A NEW SPECIES OF CHALCID (GENUS *EURYTOMA*) ASSOCIATED WITH *TEPPERELLA TRILINEATA* CAM., A WASP CAUSING GALLING OF THE FLOWER BUDS OF *ACACIA DECURRENS*.*

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(Twelve Text-figures.)

[Read 31st May, 1939.]

A detailed account of the life history of *Tepperella trilineata*, a wasp which causes galling of the flower buds of *Acacia decurrens* var. *pauciglandulosa* in the vicinity of Sydney, New South Wales, has already been published by the writer (1938).

At that time it was pointed out that the species of *Eurytoma* under discussion, hitherto undescribed, occurred so abundantly in these galls that it outnumbered *T. trilineata*, the primary gall-former.

The unusual behaviour of the larva of a species of *Eurytoma* was commented upon, and in the present paper the life history of this species is set out in detail.

The writer (1936) has already discussed the genus *Eurytoma*, and both phytophagous and parasitic species in this genus are present in Australia. The larva of *E. gahani* is first phytophagous, but later becomes a predator.

Morphology.

Specimens of this species were submitted to Dr. A. B. Gahan, Senior Entomologist of the United States Department of Agriculture, and in a letter dated 29th May, 1937, he informed the writer that it differed from any of the species in the collections at the United States National Museum. He stated that it ran close to *Eurytoma mazzinii* and also *E. acaciae*, two Australian species, but was neither of these two. He concluded that the species was possibly new. The writer has since compared specimens with all the available descriptions of Australian species of this genus and has come to the conclusion that it is undescribed, and a description of this species is included in the present paper.

Eurytoma gahani, n. sp.

The Adult.

♀ (fig. 1): Length: Average, 2·6 mm.; maximum, 3·0 mm.; minimum, 2·3 mm.

Head black, evenly and coarsely reticulate and bearing short white setae. Eyes red, this colour sometimes fading completely in mounted specimens. Mandible (fig. 2C) brown. Antenna (fig. 2B) very dark brown, except the ring joint and the base of the scape which is light brown. The scape extends a little beyond the antennal groove, terminating level with the median ocellus.

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Each segment of the funicle is very slightly wider than that preceding it. The first segment of the funicle is a little longer than wide. The second segment is a little shorter than the first and is exactly as wide as long. The third segment of the funicle is slightly longer than the second and is very slightly longer than it is wide. The fourth segment is approximately the same length as the third and is very slightly wider than long. The fifth segment is slightly shorter than the fourth and is slightly wider than long. The club, which is approximately twice as long as wide, is only very slightly wider than the last segment of the funicle.

Thorax black and, like the head, evenly and coarsely reticulate and bearing short white setae. Wings hyaline; venation light brown, the postmarginal vein is only slightly longer than the marginal vein, both being a little longer than the stigmal vein (fig. 2D).

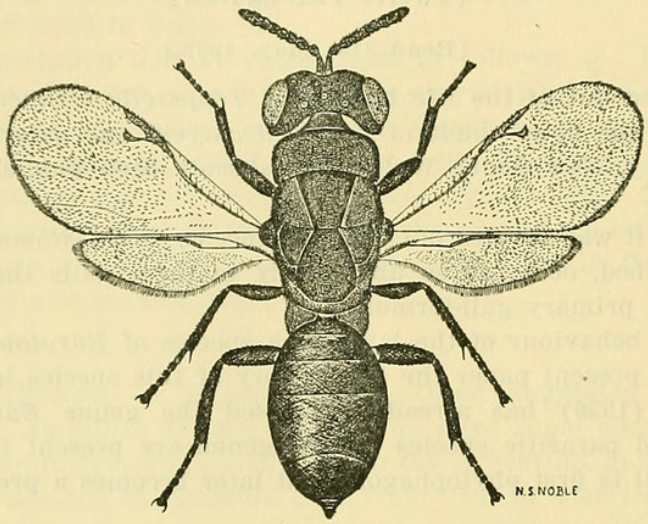


Fig. 1.—*Eurytoma gahani*, adult female (× 15).

Coxae and trochanters of all legs black. Coxae reticulate, more coarsely so on the hind leg. Outer side of coxae of hind leg conspicuously grooved distally, and in some mounted specimens the trochanter and base of the femur lie in this groove. Femur of front and middle leg dark brown except distally, where it fades to amber, tibia and tarsus amber. Femur of hind leg black except distally, where it fades to amber, tibia and tarsus amber.

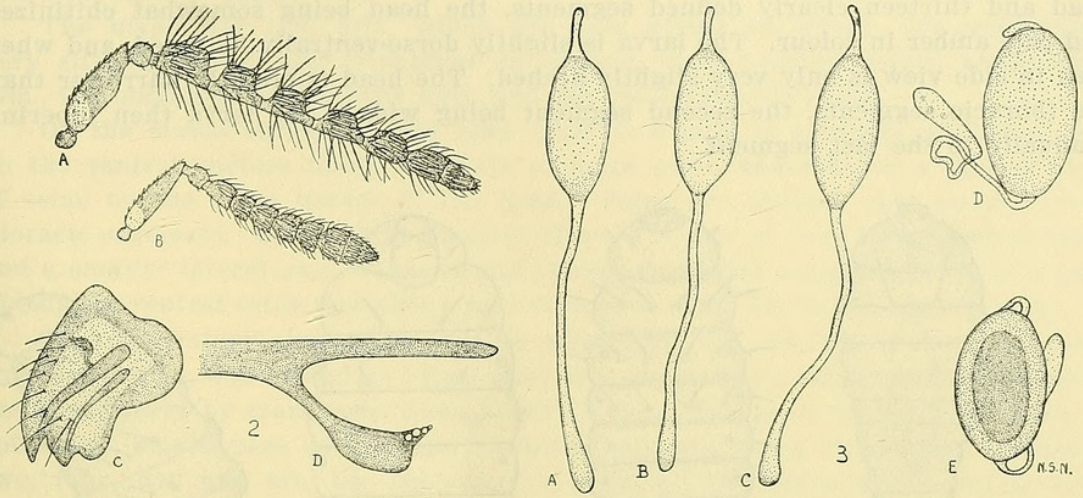
Abdomen black, rounded, not laterally compressed as is the case in many species of *Eurytoma* reared from Australian plant galls. First five abdominal segments smooth and shining, but at high magnifications fine reticulations can be distinguished on these segments. Remainder of abdomen reticulate and dull, and bearing a number of scattered white setae. No setae are present on the first and second abdominal segments. A few short lateral setae borne in a median position on the third segment. Setae on the fourth segment a little longer and in a median single row laterally, but extending a little further up on to the dorsal surface than in the third segment. Setae more numerous on the fifth segment, being scattered irregularly over the distal half of the segment.

♂: Length: Average, 2·5 mm.; maximum, 2·8 mm.; minimum, 2·2 mm. In general resembles the female, but is less robust. The abdomen is small and globular, with a distinct petiole. The antenna of the male (fig. 2A) is con-

spicuously larger than that of the female. The longest setae of the antenna are approximately the length of the segments bearing them.

The type, allotype and numerous paratypes were bred by the writer from galls caused by *Tepperella trilineata* on the flower buds of *Acacia decurrens* at Lindfield, Sydney, New South Wales, in November, 1936.

The type, allotype and five paratypes of both sexes have been forwarded to the British Museum of Natural History, South Kensington, London, and six paratypes of both sexes have also been forwarded to the United States National Museum, Washington, U.S.A.



Figs. 2, 3.—*Eurytoma gahani.* 2 : A, Antenna of male (× 36) ; B, Antenna of female (× 36) ; C, Mandible of female (× 103) ; D, Stigmal knob of female (× 103). 3 : A, B, C, Ovarian eggs; D, E, Eggs after deposition (all × 103).

The Egg.

The ovarian egg (figs. 3, A–C) is just visible to the unaided eye. It is white in colour and consists of an oval body bearing anteriorly a short pedicel with a rounded end and posteriorly a very long slender pedicel which widens out distally. The dimensions of the various parts of the egg are set out in Table 1. In general features it bears a marked resemblance to the egg of *Eurytoma fellis*, a species which has been studied by the writer (1936).

TABLE 1.—*Dimensions of Egg of* Eurytoma gahani *(in millimetres).*

	Total Length.	Ovarian Egg.						Newly Deposited Egg.	
		Body of Egg.		Anterior Pedicel.		Posterior Pedicel.		Body.	
		Length.	Width.	Length.	Width.	Length.	Width.	Length.	Width.
Average	0·447	0·137	0·062	0·044	0·007	0·266	0·017	0·158	0·091
Maximum	0·492	0·142	0·066	0·050	0·007	0·310	0·020	0·172	0·096
Minimum	0·393	0·125	0·053	0·040	0·007	0·218	0·016	0·149	0·089

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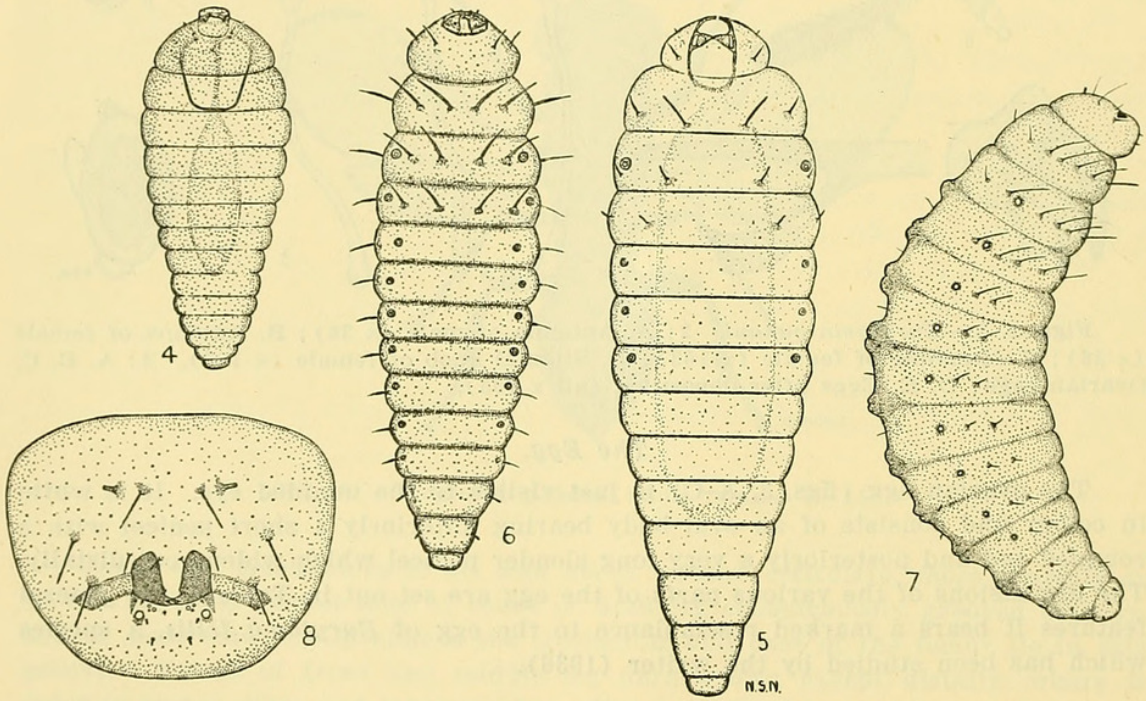
After deposition (figs. 3, D and E) both the long and the short pedicels may become flaccid and twisted.

The Larva.

Based on mandible size and shape and the distribution of setae, five larval stages are recognizable, there being one more stage than in *Eurytoma fellis*.

Stage I.—The first stage or primary larva (fig. 4) soon after hatching is clear and translucent, but after feeding the region of the alimentary tract becomes green. The smallest larva measured was 0·12 mm. in length and 0·06 mm. in width, being almost invisible to the unaided eye. It consists of a rather prominent head and thirteen clearly defined segments, the head being somewhat chitinized and pale amber in colour. The larva is slightly dorso-ventrally flattened, and when seen in side view is only very slightly arched. The head is slightly narrower than the thoracic segments, the second segment being widest, the larva then tapering gradually to the last segment.



Figs. 4-8.—*Eurytoma gahani*. 4, Ventral view of first-stage larva (× 180). 5, Ventral view of second-stage larva (× 103). 6, Ventral view of third-stage larva (× 55). 7, Lateral view of mature larva (× 20). 8, Front view of head of mature larva (× 55).

When viewed from beneath, the head is semi-circular in outline. The mouth is ventral and is surrounded by a short rounded tubular structure formed from the integument. In this respect it resembles closely the first stage larva of *Habrocytus cerealellae* which has been studied by the writer (1932) and, as in this larva, this tubular outgrowth is most conspicuous when the larva elevates the head when moving. The mandibles (fig. 9A) are triangular in outline, unidentate, lightly chitinized and pale golden in colour, slightly curved and have the tips overlapping, their average length being 0·007 mm.

Dorsally the head bears a pair of very minute truncate antennae, while ventrally and a little to each side of the mouth one pair of minute setae are present. There are no setae or papillae on any of the abdominal segments.

Towards the close of the first larval stage the development of lateral tracheal trunks, united anteriorly and disappearing posteriorly, gives the first indication of the respiratory system.

Stage II.—In general appearance the second-stage larva (fig. 5) resembles the first stage fairly closely, being still more or less translucent with the alimentary tract imparting a dark green colour to that region of the larva. It consists of a head and thirteen segments, the head now being somewhat smaller in proportion to the body segments, and being now no longer more heavily chitinized than the latter. The smallest larva measured was 0·37 mm. in length and 0·13 mm. in width.

The mandibles (fig. 9B), which are pale amber in colour, are unidentate, very slightly curved and triangular in outline, their average length being 0·021 mm., the maximum being 0·023 mm., and the minimum 0·018 mm.

On the dorsal surface of the head there is a pair of truncate antennae, and on the ventral surface there is a pair of large setae, there being a shorter pair of setae on the front border of the head. Setae are present only on the three thoracic segments. On the first segment there is a pair of very large ventral setae and a smaller lateral pair, while on the second and third segments there is a pair of smaller ventral setae and also a pair of lateral setae about the same length.

The respiratory system is now an open one. It consists of the two main tracheal trunks, one extending along each side of the body, being united anteriorly and posteriorly by transverse commissures. From the main trunks four pairs of spiracular trunks pass out to open spiracles, one pair being situated on segments two, four, five and six, the spiracles on segment two being much the largest. A limited number of tracheae pass to the various organs.

Stage III.—The third-stage larva (fig. 6) differs little in general appearance from the second stage. It is now more white in colour and the contents of the alimentary tract are dark green to almost black. The larva is very slightly dorso-ventrally flattened and in side view is very slightly arched. The smallest larva measured was 0·50 mm. in length and 0·19 mm. in width. The mandibles (fig. 9C) are unidentate, triangular in outline, amber in colour, with the tips conspicuously curved and overlapping. They average 0·035 mm. in length, the maximum being 0·040 mm. and the minimum 0·033 mm.

On the dorsal surface of the head is a fairly prominent pair of antennae, which are more or less cylindrical with rounded ends, and pale amber in colour. Between the antennae on the dorsal surface is a pair of fine setae, a second pair also being dorsal and further back and more to the sides of the head. On the front margin of the head and in front of and a little to the sides of the head, there is another pair of setae, and ventrally just above the mandibles there is also a very short pair of setae, while by far the largest on the head is a pair of ventral setae situated below and to the sides of the mouth. There are thus five pairs of setae of various sizes situated on the head.

Below the mandibles there is a large number of rounded sensory papillae of various sizes, a more limited number being situated above the mandibles.

On the first three abdominal segments there are eight setae. One extremely minute pair are dorsal and two large pairs are ventral and one pair are lateral. From segment four to segment twelve, inclusive, there are two pairs of setae, one minute pair being dorsal and a larger pair being lateral. On the thirteenth segment the lateral setae are always wanting and only in some larvae examined can the minute dorsal setae be distinguished.

During the later period of the second stage, further spiracles develop, and in the third stage there are nine pairs of open spiracles situated on segments two to ten inclusive and there is now a very well developed respiratory system. The first pair of spiracles are much larger than the succeeding ones.

Stage IV.—The fourth-stage larva is white in colour, cylindrical and arched, and tapering gently towards both ends. The smallest larva measured was 0·96 mm. in length and 0·32 mm. in width.

The mandibles (fig. 9D) are triangular in outline, still only lightly chitinized and amber in colour, slightly curved and average 0·064 mm. in length, the maximum being 0·069 mm. and the minimum 0·059 mm. The antennae, apart from size, are very similar to those of the third-stage larva, and the number and distribution of the setae on the head is the same in the two stages. The distribution and number of setae on the abdomen is, however, different. In the fourth stage there are eight elongate amber setae on the ventral and lateral surface of the first three segments, there being two small setae on each side of the dorsal surface of these three segments.

On the remaining segments there are two pairs of large lateral setae and one pair of minute dorsal setae on each segment. These setae become smaller on each succeeding segment, those on the last segment being very minute. A well developed open tracheal system, as in the third stage, is present.

Stage V.—The fifth and last larval stage (fig. 7) is cylindrical and arched, and tapers towards both ends, much more conspicuously than do any of the preceding stages. The colour varies from white to light grey. The alimentary tract is black, but this, being mainly masked by fat body, imparts a darker grey appearance to this region of the larva.

It consists of a head and thirteen segments. The average length of the mature larva is 3·32 mm., the maximum being 3·54 mm. and the minimum 2·97 mm. The average width of the mature larva is 1·07 mm., the maximum being 1·15 mm. and the minimum 0·94 mm.

The head (fig. 8) is of the typical generalized chalcidoid type, being more or less hemispherical in outline. The mandibles (fig. 9E) are now much more heavily chitinized, being brown in colour, somewhat triangular with a very broad base, bidentate, with one very much longer curved and more heavily chitinized tooth. The average length of the mandibles is 0·106 mm., the maximum being 0·116 mm. and the minimum 0·092 mm.

The head, as in preceding stages, bears a dorsal pair of cylindrical antennae (fig. 9F) and five pairs of setae of various sizes, their distribution being as in the third and fourth larval stages. Below the mandibles there are also four pairs of minute sensory setae and four pairs of minute papillae, their distribution being shown in figure 8.

The number and distribution of the setae on the abdomen is the same as in the fourth stage, i.e. there are ten large lateral and ventral setae (figs. 9, G, H, and I) and two pairs of smaller dorsal setae on the first three segments, while on the remaining segments there are two pairs of lateral and one pair of dorsal and smaller setae. With the decrease in size of the posterior segments all these setae are brought closer together and more or less form a median circlet.

A very profusely branching open tracheal system is present with nine pairs of open spiracles, one pair on each of segments two to ten inclusive.

Intermediate measurements of the various larval stages of *Eurytoma gahani* are given in Table 2.

TABLE 2.—*Dimensions (in millimetres) of the various Larval Stages of* Eurytoma gahani.

Stage of Larva.		Length.	Width.	Average Width of Head.
Stage 1	Largest	0·30	0·11	0·063
	Smallest	0·12	0·06	
Stage 2	Largest	0·51	0·18	0·098
	Smallest	0·37	0·13	
Stage 3	Largest	1·04	0·32	0·180
	Smallest	0·50	0·19	
Stage 4	Largest	1·66	0·50	0·304
	Smallest	0·96	0·32	
Stage 5	Largest	3·54	1·15	0·443
	Smallest	1·68	0·64	

BIOLOGY.

Length of Life of Adults.

Newly-emerged adults of both sexes of *E. gahani* were placed in glass tubes six inches in length and one inch in diameter. One end of the tube was covered with cheese cloth and the other was plugged with cotton wool which was kept moistened with sugar and water solution. These were held in the laboratory until death; the length of life under these conditions is set out in Table 3.

TABLE 3.—*Length of Life of* Eurytoma gahani *in the Laboratory.*

Length of Life in Days.	Number of Males.	Number of Females.	Length of Life in Days.	Number of Males.	Number of Females.
1	4	3	15	2	2
2	21	4	16	1	3
3	19	26	17	—	—
4	29	16	18	2	—
5	21	18	19	2	—
6	31	10	20	—	1
7	27	25	21	1	1
8	38	24	22	1	1
9	18	44	23	—	—
10	12	20	24	—	—
11	4	17	25	—	1
12	10	13	26	—	1
13	5	7	27	—	2
14	2	1			
			Total ..	250	240

Average length of life of male wasps, 6·82 days; female wasps, 8·17 days.
Maximum ,, ,, ,, ,, ,, ,, 22 ,, ,, ,, 27 ,,
Minimum ,, ,, ,, ,, ,, ,, 1 day; ,, ,, 1 day.

Under these conditions the average length of life was comparatively short, but limited numbers of adults lived for more than two weeks, and a few females lived for a period of three weeks or more, which is considerably longer than the adults of the primary gall-former, *Tepperella trilineata*, lived under similar conditions.

Habits of Adults.

Adults are comparatively sluggish and do not fly readily, it being possible to pick buds on which females are resting without disturbing them. However, they can fly quite well, and during November and December, 1936, on bright sunny days, large numbers were to be seen flying around the galled tree, individuals remaining on the wing for some minutes.

When confined in tubes in the laboratory, this species fed much more readily on sugar solution than did the adults of *Tepperella trilineata*.

Percentage of Sexes.

Of a total of 1,605 adults which emerged from galls in 1936, 1,028 or 64·05 per cent. were females, and 577 or 35·95 per cent. were males. It will be seen that females outnumbered males in a ratio of almost 2 to 1. It is worthy of note that in *Eurytoma fellis*, the citrus gall wasp, studied by the writer (1936), of 4,889 adults, 3,122 or 63·86 per cent. were females, a percentage which is remarkably close to that recorded for *Eurytoma gahani*.

Mating.

This species mated much more readily in the laboratory than did any of the other species from the galls on *Acacia decurrens*. There is nothing unusual in the procedure. The male spends a few moments on the dorsum of the female vibrating the antennae in front of those of the latter, and fertilization follows, the male invariably returning to the back of the female after coupling, but a second contact was never observed. The time occupied ranged from 7 to 20 seconds, the average being 11 seconds. Adults were frequently observed mating a few minutes after emerging from the galls.

Oviposition.

Unlike *Tepperella trilineata*, the female of *Eurytoma gahani* at the time of emergence from the galls has comparatively few eggs ready for deposition, and even after being kept in tubes in the laboratory and fed for some days, the number of well-developed eggs is still limited. Adults of *Eurytoma gahani* live longer and are more vigorous than the adults of *T. trilineata*, and it is probable that oviposition in the former species is a much more gradual process and extends over a longer period.

At the time the first adults of *Eurytoma gahani* emerge all the flower buds are very well developed, but it is several weeks before the tree blossoms, so that these early emergents oviposit in advanced flower buds. During the greater part of the emergence period of this species, however, the tree is in flower. It has been pointed out that in globular flower-heads in which *Tepperella trilineata* has oviposited only the upper flowers open, and many females of *Eurytoma gahani* oviposit in the fleshy green base of the unopened portion of the flower heads.

At the time the later adults of *Eurytoma gahani* emerge, viz. the last half of December and early January, the tree has completed flowering, the normal flowers have died and fallen, and the flower heads in which *T. trilineata* has

oviposited are now present as very minute galls, and in these *Eurytoma gahani* oviposits.

The tips of the antennae are held just above the surface of the plant tissues to locate a suitable oviposition site. The abdomen is then brought down at right angles to the normal position, the ovipositor is exposed and worked into the gall until some stage of *T. trilineata* is located, and then a single egg is deposited, the process of oviposition being rather protracted. At the time the first adults of *Eurytoma gahani* emerge, a limited number of eggs of *Tepperella trilineata* are present in the buds, and the egg of *E. gahani* in such instances is deposited alongside the egg of *T. trilineata.*

During the greater part of the emergence period of *Eurytoma gahani*, *T. trilineata* is present in the first larval stage, and in large numbers of dissections during December 1936, a single egg of *Eurytoma gahani* was found adhering to the integument of a first-stage larva of *T. trilineata*, and in two instances two eggs of *E. gahani* were found adhering to the integument of a second-stage larva of *T. trilineata.*

It is evident that the egg of *E. gahani* is always deposited alongside some stage of *T. trilineata*, the exact stage of development of the latter species, at the time of oviposition, apparently being of little significance.

Superparasitism.

In four instances it was evident that at least two eggs of *Eurytoma gahani* had been laid in the cell occupied by *Tepperella trilineata.*

On 14th December, 1936, and again on 15th February, 1937, two eggs of *Eurytoma gahani* were found adhering to the integument of a second-stage larva of *T. trilineata.* In both cases the eggs were at distinctly different stages of development.

On 17th July, 1936, two larvae of *Eurytoma gahani*, both in the fourth stage, were found in a cell with a maturing larva of *T. trilineata.* Both these larvae were normal and active, but the larva of *T. trilineata* was very unhealthy in appearance.

Again on 1st September, 1936, two fifth-stage larvae of *Eurytoma gahani* were found in the one cell accompanied by the dead remains of a fifth-stage larva of *T. trilineata.*

Never more than one adult, however, was ever observed to emerge from a single gall cell.

Larval Development.

The stages of *Eurytoma gahani* and *Tepperella trilineata* found in association during a period of 16 months during 1936 and 1937 are set out in Table 4. It must be remembered that as early as 16th May, 1936, gall cells were dissected in which *Eurytoma gahani* had already devoured the larva of *T. trilineata* and was in the last larval stage, and the number of such cells increased with each succeeding dissection date. The figures indicated in Table 4 apply only to dissections in which both species were still present in the cell, and this table does not give any indication of the relative abundance of the two species.

Table 4 should be consulted in conjunction with Table 5, when considering dissections during the second half of 1936, as the latter table indicates clearly at the different dissection dates just what numbers of *Tepperella trilineata* still remained in association with the larvae of *Eurytoma gahani*, the numbers of

mature larvae of the latter species present indicating the numbers of *Tepperella trilineata* which had been devoured.

Though the eggs of the two species may be found in association, it was much more usual to find the egg of *Eurytoma gahani* in the gall cell with the first-stage larva of *T. trilineata*.

TABLE 4.—*Stages of* Tepperella trilineata *and* Eurytoma gahani *found associated in Gall Cells on* Acacia decurrens *during a period of Sixteen Months.*

Date of Dissection.	Number of Gall Cells Examined.	Stage of Larvae of *Tepperella trilineata* in Cell.	Stage of Larvae of *Eurytoma gahani* in the same Cell.
		1935–36 Galls.	
11/5/36	4	4 fourth.	1 second, 3 third.
	1	1 fourth.	1 third.
16/5/36	3	3 fifth.	2 third, 1 fifth,
	1	1 fourth.	1 third.
27/5/36	1	1 fifth.	1 third.
5/6/36	1	1 fifth.	1 third.
11/7/36	1	1 third.	1 second.
16/7/36	1	1 third.	1 second.
	4	4 fifth.	3 fourth, 1 fifth.
9/8/36	9	9 fifth.	1 third, 8 fourth.
12/8/36	7	7 fifth.	7 fourth.
	3	3 fourth.	2 second, 1 third.
6/9/36	1	1 fourth.	1 third.
		1936–37 Galls.	
31/10/36	1	1 egg.	1 egg.
29/11/36	1	1 first.	1 egg.
13/12/36	1	1 first.	1 egg.
14/12/36	1	1 second.	2 eggs.
16/1/37	1	1 first.	1 first.
	1	1 second.	1 first.
30/1/37	3	3 first.	3 first.
1/2/37	2	2 first.	2 first.
	2	2 first.	2 eggs.
15/2/37	1	1 second.	1 first.
9/3/37	4	4 second.	4 first.
	1	1 third.	1 third.
	1	1 fifth.	1 fourth.
2/4/37	1	1 second.	1 first.
	4	4 third.	2 first, 2 second.
20/4/37	9	9 third.	9 second.
7/5/37	1	1 second.	1 second.
	8	8 third.	8 second.
	7	7 fourth.	6 second, 1 third.
1/6/37	1	1 third.	1 second.
	5	5 fourth.	5 third.
29/6/37	1	1 third.	1 second.
	2	2 fourth.	2 third.
	6	6 fifth.	5 third, 1 fourth.
15/7/37	13	13 fifth.	13 third.
6/8/37	14	14 fifth.	14 fourth.
13/8/37	18	18 fifth.	2 third, 16 fourth.
30/8/37	6	6 fifth.	6 fourth.
	1	1 third.	1 second.

In January and the beginning of February, 1937, the first-stage larvae of the two species were sometimes found in association, but for the greater part of the year the larvae of *T. trilineata* were one stage, and occasionally two stages, ahead of the larvae of *Eurytoma gahani* with which they were associated, and the size of the larvae of the former was always greatly in excess of the size of those of the latter species.

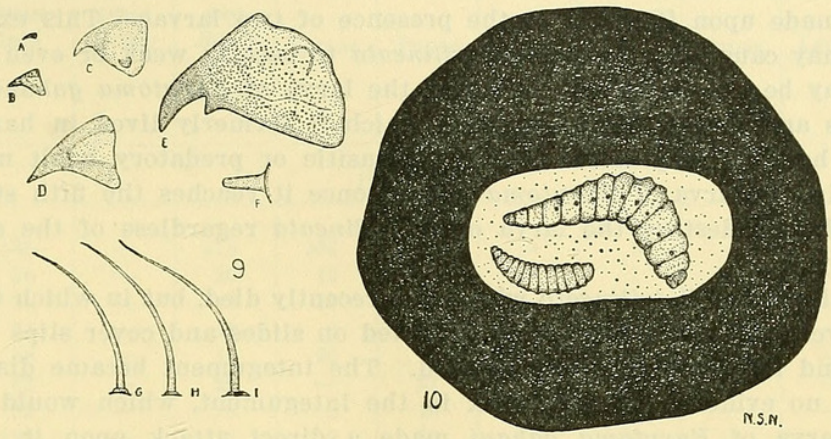


Fig. 9.—*Eurytoma gahani*: A, Mandible of first-stage larva; B, Mandible of second-stage larva; C, Mandible of third-stage larva; D, Mandible of fourth-stage larva; E, Mandible of fifth-stage larva; F, Antenna of fifth-stage larva. (× 180.) G, H, I, Setae from first segment of mature larva (× 103).

Fig. 10.—Cross section of a fully-developed unilocular gall showing a maturing larva of *Tepperella trilineata* in the cell together with a fourth-stage larva of *Eurytoma gahani*, the latter larva being the smaller (× 7). Sectioned 14th August, 1936.

During the earlier part of the larval life the plant tissues fit closely up against the integument of the larvae, and there is no room for movement. As the two larvae feed upon the contents of the surrounding nutrient layer, their alimentary tracts, which are blind sacs, become green in colour, and gradually as the nutrient layer is devoured and the galls increase in size, the two larvae are to be found in fairly large gall chambers in which there is room for movement, and while it is more usual to find the small larva of *E. gahani* touching the larva of *T. trilineata*, the two larvae are sometimes found at opposite ends of the chamber (fig. 10).

All stages of *Eurytoma gahani*, except the last larval stage, possess some powers of locomotion, the second and third larval stages in particular being able to crawl along quite actively. With the increased space in the gall chambers is correlated the further development of the respiratory systems in the two species of larvae. This has been referred to when discussing the morphology of these species.

The two species of larvae continue to develop normally together until the late winter, when it is found that the majority of the larvae of *T. trilineata* have reached the last larval stage. At this time the galls have also reached their full size. However, larvae of *T. trilineata*, which are present in cells with the larvae of *E. gahani*, are never able to pupate, and by the time the larvae of the latter species reach the fifth or last larval stage, the larvae of *T. trilineata* have an unhealthy appearance, and are sluggish and abnormal. Eventually the cells are found to contain maturing larvae of *Eurytoma gahani* and the dead remains of the larvae of *T. trilineata*, and finally all traces of the latter disappear, having

been devoured by the last-stage larvae of *Eurytoma gahani*, which reach maturity and subsequently pupate in the cell formerly occupied by the two species. Factors which bring about the destruction of the larvae of *T. trilineata* are not clear.

It is possible that the exhaustion of the food supply may play an important part, as examination of cells in which the larva of *T. trilineata* are dead shows that the inner wall is hard and dry, the nutrient layer having completely disappeared, this exhaustion of the food supply possibly being due to the extra demands made upon it owing to the presence of two larvae. This exhaustion of the food may cause the larva of *T. trilineata* to become weak or even to die, and hunger may be the factor which causes the larva of *Eurytoma gahani* to become predaceous and devour the larva with which it formerly lived in harmony. On the other hand, it is possible that the parasitic or predatory habit may develop normally in the larva of *Eurytoma gahani* once it reaches the fifth stage, and it may attack and destroy the larva of *T. trilineata* regardless of the state of the food supply.

Many larvae of *T. trilineata* which had recently died, but in which the stomach contents were still quite fluid, were mounted on slides and cover slips were superimposed and light pressure was applied. The integument became distended, but there was no evidence of any break in the integument, which would be present had the larva of *Eurytoma gahani* made a direct attack upon it. Continued pressure of the cover glass usually forced the stomach contents out through the anus. In more shrivelled specimens of dead larvae of *T. trilineata* gaping ruptures were present in the integument. These must have been made by the larva of *Eurytoma gahani*, but it seems much more likely that these ruptures were made after the death of *T. trilineata*, as otherwise such ruptures should be present in all the dead larvae.

In any case *Eurytoma gahani* behaves as a predator rather than a parasite, and though many hundreds of cells were examined in 1936 in which both species of larvae were present, it was only on very rare occasions that the larva of *Eurytoma gahani* was actually observed feeding on the larva of *T. trilineata.*

Though the great majority of the larvae of *T. trilineata* were devoured during August, 1936, at each weekly examination of galls from May onwards occasional maturing larvae of *Eurytoma gahani* were found in cells with dead *T. trilineata* larvae of the last stage. Though at any particular period of the year the majority of the larvae of *Eurytoma gahani* are at the same stage, a few cells may be found in which the larvae of this species are more advanced.

In Table 5 are set out the results of a series of gall dissections during the last six months of 1936 and also in August and September, 1937, and which indicate the various stages of both *Tepperella trilineata* and *Eurytoma gahani* present. Some maturing larvae of *Eurytoma gahani* were found as early as 16th May, 1936, but it will be seen from Table 5 that in the dissections of galls on 3rd August and 9th August only six larvae of *Eurytoma gahani* were found alone, while the larvae of the two species were still together in 90 cells.

On 22nd August, 1936, however, in 52 out of a total of 58 cells examined it was found that the larvae of *Eurytoma gahani* had devoured those of *T. trilineata*, and in 1936 and 1937 it was mainly during the last half of August and the first half of September that the majority of the larvae of *E. gahani* devoured those of *T. trilineata* and reached maturity. A remarkable increase in the size of the larvae of *Eurytoma gahani* occurs during this time, larvae of this species which have devoured the larvae of *T. trilineata* increasing to twice the size

TABLE 5.—*Results of Dissection of Galls on* Acacia decurrens *showing Stages of* Tepperella trilineata *and* Eurytoma gahani *present during the last half of* 1936 *and in the spring of 1937.*

Date of dissection.	No. of Cells Examined.	No. of Emergence Holes.	Cells containing both *T. trilineata* and *Eurytoma gahani.*	*Tepperella trilineata.*			*Eurytoma gahani.*			Cells occupied by other Species.
				Larvae.	Pupae.	Adults.	Stage V Larvae.	Pupae.	Adults.	
1936 Galls.										
8-16/6/36	545	—	278	262	—	—	5	—	—	—
26/7/36	36	—	20	15	—	—	1	—	—	—
28/7/36	30	—	13	16	1	—	—	—	—	—
3/8/36	75	—	49	8	13	—	5	—	—	—
9/8/36	68	—	41	20	6	—	1	—	—	—
18/8/36	82	—	26	—	21	—	35	—	—	—
22/8/36	85	—	6	8	19	—	52	—	—	—
30/8/36	136	—	13	9	30	1	83	—	—	—
6/9/36	253	—	14	2	40	3	144	—	—	50
9/9/36	77	—	5	—	12	1	45	—	—	14
13/9/36	98	1	1	—	14	9	44	—	—	29
20/9/36	151	35	—	—	2	10	69	—	—	35
27/9/36	222	42	1	—	1	11	142	—	—	25
4/10/36	177	34	2	—	4	4	103	1	—	29
11/10/36	113	18	—	—	—	—	63	7	—	25
18/10/36	153	54	—	—	—	—	67	11	—	21
25/10/36	102	28	—	—	—	—	39	31	—	4
1/11/36	114	48	—	—	—	—	27	37	—	2
8/11/36	109	46	—	—	—	—	15	44	4	—
15/11/36	35	15	—	—	—	—	1	17	2	—
22/11/36	44	25	—	—	—	—	—	14	5	—
1937 Galls.										
6/8/37	20	—	17	3	—	—	—	—	—	—
13/8/37	43	—	23	10	4	—	4	—	—	2
30/8/37	57	—	23	5	15	—	6	—	—	8
13-16/9/37	516	—	11	—	84	8	322	—	—	91

First adult of *Tepperella trilineata* emerged on 7th September, 1936.
Last ,, ,, ,, ,, ,, ,, 12th October, 1936.
First ,, ,, *Eurytoma gahani* ,, ,, 30th October, 1936.
Last ,, ,, ,, ,, ,, ,, 5th January, 1937.
The first adult of *T. trilineata* of the following generation emerged on 19th September, 1937.

of larvae of the same stage which are still accompanied by the normal larvae of *T. trilineata.* This great increase takes place in a very short space of time, and it is evident that at this period the larva of *T. trilineata* provides an abundant source of highly nutritious food.

All the available evidence points to the fact that after the larva of *Eurytoma gahani* devours the larva of *T. trilineata* it partakes of no further food, but it is evident that this species remains in the mature larval stage within the galls for several months prior to pupation.

A number of larvae of *Eurytoma gahani* were taken from cells in August after devouring the larvae of *T. trilineata* and were measured, and they were just as large as larvae of the same species removed from the galls several months later. Moreover, it has already been pointed out that at the time the larva becomes predaceous the inner wall of the gall cell or chamber is hard and dry.

Many larvae of *Eurytoma gahani* which were removed from galls on 2nd August, 1936, and placed on cotton wool in petri dishes remained alive for periods of two and three months and finally voided waste matter and pupated normally.

The smallest and the largest larvae of the various stages of *Eurytoma gahani* measured are set out in Table 2. It will be seen that the growth in the various stages is fairly regular, there being comparatively little overlapping in size in the various stages, and that the larva almost doubles its size during the last larval stage.

Dissection of the larvae of *Tepperella trilineata* which are in cells with *Eurytoma gahani* shows that numbers of them contain also larvae of a parasite, *Megastigmus* sp. As *Eurytoma gahani* devours the larvae of *T. trilineata* it accidentally also becomes a predator of the larvae of *Megastigmus* sp. in those cells.

During 1936 and before any of the larvae of *Tepperella trilineata* had been devoured, six twigs of galls were taken and every cell examined and the species present recorded. Cells containing strange larvae were discarded, and the number of cells in which *T. trilineata* occurred alone and with *Eurytoma gahani* were recorded, and then all the larvae of *T. trilineata* were dissected in order to determine whether *Megastigmus* sp. was present. The results of these dissections are set out in Table 6.

TABLE 6.—*Numbers of Larvae of* Tepperella trilineata, Megastigmus sp. *and* Eurytoma gahani *present in Galls on* Acacia decurrens *at Lindfield, Sydney, in 1936.*

Twig No.	Total Gall Cells.	Total Cells containing Larvae of *T. trilineata.*	Total Cells containing Larvae of *Megastigmus* sp.	Cells containing Larvae of *Eurytoma gahani.*	Cells containing only Larvae of *T. trilineata.*	Cells containing Larvae of *Megastigmus* sp. within Larvae of *T. trilineata.* Larvae of *E. gahani* absent.
1	54	54	15	25	21	8
2	63	63	27	29	19	15
3	54	54	27	26	15	13
4	136	136	50	78	36	22
5	116	116	40	68	35	13
6	122	122	52	67	29	26
Total ..	545	545	211	293	155	97

Knowing the habits of these three species, it is evident that though there were originally 545 cells containing larvae of *T. trilineata*, only 155 or 28·44 per cent. of this species could have emerged as adults, while from the same galls, though 211 larvae of *Megastigmus* sp. were present, only 97 or 17·80 per cent. could have

emerged as adults, while of the 293 larvae of *Eurytoma gahani* present and which occupied 53·76 per cent. of the cells, all would have emerged as adults, no larvae of this species ever having been found parasitized, though many hundreds have been examined. In the spring of 1937 examination of a further series of 545 gall cells from the same tree showed that 362 or 66·42 per cent. would have yielded adults of *Eurytoma gahani*, this remarkably successful species having increased in numbers at the expense of *Tepperella trilineata* and *Megastigmus* sp. as compared with 1936.

The preceding figures give an excellent idea of the relative abundance of the three species of Chalcids in the galls. It is of interest to note that until the larvae of *T. trilineata* and *Eurytoma gahani* reach the last stage, the development of *T. trilineata* when associated with *E. gahani* was just as rapid as that of larvae which were in cells alone, indicating that during this period the presence of the larva of *Eurytoma gahani* has no visible adverse effect upon the larva of *T. trilineata*. This is further borne out by the fact that development of galls in which the two larvae are associated in the cells is just as rapid and normal as in galls in which the cells were occupied by the larvae of *T. trilineata* alone.

The association of these two species of larvae in the one gall chamber is a remarkable and unusual one.

Kinsey (1920), who has made an exhaustive study of cynipid wasps, which are the main gall-formers of the United States, in discussing inquilines in the galls, pointed out that no struggle existed between these and the primary gall-formers, that the larvae of the two species lived in closely identical environments, but that they did not come in contact with one another or interfere with one another in any way. Judged on this basis, *Eurytoma gahani* could not at any stage be classed as an inquiline. In some respects during its early larval stages its behaviour resembles that of an inquiline, but it is always a competitor and becomes a predator in its last larval stage.

Triggerson (1914) recorded an unusual phenomenon in the case of a Cynipid gall wasp, *Dryophanta erinacei*, in America. A second species of Cynipid, *Synergus erinacei*, destroyed the larva of *D. erinacei*, and then tunnelled through the galls to the various cavities and fed upon the occupants.

The occurrence of the parasitic and phytophagous habit in a single chalcid species has been observed by a number of workers, but the behaviour of *Eurytoma gahani*, in a number of respects, is unusual. It is the intention of the writer to discuss phytophagy and parasitism in the Chalcidoidea in a later paper.

Pupation and the Pupal Period.

As with the other species studied in this gall complex, no waste matter is voided during larval life, but some days prior to pupation the larva voids from the anus a quantity of black and fairly solid waste matter. In the gall cells this waste matter usually becomes broken to fine black particles which adhere to the larva and later the pupa, but sometimes it remains as one long twisted black strand adhering to the tip of the pupa. The quantity of waste matter voided by the mature larva is considerable and much more than in any chalcid larvae previously studied by the writer.

On first passing to the pupal stage, the pupa is a uniform white in colour, but within twenty-four hours the head, thorax and wing buds become amber and the pupae remain thus for approximately two weeks, when they gradually commence to turn black, and some days before emergence the pupae are a

uniform black. The average length of the pupa of *Eurytoma gahani* is 2·46 mm., the maximum being 2·66 mm., and the minimum 2·19 mm.

From August until November, 1936, large numbers of mature larvae were dissected from galls and placed on either blotting paper or cotton wool in petri dishes, and fifty-eight of these pupated in a normal manner and eventually emerged as adults. The pupal period under these conditions is set out in Table 7. It will be seen that the pupal period ranged from 25 to 36 days, the average for male wasps being 32·84 days and for female wasps 33·13 days. The first pupa was found in a gall on 4th October, 1936, and the first adult of *Eurytoma gahani* emerged on 30th October, 1936.

TABLE 7.—*Pupal period of* Eurytoma gahani *in the Laboratory, 1936.*

Pupal Period in Days.	Number of Males.	Number of Females.
25	—	1
26	1	—
27	—	—
28	1	1
29	1	2
30	1	1
31	1	1
32	4	1
33	7	6
34	5	8
35	3	7
36	3	3
Total ..	27	31

Average pupal period of male wasps, 32·84 days ; female wasps, 33·13 days.
Maximum „ „ „ „ „ 36 „ „ „ 36 „
Minimum „ „ „ „ „ 26 „ „ „ 25 „

Emergence of Adults.

Adult wasps emerge by eating a cylindrical channel out to the exterior of the gall. In figure 11 is shown graphically the daily emergence of 2,779 adults of *Eurytoma gahani* from galls on *Acacia decurrens* in 1936.

It will be seen that emergence commenced on 30th October, 1936, and continued until 5th January, 1937. Though the emergence period extended over 68 days, it will be seen that by far the greatest numbers emerged during the second half of November and the first half of December. This emergence period was approximately twice as long as that of *T. trilineata* from the same tree.

In figure 11 is also shown graphically the emergence of 1,058 adults of *T. trilineata* and 1,559 adults of *Megastigmus* sp., an internal larval parasite of *Tepperella trilineata*. While figure 11 indicates the emergence periods of the three species, it does not represent their relative abundance, as it was not always possible to obtain emergence records of the three species from the same galls, the total period being so extensive that galls used in the early part of the emergence period became so hard and dry that they were unsuitable for later emergence

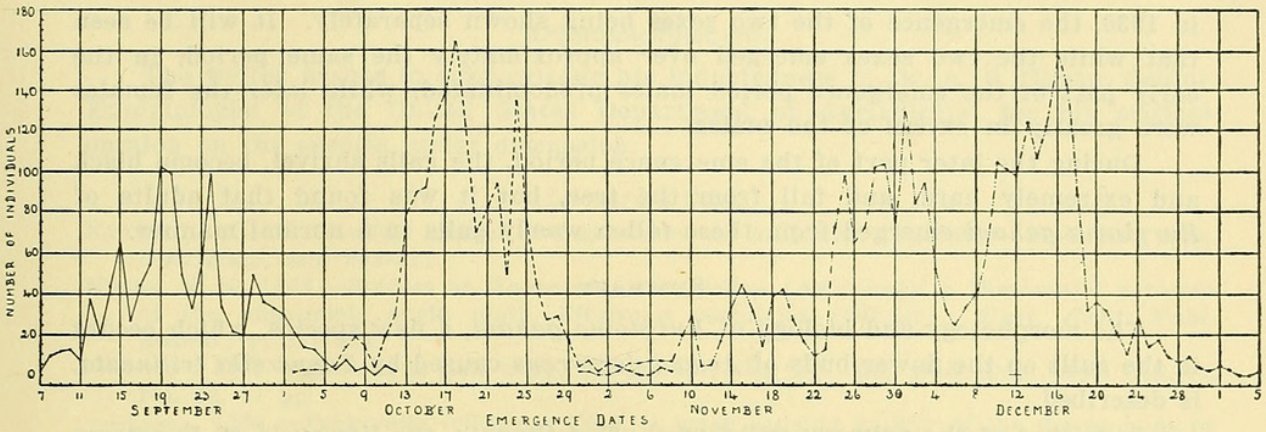


Fig. 11.—Graph showing daily emergence of *Tepperella trilineata*, *Megastigmus* sp. and *Eurytoma gahani* in 1936-37, from galls on *Acacia decurrens*.
(1058) *T. trilineata* ————
(1559) *Megastigmus* sp. - - - - - - - - - - - -
(2779) *E. gahani* —··—··—··—

records. It will be seen that the first adult of *Eurytoma gahani* did not emerge until eighteen days after the last adult of *T. trilineata* emerged and only six days before the last adult of *Megastigmus* sp. emerged.

In figure 12 is shown graphically the emergence of 1,605 adults of *Eurytoma gahani*, representing the total emergence of this species from one batch of galls

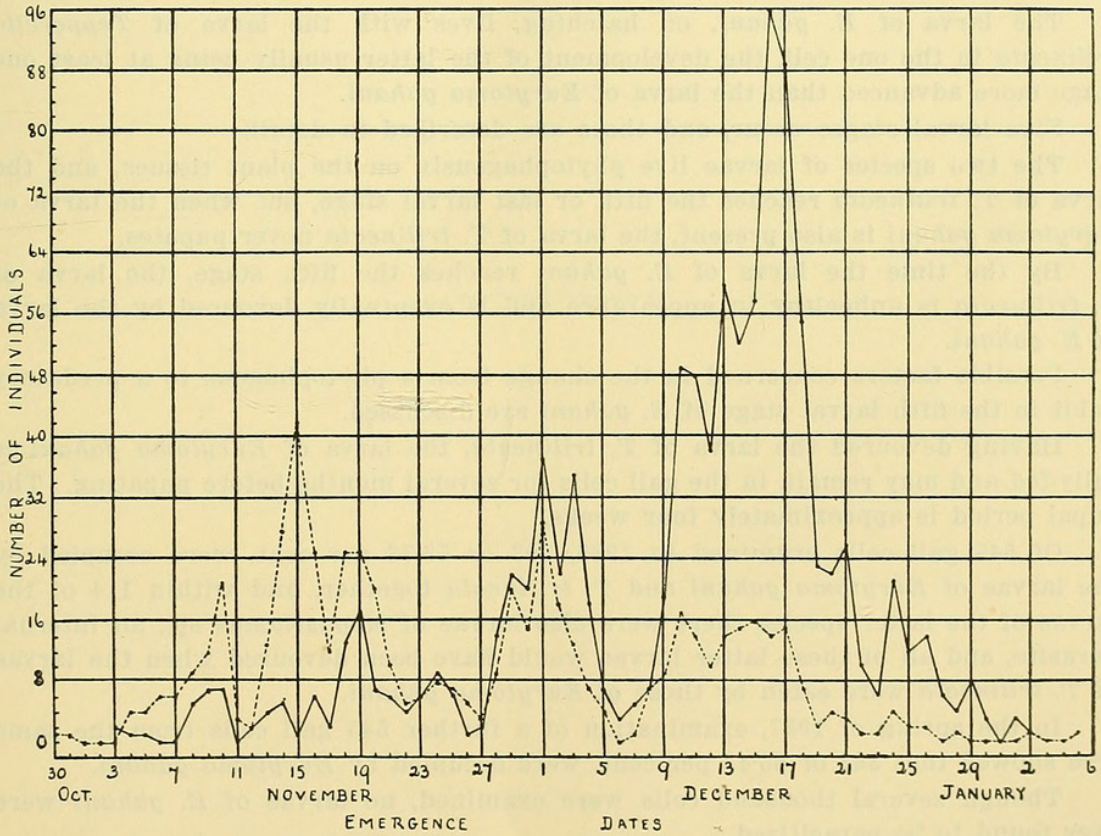


Fig. 12.—Graph showing daily emergence of 1028 females and 577 males of *Eurytoma gahani* from galls on *Acacia decurrens* in 1936-37.
(1028) females ————
(577) males - - - - - - - - - - - -

in 1936, the emergence of the two sexes being shown separately. It will be seen that while the two sexes emerged over approximately the same period, in the early part of the emergence period males predominated, while later the females were greatly in excess of the males.

During the later part of the emergence period, the galls shrivel, become black and extremely hard, and fall from the tree, but it was found that adults of *Eurytoma gahani* emerged from these fallen woody galls in a normal manner.

Summary.

The morphology and biology of *Eurytoma gahani*, a new species, which occurs in the galls on the flower buds of *Acacia decurrens* caused by *Tepperella trilineata*, is described.

Like that of the primary gall-former, *T. trilineata*, the life cycle of *Eurytoma gahani* is annual.

The adults of *E. gahani* emerge from the galls mainly during November and December, some time after all the adults of *T. trilineata* have emerged.

Of 1,605 adults of *Eurytoma gahani* which emerged in 1936, 1,028 or 64·05 per cent. were females and 577 or 35·95 per cent. were males. The average length of life of male wasps was 6·82 days, and of female wasps 8·17 days, but the maximum length of life of male wasps was 22 days and of female wasps 27 days.

The egg of *Eurytoma gahani* is deposited alongside the egg, or more commonly the first-stage larva, of *T. trilineata* within the minute acacia flower-buds or aborted flower-heads.

The larva of *E. gahani*, on hatching, lives with the larva of *Tepperella trilineata* in the one cell, the development of the latter usually being at least one stage more advanced than the larva of *Eurytoma gahani*.

Five larval stages occur, and these are described in detail.

The two species of larvae live phytophagously on the plant tissues, and the larva of *T. trilineata* reaches the fifth or last larval stage, but when the larva of *Eurytoma gahani* is also present, the larva of *T. trilineata* never pupates.

By the time the larva of *E. gahani* reaches the fifth stage, the larva of *T. trilineata* is unhealthy in appearance and is eventually devoured by the larva of *E. gahani*.

Possible factors concerned in the change from a phytophagous to a predatory habit in the fifth larval stage of *E. gahani* are discussed.

Having devoured the larva of *T. trilineata*, the larva of *Eurytoma gahani* is fully-fed and may remain in the gall cells for several months before pupating. The pupal period is approximately four weeks.

Of 545 gall cells examined in 1936, 293 or 53·76 per cent. were occupied by the larvae of *Eurytoma gahani* and *T. trilineata* together, and within 114 of the larvae of the latter species there were also larvae of *Megastigmus* sp., an internal parasite, and all of these latter larvae would have been devoured when the larvae of *T. trilineata* were eaten by those of *Eurytoma gahani*.

In the spring of 1937, examination of a further 545 gall cells from the same tree showed that 362 or 66·42 per cent. were occupied by *Eurytoma gahani*.

Though several thousand cells were examined, no larvae of *E. gahani* were ever found to be parasitized.

The presence of the larva of *E. gahani* does not affect the development of the galls.