. 23). Here the antennal segments are more regular, and the armature consists of strong bipectination. Not only is the strigil greatly enlarged, being about four-fifths of the length of the tibia, but its outer margin is free right to the base, and there is no concavity similar to that generally found in the group.

Arctiidae.

In the Arctiidae the antennae are usually small, and have little armature. The strigil, which is usually not highly developed, shows in some forms, as *Schistophleps* (fig. 24), the same extension of the attaching membrane as in the Melanchrinae. *Comarchis* and *Celama* also exhibit this character, though in a less degree. *Ardices* possesses an unusual type of strigil for this family, it being long, free throughout the entire length of the lower fissure, and covered outwardly with dense hair-scales (fig. 25). *Metacrias* also displays a peculiar strigil. The tibia in this genus is very short; it is also somewhat curved and hollowed out beneath. In this convexity, its base being deeply sunk in the limb, lies a broad naked strigil (fig. 26).

Syntomidae.

The Syntomidae offer no unusual strigilar features, the organ being rather small, centrally folded, and broadly lanceolate, with the usual fringe of hairs on the outer margin.

NOTODONTOIDEA.

Notodontidae.

In *Neola semiaurata* Walk. the strigil in the male is strongly concave to the tibia and follows a somewhat spiral course. In *Epicoma tristis* Lewin the organ is also concave, but has no spiral twist (fig. 27). In the females of both these species the strigil is absent, as it is also in the very peculiar *Ochrogaster contraria* Walk.

Sphingidae.

The hawkmoths have a well-developed strigil occupying the middle third or more of the tibia. It is concave to the limb, centrally folded, and bears a fringe of stiff spines on the margin of its inner fold (Plate 18, fig. 2). Though the edges meet, they are not fused except towards the apex. The organ is deeply set in the tibia at the base, and is almost entirely exposed (fig. 28). In *Metamimas australasiae* Don., however, the fringe of hair which in all species occurs on the outer side of the tibia is curved round, the lengthened upper part of it acting apparently as a spring to keep pressure on the strigil, and the lower part forming a rounded channel to receive the antenna (Plate 18, fig. 1).

GEOMETROIDEA.

Throughout this superfamily the strigil shows little variation. It usually occupies from one-half to one-third of the tibia apically. It is generally only partially folded, so that the lower fringed part can be seen

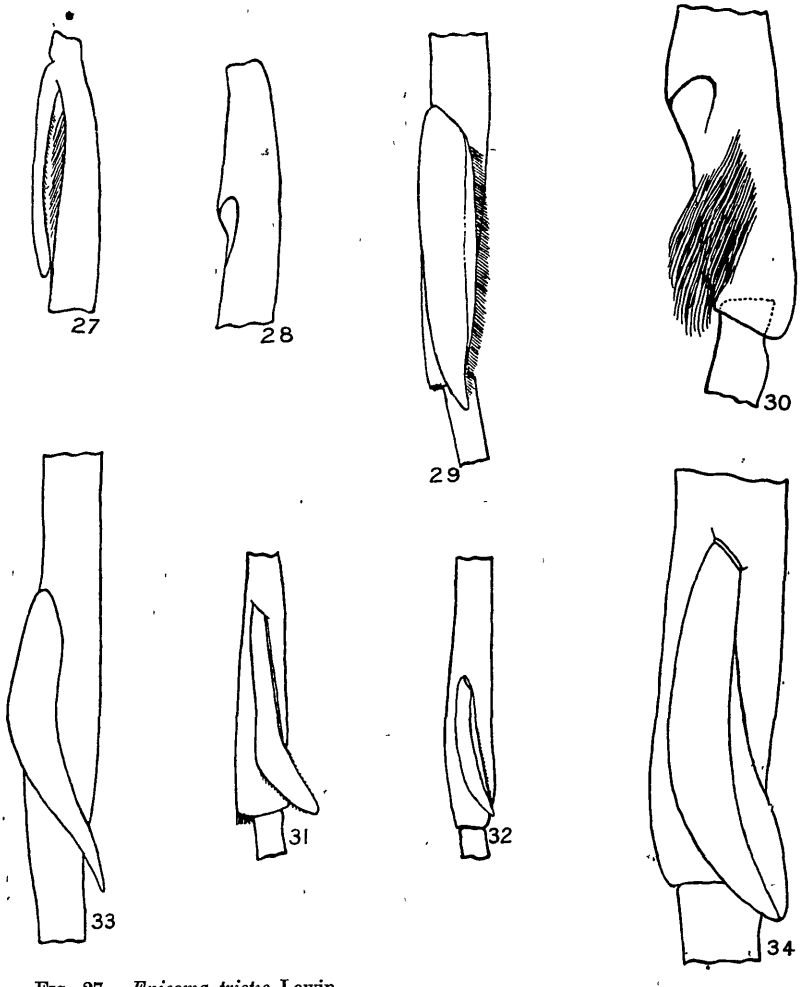

FIG. 27.—*Epicoma tristis* Lewin.
FIG. 28.—*Cephanodes janus* Misken. Portion of tibia with strigil removed.
FIG. 29.—*Venusia undosata* Feld.
FIG. 30.—*Tatosoma lestevata* Walk. Portion of tibia with strigil removed to show dense tuft of hair beneath.
FIG. 31.—*Declana junctilinea* Walk. Strigil in male.
FIG. 32.—*Declana junctilinea* Walk. Strigil in female.
FIG. 33.—*Papilio macleayanus* Leach.
FIG. 34.—*Signeta flammeata* Butl.

projecting (fig. 29). The brush on the tibia is long and dense (fig. 30). Many of the species provide excellent examples of the correlation between antennal armature and strigilar development. In those forms in which the antennae of the male are bipectinated while those of the female are

simple the strigil is invariably found to be much reduced in the latter sex. For instance, in the male of *Venusia undosata* Feld. (see fig. 29), which has strongly bipectinated antennae, the strigil is more than half the length of the tibia; but in the female of the species, the antennae of which are simple, the organ is only one-quarter the length. The same sexual difference in antennae and strigil occurs in *Xanthorhoe*, *Notoreas*, and *Selidosema*, but in *Dasyuris*, where the antennae are simple in both sexes, there is practically no difference in the size or condition of the strigil. In *Declana* most of the species have strongly pectinated antennae in the male and less strongly pectinated or simple antennae in the female. Figures of the tibiae in both sexes of *Declana junctilinea* Walk. under equal magnification are given, in order to show not only the difference in size, but the strong bend or angle of the apical portion in the male (figs. 31, 32).

URANIOIDEA.

Uraniidae.

The striking day-flying North Australian moth *Nyctalemon orontes* Linn., so like a butterfly superficially, has a strigil resembling that of *Papilio*, but less folded and shorter in proportion.

PAPILIONOIDEA.

In the butterflies many of the families have more or less reduced anterior legs, and in such families the strigil has disappeared. In those families in which the forelegs are normally developed, however, a strigil is present. It is usually rather long and narrow, folded completely round, and partially fused (fig. 33). In the Hesperidae the strigil is almost hidden in a tuft of hair-scales. It is folded almost into a tube, though the edges are not fused. It lies strongly convex to the limb, and if viewed from the right angle an aperture may be observed between the two, with the hair on both surfaces directed towards the middle line (fig. 34).

In conclusion, it may be pointed out that many of the families of the Lepidoptera have not been examined, but it does not seem probable that the investigation of these will materially affect the conclusions arrived at, which may be summarized as follows: In the Lepidoptera, with comparatively few exceptions, a strigil or comb for cleaning the antennae is found on the anterior tibiae. This strigil is a modified spur which has become flattened and covered with hair beneath. In some of the most specialized forms this flat leaf-like organ has been completely folded round, the margins meeting and becoming fused so as again to take the form of a hollow spur. In one group, the Hepialidae, the strigil does not seem to have been derived from a spur, but to have originated as an outgrowth of the tibial wall. Almost invariably the development of the strigil is found to be correlated with the condition and armature of the antennae, whether such condition be sexual or systematic.

I desire to express my thanks to Dr. R. J. Tillyard, Chief of the Biological Department, Cawthron Institute, for reading the text, and for much encouragement and advice during the carrying-out of the investigation; also to Mr. W. C. Davies, Curator of the Institute, for the excellent photographic plate.

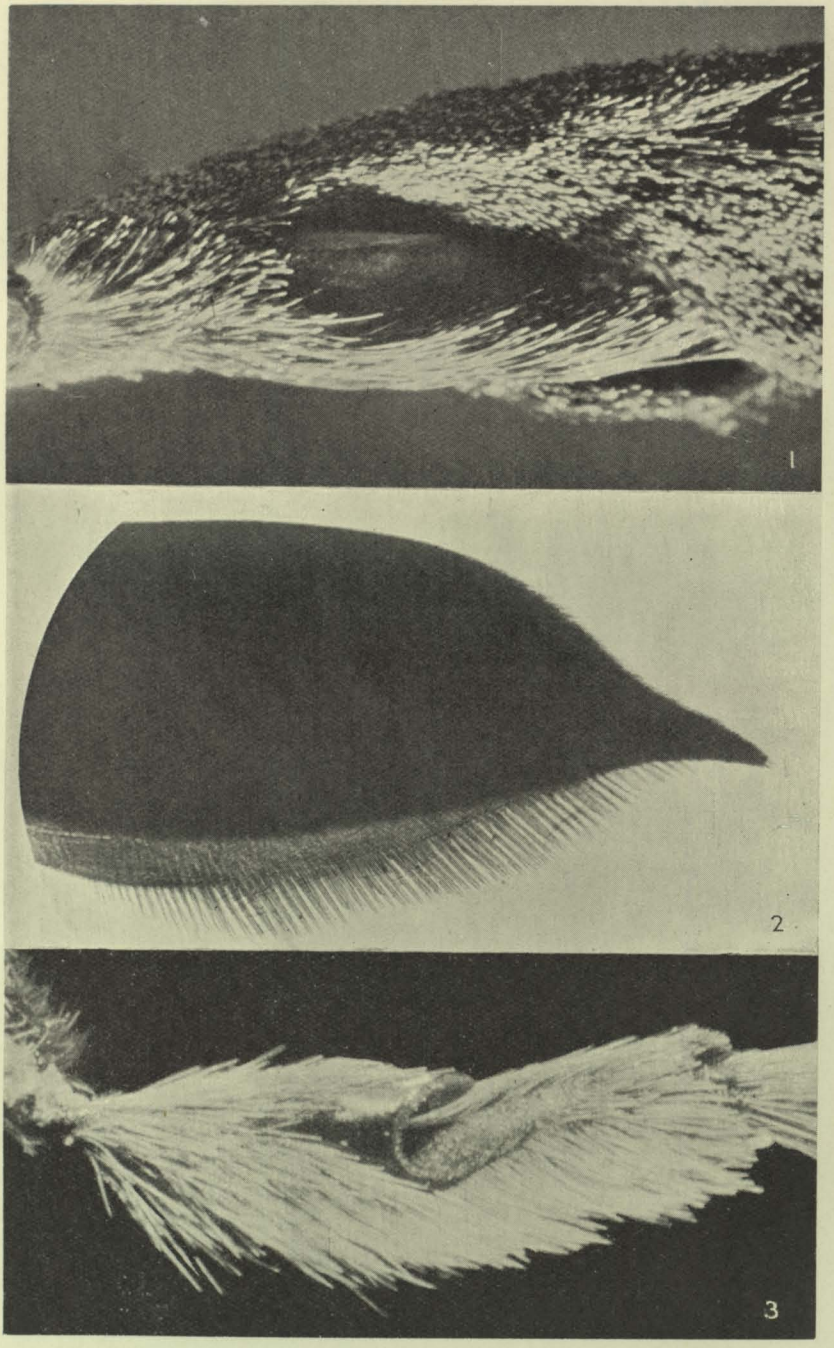

FIG. 1.—Portion of tibia of *Metamimas australasiae* Don. with strigil *in situ*.
FIG. 2.—Apical portion of the strigil of *Sphinx convolvuli* L., to show fringe of spines.
FIG. 3.—Tibia of *Porina jocosa* Meyr. with strigil *in situ*.

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