Thesis

for degree of M D

on

Blatta Orientalis

by

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Thesis

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Fig. 1 Male Armature

a. Axe b T-shaped plate external surface b' Internal surface Yellow Area from which Dorsal Valve of Shell has been broken off. C. In Brown Fork and Fork Plate. In Blue Horn. In Mauve Bent Plate In Yellow Connecting Bands. d. Shell slightly opened. Projecting Lip of lower Valve shown in Yellow f. Tongue. g From above and inner side Yellow-Penis. Red-Spermatic process Mauve-Dorsal limb and Shike Blue Ventral limb and shike of Horse Shoe. g' From below as in g and in Brown small Y-shaped plate. In green attachment of tenaculum. h: Tenaculum j. Ninth Sternum

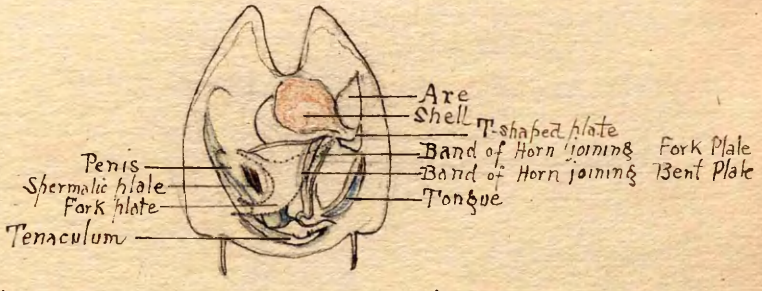

Fig 2.

Male Armature from above and the front

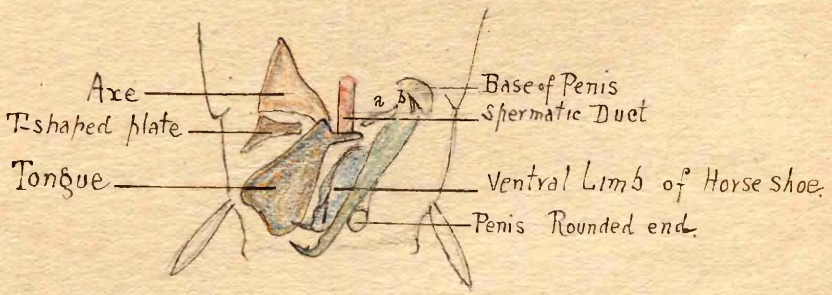

Fig 3 Male Armature from Below. a. Intermediate plate b Y-shaped plate.

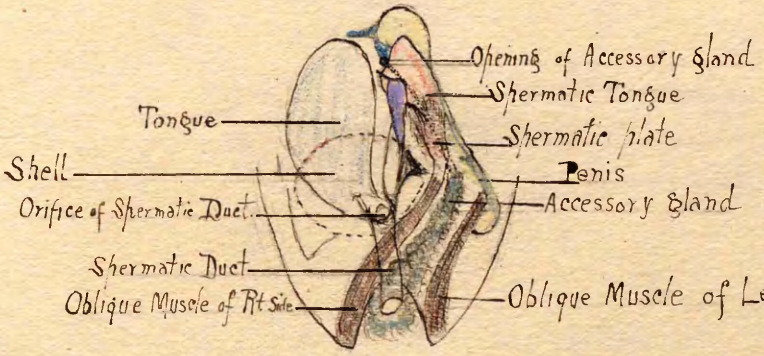

Fig 4 Oblique Muscles Spermatic Orifice and Accessory Gland

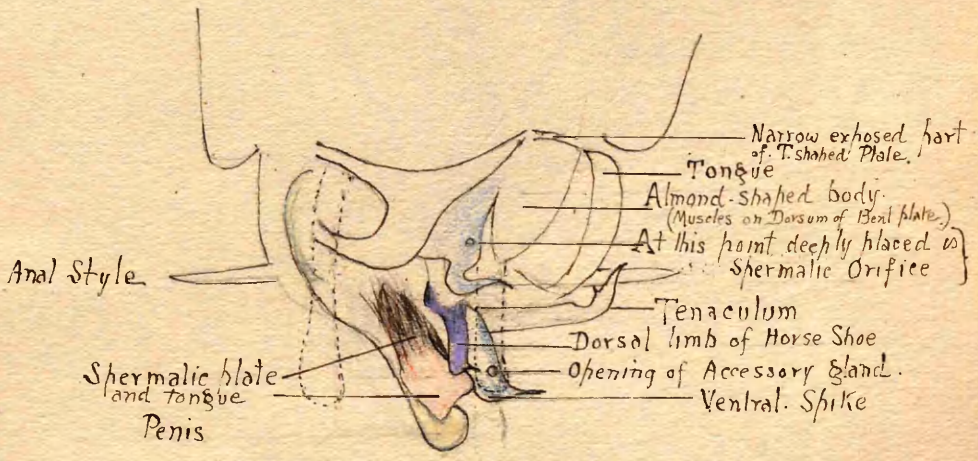

Fig 5. Male Armature in position

Position of Female Ant Gonapophyses Indicated. ---

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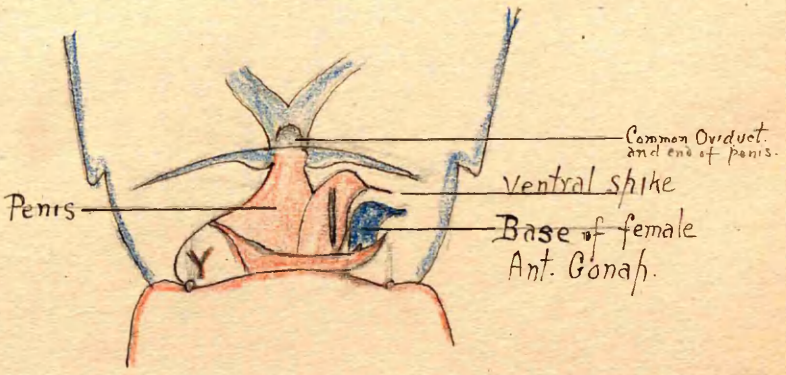

Fig 6

♂ Parts United female seventh Sternum removed.

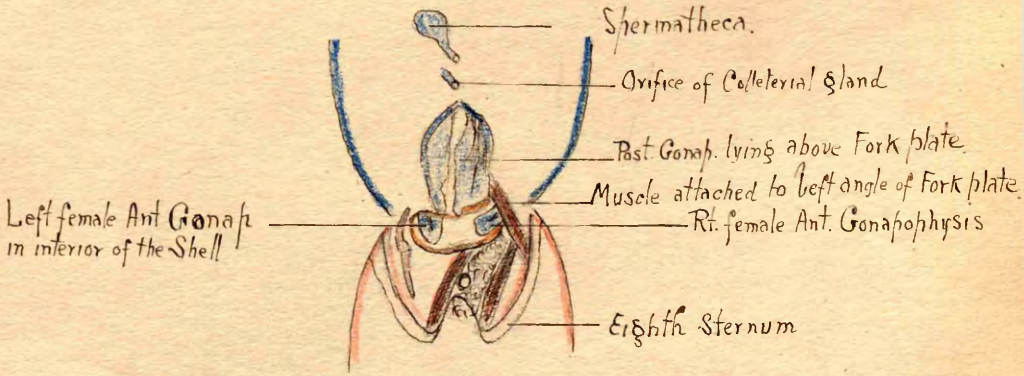

Fig. 7. ♂ United Parts Dorsal Valve of Shell broken through

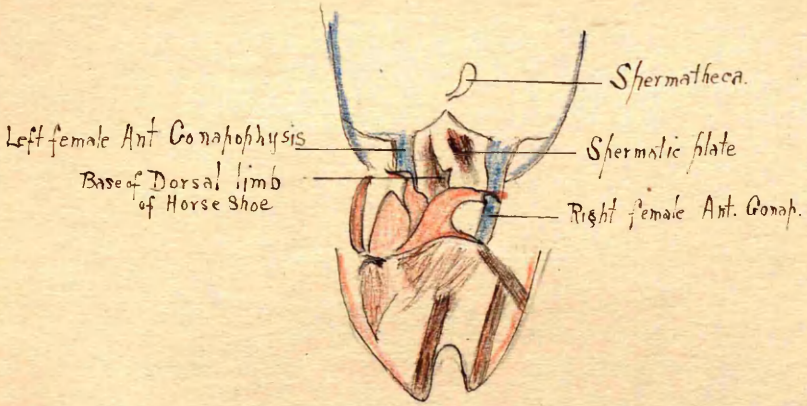

Fig 8 Male and Female parts United Male in Red Female in Blue

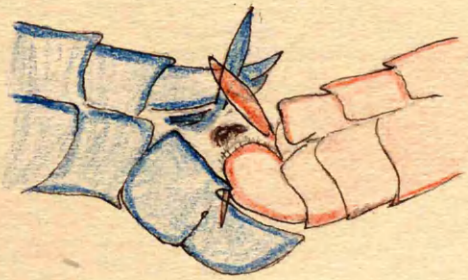

Fig 9 . Showing Anal Style lodged in Sternal notch.

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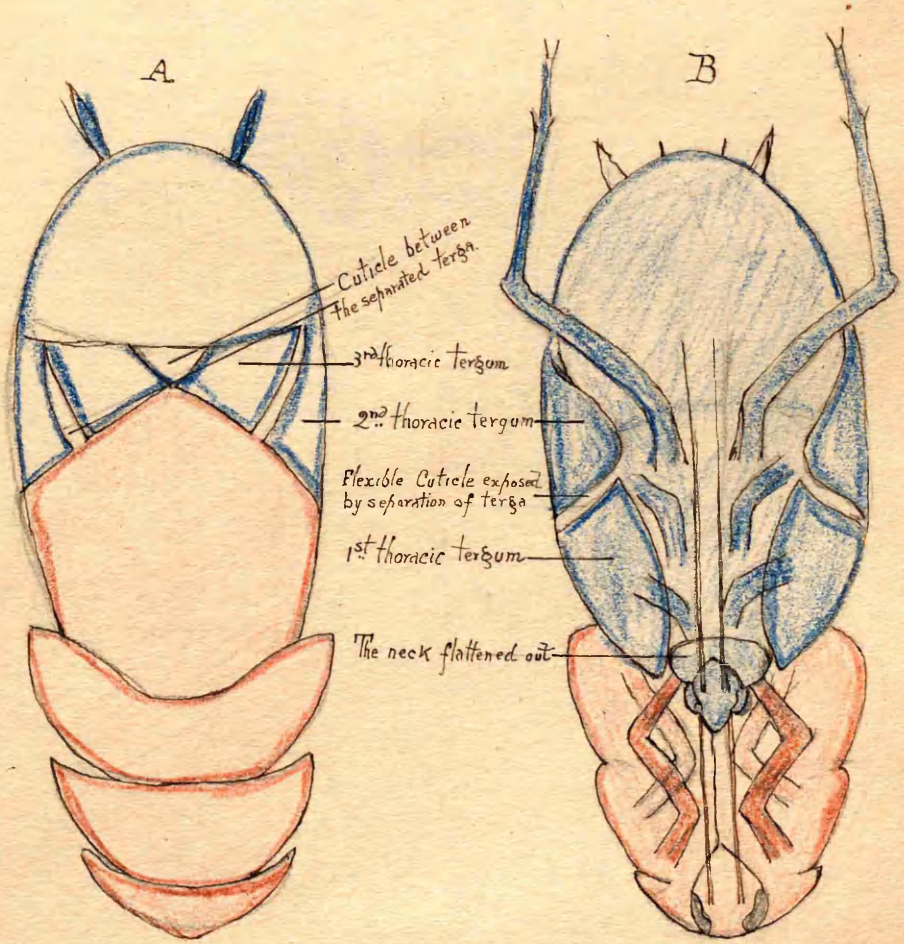
Fig 10. The process of Ecdysis half way from a specimen fixed in Spirit. A Dorsal View B Ventral View



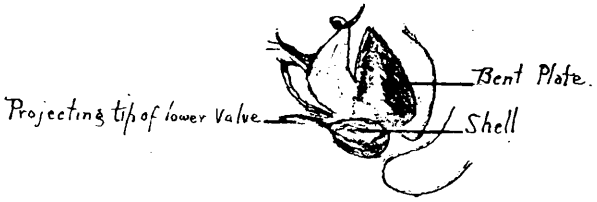


Fig 11. Oblique position of Shell and the Bent plate.

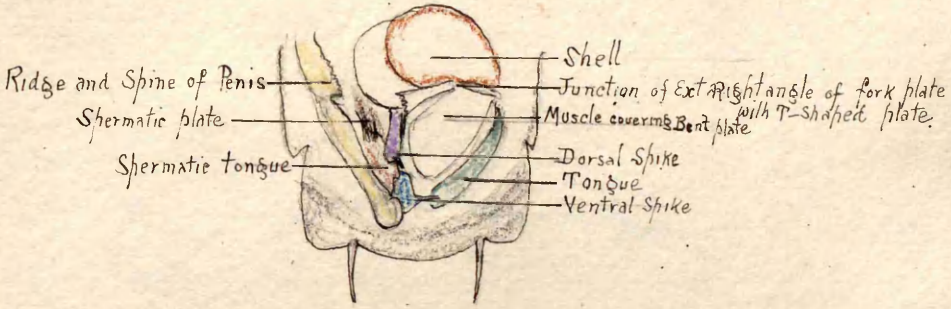


Fig. 12 Male Armature. Fork and Horn removed

Fig 13 Male Armature from behind and below.

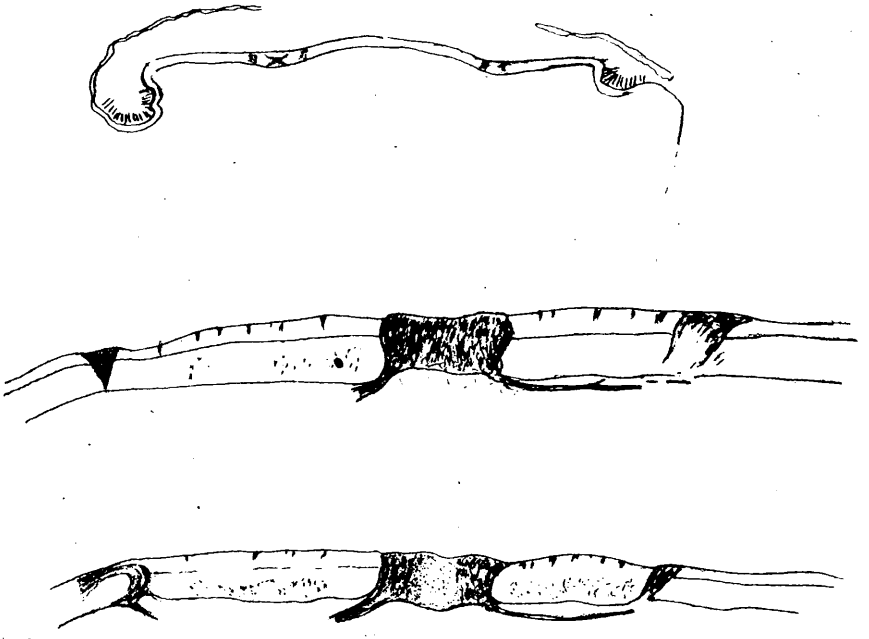


Fig 14 Sensory Organ in the Third Thoracic Tergum of the Male

K

Blatta Orientalis

General Account of Habits and Senses.
These insects live on the vertical plane and only descend in search of food, when disturbed they climb up a wall of their box where also they sleep undergo ecdysis the males and females copulate and the females drop their egg cases. During sleep and also during the process of ecdysis the claws of the tarsus retain a hold of the wall mechanically. They detect slight differences in temperature and will remain close to the bottom of a wall if the temperature there suits them better, otherwise they go as high up as they can get where they seem to feel safer.

Young ones will sleep in the sunshine for the sake of the warmth

The Sense of Sight which they possess is of very little use beyond detecting changes in the amount of light. When a box in which they are confined is partly lit up they settle in the darker part but when it is equally illuminated all over they are not alarmed. They can distinguish between light and darkness only when they have the two side by side for comparison. They stand a bright light provided it developes gradually and when kept in a box with a glass cover their ordinary habits can be observed without difficulty provided that care be taken to avoid moving shadows passing near them; they are quite unconscious of the observer. An ordinary wax taper with the end frayed out, passed through a hole in the box is a convenient means of driv-

ing them about or of directing them from one box into another. When very gently pushed with the taper they will resist and seek to push it away with their feet especially the hind ones, yielding however to stronger pressure they can be moved about as required by the exercise of a large amount of patience without frightening them. They will eat or drink from a taper and even try to retain hold of it when it is being withdrawn.

In driving them from one box to another through an opening about half an inch in diameter, it is soon evident that they cannot see this opening, and they never become conscious of its presence until one or both the antennae are passed through it. They may be brought close up to it many times before the antennae happen to pass through, then however there is no further

difficulty and they pass through it readily. When kept in a double box with a similar communicating opening between its divisions they will always go into the dark one when the other is lit up, finding the aperture by means of the palps and antennae. Nor can they detect an opening by means of their feet as two or three of them may be partly through without their becoming aware of it; and even when the head and basal parts of the antennae are pushed through they come back again to where the tips of the antennae have remained. Often when one passes through an aperture others will follow quickly apparently detecting the disappearance of the black body, and on occasion the male can tell the position of the female head by her movements when they are not in touch with one another.

* They never seek to enlarge an opening unless they can pass the antennae through it; consequently a small round opening three or four times the diameter of the antennae being used with a whip-like movement only do not pass through it. Whereas a long narrow slit barely as wide as the diameter of the antennae is frequently enlarged as the antennae can be passed through this by their whip-like movement.

The best developed sense and that upon which they rely for the most part is that of Touch residing in the antennae and palpi and for special purposes in the cerci. The antennae are the only organs that enable them to obtain definite information of what is around them at any distance away,* the palpi give information about those things which are near at hand: They are provided, as it may be expressed, with the means of near-touch and of far-touch The antennae are to them (among other things) what a stick is to a blind man. The latter deprived of his stick will not venture to walk far if at all, and a Cockroach deprived of its antennae remains stationary for the most part moving seldom and never going far. When pushed on to food or water it will eat or drink remaining when finish-

ed with its palps resting on the food as if asleep only after an hour or two finding its way back to the warm wall of its box. Especially the more active immature insects may be seen when running along the wall of a box, to stop abruptly whenever the tips of the antennae touch the adjoining wall. To fulfill this purpose they are relatively longer in the immature and in the male than the female, since the male can run more quickly having longer legs and being of lighter build he requires longer notice of the presence of an obstacle

The antennae and palpi are used to investigate bodies not by being applied to them with varying degrees of pressure like the human finger, but by repeatedly tapping them or drumming on them; that is to say by ~~palpation~~ percussion as distinguished

from palpation. ~~Parallel to this one may determine~~ It is possible that vibrations are set up in this way in the organs themselves varying according to the density of the body examined and that information is so obtained by the insect. Parallel to this one may determine the comparative density of bodies by striking a tuning fork on them and determining by means of the finger the intensity of the vibration produced by equal strokes.

The reasons adduced for inferring that the sense of smell resides in the antennae in insects are not satisfactory. Exposure to an irritant vapour causes an insect to draw the antennae through the mouth parts but it may be rubbing the mouth parts not the antennae. If it be said that the vapour is so weak as to be merely an odour it may be

asked why should the olfactory organ be rubbed when an odour is perceived In man an irritating vapour may cause the nose to be rubbed but the sensation is quite different from an olfactory one; and such a vapour will also act upon the conjunctiva causing the eye to be rubbed. And some vapours such as Chlorine cause an irritation of the lower air passages only (or chiefly) though at the same time the odour of it is perceived by the nose. The loss of the antennae (in the case of the cockroach) and the consequent difficulty in locomotion sufficiently accounts for the deprived insect not finding its way to food without any necessity for assuming that its sense of smell is lost.

A cockroach may sometimes be seen with its antennae pased out of the box through a slit and then they may be breathed on and bent thereby without causing their withdrawal

whereas breathing on the body of the insect will make it run away terrified.
Cockroaches may be observed seeking and finding food by means of the sense of smell but no information as to the site of the olfactory organ can thus be obtained.

The differences between the two Sexes are connected with reproduction
These are (a.) in the Male in addition to the essential glands and ducts.
1 The presence of wings and beneath them a sensory organ (tactile)
2. A narrower abdomen than that of the female capable of telescopic extension and a provision for this in the extra length of the connectives between the abdominal ganglia of the nervous system.

3° The presence of anal styles.
4 An asymmetrical genital armature very different from that of the female.
(b) In the Female in addition to the glands and ducts and spermatheca are -
1. A dilatable genital pouch
2. The wedge shaped form of the seventh sternum and the notches in its free edge at the junction of its two halves.
3. The oviposilor part of which forms a genital armature interlocking during copulation with that of the male

The Wings.

From the presence of wings it has been generally assumed that the male has the power of flight. The Naturalist of Selborne states that the males gain entrance to houses

(1) Invertebrated Animals

(2) Figures inserted by Mrs. [illegible] (Lübeck)

previously free from them by "flying in at the casements from the neighbouring houses" but as he goes on to say "How the females get from house to house does not so readily appear" the males no doubt came by the same route as the females and the presence of wings is the only ground for the statement. (1) Huxley states that the male has "at any rate the capacity for flight" a form of statement which shows his opinion to be founded on anatomical grounds; such however is not to be relied on as for example (2) in Polynemus Natans (Hymenoptera) the wings are used for swimming without there being any indication of such a function in their structure and the insect is incapable of flight.

Males and females develope from the same egg case and reach maturity together and are always found associated with one another.

And there is no circumstance from which it might be supposed that flight would be an advantage to the male
A male can escape from a glass tumbler placed mouth upwards but neither the immature nor the female can do so, and it might be inferred from this circumstance that the male could fly. However watching a male shows that he escapes by crawling up the glass without using his wings at all. Some males can run up the glass with great rapidity: they are no sooner in the tumbler than they are out again. others frequently slip back and take a long time to reach the top.
When placed in the following circumstances the male would almost certainly fly if he could. Put on a table and heated on (which terrifies him) he will run to the edge and then fall heavily to the floor

as often as not falling on his back
When he is in a tumbler if a piece of
wax taper to which a thread is attached
be put in beside him, he will crawl on
to it and may then be suspended in the
air. He can crawl up a double thread
No 40 but not a single one. When sus
pended he keeps crawling backwards and
forwards along the piece of taper turning
with difficulty at the ends. After a time
he loses his hold when turning and falls
down. He evidently knows he is in the
air and stretches out his antennae to
see if anything else is within reach
but does not move his wings at all.
Only one or two aphides out of many which
have never flown can be made to fly by
isolating them but this is not the case with
those that have been on the wing before.
The wings are in all probability not

used for flight. They are however used in connection with copulation when they are raised and strangely enough when the attempt at copulation fails they are vibrated as if the insect were flying, but no vibration occurs if copulation takes place.

These unsuccessful attempts have been imperfectly described by Cornelius and as being the act of fertilisation as follows:-

"When the female has become perfectly still "the male goes in front of her brings the "end of his abdomen towards hers Then "moves backwards and pushes his whole "length under the female. The operation "is so rapid that it is impossible to give "an exact account of the circumstances "Then the male creeps out from beneath "the female raises high both pairs of "wings and goes off." The following is

an correction of this account:- The male pushes not his whole length but only his last thoracic and abdominal segments beneath the female. the wings being raised and not passing under the female at all and as he comes out from beneath he drops them, to raise them again the next moment, and in addition extends them & vibrates them rapidly for an instant or so.

The main function of the wings is to form a movable protective covering to the third thoracic tergum covering other parts by the way.

Fig. 14. The Sensory Organ is situated in this tergum in the cuticle. one on each side about the middle of each lateral half of the tergum
On the right side it consists of three-

aggregations of nerve fibrils passing through the whole thickness of the cuticle to terminate in enlarged ends on the free surface. Fibrils running beneath the cuticle connect these with one another, and single fibrils with dilated ends pass through the cuticle to the free surface in the spaces between the aggregations. On the left side the structure has only two aggregations, otherwise it resembles that of the right side.

The nerve to these organs appears to reach them by passing inwards from the pleural margin.

Search was made for some kind of structure sensitive to touch in this situation on account of what was observed to take place at the beginning of the process of copulation; but except in one instance namely in the case of a without success

newly born adult male that was immersed in gold chloride solution before any darkening or hardening of the new cuticle had taken place And as a second such specimen has not been obtained up to now the structure is only known from transverse sections.

The function of this organ is to indicate to the two sexes, when stimulated by the female mouth parts, that the two individuals are in a certain relative position to one another such that extension of the male abdomen will bring their genital openings into such an apposition that the penaculum may be forced into the left sternal notch of the female by being protruded and directed upwards.

The existence of some structure similar to this may account for the retention of the wings in the male only, which obtains

*This sensory structure occupies a position analogous to that of the tympanum on the first abdominal segment of Acridian insects and to that of the tympanum of the Gryllidae on the second abdominal segment and is like them covered by the wings.

so extensively in insects.*

The narrow form of the Male Abdomen enables it to pass easily between the legs of the female and its telescopic extension enables him to reach back to the tail end of females of different sizes when the female mouth is applied to the sensory organ just described. During extension too, the anterior soft parts of the abdominal terga, which usually lie under cover of the terga in front, are exposed and are probably sufficiently sensitive to indicate to the male the progress of the female forwards, and when it is time for him to raise the wings that she may reach the organs beneath them.

Some substance must fill up the enlarged area within the abdomen that is produced by this

extension. It is most probable that it is air which does so as the amount of a liquid fluid that would be necessary could hardly be furnished. The extension though not to the greatest degree is often retained for a considerable time (up to half an hour) when the male is in the presence of females. And during this time only, the male is able to crawl on the under surface of smooth glass. He cannot however do this well, frequently falling in the attempt. Some manage better than others and one was observed to crawl eighteen inches in this position failing however to pass safely on to the side of the box From this it would seem that the extension is accompanied by a diminution in the specific gravity of the insect and this could be brought about by distention with air provided it attained a higher temperature than the surrounding atmosphere.

Air sacks naturally occur to one in this con-

section and though these have not been found in the cockroach yet as they would be empty when the insect comes to be examined their presence may have escaped notice. However that may be there is in ordinary inspiration an increase in the capacity of the abdomen from which it is certain that there are structures within it capable of holding variable volumes of air. It has generally been assumed that the large tracheal tubes are the structures concerned. This however can hardly be the case since large and small tubes are both in the one cavity and consequently a negative pressure would cause an expansion of the small thin-walled air tubes long before it could affect the large tubes with their spiral thickenings. A moderate distention of the innumerable capillary air tubes would fill up a considerable increase in the area of the abdominal cavity.

It should also be borne in mind that the alimentary canal is capable of distention with air.

The greatest degree of extension of the male abdomen lasts only momentarily and takes place while the male is beneath the female and immediately before the attempt to fix the tenaculum is made.

A male that had become motionless under water was taken out and as he revived telescopic extension of the abdomen occurred and was increased temporarily by a spasmodic movement and at the same time the genital armature was protruded and moved a little out and in.

When the male crawls on the under surface of smooth glass those sides of the claws, which ordinarily look towards one another, are applied to the glass and the claws are directed away from one another. The

arolium lying between them is also pressed against the glass but no other part of the tarsus touches it

The immature ♀ in whom the arolium is less developed ♀ the female never exhibits this capacity at all; the female sometimes will put her two forelegs on the glass as if to walk on its under surface but apparently dare not venture farther The circumstances in which this power can be of any use to the male insect must be very rare, and it may be retained merely through its association with the ability to extend the abdomen otherwise of use and with the retention of wings, having a function, though now useless for flight.

The tarsi are very much alike in the two sexes the male ones being just a little longer. It is only those of the male

however that are actively concerned in pairing. As the female advances forwards on the back of the male he guides his abdomen backwards beneath her by means of the cerci; directing them straight backwards parallel to the middle line he drums with them on the ventral surface of her abdomen rapidly and forcibly, till they reach back to and pass upwards one on each side of the anterior half of the seventh sternum: then the attempt to fix the tenaculum is made. It does not seem probable that this drumming should cause any sensation to be experienced by the female unless possibly through the production of vibration in some structure in the cavity of the abdomen.

This action of the male cercus was first noticed in the case of a male that had only one, and seemed to wield it with more than

usual vigour. The cerci of the female in some instances at any rate vibrate rapidly through a very small angle immediately upon the insertion of the male organs, without coming into contact with any part of the male, a movement of the nature of an expression.

The Male Armature

This structure together with muscles belonging to it occupies the concavity of the ninth sternum, its most dorsal portion rising a little above the level of the margins of the sternum. It presents no trace of a symmetrical arrangement on the two sides of the body

Fig 1. The Ninth Sternum is remarkable for its length and the rigidity of its anterior margin. It extends anteriorly over the soft portion of the eighth sternum reaching almost to its anterior edge and consequently reaches farther forwards than the posterior edge of the seventh sternum. The anterior transparent half of this sternum is concave from side to side on its upper surface As it goes forwards from the posterior thicker portion the lateral edges curve gradually towards one another and as its anterior edge is deeply notched two symmetrically placed tooth-like

processes project directly forwards from the anterior margin. These processes are thickened and less transparent than the central part of this portion, and a narrow thickened part forms the margin elsewhere. This thickening enables the part to give attachment to muscles. The anterior margin of the eighth sternum has a similar toothed form without however any thickening, and when the two are seen from above the broader toothlike processes of the eighth form a narrow border round those of the ninth sternum.

Fig 7.

The thick posterior portion (towards its anterior edge however it is often transparent) is concave from side to side and from before backwards; it is somewhat quadrate with rounded angles; its anterior edge is slightly convex forwards where it joins the anterior portion, and its posterior free edge in its middle three fifths forms a slight

projection convex backwards at each end of which an anal style is attached.
Each style projects directly backwards and has a slight concavity looking towards the middle line. They can be freely moved as a whole having a joint at their bases but cannot be moved by the insect itself.
In Phyllodromia etc one of the styles is replaced by a notch; the same kind of structure as that into which they are adapted to fit in B. Orientalis.

Fig 1. On the right side the proximal part of the armature is an Axe-shaped plate which lies on the anterior thin half of the ninth sternum. It presents two angles dorsally an anterior and a posterior and a rounded end ventrally: its long axis being dorsoventral

and having a curve parallel to that of the sternum from which it is separated at its uppermost part by a layer of muscle The posterior edge of this plate is curved presenting a slight concavity backwards having a crescentic space between it and the lower end of the cross piece of the T plate. The dorsal edge is straight and horizontal lying in the same plane as and parallel with the edge of the sternum. The anterior edge is directed obliquely downwards and backwards, and as well as the dorsal is free from attachments. The anterior angle is free; the posterior articulates with the anterior end of the horizontal limb of the T shaped piece, and the rounded end with the ventral valve of the Shell.

Fig 1. The T-shaped plate lies immediately behind

the Axe with the posterior angle of which the anterior end of the long limb articulates The long limb is placed horizontally with the free end anterior: the upper half of the cross piece curves inwards while the lower half is directed downwards. The end of the upper cross-piece is prolonged anteriorly and articulates
Fig 2 with the right angle of the Fork-plate. The lower crosspiece articulates with the Ventral valve of the Shell by its end and by its internal surface it is continuous by a narrow neck with the dorsal valve.

Fig. 1. The Shell, composed of two valves is placed
Fig II. obliquely passing inwards & upwards to the left from its attachments to the lower end of the crosspiece of the T-shaped plate and the rounded end of the Axe. It crosses the middle line lying above the terminal

*When the shell is closed (its usual position) a rounded aperture at its right side leads into interior.

part of the spermatic duct and over part of the spermatic plate. The posterior part of the dorsal valve and the intermediate part of the ventral are thick hard and black, the anterior parts of both are thin & flexible and continuous with one another forming a hinge which allows the shell to open. The dorsal valve sends a short process downwards into the crescentic space between the T-shaped plate and the axe, to join a simular process directed upwards from the ventral valve. The central part of the posterior free edge of the dorsal valve is convex from side to side and projecting downwards fits into a corresponding concavity in the ventral valve which however is not at its margin.* The margin of the lower valve except at its right end projects backwards and inwards distal to the dorsal as a thinner

and lighter coloured portion with a free edge convex posteriorly. The cavity of the shell is spherical compressed from the outer side and above downwards and inwards

Fig 7. During copulation the ends of the anterior gonapophyses of the female are received into the shell one at each end separated from one another by the projecting lip of the dorsal valve. Owing to the oblique position of the shell the female right process is on a higher level than the left; this however is usually diminished by an oblique position of the abdomen of the male.

Fig. I and II The Bent plate has its anterior edge above and overlapping the right side of the dorsal valve of the shell. It is somewhat triangular in shape, the apex pointing backwards and

has its outer half bent downwards forming an angle with the inner half. Its outer angle is attached to the lower limb of the T shaped plate close to the neck which passes into the dorsal valve of the shell. The dorsal surfaces are covered by muscle, attached to them and anteriorly to the cross piece of the T shaped plate, forming a white almond-shaped elevation. The outer side is free and the edge of the Tongue curls round it from below. The inner side is in contact till near the apex with the limb of the Horn.

The limb of the Horn projects backwards along the inner side of the Bent plate with the basal inner portion of which it is continuous by means of a narrow curved and hardened band. About the middle of its length the hardened part suddenly becomes

* A species from S. Africa closely resembling P. Americana

much broader and at the same time the limb is more widely separated from the Bent plate Posterior to this it becomes narrow and terminates as the Horn bending upwards and inwards then downwards and outwards taking a single turn of a spiral. The horn lies on the external surface of the Tongue near its most distal part. It tapers to a fine point and yields to slight pressure In B Americana this process very closely resembles a short Cork screw. In * it has no spiral curve at all and is directed inwards only

From the outer edge of the limb of the Horn
Fig. 2 a lathe-like band passes upwards and outwards and becomes continuous with the external angle of the Fork plate just before it articulates with the upper end of the cross piece of the T shaped plate.

The Bent plate directs the left anterior gonapophysis of the female into the Shell by preventing it from passing outwards while the horn separates it from the posterior gonapophyses and directs it downwards towards the same part.

The Fork-plate is the most dorsally situated part of the armature. It presents a base anteriorly ending in a right and left angle; it narrows as it goes backwards turning at the same time to the left so that it presents a convex ~~free~~ border to the right and posteriorly and a smaller concave border forwards and to the left ^ the two ^ latter being free. The end now directed forwards and a little to the left terminates as a two pronged fork. The right angle after receiving the process from the limb of the Horn articulates with the end of the upper cross piece of the 'T' shaped plate. The left angle

Fig 2.

sends a process downwards and to the right slightly curved with the convexity backwards and lying just above the projecting lip of the ventral valve of the shell, to terminate between the base of the Beul plate and the right border of the shell, The and then gives attachment to a muscle which passes forwards and outwards to the left to the middle of the left margin of the ninth sternum.

The basal part of the convex border which looks to the right is continuous with the limb of the Horn by means of a soft fold which passes to the right and a little downwards to the left side of the limb of the horn.

The fork directs the right female gonapophysis upwards into the left end of the Shell one prong lying above the other below.

. During copulation the ends of the female posterior gonapophyses lie on the dorsal surface of the Fork plate.

Fig. 1. The Tongue plate passes outwards and backwards to the right from the middle
Fig 3 line where it lies beneath the orifice of the spermatic duct, and curls round the outer side of the Bent plate. It lies beneath all the other parts of the armature. on the right side and external to them all at its distal part. It is narrow in the middle line gradually broadening as it passes outwards & backwards. At its narrow base it gives off a small process which crosses the middle line coming nearly into contact on the left side of the body with the inner end of a narrow
Fig 3 plate whose outer end is nearly in contact with the recurved part of the base

of the penis. The outer surface of the Tongue is slightly convex hard and dark coloured: the inner is white soft and slightly concave being formed of muscle covered by soft cuticle. The lining passes at the base of the Tongue to the under surface of the Horse Shoe process forming a fold beneath the opening of the Spermatic duct. This process like those on the left side is freely moveable at its base and during copulation is pushed forwards and its posterior part outwards so that there is an interval between it and the Bent plate This structure in the resting position may act as a defensive covering to the rest of the armature on the right side It is apparently too far out when the armature is extended to be of any use as a guide to the female part.

Figs 6.1 3 In the concavity of which lies a small Y shaped
3 sclerite just distal to which the tenaculum arises.

The parts of the armature on the left side are all freely movable at their bases having no rigid attachments except to one another.

The Penis extends nearly as far forwards as the middle of the transparent half of the ninth sternum and backwards just distal to the convex border of the Fork plate. It lies obliquely passing inwards and backwards and also obliquely from above downwards, its lower edge being farther inwards than the upper. The base, outer and lower surface and rounded end are hardened while the dorsal surface is soft. The base arises below and internally close to the small plate intermediate between it and the Tongue as a narrow hardened part at first directed forwards upwards & outwards forming an arch[3] then is continued backwards broadening and forming the lower & outer surface

* Species from S Africa

along which it is continued into the rounded end. At the middle basal fourth the hardened part projects upwards forming a serrated ridge ending distally in a short spine.
In * a long spine occurs in the situation of this spine
The rounded end of the penis lies midway between the line of the left anal style and the middle line. The position varies however and the parts being permanently protruded it may occupy the middle line. In the newly born adult male it lies in the line of the left anal style. The inner & lower surface of the penis is intimately united to the Horse shoe process and its upper surface to the basal part of the spermatic process. The penis lies in a sheath at its basal end formed by the lining of the genital pouch from which it can be projected carrying with it backwards

and to the middle line the Tenaculum Horseshoe and Spermatic processes. During copulation the rounded end of the penis passes into the common oviduct or uterus of the female.

Fig. 1 The Horse shoe process arises close to the left side of the Spermatic opening presenting inwards a rounded edge formed by the central part of the Horse-shoe plate. From this a narrow process is sent forwards and outwards terminating on the lower surface of the penis opposite the attachment of the tenaculum close to the Y shaped small sclerite. The process passes backwards closely attached to the inner and lower sides of the penis and to the spermatic process. The dorsal limb of the Horseshoe runs along inside of the inner edge of the spermatic plate, and its free end together with the spine which it carries projects over the lateral expansion

of the Spermatic Tongue. The dorsal spine projects downwards and a little inwards from the free part of the dorsal limb a little way from its end

The ventral limb of the Horse-shoe as it goes backwards comes to lie more beneath the penis its terminal part being mostly under cover of the distal end of the penis but its end is free on all sides The ventral spine is directed inwards from the end of the limb lying to the right of the penis and reaches across the middle line to come into contact with the external surface of the Tongue.

Between the two limbs of the HorseShoe is a white soft area which is continuous posteriorly with the lateral expansion of the Spermatic tongue On this surface close to the base of the free end of the ventral limb is the opening of the accessory gland. From the inner border of the ventral limb at the beginning of its distal third

Fig. 3 et 6 a narrow dark band passes backwards along the ventral surface of the free end of the limb

The ventral spine prevents the female gonapophysis passing too far downwards and during copulation it lies anterior to the anterior end of the left female anterior gonapophysis. The dorsal spine which is much shorter appears to direct the abovementioned gonapophysis downwards so that it may be applied to the soft area of the Horse-Shoe and the lateral expansion of the spermatic tongue.

Fig 5- The plate of the Spermatic Process lies on the upper and inner aspect of the penis with its inner edge close to the dorsal limb of the Horse-Shoe, and its middle length is just distal to the spine of the penis, which lies on its outer side.

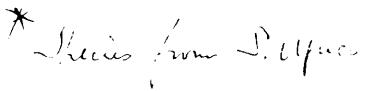


Fig 5. The Spermatic Tongue passes backwards from the spermatic plate lying free on the distal part of the penis. Its inner & right edge is hardened beneath and forms a lateral expansion downwards on to the soft area of the Horse-shoe. The lower surface is also dark and hard at the tip forming a small knob which projects downwards fitting into a hollow in the penis close to its end.

In P. Americana a wide space intervenes between the spermatic tongue and the penis In * in which the penis terminates in a long slender style the hardened knob of the spermatic tongue is large and rounded and a flat short process lies above it whose angular tip is very slightly free.

The spermatic tongue is applied over the opening of the Spermatheca

Figs. 1 & 6. The Tenaculum lies to the left of the other parts of the armature. It is just a little longer than the penis. ~~the longest process.~~ It is loosely attached by soft membrane to the outer and lower part of the penis about the distal end of its proximal fourth and immediately distal to the Y shaped sclerite. It at once becomes free on every side and is directed backwards & inwards along a groove between the lower surface of the penis and the outer and lower surface of the ventral limb of the Horse-shoe process. It passes below the rounded end of the penis which projects backwards over it, and its anterior surface here is in contact with the ventral limb or spine of the Horseshoe It is almost as far back as the posterior edge of the ninth sternum in the middle line, from which it curves a little forwards on the external surface of the Tongue where it ends in a lance-shaped extremity. Near its

* Notes from S. Africa.

end a hook is formed by a hollowing out of its anterior and upper edge and the projection of a short spine or barb at the distal end of this hollow.

In P. Americana the Hook is at the very end of the lenaculum formed by a rectangular bend It is like that of B orientalis in * save that the lance-shaped end is directed at right angles to the other part.

By means of the lenaculum the male catches hold of the female; the hook being fixed from below in the left sternal notch of the female. It then forms a radius for the rotation of the male to the right to the extent of quarter of a circle, and then bends at its base to allow of the completion of a semicircular turn, and at the same time assists in the rotation of the penis, spermatic, & horse-shoe processes which makes their upper and inner surfaces look directly upwards, by pulling

downwards the external border of the former.

During copulation the tenaculum lies from side to side beneath all the other hooks of the armature.

Fig 4. The Oblique Muscles.

Two muscles are of peculiar interest; they arise symmetrically on the two sides one from each of the tooth like processes of the ninth sternum, but both terminate in the armature on the left side.

The left muscle passes backwards, then backwards and outwards from the middle line and is inserted into the inner side of the base of the penis. The right oblique muscle passes backwards then inwards and backwards crossing the middle line obliquely, above the spermatic duct to pass beneath the spermatic plate into the spermatic process. As it crosses the spermatic duct it is in contact with the anterior left margin of the shell.

The two muscles throughout their courses

are almost parallel to one another. In the middle line the space between them is occupied by the vesiculae seminalis, spermatic duct and the accessory gland. On the left side by the accessory gland alone which accompanies the right muscle lying on its left edge into the spermatic process.
The action of these muscles is evidently to retract the armature.

Fig 4 The accessory gland. The larger hart lies in the middle line beneath the vesiculae seminalis and beneath und at the sides of the spermatic duct; its middle portion however is on the left side maintaining its position between the two oblique muscles. Passing dorsally to the left along the inner border of the right oblique muscle it comes to lie on a higher level than the spermatic duct und becoming elongated and narrow passes into the

Spermatic process in which it runs obliquely backwards inwards & downwards to reach the Horse shoe process to open at the base of the central spike again reaching the middle line.

These circumstances indicate that the a-
-symmetrical nature of the armature has arisen in part in a transference of parts from the right side to the left and that probably the spermatic process is the part of the right side corresponding to the penis, the accessory gland lying originally between them in the middle line.

The terminal part of the Spermatic duct
Fig 3. as it passes backwards lies in a hollow in the mass of the accessory gland, then it passes beneath the left edge of the shell and
Fig 4 shortly opens into a pouch on the dorsal surface of the tongue, formed by folds of soft membrane

which pass from the internal surface of the tongue to the lower and upper edges of the Horse Shoe process.

The female Genital armature is symmetrical and is composed of part of the ovipositor namely the two anterior gonapophyses. These parts are very simple in form compared to the corresponding parts in the male. It may be pointed out that the anterior gonapophyses are attached at their anterior extremities on their outer and upper aspects leaving a slightly projecting rounded end looking forwards. Anterior to this end of the left side during copulation the ventral spine of the male, lies

Fig 9. The Sternal Notches one on each side are placed at junction of the two halves of the seventh sternum on the free edge; their opening looking backwards and upwards. The left one is frequently more open at its deep part than the right one, more like a U contrasted with that of the right which more resembles a V. But there is never much

difference and often none at all. Yet the left one has a function in addition to that which it has in common with the right one, which is to receive and lodge the anal styles of the male after they have been directed outwards by the wedge-like terminal half of the seventh sternum. The special function of the left sternal notch is to act as the eye in which the hook of the male tenaculum catches.

Fig 5 The position of the male parts just before insertion may be taken to be that which they occupy while interlocked with the female parts as follows.

The tenaculum lies from side to side parallel to the free edge of the ninth sternum above and just anterior to it, lying below all the other parts of the armature with the hook

close to the right anal style.
The penis has moved as a whole backwards and its rounded end has come into the middle line and lies distal to the ninth sternum. It has also rotated so that the surface which looked upwards and inwards now looks directly upwards, as does the free surface of the Spermatic process.
The Horse shoe process from its intimate connection with the penis takes part in this rotation and movement towards the right Its ventral limb towards its distal end lies on the right side & has moved upwards so that it now lies on a higher level than the end of the penis. The latter is now the most distal of all, and the most ventral of all (except the tentaculum which however lies much further forwards) the parts of the armature. And the soft area of the horseshoe looks more upwards
The Tongue as a consequence of the movement

inwards of the processes of the left side is carried outwards and a space intervenes between it and the Bent Plate and room is left for the passage of the left female gonapophysis

In the female before interlocking occurs the genital pouch is dilated and the anterior gonapophyses have their free ends widely separated so that the two processes lie parallel to one another throughout their whole length

The union of the sexes occurs as follows. The female when ready to breed and in the presence of the male of which she is aware without contact, probably through the sense of smell, dilates the genital opening and then in it the gonapophyses may be seen to diverge. The male becomming aware of the presence of the female and of her condition also by means of the sense of smell, rushes about and ex

tends his abdomen so that it presents a ringed appearance from the alternate light and dark portions of the sterna. They are unable to find one another unless by coming into contact as it were by accident: the sense of smell apparently not being keen enough to indicate a position exactly and the sense of sight not availing. Even when they have knocked up against one another the male cannot distinguish the head end of the female as he may attempt to push his abdomen beneath her abdomen from the side or tail end. Sometimes he may be seen to touch the back of the female with the middle part of his antennae as if he could tell by feeling the free edges of the terga in what position her head lay. However if the female takes a step or two the movement indicates to him the position of her head and he runs in front of her and brings the end of his abdomen beneath her

head She then begins to palpate or drum on his terga with her palpi moving onwards towards his head: the male meanwhile moving in the opposite direction and vibrating his cerci against her sterna When by means of these movements (the male wings having been raised) the female mouth parts come to be applied to the sensory organ in the third thoracic tergum of the male neither of the two insects move their legs until the tenaculum is fixed. The male now extends the abdomen still farther till the cerci pass upwards on each side of the anterior half of the seventh sternum of the female, then the tenaculum is protruded along with the other processes of the left side of the male armature and elevated above the left edge of the seventh sternum to be drawn downwards immediately by the retraction of the tenaculum itself and of the abdomen to catch in the sternal notch. Whenever the tenaculum has caught the male wheels to the

lowering his wings and
right passing beneath the right legs of the
female, the tenaculum acting as a radius
for the first part of the turn bending at
its base to allow of the completion of the
wheel, which brings the middle line of
the two insects into one straight line,
their heads looking in opposite directions,
and causes the genital openings to face
one another exactly. When copulation occurs
on the vertical plane as is almost invariably
the case and the female right-side happens
to be uppermost she does not lose hold,
probably the anterior legs catch again before
the posterior have to be taken off the wall.
This movement will tend to give a predominance
to the right side in the males.
The two openings then facing one another the male
standing higher than the female on his long legs di-
rects his terminal sternum downwards on to the upper
surface of the apex of the wedge-shaped half of the seventh
sternum so that an anal style lies on each side of it and

pushes the end of
his abdomen backwards ~~and~~ till the basal part of
the wedge directs the styles outwards as they go
backwards to be arrested by the sternal notches,
Fig 9. from which their free ends project outwards
and downwards on the sides of the sternum.
The rounded end of the penis at the same
time passes into the common oviduct
and the spermatic tongue lying above it
is applied to the roof of the female pouch
between and anterior (♀) to the bases of
the anterior female gonapophyses, covering
the opening of the spermatheca.
The horse shoe process passes along the inner
and lower sides of the left gonapophysis and
the latter comes to lie between the dorsal spike
above and the ventral spike below. against
the soft area of the horse shoe and the lateral
expansion of the spermatic tongue, but
when the parts are fully inserted the ventral
spike lies anterior to the anterior rounded end

of the left anterior gonapophysis.
Passing farther into the male the left anterior gonapophysis is separated from the posterior gonapophysis and directed downwards by the Horn and inwards by the Bent plate
Fig 7. and its post termination enters the opening of the shell at its right end.
The right female anterior gonapophysis passes into the male above the basal portion of the penis to the inside of the ridge of the penis, and is directed by the Fork beneath the band which passes from the left angle of the Fork plate to the base of the Bent plate, ~~and~~ on to the surface of the projecting lip of the ventral valve of the shell and its post end enters
Fig. 7. the cavity of the shell at the left end of its opening.
Fig 7. The posterior gonapophyses are directed upwards by the Fork and the Horn and

* The female gonapophyses if asymmetrical would not be available to form the ovipositor

come to lie on the fork plate towards its
Fig. 7. right angle their ends being directed towards the anus of the male
The end of the right gonapophysis owing to the obliquity of the shell lies on a higher level in the male than the left but a compensating obliquity of the transverse axis of the male leaves them actually on an equal level or very nearly so.

It is remarkable that such a complicated and asymmetrical structure as the male armature should be adapted to interlock with two such simple linear processes as the anterior female gonapophyses. *
The asymmetry of the male armature may have had its origin in connection with rotation having occurred after the interlocking of the parts in an earlier mode of pairing. The intersection would then have taken place while one insect was above the other their bodies being

* The ends of the gonapophyses caught by the shell and the end of the penis by the stem

sufficiently flexible to admit of this.

The contrivance leads to the two sexes being united by a very secure hold* and in a very precise manner but in what means way and by what route the seminal fluid passes into the spermatheca is not very obvious.
It is probable however that the seminal fluid becomes mixed with the secretion of the accessory gland in the space which lies between their orifices; namely the space bounded below by the base of the Tongue, inwards by the horse shoe process, above and to the outside by the left gonapophysis, and that it is from this directed upwards and inwards to the middle line on to the surface of the Spermatic tongue & then forced upwards into the Spermatheca.
This space however does not appear to be a closed channel, and there is not anything to prevent the

fluid from passing across the middle line to the right gonapophysis or backwards away from the female into the shell. Possibly the fluid is thick and capable of being retained in an incomplete channel or it may be that a swelling up of soft parts completes the channel not persisting however in a fixed specimen

The union lasts about 45 minutes which shows that either the fluid undergoes some kind of preparation e.g. intimate admixture with the secretion of the accessory gland or that it is transferred in a small quantity at once. The couple usually occupy a position on a vertical wall and male and female may be in any position on it relative to one another, showing that gravity has nothing to do in the matter

While the union lasts there is a slight to and fro movement anteroposterior of the male abdomen together with a slight movement of

rotation. The left cercus can be seen descending and being raised to the level of the other alternately; the right cercus moving upwards & down again. These movements are apparently the result of movements of the interlocked parts but the female abdomen remains motionless.

The style and notch arrangement limits the extent to which the processes pass into the genital pouches and also prevents all but the slightest movement of the one set upon the other in a vertical direction but the notch being somewhat wider than the style admits of the above mentioned movement of rotation.

If the two individuals be killed while united the process appears to proceed as usual and the parts separate after the usual interval. They may however be fixed permanently together by immersing them in Spirit.

The union of the two sexes cannot be terminated voluntarily by them until after the usual interval. no matter how much they are alarmed. Should they however fall upon their backs they may separate as the result of violent struggling, kicking one another away with their hind legs and trying to turn on to their feet. For this reason killing them with Chloroform is not a good way of obtaining Specimens
The male is more easily alarmed than the female and may attempt to run away but cannot move the female. When the female however is alarmed she runs away pulling the male after her. Should this happen the process of transferring the seminal fluid is interrupted for the time being as is shown by the union lasting longer than usual ~~extending~~ if they move about much to ~~abo~~ (on one such occasion) seventy five

Minutes

The cerci of the male are not essential to pairing but their absence renders it difficult and would no doubt prevent a male from pairing if other males were available, as he requires a great number of chances. When the female comes over the end of his abdomen a male wanting the cerci, does not push backwards but leaves the matter to be brought about by the advance of the female only. However he will raise his wings and when she reaches the sensory organ he extends his abdomen as usual and elevates his tenaculum but his abdomen does not remain exactly beneath that of the female and the notch is not found. It may be found however after many attempts. Once the tenaculum is fixed the absence of cerci makes no difference.

This illustrates the fact that an organ may be of great use for a certain purpose and yet not be absolutely essential to that purpose. It is not correct to infer that because an animal deprived of an organ can fulfil a particular function that the lost organ was not used in the performance of that function as it may indeed be the only function of the organ in question.

A female without dilating the genital pouch may as observed by Cornelius advance over a male (or another male may do so) who will in the usual way attempt to fix the tenaculum but will not succeed. He will try a time or two and then suddenly rush forwards as if he could stand the stimulation of the sensory organ no longer. When from

beneath the female he lowers his wings for a moment then raises them again and further extends and vibrates them rapidly as if trying to fly It would seem then that the energy set free by stimulation of the sensory organ was ordinarily expended in the movement of the genital armature and failing that is discharged in the vibration of the wings.

When the wings are raised to uncover the sensory organ they are held so that the caudal segments of the posterior ones are placed vertically forming a fence on each side while the wing covers held upwards vertically and a little outwards form a fence in front. This prevents others crawling over the male and at the same time prevents one from observing what the female does when her mouth parts are

applied to the third thoracic tergum. (It may be mentioned that a small caudal part of the wing cover which folds beneath the cover is placed vertically like that of the posterior wing) It can be seen however that the female keeps moving her head and palps. Though the action of the wings produces no indication of flight it may be inferred that flight occured in connection with some former method of pairing. It seems then that in this insect the existence of a protective covering has diminished the general tactile sensibility of the body and that as a compensation it has been retained & increased at one special point. Otherwise the two individuals would have great difficulty in bringing their genital openings into apposition all the more as they have but little flexibility A similar state of matters may be expected

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to occur in other animals whose external covering has little sensibility or whose structure does not admit of much flexion for example Fishes! in whom too, the function of the lateral line has not been ascertained.

The cerci are actively employed by the male and in the female they vibrate a little on occasion and they may also serve to give warning of obstacles against which the egg case might be knocked. These uses however do not sufficiently account for their presence in a well developed form on emergence from the egg case. In Mantis they are used in connection with escape from the egg chamber but not so in the case of the Cockroach as the young emerge from the case upwards and the cerci are directed backwards. But in addition in Mantis the young remain

that passes
suspended by a thread from the chamber
to the cerci until they moult for the first
time, and it is fairly probable that
in Blatta they are concerned in all the
ecdyses.

The process of ecdysis is as follows:-
Fig 10. The insect takes up a position on a wall
with the head downwards and the
posterior legs directed upwards in which
position the claws inserted into the wood
best resist a downward pull. The
other legs are also fixed on to the wall
The mesothoracic tergum splits in the
middle line and at once the rent ex
tends backwards into the third thoracic
and forwards into the first thoracic terg-
um and then along the middle line of
the neck and into the head along the
epicranial suture to end at the
fenestrae on each side. At this time

The antennae are waved about and there is an agitation in the interior of the insect, the sides coming alternately a little way through the opening. This is the only approach there is in the whole process to anything like struggling. When the opening is complete and the body projects a little way through it, the antennae are carried outwards and then backwards to pass beneath the anterior legs, or the middle pair as well, and come to lie in the middle line where they were when the insect emerged from the eggcase. When only passed beneath one pair of legs however they project outwards and outwards with a concavity directed forwards, between the anterior & middle legs. The legs are removed from the wall to let them pass but the antennae are never long enough to reach back

to the claws of the hind legs which remain fixed all the time. As the antennae are directed backwards the head
Fig 10 becomes completely flexed. The insect now falls slowly out as it were growing out of the old skin and in about half an hour the anterior pair of legs are free. They are held out with the tarsi close to the edge of the abdomen not in contact with anything for a minute or so; then the tarsus is placed on the wall, as if the limb were being exercised or tested, at intervals until the insect is ready to walk again. The other pairs of legs follow in a minute or two and are treated like the anterior ones just at the time the hind legs become free the antennae now about half way out of the old covering are pulled out and brought forwards either by passing

outwards beneath the anterior legs or directly forwards by being doubled up into the form of a whip. When directed forwards their tips are rested on the wall at first for a little and at intervals afterwards as if to avoid any strain on their basal portions

The insect is now all out of the old skin except the terminal two or three segments of the abdomen & the cerci and it hangs free in the air in this position occasionally setting its feet to the ground that is to say the wall. As it hangs, it is directed outwards from the wall forming an angle with it and with the ~~wall~~ old skin; that is to say the ventral surface has come out to a greater extent than the dorsal. It is probable that the cerci are used to retain a hold of the old skin and to regulate the ecdysis. For though the

insect hangs with its legs and antennae free normally for about quarter of an hour if attacked or if alarmed as by being exposed to the vapour of chloroform it will come out and run away apparently as if it had no attachment to the old skin which remains hanging. S. frightened out of its old skin as soon as the antennae and posterior legs are free it runs only by means of its anterior and middle pairs of limbs holding the last ever one backwards with the tarsi close to the edge of the abdomen, knowing that they are less ready for use as they have come out last, and that they are essential to the safe performance of the next moult. If the insect while hanging be gently touched it puts its feet to the wall to steady itself, to take them off again when left alone.

The tip of the abdomen of the old skin may be cut off as the insect hangs mostly out of it but the curling in of the cut edge prevents a view of the insect or its cerci being obtained It is a peculiar fact that of a cockroach dies slowly as from natural causes when dying and after death the cerci are directed straight backwards whereas if it be killed suddenly they remain in the ordinary position

Provided the antennae are not free and directed forwards the insect may
Fig 10 be killed while partly in the old skin by being immersed in spirit. It makes no effort to come out of the old skin simply curves itself with a dorsal convexity.

The fenestrae may have something to do with the limitation of the rent in the old cuticle Should it extend on to the lateral aspects of the head, part of the old skin would be apt

Mr. Cormack Mill & Denny

to break away and remain attached to the new one, possibly to be a serious encumbrance. The process of ecdysis has been described as occurring in a manner different to the above, apparently from observations made on a cockroach which had lost its foot hold and fallen down or in which some difficulty or other had arisen.

Instances in which the process has been prolonged from any cause are more likely to come under observation than those wherein the process has taken only the normal time. When an insect has been knocked down during ecdysis it will attempt to struggle out and succeeds in this or does not according to the amount of progress it had made when disturbed. The legs must be very soft to enable them to come through the joints and the tarsi are delicate structures, so that active muscular efforts would inevitably dam-

age the legs. A cockroach one of whose hind legs came free that is to say the old claw lost its hold of the wall struggled violently incited to do so from its hanging off the perpendicular, with the result that its legs were curled up and rendered useless, and it died three days afterwards. Sometimes the antennae fail to come loose yet the rest of the body does get free probably by arching with a dorsal convexity but the old skin remains attached to the antennae, and prevents the insect from walking. Eight young ones from the same egg case all died at the first ecdysis the old skin remaining adherent to the antennae. This is an instance of a family disease due to a thickening of the distal parts of the antennae.. Cockroaches that have been disturbed during or soon after ecdysis remain of

a lighter colour than normal and do not thrive well - In the case just mentioned in which struggling occured there was only a slight darkening in irregular ~~interwals~~ patches.

Light seems to have no influence in producing the darkening of the skin. On the contrary when kept in total darkness the darkening occurs more rapidly as if to make them resemble their surroundings the sooner

The Periods of Incubation and of Development

Copulation as a rule occurs before the production of each case of eggs, but if males be excluded second and third cases will be produced from the one union but it cannot be said whether all prove fertile or not.

The egg case develops on the sixth or seventh day after pairing, and is dropped one day later. In cold weather however and if the female has been made a captive after fertilisation it may be carried several days longer.
The female lets the case fall as she sits on the wall with her head uppermost from the height of an inch or so, and falling on wood, it makes a distinct noise. The female then descends and goes over it with her palpi as if examining its surface. Then she attempts to dig a hole scraping the wooden floor with the claws of her fore legs making a clearly audible scratching sound and if fine ashes are in the box she in some instances actually makes a hole and buries the case in the ashes, leaving only the ridge exposed. Others take less trouble and leave the cases lying on their sides. The cases however if left loose are moved about apparently

The legs are used to stand on before the internal
are directed forwards but not for locomotion

in response to changes of temperature.
The young emerge after an incubation
period of about sixty-six days at a temperature
of about seventy degrees F
They come out upwards with what resembles
a vermicular movement and come through
the narrow slit which can be seen in the
empty case without dilating it.
The feet lying close together with the antennae
between them are not used to assist and
the cerci are directed straight backwards.
When completely out they remain motionless
for a little then they stretch out the legs and
stand upon them: next the antennae are
brought forwards from below, doubled like
a whip the body being arched backwards.
They rest a minute or two before running
about but if disturbed they run away with-
out difficulty at once.
The first moult occurs about the eleventh

* When two or three months old the young become black and coincident with this develope the two bands of tenacious mucous substance near the end of the abdomen on the terga These bands afterwards persist in all the remaining stages except in the case of the adult male whose colour again has become lighter. They would however in the male interfere with the pairing.
They may be absent in individuals in bad condition.

day. In one instance the first six moults were at the following intervals

From hatching to the	First Moult.	11	days
From the 1st to the	2nd "	13	days
" " 2nd " "	3rd "	9	"
" " 3rd " "	4th "	14	"
" " 4th " "	5th "	13	"
" " 5th " "	6th "	25	"

After the sixth moult the insect was lost by escaping. It would then be about one third of the adult size. The length of the interval appears to depend on the rate of growth and that varies according to the temperature and food supply etc *

From emergence to reaching the adult state takes about 270 days In one instance 273 days from ~~December 20th~~ august 27th 1901 until May 27th 1902 ~~another~~ Another took 292 days. Both these were developed from one egg case. Other individuals have

taken respectively 300 days 314 days 320 days. up to 582 days. One individual born on the 17th of Sept 1901 was only apparently half grown on the 20th of May 1903. It has taken already a period of 600 days.

The period of 273 days may be taken as the normal period though of course it may be shorter in more favourable circumstances.

The very great extension of the period is remarkable and its occurrence shows that a few observations may lead to very erroneous conclusions in such a matter. The instance in which 600 days have been spent by a Cockroach in growing to have the usual size confirms the correctness of the observation of Cornelius that four years may be taken to reach the adult state. The other instances just mentioned however show

in all probability
that what he observed was an unnatural occurrence.
It is a singular circumstance that the period of larval development of the cock roach should practically coincide with that of human utero-gestation.

From the deposition of the eggs to reaching the adult state takes about eleven months and the adults begin to breed when twenty days old or earlier. This will allow of a fairly rapid increase in their numbers.

When a number of females are kept in a box without males some of the egg cases produced are smaller than usual In one instance the egg case was as small as and closely resembled a grape seed an approach to the one egged egg

cases of the Phasmidae which likewise resemble some kinds of seeds.
From external examination this case appears to contain two eggs a very great reduction from the normal sixteen, due either to the absence of males or the bad effects of confinement.

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