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Biology of a new Halictine Bee
and Specific Descriptions of its Parasites.

By Tarlton Rayment,
Sandringham (Victoria), Australia.

(With 14 Text-Figures.)

(Continued from vol. 3, 1936, p. 294.)

Hurst (p. 333) says: — — „A new species in nature is always based genetically on an old species, and in the course of evolution the influence of the ancestral species becomes less and less until in course of time the old specific characters are obliterated in the modern species, which bears a new set of specific characters. It is true that the old generic and family characters remain in the new species, but in the course of evolution even these disappear in new genera, families, orders, classes, phyla and kingdoms".

Halictus emeraldensis and its mutations provide very good material for demonstrating the effects of chromosome phenomena in the gregarious bees, and the chromosomes of typical and mutated females are now being studied.

Slide preparations of the pollen on the femora of some mutated females show that it had been gathered from two botanical species, flatweed and another unknown plant, the pollen of which was globular, with almost every granule exhibiting a short pollen-tubule — sometimes two, and even as many as three (Fig. III, 17). Where the generative nucleus had moved to one of the tubules, the others had ceased to grow. This is the first occasion, in many thousands of examinations, that the author has observed the growing condition to be general throughout the pollenmass. The granules resemble those of *Leucopogon*, but none of these plants was discovered in the locality.

The author (p. 291) had already drawn attention to the assembling, in one large colony, of the „nests" of other closely related species of *Halictus*, but investigation of the biology of the mutations was always defeated by the extremely friable nature of the sandy soil making it impossible to identify the course of any particular shaft for more than an inch or two; the diameter being only 2 mm. or so, three or four grains of sand are sufficient to mask the shafts completely.

Whilst checking the virgin females of the February generation of *H. emeraldensis* as they emerged from their natal shaft, the author was astonished to see a bee, returning from the flowers, suddenly fall dead on to the colony-site. It dropped from a height of about 22 cm. Later, when the field observations were concluded, microscopical examination proved it to be a mutation, with a huge, quadrate head-capsule more than twice the size of that of the typical male, and formed like the head of *Megachile* (Fig. XII, 12—13—14).

Had this specimen been taken in any other circumstances, it would most certainly have been described as a new species in the genus *Evylaeus*. The huge mandibles are red, as are the labrum, clypeus, and tarsi of the legs; the puncturing of the mesothorax is of two sizes, and the apex of the abdomen has a large broad red plate, which is absent in the much smaller typical male; the genitalia has two more appendages as shown in Fig. III, 4.

This remarkable creature had been visiting the flowers, for its robust, female-like form was well dusted with pollen-granules. The specimen is of great interest, since it is the only male that emerged with the February virgins, but the circumstances in which it was caught precluded its being prepared for examination of the chromosomes. This abnormal male is actually larger than the female.

Fabre (p. 457) relates that, in *H. cylindricus*, he found a lone undeveloped male among a generation of parthenogenetic females, and which died in its pupal shroud. Fabre said it was an „accidental", but the death of the two males may indicate the presence of a lethal factor.

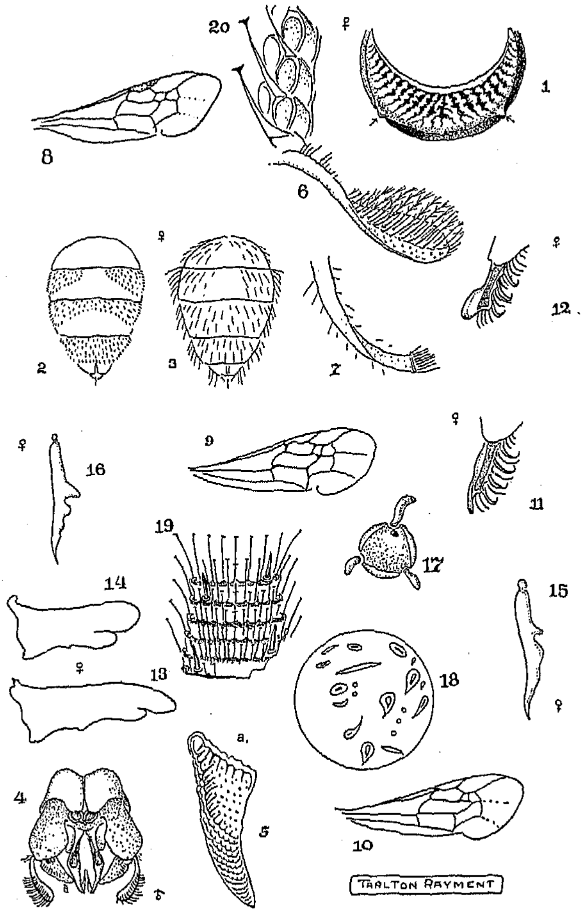


Fig. III.

1. Rugose area of the metathorax of a mutated female. Compare the pointed angles of the truncation with those of *H. imitans*, Fig. II, 14. 2. Moss-like hair of abdomen. 3. Long loose straight hair of mutation. 4. Genitalia of mutated male. 5. View of the genital process of normal male. 6—7. Mutated forms. (a) Enlarged view. 8—10. Anterior wings of mutated females; note the form of the second cubital cell and the position of the first recurrent nervure. 11. Lateral view of the appendage of female labrum. 12. Mutated form. 13. Bidentate mandible of female *Halictus*. 14. Mutated form. 15—16. Views of the hind calcariae of mutated and normal females. 17. Pollen-granule with the generative nucleus about to enter the tubule. 18. Nuclear cell-bodies in egg taken from the oviduct of a December female. 19. Portion of upper surface of glossa showing the arrangement of the peg-hairs. 20. Surface of glossa more highly magnified.

The halictine morphological characters which are hereditary, and subject to mutation, are shown in the following pairs:

1. Stature:	Robust	Slender.
2. Head:	Large and thick	Small and thin.
3. Mandibulae:	Short, broad, bidentate	Long, narrow, simple.
4. Glossa:	Longer than palpi	Shorter than palpi.
5. Labrum:	Appendage simple	Appendage complex. (F).
6. Antennae:	Long	Short.
7. Metathorax:	Rugose	Smooth.
8. Rugae:	Fine and dense	Coarse and few.
9. Tegument:	Dull; dense punctures	Polished; minus punctures.
10. „	Black	Coloured.
11. Hair:	Dense, short, moss-like	Sparse, long, straight.
12. Colour of:	Silver-white	Orange-black.
13. Sixth tergum:	With a plate	Minus the plate. (M).
14. Genitalia:	With palpi	Without palpi. (M).
15. Hind calcar:	Large teeth	Simple. (F).
16. 2nd. cubital:	Longer than high	Higher than long.
17. 1st. recurrent:	Meets 2nd. cubital	Meets 3rd. cubital.
18. 3rd. intercubitus:	Strong	Weak.

Architecture.

The site of the colony is in red ground compacted by foot-traffic and, therefore, too hard to promote plant-growth; it is on the warm-northern slope of the hill. The path under survey is a very old one, but recently has had very little traffic of any kind. The several small entrances are distributed over an area about one metre square, and the bare surroundings are in strong contrast to the resting sites of *H. victoriellus* Ckll., which always seeks out well-grassed land for its home (Rayment p. 264).

The main shaft goes straight down for about 23 cm., with a diameter of slightly more than 3 mm. Horizontal galleries are driven at various levels, but the majority are at a depth of 20 cm.; each gallery is from 2 cm. to 3 cm. in length, and terminates in an oval cell measuring 8 mm. at the long axis, and 4 mm. at the short. There is a small ante chamber at the entrance, and which is large enough to accommodate the sentinel at the door.

The wall of the cell is smoother than the wall of the shaft, though it is somewhat finely ribbed when viewed through the microscope; the pattern being due to the scooping action of the mandibulae. This is the first occasion that any lining has been definitely perceived in the cells of an Australian *Halictus,* and although the colloidal skin is exceedingly thin, it is sufficient to modify the „trowelling" of the jaws; hence the smooth interior.

Since there are no pebbles in the fine red soil, the excavation of the several chambers presents no obstacles such as are encountered in gravelly land, or ground permeated with the roots of plants. The interior is coloured a shade darker than the soil. The lining of the cell is hyaline, exceedingly thin, and so extremely brittle that all attempts to remove it were unsuccessful. Filling the cell with water proved it to be waterproof, and still adhering closely to the encompassing soil. Petrol and turpentine failed to dissolve the colloidal skin which is probably the secretion of the salivary glands in the head. It has an oily brightness.

The method of applying the membrane is similar to that used by all other bees; the glossa is extruded, and as the head rises and falls, the secretion pours down the glossa and is laid on with the tip of the torgan. The product of this *Halictus* lacks the pliable quality of the „purses" of *Paracolletes*, and is even more brittle than the „skin" cell of *Euryglossa*; the linings of both these bees may be removed intact from the chamber (Rayment p. 31).

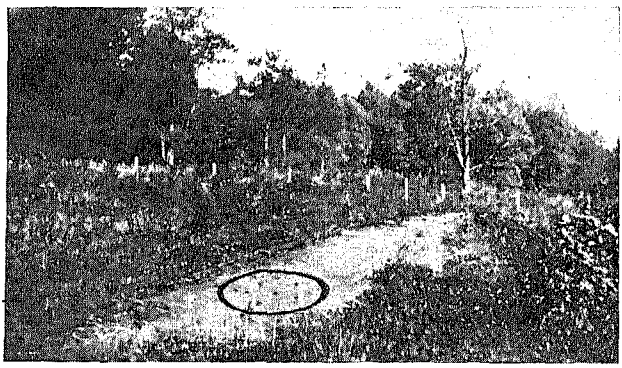


Fig. IV. The site of the halictine colony is indicated by the circle.

It is now ascertained that colloidal cell-linings are not restricted to the broad-tongued (Obtusilingues) bees, but are common to all the Australian genera at least, the pointed-tongued (Acutilingues) bees included.

After the store has been gathered, and the egg deposited, the cell is closed with a „stopper", or plug of loose earth, measuring 4 mm. in diameter, by 3 mm. thick. The plug is slightly tapered, and concave at each end, the smaller rougher depression being in the cell. Microscopical examination shows that the material has been „worked" by the mandibulae, and a small proportion of some biological substance added. However, the light plug breaks down almost instantly in water, but does not stain the liquid, and is much lighter than an equal volume of the red earth. The method of closing the cell is evident. The circumference of the aperture first receives a row of pellets, and two more concentric rows are then added, leaving only a minute hole in the centre, which is closed finally with a single pellet. More loose material is then thrown on, and the outer end appears to be pressed slightly concave with the insect's head. Roland W. Brown (1934) described some fossil bee-chambers, (Anthophorid?), the plug of which was constructed in a spiral.

It seems that the galleries, too, are filled in, but with the debris from other excavations, for the cells often appear to be quite isolated in solid earth; moreover, little spoil is thrown out of the pit-mouth; no „volcano“ being formed at the entrance, as in *H. seductus* Ckll. (Rayment, p. 318), because the material is utilized below. The entrance to the shaft is consolidated with a small ring of hardened mud, which does not crumble away under the traffic of the several bee-sisters, and the searching mutilla, but it disappears quickly before the onslaught of two wasps, a red and black thynnid, and a black and yellow arpactid.

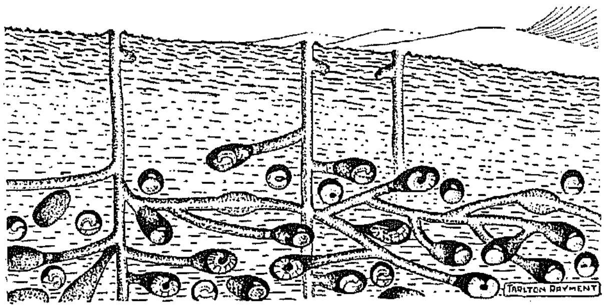


Fig. V. Graphic section of portion of the shafts and cells.

One nest that was dug out yielded 36 provisioned cells which had been constructed by the five female bees found in occupation. New tunnels had been driven from the main shaft, from old galleries, and even from abandoned cell-chambers. The depth and arrangement conform with the observations of Fabre (1915) recorded in his studies of the French species, *H. cylindricus*, and the number of cells, 36, divided among the mothers, gives about the same average for each bee. The cell-lining, too, is similar, but the chambers of both *H. cylindricus*, and *H. emeraldensis* lack the strong, porcelain-like interior of Fabre's other bee, *H. zebrus*.

Larval Food.

The spring brood is nourished on pollen-puddings composed mainly of granules from the flat-pea, with a small proportion from capeweed, rice-flower and garden aster; a rare tetrad from the red heath is found in some, and a few puddings are composed entirely of pollinia from the „prickly moses“ and silver wattle.

The pudding is spherical, but not so perfect as that described by Fabre, yet it is a very good sphere, considering that no rotatory movements are used during the modelling, and measures 4 mm. in diameter. In addition to a small amount of nectar, it also contains a minute percentage of some other biological substance, which is added probably during the regurgitation of the nectar while kneading the mass. In no case were any loose granules observed about the interior of the cells.

The colour of the store varies from creamy to cadmium-yellow and brilliant orange-chrome, and since the contents are harvested from similar plants, the difference is not easy to explain. It was repeatedly observed that the pollen-loads collected by the hive-bee from *Bursaria spinosa* differed in colour from those gathered by wild-bees working on the same shrub. It is now suggested that such differences are due to the incorporation by the bee of other substances, nectar, and a secretion from the pharyngeal glands of the head.

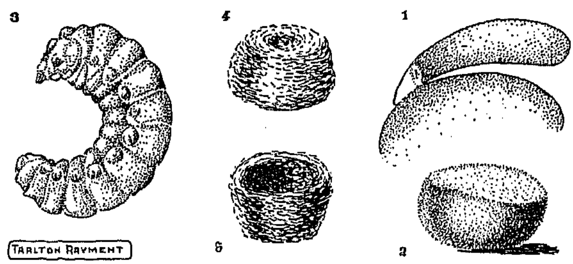


Fig. VI. 1. The egg is attached to the pudding, at the caudal pole, with a clear glassy agglutinative. 2. The periphery of the pudding is not eaten first. 3. The larva after the „pudding" has been consumed. 4. Two views of the earthen plug.

Fabre described the outside of the store as shining, and containing a larger proportion of honey, and asserted that the sweeter circumference was eaten first by the young larva; the dryer interior being consumed last.

The puddings of *H. emeraldensis* do not vary in consistency, the interior being equally as moist as the exterior, but they quickly harden and dry on exposure to the atmosphere of a living-room, and this is not the case where honey is the sole addition to pollen (Heselhaus 1922). After a long study of the feeding habits of wild-bees in many genera, the author is of the opinion that no larva is fed exclusively on honey and pollen (Rayment p. 539). This Australian *Halictus* does not consume the periphery first; the whole of the store is eaten in horizontal layers.

A pudding taken from one larva and given to another is accepted instantly, but it was observed in such cases that a clear liquid flowed in sufficient quantity to immerse the mandibulae; this did not occur where the larvae were eating their original puddings. The liquid is probably the product of the salivary glands, and it is possible that certain pollens require more glandular secretion for their digestion; it may be found that certain substances excite the glands to greater activity, but this aspect could not be investigated.

The stores for the feeding of the summer brood are gathered from an entirely different group of plants. Females of the December generation harvest white granules from the christmas-bush, which is a mass of flowers when the blackberry has just finished blossoming, and visit the trailing-hop, the few late flowers of the handsome flat-pea and the tea-tree. The wiry *Bauera* blooms during the larval period and, consequently, is of no value to this bee.

Definitely, there is no „progressive-feeding" of the larvae in this species; the sole food-supply is the pollen-pudding, and when the mother has provided that she seals the cell almost immediately. Moreover, larvae in the control cells developed normally (Wheeler 1933 p. 148).

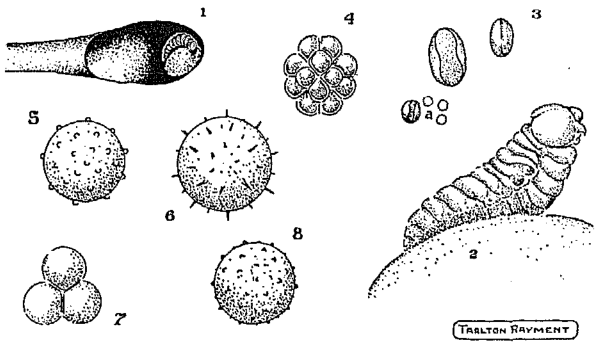


Fig. VII. 1. Cell with pudding and feeding larva. 2. Larva resting between „meals" (6th. day after hatching). 3, 4, 5, 6. Pollen-granules from *Platylobium formosum; pollinia of Acacia verticillata; Pimelia flava; Aster petiolatus.* 7. Tetrad from *Epacris impressa.* 8. Granule from *Cryptostemma calendulaceum.*

Only one bee, a small red and black species, *Exoneura hamulata* Ckll., was observed to visit the pinkish flowers of this plant, but this honey-gatherer harvests from a large number of botanical species, including blackberry.

The pollen-mass was removed from one December female as she was about to re-enter her shaft, and under the microscope, it was found to consist of a mixture of granules from five unrelated plants; garden *Calliopsis;* tea-tree; christmas-bush; flat-weed and trailing-hop. This wide range is unequalled by any other bee studied by the author, and is in sharp contrast to the habit of the hive-bee, which limits itself to a single botanical species during each excursion.

This total change of food is parallel with what obtains in *H. victoriellus* Ckll. (Rayment p. 247), and many other species that rear two or more broods each season, but does not apply to those halictine bees that have but one brood of males and females annually. Such a bee is *H. mesembryanthemi* Ckll., the pollen-puddings of which are harvested almost exclusively from *Carpobrotus aequilateralis* (Rayment, p. 285).

Wheeler cites Legewie's (1925) and also Armbruster's (1916) account of a German species, *H. malachurus*, and both these authors claim that only larvae pass through the winter, to emerge fully developed in the spring. Both agree that the brood-cells are not closed after oviposition, Stöckhert (1923) however, says that the brood-cells are closed after oviposition, and that the females of the autumn generation hibernate in the maternal nest.

Composition of Puddings.
Removed from the Halictine Colony at Emerald 11th October 1936

No.	Colour	Percentage of Botanical Species				
		Platylobium	*Pultenaea*	*Acacia*	*Pimelea*	*Epacris*
1	Orange	70	30	—	—	—
2	Yellow	70	20	3	7	—
3	Orange chrome	70	28	2	—	—
4	Yellow ochre	70	25	1	3	1
5	Yellow ochre	70	20	10	—	—
* 6	Cadmium yellow	70	20	7	1	1
7	Yellow ochre	100	—	—	—	—
8	Orange chrome	80	20	—	—	—
9	Yellow ochre	80	18	—	2	—
*10	Orange chrome	70	15	14	—	—
11	Orange chrome	70	20	10	—	—
12	Orange chrome	—	—	100	—	—
*13	Orange chrome	40	30	15	2	12
14	Yellow ochre	85	10	2	2	1
15	Orange chrome	5	5	90	—	—
16	Orange chrome	50	50	—	—	—
17	Orange chrome	50	40	—	10	—
18	Yellow ochre	55	40	3	2	—
*19	Orange chrome	70	29	—	—	—
*20	Yellow ochre	70	25	2	2	—

* Contained a few granules from garden *Aster*, cape-weed and wild-hop.

In *H. emeraldensis* the fully developed autumn females definitely hibernate in their natal cells; Cell-chambers containing only puddings and eggs were found to be sealed. Excavation of the original colony, in April, revealed only one very late larva, but not a trace of any food, although there were present many hundreds of fully-developed females.

Larval Development.

The egg is elongate-oval in form, slightly bowed, and a little thicker at the cephalic pole. It is white in colour, with the surface of the chorion sculptured with a more or less hexagonal pattern: the imprint of the well-defined follicle cells lining the ovariole. The egg measures 1.60 mm.[1]) length. The aperture of the micropyle — through which the spermatozoon enters — cannot be distinguished. The caudal pole is tipped with a perfectly hyaline agglutinative, which attaches the egg rather firmly to the pollen-mass, and is a secretion from a gland at the apex of the abdomen.

The chorion splits at the cephalic pole about 90 hours after deposition; the time varying with the temperature. It was found by experiment that the best results were obtained with eggs and larvae when kept at 15^0 C. Above this figure, moulds of several kinds began to grow on the pollen.

In an endeavour to simulate the natural conditions, several small wooden cups, each containing a feeding larva, were placed in an unglazed earthen-ware vessel, and buried in the soil at 25 cm., but numerous other moulds soon ended the experiment. It is rather difficult to determine exactly the degree of moisture required for the normal development of these bees. On the other hand, the amount of air appears to be of little consequence, for larvae in small tins sealed completely with two coverings of paper, for eight days, developed normally.

A number of feeding larvae were inclosed in small wooden cells, the covers of which fitted fairly tightly, and a small jar of water — to which was added a few crystals of carbolic acid — was set on top, and the whole covered with a damp flower-pot; the drainage hole of which was closed with a cork. These larvae were exposed to daylight, for 30 minutes or so each day, during examination under the microscope, and although considerable activity was brought about by such exposure, all were reared to apparently normal maturity.

The majority of the eggs for the first brood are deposited by the first of October. There ist a very large yolk, deutoplasm, and this sus tains the creature for several hours after its emergence from the shell — in one instance, 23 hours elapsed before the larva commenced to eat.

[1]) This is an extraordinarily large egg for so small a bee, for it equals that of the hive-queen. She often reaches 17 mm. in length, whereas the *Halictus* is only 6 mm., and correspondingly narrower.

The caudal end does not move, but the cephalic half waves to and fro as the mandibulae scoop off the pudding; the action of the jaws resembling two firely-pointed rakes being brought together very quickly; the labium, assisting the ingestion of the food, suggests the „mouthing“ of a toothless human. The acute tips of the larval mandibulae are slightly amber, being more strongly chitinized, and are furnished with a molar-like process for crushing the pollen-granules.

The larva ceases to eat for certain periods, and „rests“, with the cephalic half of its body raised high off the pudding; the mandibulae open and close spasmodically; a regular pulsation of the vertex occurs, and circular depressions about the spiracles rise and fall, but with no discernable rhythm. The last remnant of food to be eaten is that lying immediately under the caudal end, which has never moved, and to reach it the head is bent round until the larva is coiled like the letter C; this posture is maintained until the faeces are about to be discharged. The diameter of the coiled larva measures 5 mm., and at this stage, the bright-orange pollen-mass, packed in the distended mesenteron, shows through the pellucid larval skin as a pinkish suffusion, against which the large oenocytes of the fat-body (trophocytes) are conspicuous as opaque white discs, most numerous along the dorsal surface.

By the 26th of October, about sixteen days after hatching from the egg, 86 per cent of the larvae have consumed the whole of the food; the few eggs and young larvae then present represent the last progeny of the spring series.

It was observed that about 30 per cent of the puddings, with their accompanying larvae, were very much smaller in size, though the development of these proceeded normally, and resulted in males. No cocoon of any kind is spun by the larva, which lies quite naked in the cell.

About the 4th of November, that is, 21 days after emerging from the egg, and about 10 days after the last of the store was consumed, the larvae squirm about slightly at the caudal end, and straighten out the body before discharging an elongate-ovate excremental pellet of russet colour. Altogether, some 15 or 20 pellets are voided at intervals, and the creatures remain more or less straightened, and measuring about 7 mm. in length.

A larva was dissected 7 days after it had voided its faeces. The segments were then prominently ridged, though sharply depressed along a median line of the dorsal surface. Laterally, a thick, welt-like line indicated the elements of the buds that ultimately develope into appendages. Microscopical examination of the fat-body (deutoplasm) revealed the conspicuous oenocytes floating free as large opaque discs, but none was of the pear-shaped form figured by Snodgrass (p. 210).

A few oenocytes were already aggregating into the compact groups which are characteristic of the pupal stage; the fat-cells being large, and closely packed with oil-globules. On the 14 th of November, 23 days after the last of the pudding had been consumed, the skin of one larva was observed to split down the frons; the fissure gradually extending along a median longitudinal line of the body.

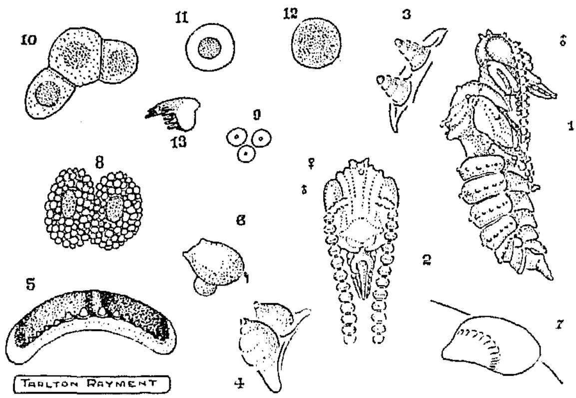


Fig. VIII. 1. Pupa. 2. Frontal view of head of pupa. 3, 4, 5. Nodes on the scutellum, postscutellum and tergite of pupa when pigmentation begins. 6. Larval mandible atrophies before the pupal stage is reached. 7. The cornules developing in the pupal eye. 8. The fat-cells of the fully-fed larva are packed with oil globules. 9. Leucosites. 10. The granular oenocytes aggregate as the pupa develops. 11, 12. Oenocytes as floating free in the larval body. 13. The chitinized mandibulae are cast off with the larval pellicle

About November 17th, the base of the larval mandibulae enlarged into two beads, the acute hard portion becoming atrophied, and later, falling off with the larval pellicle. The elements of the cornules are just visible in the developing compound eyes, but no pigment of any kind is present at this stage. There is considerable movement of the caudal end of the body during the ejectment of the faeces, but after the splitting of the larval cuticle the creature remains quite still, except when exposed to daylight.

All larvae removed from the nest are immaculate, but those reared in the artificial cells and, therefore, free of the presence of mites, often become soiled with their own faeces. The frequent exposure to light during examination caused the pupae to „flick" and wriggle abnormally, but did not cause the younger ones to cease eating. Dissection of larva, six days after the consumption of the last of its food, showed that the proctodeum was still unconnected with the mesenteron, but the connexion is complete two days later.

The application of nitric acid to the russet-coloured pellets of excreta of one larva, instantly changed the colour to pale-yellow, and under the microscope, the empty shells proved to be those of pollinia from the two wattles.

Between the 18th and 20th of November, the extraordinary development of the larvae is revealed. The third pellicle is ultimately cast off, but remains attached to the caudal end for a day or two; it is finally detached as a wrinkled circlet of dry, glassy skin.

In three days the segmentation of the flagella is completed, as is also that of the maxillary palpi; the compound eye is as yet uncoloured; the embryonic wings being large, and the legs almost of full length, although the fifth tarsal segments have not progressed beyond the two „beads" stage; the ocelli appearing as three long sharp nodes. Each dorsal segment of the abdomen has a transverse row of fourteen or so small nodes; the scutellum has two very prominent ones, those of the postscutellum being globose. A large node occurs on the developing wing where the basal nervure will finally show, and two more are at the axillae of the wings. There is, also, a large one at base and apex of the tibiae. The invagination of the apical segments of both male and female *Halictus* is of special interest. The antennae of this species, compared with those of the pupa of the hive-bee, seem unduly large. The pupae of *Paracolletes*, *Euryglossa*, *Bremus* and *Apis* lack the abdominal nodes (Rayment pp. 32, 149, 500).

About the 24th of November, the majority of the pupae exhibit a pale brownish-pink pigment between the cornules, the lenses of which are then perfectly defined; the retina is the last to colour.

The male pupae from the smaller puddings measure only 5 mm. in length, and are not nearly so robust as the females, though they develop three or four days earlier. The smaller puddings appear to be identical with those of the females in every way except volume, but none was subjected to investigation for any chemical differences which may be present.

On the 26th of November, the first slaty-grey pigmentation appeared on the second abdominal sternum of the males; the colour deepened to black in about twentyfour hours, and spread slowly to the seventh segment and the metathorax as a dark-reddish suffusion.

About the second week in December pigmentation is complete; the final ecdysis takes place, and in another day or two, the imagines emerge. Over two months elapse from the laying of the egg to ultimate development, and it will be seen from the accompanying table that the data gleaned from the artificial cells accord very well with what obtains in the colony in the field.

The second brood, which emerges about 15[th] February, is composed exclusively of females, and their behaviour does not differ greatly from that already described, except that they harvest creamy granules from messmate and a few from wild-hop.

By the 1[th] of March only a few females are in evidence, though the temperatures are still high, but eight days later, only an odd shaft remains open, and the last of the females has disappeared. In the cells below, the fully-fed larvae approach the second ecdysis. The messmate trees have completed their blooming, and as this is the driest period of the year, even the flatweed ceases to flower, so that the district is devoid of all blossom. The generations of this *Halictus* are thus beautifully correlated to the inflorescence of the local plants.

The April generation, which is composed exclusively of females, is the last for the season, and reaches maturity about the 15[th]. At that date the temperatures are low, and frosts not infrequent, these bees, therefore, seldom if ever fly from the nest, though during the warmest hours of the day, a few of the earliest ones may leave their cells, and excavate in a desultory manner, so that minute quantities of spoil may be seen at the mouth of any shaft then open.

On digging a section of the colony on 20[th] April 1936, hundreds of fully-developed females were found quiescent in their natal cells. Thousands of acarid mites are present in the chambers when the season closes. Autumnal rains soon seal the shafts, and the virgin bees hibernate during May, June and July. Not one male bee is present in this generation. Plath (p. 87) found numbers of bumble queens in a hibernaculum near the entrance to the colony.

The increasing warmth of August arouses them from their torpor, and they emerge from their cells and crowd along the galleries ready for flight on the first bright day.

The author proposes to study the chromosomes of the various generations during the season 1936—1937. The gross morphology of the Australian parthenogenetic females does not differ materially from the bisexual generation, and thus diverge charply from the European species, *H. malachurus,* which has a smaller parthenogenetic female, *longulus,* as reported by Legewie.

Summary.

The life-cycle is as follows —

1[st] Females emerge from hibernation, and fly during the end of August and beginning of September.

2nd Males and females emerge together, and mate, early in December.
3rd Females emerge in February.
4th Females are fully developed by the middle of April, but do not fly; they hibernate in their natal chambers during the three winter months, and emerge in spring.

Table of Development.
Halictus emeraldensis.
In Artificial Cells at Temperature 15° C.

Oct. 10. Eggs deposited; removed from colony with pollen-puddings.
„ 14. Chorion split; larvae emerge; commence to eat.
„ 17. First Ecdysis.
„ 22. Second Ecdysis.
„ 26. Pollen-puddings consumed. Larvae rest. Oenocytes not so conspicuous.
Nov. 3. Pellicles become dull and flaccid.
„ 4. Proctodeum connects with mesenteron.
„ 14. Faeces have been voided at intervals.
„ 24. Third Ecdysis commences.
„ 28. Desiccation of pellicle.
„ 30. Third Ecdysis completed. Pupae revealed.
Dec. 4. Compound eyes coloured pale-brown. Temperature raised to 23° C.
„ 9. Pigment shows on second sternum [1]).
„ 12. Pigmentation complete, except on appendages. Males colour in 8 days; females in 4.
„ 14. Fourth Ecdysis.
„ 16. Male Imagines emerged from cells.
„ 18. Female Imagines emerged.

Behaviour of the Individual.

On the 6th of September, 1935, small spots of the compacted earth over the shafts were observed to crumple suddenly, and then roll over as they were thrust aside by bees coming up from below. The soil is damp enough to hold together, and the scanty fleece of the newly-emerged insect is hardly contaminated. On reaching the surface, the bee hesitates at the pit-mouth for a moment, and brushes its abdomen and flagellae with its legs. The wings are already dry, and after a short basking in the sun, it takes wing.

This first essay in flight is for orientating the site of the colony, and the location is thereafter fixed indelibly in the insect's memory; the

[1]) In this paper the propodeum is not counted as the first of the abdominal segments, though it is so morphologically.

details of the shaft are memorized later. With her head to the colony, she executes at first small serrated circles, and then ever-widening ones until some of the favoured food-plants are encountered — the distance seldom, if ever, exceeds 100 metres. The bee then alights, and refreshes herself at the blossoms of the wild-hop and flat-pea.

Her first appetite appeased, she rests on a leaf or grass-stem, enjoying the warmth of the sun. When a small cloud passes over, she remains quiet, but should any definite change to cooler weather be imminent, then she at once returns to the natal shaft, and remains below, in the earth, in a semi-comatose condition, until the sun shines again. Rain may close the mouth of the shaft for over seven days, but the bee is unharmed, subsisting meanwhile on the nectar in its sac.

The bees have no difficulty in finding their own particular shaft, and alight almost on the rim of the aperture, into which they dive instantly. No pollen was observed on the harvesting-hairs of females seeking shelter from the weather, but microscopical examination of the honey-sac revealed numerous granules in the nectar.

The strong flight of females indicated the existance of a populous „nest" of these gregarious bees, and a cut was made to reveal a section of the colony. A trench, 30 cm wide and 40 cm deep was taken out carefully to isolate a central sod of earth. A table-knife was then used to pare off slices of soil, and as the shafts were approached, the parings were cut progressively thinner.

The nature of the soil permits this kind of work to be performed very satisfactorily, and since it contains neither stones nor roots, the slices do not crumble, and may be lifted out clear of the trench, so that there is very little debris to obstruct the observer. Even a few loose grains of earth are sufficient to create difficulties by masking the small shafts.

At a depth of about 20 cm., in the firmer clean soil lying under the uppermost stratum of charcoal debris left by the forest fires of the past, the galleries and cells were so numerous that the central block of earth was lifted up with the hands without effort, for the earth had separated along the „line of weakness" created by the hundreds of horizontal galleries. All the bees were picked up with bare fingers, and not once was a sting inflicted, nor did the colony give any indication of concerted attack, although many hundreds of insects were a-wing.

When the colony was thus exposed to the light, thousands of fully developed bees were seen to be arranged along the galleries in single file, but close enough to touch one another. All were fully developed, but appeared at first to be somewhat comatose, but a short exposure to the warmth of the sun was sufficient to set the antennae quivering, and soon the majority was taking wing.

While the insects remained still, a rapid survey was made with a hand-lens; plainly, all were female. 100 individuals were taken from various parts of the colony, and examined critically under the microscope to determine the sex. All proved to be females.

The following day numbers of bees were observed flying over the site. They did not alight often, but maintained a constant dashing to and fro at 5 cm. or so above the ground. Since it is a rule of the Apidae for males to emerge first, it was essential to examine the flying bees, and a further 100 specimens were caught a-wing with the collecting-net, and these were examined critically for sex, but not one male was identified. Examination of a dozen bees for seven consecutive days produced a similar result.

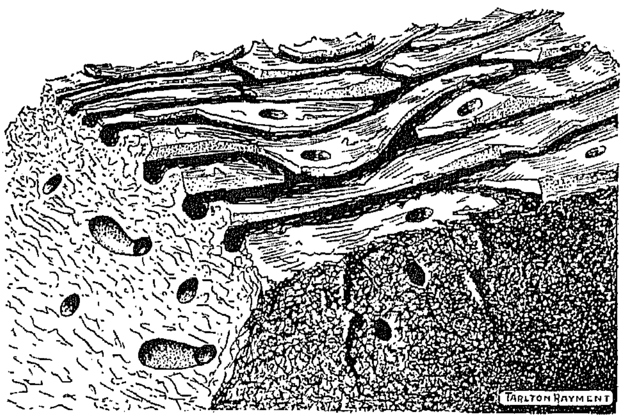


Fig. IX. Underneath surface of a sod of earth showing the galleries of *H. emeraldensis*, sp. nov.

Fifteen bees were taken from one shaft, and as these were the entire complement of the nest, special attention was given to the determination of sex, and once more no males were found. Further examination for sex was considered unnecessary. The spring bees which issue during the first week in September, are exclusively females.

The bee's first act is to visit the flat-pea for refreshment, but she returns almost immediately to seek out a site for her „nest". The females pass rapidly over the area while memorizing its details; they may alight once or twice, and even take out a few grains with their mandibulae, but for some reason not apparent, the site is suddenly abandoned, though the new one selected seems to be identical with that just rejected.

Although hundreds of galleries intersect below, comparatively few shafts are visible on the surface, so that many sisters use the same hatchway for ingress and egress. The searching bees, then, are probably only seeking the best position for sinking into the family gallery below. The soil is scooped out with the mandibulae, and as soon as the depth permits, the coarsely-toothed calcariae of the hind legs are brought into into action as the insect rotates in the shaft, thus paring down the wall. Spoil loosened by the mandibules is passed back by the anterior legs with the coxae and femora pressed together; the median pair transfer the material to the posterior legs, and by them is levered up the shaft, assisted by the sixth abdominal tergum as the insect backs out.

So soon as the cell is excavated, and lined with its colloidal membrane, the mother bee returns to the flowers, and fills her sac with nectar. The pollen is brushed off the floral anthers with the hairs of the tarsi of the anterior legs, and occasionally, the granules are touched with the glossa. Usually, the harvesting is done during the warmest hours of the day, when the natural oil of the pollen makes it cohere readily. The bulk of the pollen is carried on the long plumose hair of the posterior coxa, trochanter and femur, a much smaller quantity on the tibia, and a moderate quantity on the abdominal scopa.

There is considerable coöperation among the sisters, and during the feeding of the brood, the entrance to the shaft is seldom unattended. A female closes the aperture with her head, but moves back into the antechamber to permit the entrance of a sister returning from abroad. After a short period of such duty, the erstwhile guardian departs for the fields, and the post is „manned" by another sister from below.

Should a mutillid project her antennae over the orifice, the sentinel will unhesitatingly rush forth with gnashing mandibulae and drive the parasite away. On one occasion, a mutillid descended a shaft during the absence of the guard, but in a minute or two it was escorted to the surface between two sister bees. Fifteen minutes lather the mutillid again picked up the scent of the same shaft, and approached to the very rim, but she appeared to remember her previous experience, and hurriedly drawing back, scurried off to safer ground.

The remarkable feature in the life of the December females is the copulation with the males, but apart from that sexual act, their behaviour does not differ from that of the September generation. The close of the old year, and the opening of the new, is spent, appropriately enough, in making puddings from the christmas-bush, which is then at the apex of its inflorescence.

By the time the cells are completed and sealed, rain has closed the apertures of the shafts with a few grains of soil. Only an odd orifice remains, and it is unguarded, for the mothers, worn out with toil, meet death while searching abroad for the nectar of life.

Males.

Biting through the sealing-plug with its mandibulae, the male issues from the cell, kicks its way along the loose earth of the galleries, and at last ascends the shaft to the surface. Resting for a moment in the warmth of the sun, he flicks off any specks of dust adhering to his scanty hair, and takes wing without orientating himself. There is no necessity for him to do so, for he will never again descend the shaft from which he emerged. Plath (p. 111) says he has never known a male bumble to return to the nest.

He darts away into the sunshine, but soon alights, on a flatweed flower nearby, for his first taste of nectar. The ambit of his activities lies within a radius of 30 metres from the colony, and after refreshing himself, returns to the site, and ranges tirelessly to and fro over the bare earth, but seldom more than 5 cm. above it.

It is during these searches that he meets with a female seeking a new nesting-site, and immediately accouples with her in the air; the pair almost immediately alighting to complete copulation, which is of only momentary duration. The female resumes her task, and the male again resorts to the blossoms. The sexual act is not followed by death as is the case with the drone of the bee-hive.

If the wind be cool, or the sky overcast, the males rest on the grass or any flowers nearby, and when night approaches, they bury themselves, head down, in the numerous florets of the flatweed, and thus protected, await the reappearance of the sun. During the day, they will sometimes rest on the underneath of the flowers, and not one can be seen, then suddenly, they will appear as though having materialized out of the air.

The life of the male in the winged form is not more than seven or eight days, and by the time the puddings are being prepared, most of the males have succumbed; their dead bodies often being found in the flowers, as though death had come upon them as they slept.

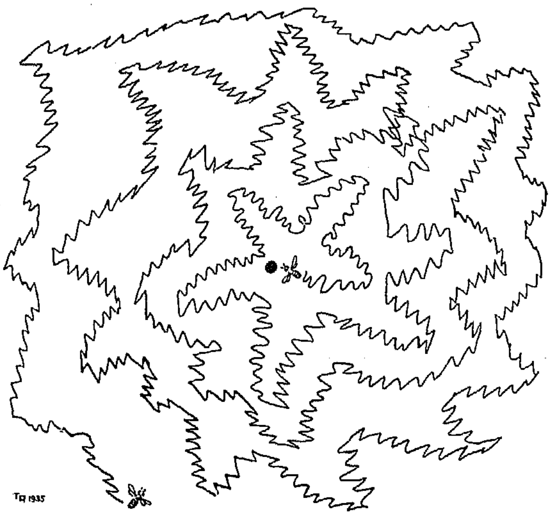
Range of Flight

The activity of the harvesting-bees of one shaft was checked on the afternoon of the 13th February, 1936. From 3.35 to 3.50. In the fifteen minutes 39 fully-laden females entered, but 4 came out again still laden, evidently, these had entered the wrong shaft; 16 emerged and departed for the flowers.

Numbers of bees in each generation were used for a series of experiments to determine the range of flight. All the females were obtained just as they were about to descend the shaft, fully laden with honey and pollen and, therefore, anxious to reach the nest quickly.

To avoid any possible injury from handling, and complications arising from contact with the odour of a human being, the bees were captured singly with the collecting-net. Each was held up close to the cotton threads, and a spot of water-colour was placed neatly on the thoracic disc exposed in the mesh.

The net was then given to an assistant, who ran to a point 50 metres distant, and released the insect by turning the net inside out. A white signal was displayed when the insect took wing; the observer at the colony registering the time on a stop-watch, and inserting a small wooden peg into the aperture of the shaft under observation.



Ffg. X. Chart of the orientating flight of the female *Halictus*.

Not one bee flew immediately from the open net; all engaged for a minute or two in a desperate effort to cleam off the colour by passing the median pair of legs up over the mesothoracic disc and brushing vigorously before taking wing. Much time was taken up in this way. Even then the bees did not fly straight home, but alighted for a further cleaning, until so little colour remained that identification of the returning bees, at the selected shaft, was rendered most difficult.

Putting the females into a test-tube with wheaten flour, and getting them well whitened, did not bring any better success, since the bees cleaned themselves very thoroughly before returning. The insect's propensity for keeping the body-hair immaculate precludes the successful marking of individuals with paints and powders. Mutilation was not considered, since the victims would then be in a still more unnatural condition.

The best for the unsatisfactory results was obtained from tests made with the December generation of females, all of which were marked with light-yellow. Three (marked D) were released at 100 metres from the colony, and evidently experienced great difficulty in returning from that distance.

No. 1.	Released	$2.14^1/_2$ P. M.	Returned	2.18.	Time taken	$3^1/_2$ min.
„ 2.	„	$2.22^1/_2$.	„	2.25.	„ „	$2^1/_2$ „
„ 3. (D)	„	2.29.	„	2.37.	„ „	8 „
„ 4.	„	2.38.	„	$2.39^1/_2$.	„ „	$1^1/_2$ „
„ 5. (D)	„	2.47.	„	3.7.	„ „	20 „
„ 6. (D)	„	$3.23^1/_2$.	„	3.37.	„ „	$13^1/_2$ „
„ 7.	„	3.41.	„	3.45.	„ „	4 „
„ 8.	„	$4.7^1/_2$.	„	$4.13^1/_2$.	„ „	6 „

The hairs being more or less sensory in function, are no doubt irritated when stuck together by paint or other such media, but this is not the case when flour is used, because honey-bees will often collect and carry such meals in their corbiculae.

Commensals and Parasites.

Mites.

The shafts and cells were thickly infested with minute white acarid mites, 0.60 mm. in length with a breadth of 0.40 mm. (Fig. XI). They exhibited a strong aversion to light. Forty or so were counted in the length occupied by each bee, but not one mite was found on any *Halictus*. A gravid female, whose abdomen was greatly distended, lived in a bee-cell which was under daily observation, but not once was it seen on the larvae. She often applied her mandibles to the cell-walls, as though scraping, and frequently voided a droplet of crystal-clear liquid which was immediately absorbed by the wall. Tke mites die within twentyfour hours after being removed from the bee-colony, and it seems that the vast numbers are of definite service in maintaining a hygienic condition in such a crowded community.

There is a curious segregation of the sexes at one period, for all the mites taken from one bee-cell will sometimes be males, while an adjacent cell will contain only females. A mutillid, captured on emerging from a shaft of the bees, was examined under the microscope, and two mites were observed clinging to the base of the sting, and another was on the second tergum. The acarids are undoubtedly distributed, by this medium, to any new shafts; the bee cannot act in this way because she limits herself to her own home.

In all the sealed cells the excremental pellets of the bee lie on one side of the wall, and are quite hard and dry; but this is not the case with those voided in the artificial cells, for there the pellets remain somewhat moist, and soil the larvae more or less. It would appear that the mites derive their sustenance from the biological debris of the larval bees. Plath (1934) arrived at a similar conclusion after a study of the mites, *Parasitus bomborum*, in nests of bumble-bees.

A very much larger mite, of a bright-golden colour, and measuring 1 mm. in length with a breadth of 0.50 mm., was removed from the metathorax of one harvesting bee, but it is of an entirely distinct genus. The mites have been submitted to Doctor Norma Leveque, Colorado University, for determination.

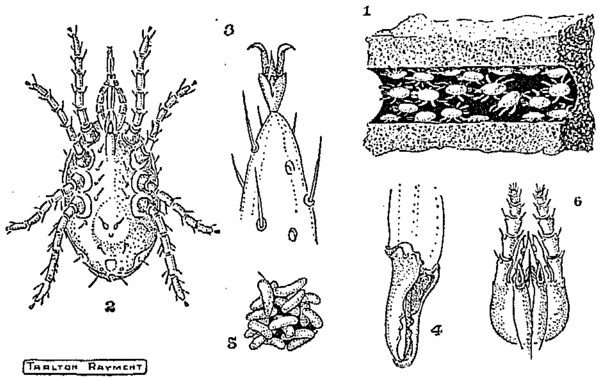


Fig. XI. 1. Section of bee's gallery, 8 mm. long, showing mites on the wall. 2. Ventral view of male mite. 3. Apical segment of the leg. 4. Mandibulae of the mite. 5. Excremental pellets of the bee. 6. Mouth-parts of the female mite, ventral view.

Mutilla.

Several small but beautiful species are parasitic on the halictine larvae; four are new, and the other is *E. picta* Raym. though this varies so greatly in size as to mislead the observer, there is, too, slight differences in colour. The smallest forms, 5 mm., result when the host is a male-bee, larger mutilla, 7—8 mm., are reared on the female-bee which, of course, has greater bulk, but the largest specimens, reaching 10 mm. of the type, are produced only when the host is the big thynnid wasp, or the wild-bee, *Paracolletes tuberculatus*, which is found on the coast (Rayment p. 157).

The amount of food available is the factor determining the size of the creature; the limited pollen-pudding produces the small male-bee which, in turn, restricts the stature of the mutillid feeding on it. Two puddings were supplied to several male bee-larvae, in an endeavour to increase the ultimate stature, but only one pudding was consumed. This refusal of additional food is easily explained; the whole of the pollen ingested is held in the mesenteron for several days, and when that organ is filled, no more food can be eaten. Dissection revealed that one pudding is sufficient to distend the mesenteron to its capacity. Since the volume of food cannot be increased, experiments in feeding a much richer quality are now in progress.

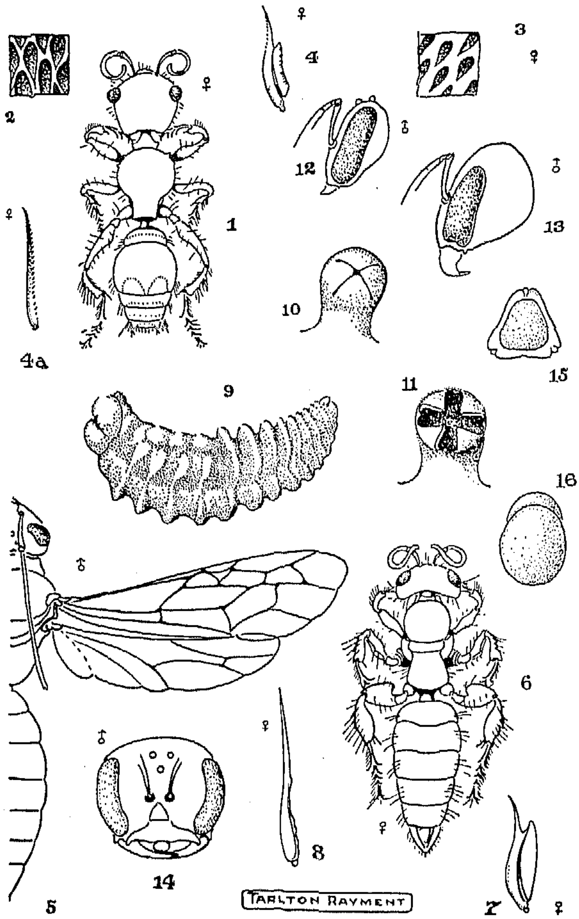


Fig. XII. 1. Adult female *Ephutomorpha emeraldiana*, sp. nov. 2. Sculpture of the abdomen. 3. Sculpture of the abdomen *E. picta*, Raym. 4. Strigil of anterior leg *E. emeraldiana*. 4a. Calcar of the posterior leg. 5. Male of Thynnid wasp. 6. Female of Thynnid wasp. 7. Strigil of anterior leg. 8. Calcar of posterior leg. 9. Larva of *Halictus emeraldensis* just before third ecdysis. 10. Proventricular valve shut. 11. Valve open. 12. Lateral view of head-capsule, normal male *Halictus emeraldensis*. (Hair not shown in these diagrams.) 13. Lateral view of head-capsule, mutation male. 14. Frontal view of head-capsule of mutation. 15. Messmate pollen-granules form the bulk of the February puddings. 16. With a very small proportion of granules from wild-hop.

A small mutillid, *E. emeraldiana*, sp. nov., was observed, on 28th of October, to be searching over the site of the colony; her straightened antennae executing a constant vertical movement, and it seems that the numerous olfactory? pores of her antennae assist her to find the bees' shafts by scent; in every case, the mutilla work up against the wind.

After a minute or twoo the parasite discovered a shaft and entered, but did not immediately descend; she proceeded to construct a plug of earth, one mm. or so below the surface, to close the shaft; the task occupying about seven minutes. Three minutes later the mother-bee arrived, and was evidently nonplussed at the obstacle, but she at once attacked the plug with her mandibulae, and after seven minutes labour had the entrance clear once more for her descent. Ten minutes later the mutillid reappeared at the surface, and projecting her antennae, repeated the scissors-like vertical movement, and then emerged; whereupon she was captured by the author.

The mouth of the shaft was immediately surrounded, with a metal ring, for positive identification, and a block of earth, 1700 c. dm. was at once excavated and carefully dissected. The bee-larvae were mostly fully-developed, and had just emptied the mesenteron. A mutillid egg was found on one.

It was evident that, since the gallery down below had first to be cleared before the parasite could deposit its egg on the larval bee, it was essential to delay the mother-bee sufficiently long to enable the "breaking-in" to be effected without interference. Mutilla caught near the cells usually have the sting protruding, and as it is a very long one for such a small insect, it should be capable of penetrating the loose structure of the cell-plug.

Wasps.

A female thynnid (Fig. XII, 6) was observed digging down in the small shafts which she had to enlarge to admit her. In several bee-chambers cocoons, 10 mm. in length, pearshaped, and light-brown in colour were obtained. These were surrounded with about a dozen empty cases of some insect (?) only 4 mm. in length. Examination of the excremental debris packed in the end of the wasp cocoons, showed a number of such scales. It was impossible to determine which had eaten the other, but the wasp cocoons were unbroken, with scales inside, which is very significant, but not conclusive, since such small objects could quite easily become attached to the cocoon during its construction.

About the middle of October, the swift black males of this thynnid wasp may be observed darting over the site of the bee-colony, and during the hottest hours of the afternoon, mated pairs may be taken with the collecting-net. They appear to have some relationship to *Thynnoides mesopleuralis* Turn. which is reputed in New South Wales to attack the strawberry grub. Of course, there are extensive strawberry gardens at Emerald. In March a black and yellow arpactid wasp may be observed excavating in the colony site.

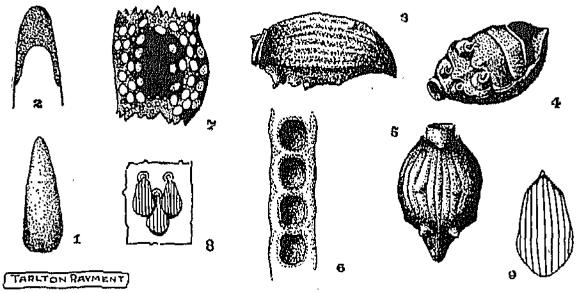


Fig. XIII. 1. Cocoon of the thynnid wasp. 2. Excremental debris in end of cell contains insect (?) scales. 3, 4, 5. Lateral, ventral and dorsal views of such "shells". 6. Portion of striae, showing pits. 7. Scales clustered about the pits. 8. Diagram to show the arrangement of the scales. 9. Enlarged scale.

Collembola.

Several of the bee-cells contained numbers of soft-bodied, milk-white, hairy springtails measuring only 1 mm. in length, but capable of leaping to a height of 6 cm. Half a dozen were imprisoned in a phial, with a little damp earth, and a pollen-pudding of the bees. They thrived in such quarters, and later, when cleared and mounted for microscopical study, pollen-granules could be observed in the stomach. These insects are in the Family *Entomobryidae.* I propose the name *Entomobrya emeraldica,* sp. nov., and append a description of the species. It will be seen from the drawings that the mandibulae have a molar area eminently suitable for crushing pollen-granules, and which is not unlike that of the larval bee and the larva of a pollen-eating beetle, *Brachypeplus planus* Er. (Rayment p. 548).

Later, on discovering an entirely subterranean plant growing in the grey soil, it was placed, together with some earth, in a glass jar for removal. Circumstances prevented me from seeing the vessel for over thirty days, but when it was examined dozens of „springtails" were present, feeding on the humus. There was a number of minute white eggs of unusual form, and these may have been laid by the Collembola. Some exceedingly small acarid mites were associated with these insects. One *Halictus,* taken when leaving the nest, had a springtail in its mandibulae. For over four months I have been breeding these Collembola successfully in a glass jar containing a little earth.

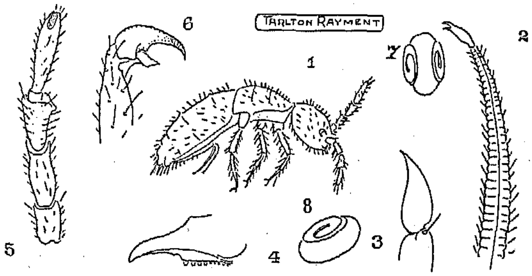


Fig. XIV. 1. Adult springtail, *Entomobrya emeraldica*, sp. nov. 2. Dens and mucro of spring. 3. Maxilla with seta. 4. Mandible showing molar area. 5. Antenna. 6. Claw and empodium. 7. Eggs found in association with the Collembola.

Summary.

There is no progressive feeding as Fabre suggested of his species, and one pudding fills the mesenteron to its capacity. There are three generations as reported by Armbruster and Legewie of *H. malachurus*, but the females of the parthenogenetic and the bisexual generations of the Australian bee do not exhibit the differences found in the German form, *H. longulus*. The mating of the sexes takes place above the surface of the colony as maintained by Stöckhert, and the third generation of fully developed females hibernates over the winter in the natal cells as claimed by the same author; Legewie and Armbruster do not agree on this.

The December males and females of *H. emeraldensis* are indubitably the progeny of the overwintered virgins which cannot mate, since there are no males. The author, therefore, agrees with Professor Wheeler that the Dzierzon rule has been „shot to pieces".

The February generation is exclusively female and remain unmated, and are the progeny of the pairs of December, and are the mothers of the April females.

There is a slight overlapping of the broods, but none of the mothers lives to see its progeny emerge, and the author agrees with Legewie that matriarchy is not essential for the development of social life. New colonies are established by lone females, but the reason for her action has yet to be sought; almost all remain in the parent colony.

As Professor Wheeler (p. 122) remarks, the biology of *Halictus* is an extremely difficult study.

Order *Hymenoptera.*
Suborder *Heterophaga.*
Division *Andreniformes.*
Family *Andrenidae.* Subfamily *Halictinae.*

Halictus emeraldensis sp. nov.

(Fig. II.)

Female: Length, 6 mm. approx. Black.

Head transverse, bright; face with scattered pale hair; frons finely striato-punctate; clypeus shining anteriorly, a delicate sculpture, large scattered punctures; supraclypeal area shining on disc, punctures smaller, a delicate sculpture; vertex sharply developed, a few pale-ochreous hairs; compound eyes reniform; genae with numerous silvery-white plumose hairs; labrum with a peculiar appendage (Fig. II, 3); mandibulae feebly bidentate, black basally, reddish apically: flagellae obscurely lighter beneath.

Prothorax with short moss-like hair on anterior corners; tubercles fringed with dull-white hair; mesothorax shining, closely punctured, a few obscure diagonal striae anteriorly, the punctures tending to run in lines; scutellum similar, but punctures uneven; postscutellum rougher, with more pale hair; mesothorax crescentic, short radiating rugae connecting with short spurs, shining, long white hairs laterally; abdominal dorsal segments shining, hind margins narrowly lighter and polished, one and two with numerous punctures smaller than those of mesothorax, others with only piliferous pores, two and three having long lateral patches of dull-white hair, four dusted all over with similar hair, apex with reddish rima and a few long white hairs; ventral segments have wide pallid margins, and a thin scopa of curled white hair.

Legs with numerous white hairs, especially on the femora; tarsal hair somewhat golden; claws bifid, amber with red tips; hind calcar has one large tooth and an undulate edge beyond; tegulae piceous, with a polished area; wings subhyalin: nervures dull-amber, first recurrent not always meeting the second intercubitus; second cubital cell large and slightly contracted at apex; pterostigma large, dark-amber; hamuli seven, very weak.

Male: Length, 5 mm. approx., and not so robust.

Antennae longer: the face narrower with much pale hair; the clypeus having a yellow mark as shown in Fig. II, 11. Mandibulae simple. The legs are more slender, with reddish-amber tarsi; the sculpturing of the integument agrees with that of the female, but the abdomen lacks the white hair-bands.

Locality: Emerald, Victoria, female (6th September), male (14th December).

Allies: *H. imitans* Ckll., which has the angles truncating the mesothorax developed to a point, with the finer striae more or less parallel (Fig. II, 14). Professor Cockerell, to whom I submitted specimens of the new species, writes: „. . , like *H. imitans*, but it is definitely different on the structure of the metathorax, which is larger in *H. imitans*, with much longer, though finer, plicae. The basal hair-bands of abdomen of the new species are denser, and slightly ochreous".

A western race, with a wider area on the metathorax with longer and coarser rugae; apical margins of the tergites broadly amber, and the legs somewhat rufous, was collected by F. E. Wilson, and C. Borch as far back as October 1928, in the Grampian hills, but I had put the specimens aside for further study. Since that time linking forms have been found at Kiata, Belgrave and Ringwood, all these localities being in Victoria.

Family *Mutillidae.*

Ephutomorpha emeraldiana, sp. nov.

(Fig. XII, 1, 2, 4.)

Female: Length, 6.5 mm. Black and red.

Head dark-red, vertex suffused with blue-black, a few pale hairs, rugoso-punctate, punctures somewhat pear-shaped; frons with a small basin-like depression; compound eyes small and black; genae reddish, with a few appressed white hairs; mandibulae long, acute, with an obsolete inner tooth, reddish-amber; antennae reddish, with a few long white hairs on scape, beneath the base of the flagellum, and the segments apically, suffused with black.

Thorax blackish-blue, suffused with reddish dorsally, rugoso-punctate, a few pale hairs apically. Abdomen shining black, the punctures exceedingly long and so dense that only a fine line separates them; segment one with a band of golden hair apically, two with a pair of large hairy pear-shaped patches, four and five with a tuft of similar hair, and six with a large naked striate plate.

Legs ferruginous, the femora wholly, and the tibiae and tarsi apically, suffused with black.

Locality: Emerald, Victoria (30th October, 1935).

Allies: *E. picta* Raym. which has a bronze abdomen, with punctures not so long, and widely separated (Fig. XII, 3).

Taken from the shafts of *Halictus emeraldensis* Raym. on which the female mutillid is parasitic.

Ephutomorpha peremeraldiana, sp. nov.

Female: Length, 6 mm. approx. Blue and red.

Head small, metallic-blue, the large oval punctures arranged in rows;

compound eyes small, black; genae sculptured like frons, with white hair; clypeus, labrum, and base and apex of scape all reddish-ferruginous; flagellum blackish above, ferruginous beneath, with second segment longest; mandibulae reddish-black apically, with a strong inner tooth.

Thorax coarsely rugoso-punctate, red, dorsally suffused with blue, a few black hairs, beneath the hair is white. Abdomen metallic-blue, punctures well separated, highly polished, a little white hair at base of segments two and four, apically much long black hair, and a red naked plate, venter with white hair.

Legs tarsi and claws red, white hair.

Locality: Emerald, Victoria (January 1936 Rayment).

Allies: *E. emeraldiana* Raym. which has dense punctures on black abdomen. *E. peremeraldiana* resembles the smaller forms of *E. picta*, which has a very large head, and the pitting of the integument is different.

Taken from the shafts of *Halictus emeraldensis* Raym.

Ephutomorpha redanamelia, sp. nov.

Female: Length, 5 mm. approx. Red.

Head exceedingly coarsely rugoso-punctate, a few amber hairs; compound eyes small, circular, black; genae coarsely punctured, with white hair; clypeus and labrum reddish-ferruginous; mandibulae long, reddish-amber basally, black apically, an obsolete inner tooth; scape ferruginous, flagellum suffused with black, and second segment longest.

Thorax coarsely rugoso-punctate; posteriorly and laterally a black band ending some distance from the prothorax; a few pale hairs. Abdomen with a large blackish suffused patch on segment two; anteriorly the few long hairs are white, posteriorly they are mixed with golden, and are more abundant; the extreme base black, and the sixth segment with a large dark-red naked plate; the dense punctures are long and pear-shaped.

Legs and tarsi more or less suffused with a blackish tint, except the coxae, which are clear ferruginous; hair white.

Locality: Emerald, Victoria (November 1935 Rayment).

Type in the collection of the Division of Economic Entomology. C. S. I. R. Canberra, F. T.

Allies: *E. emeraldiana* Raym. which has a black abdomen.

Taken from the shafts of *Halictus emeraldensis* Raym., on which the female mutillid is parasitic.

To keep the various insects described in this paper linked up, by the name of the locality, I have used an anagram of *emeraldiana*.

Ephutomorpha melanaderia, sp. nov.

Female: Length, 6 mm. approx. Black and bronze. Slender.

Head black, with huge contiguous pits, a fine raised line running from the insertion of the antennae to the base of the compound eye; clypeus minutely dentate anteriorly; compound eyes prominently bulging, small, circular and black; genae with long white hair constrasting with the black of the vertex; labrum amber; mandibulae black, flagellum obscurely reddish beneath.

Thorax with large contiguous pits, black dorsally, with a few black hairs; abdomen with dense pear-shaped punctures, blackish-bronze, with dense golden hair apically, and scattered long black ones on dorsal segments, venter has white hair, extreme base reddish.

Legs tarsi and claws reddish-ferruginous, with a few white and black hairs.

Locality: Emerald, Victoria (November 1936 Rayment).

Allies: *E. picta* Raym. which is a much larger and robust insect, with a blue head. The five mutilla show close affinity.

Taken from the shafts of *Halictus emeraldensis* Raym.

The specific name is another anagram of *emeraldiana.*

Ephutomorpha picta perpicta subsp. nov.

Female: Length, 7 mm. approx.

Very like the small forms of *E. picta* Raym. but the head is small, and not like the wide thick one of the species. The pitting of the subspecies is slightly different.

The five mutilla described in this paper are all from the halictine colony, and they may have originated as mutations of *E. picta.* Their biology is different, however, but the halictine mutations throw some light on that aspect; the research did not permit of any investigation into the genetics of the mutilla.

Order *Collembola.*
Suborder *Arthropleona.*
Family *Entomobryidae.*

Entomobrya emeraldica sp. nov.
(Fig. XIV.)

Length: 1 mm. Milky-white; integument very smooth, the whole insect having numerous fine bristles. Head large, the four segments of the antennae of the following proportions; one 40; two 85; three 75; four 150; the apical segment is hollowed at the tip; no pore-organs are visible; a minute post-antennal organ, the mandibulae, palest-amber in colour, have acute tips, and a strongly developed molar area having about a dozen strong teeth graduated in size; the mouth-parts retracted, but the transparent mount shows the stout maxilla with the palpus reduced to a single seta as shown in Fig. XIV, 3; ocelli absent, but vestiges of ommata show faintly.

Pronotum not distinct, thoracic plates fused; abdomen with six indistinct segments, the second having a small node on the dorsal surface; collophore being invisible on the type; the slender dentes, finely crenulate for their entire length up to the mucro, are hollowed on the inner surface, and hairy on the exterior.

Legs of four segments, the femora being longest, the claw is very large and strong, the empodium short and leaf-like.

Locality: Emerald, Victoria (24th November 1935 Rayment).

Allies: This seems to have some affinity to the larger *E. mawsoni* Till. though the hind tarsus lacks the long tenent hair of that species. In a specimen mounted in „Euparal" (H. Britten formula) the compact masses of large granular oenocytes can be seen clearly. This is the first spring-tail described from Victoria, and the genus is added to the insect-fauna of the State.

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