ECOLOGY OF OVIPOSITION AND THE STRUCTURE OF EGG-PODS AND EGGS IN SOME INDIAN ACRIDIDAE

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(With 19 Text-figures)

CONTENTS

I—INTRODUCTION

Little work has been done on the ecology of oviposition and egg-pots, etc., of Indian short-horned grasshoppers (Orthoptera, family Acrididae), except in the case of Desert Locust, *Schistocerca gregaria* Forskal and one or two other species. Considerable work, however, has been done by Zimin (1935 ; 1938) on the Russian species, by Waloff (1950) on those of Great Britain and by Morales Agacino (1951) on the Spanish species.

In the present account the author has described the mode of oviposition in 14 northern Indian species occurring in Dehra Dun and Saharanpur Districts of Uttar Pradesh, the ecological relationship to soil in 20 species, the structure of the egg-pods in 14 species and of the egg-chorion in 10 species, all from the same area as mentioned above.

The author wishes to thank Dr. M. L. Roonwal, F.N.I., Chief Research Officer (Forest Entomologist), Forest Research Institute, Dehra Dun (now Director, Zoological Survey of India, Calcutta), under whose guidance this work was carried out, for his stimulating advice and encouragement during the progress of this work.

II—MODE OF OVIPOSITION

(a) *General*

Künckel d' Herculais (1893-1905) first observed the process of oviposition in *Schistocerca gregaria.* Fedorov (1927) studied the details of oviposition, by means of a special cage, in the Egyptian grasshopper,

Anacridium aegyptium. Uvarov (1928) described oviposition in general in the Acrididae. Agarwala (1951) gave a detailed account of oviposition in *Locusta migratoria migratorioides*. Katiyar (1955, 1956*a*) briefly described oviposition in two Indian species, namely, *Aularches punctatus* and *Parahieroglyphus bilineatus*.

The present account deals with oviposition in the following 14 species as observed in the insectary as well as in the field under natural conditions :—

Subfamily (i) *ACRIDINAE*

1. *Ceracris deflorata* Brunner
2. *Phlaeoba panteli* Bolivar

Subfamily (ii) *CATANTOPINAE*

3. *Choroedocus insignis* Thunberg
4. *Choroedocus* sp.
5. *Eyprepocnemis roseus* Uvarov
6. *Hieroglyphus banian* Fabricius
7. *Hieroglyphus nigrorepletus* Bolivar
8. *Parahieroglyphus bilineatus* Bolivar
9. *Schistocerca gregaria* Forskal
10. *Spathosternum prasiniferum* Walker
11. *Xenocatantops humilis humilis* Serville

Subfamily (iii) *OEDIPODINAE*

12. *Locusta migratoria migratorioides* Reich & Frm.

Subfamily (iv) *PYRGOMORPHINAE*

13. *Aularches punctatus* Drury
14. *Chrotogonus concavus* Kirby

(b) *Observations and discussion*

In all the 14 species studied, the abdomen of the female, during oviposition, is extended out gradually to almost double its normal length. The mechanism of the extension is obscure. Künckel d' Herculais (1893-1905) maintained that the primary cause of extension is blood pressure. The deposition of eggs and their orientation in the egg-pod is fundamentally similar in all these species but there are important differences in detail which are described below.

After depositing the frothy material, the female extrudes the eggs one by one after a little pause between two successive eggs. Each egg passes out between the tips of the dorsal valvulae of the ovipositor. The micropylar end of the egg always comes out first and points downwards during oviposition and, thus, that end always points downwards in the egg-pod. When all the eggs have been laid, the female plugs the egg-pod in one of the two following ways, the exact method differing with the species, thus :—

i In the cases of *Aularches punctatus*, *Ceracris deflorata*, *Choroedocus insignis*, *Choroedocus* sp., *Chrotogonus concavus*, *Eyprepocnemis roseus*, *Phlaeoba panteli*, *Spathosternum prasiniferum*, and *Xenocatantops humilis humilis*, the female makes a fragile, frothy cap above the eggs. In the cases of *Hieroglyphus banian*, *H. nigrorepletus* and *Parahieroglyphus bilineatus*, the female plugs the egg-pod with some secretion which forms a hard cap above the eggs. A little hardened secreted material is also deposited above the cap. Ghen the female withdraws the abdomen from

the oviposition hole, it scraps the surface of the soil around the hole with its hind-legs and throws it on the top of the hole to cover it completely. In a few cases, the soil is so nicely levelled that no trace of the hole can be detected from the outside.

During oviposition the various species make different angles varying from about 10° to 65° with the body above the surface of the soil and from about 80° to 140° below the soil with the abdomen. The angles are measured from the ventral aspect of the female. An accurate measurement of the angles is rather difficult due to the small size of the females in two species, namely, *Spathosternum prasiniferum* and *Chrotogonus concavus*. This varying range of angle during oviposition has been studied by me under 3 categories. The angle so made seems to be correlated with the mode of copulation of which I have recognised three types as follows :—

Mode I—Male rides on the back of the female head to head during copulation.

Mode II—Male comes to be on the side of the female during copulation.

Mode III—Male neither rides on back of the female nor lies at her side, but hangs passively attached to the abdomen of the female during copulation (Katiyar, 1952 & 1956).

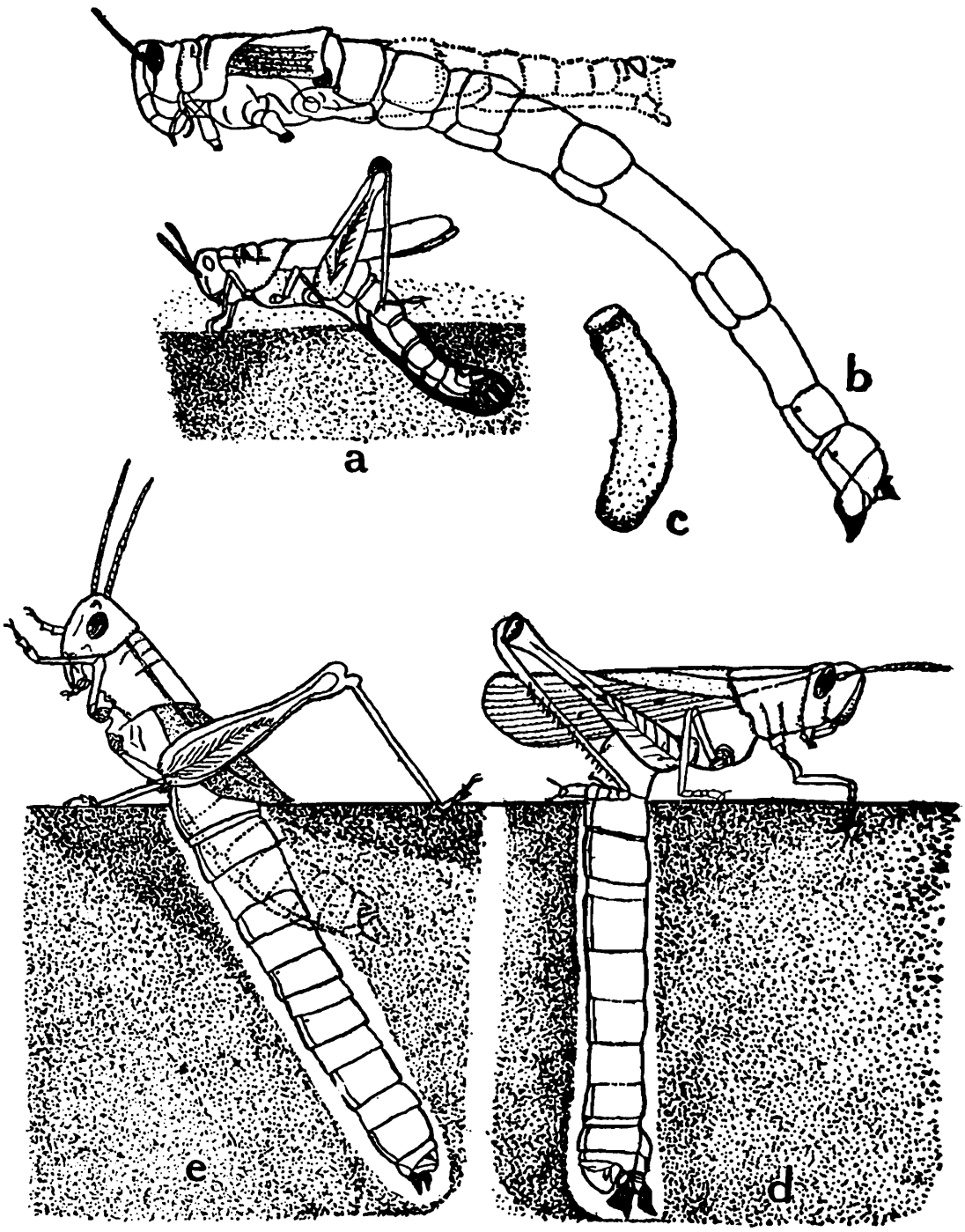
The three types of ovipositions are described below :

(i) *The First Category*.—The female as usual searches for a suitable place for oviposition. It then makes a slanting hole (Text-fig. 1*a*) with an angle of 10°—25° above the soil with the body and of 120°—140° below the soil with the abdomen. This type of posture was observed in all the 10 species which copulate by Mode I, and in *Phlaeoba panteli* which copulates "dorso-laterally", *i.e.*, intermediate between Modes I and II. The species are :—

1. *Aularches punctatus*
2. *Ceracris deflorata*
3. *Chrotogonus concavus*
4. *Eyprepocnemis roseus*
5. *Hieroglyphus banian*
6. *Hieroglyphus nigrorepletus*
7. *Locusta migratoria migratorioides*
8. *Phlaeoba panteli* (Mode of copulation between Modes I and II)
9. *Schistocerca gregaria*
10. *Spathosternum prasiniferum*
11. *Xenocatantops humilis humilis*

(ii) *The Second Category*.—The female first starts digging the hole in a slightly slanting position as in Category I. A little lower down, the angle of the hole is changed to a right angle with the surface. The female thus makes an angle of 15°—35° above the soil and of 80°—90° below the soil (Text-fig. 1*d*). Two species, *viz.*, *Choroedocus insignis* and *Choroedocus* sp., fall in this category and both copulate by Mode II.

(iii) *The Third Category*.—The female makes an angle of 45°—65° above and of 110°—120° below the soil. The entire body of the female remains virtually in a straight line during oviposition. The only species falling under this category is *Parahieroglyphus bilineatus* ; it copulates by Mode III (Katiyar, 1952). Unlike other categories, the female here buries itself in the ground up to the hind tibia (sometimes up to the hind tarsi and even claws) and the head is lifted up. Thus, during oviposition, the body-parts above the soil form a straight line with the abdomen below the soil (Text-fig. 1*e*).



TEXT-FIG. 1.—Oviposition in the Desert Locust, and in *Choroedocus insignis* Thunberg and *Parahieroglyphus bilineatus* Bolivar.

(*a*) Female grasshopper, Desert Locust, during oviposition (after Gibson). (*b*) Extension of abdomen of female Desert Locust during oviposition ; dotted outline shows the normal size of the abdomen (after Vosseler). (*c*) Egg-pod of Desert Locust. (*d*) Extension of abdomen of female *Choroedocus insignis* Thunberg during oviposition. (*e*) Extension of abdomen of female *Parahieroglyphus bilineatus* Bolivar during oviposition.

III—Ecology of oviposition in some Indian Acrididae

Some general ecological observations on 20 species of Acrididae studied around Dehra Dun in relation to egg-pod deposits are recorded here.

All the species of Acrididae studied around Dehra Dun deposit their eggs under the soil-surface in egg-pods. For this study several hundred females, of different species have been watched in different localities in fields as well as in different cages in the insectary, trying in

two or three places and then finally selecting a suitable place for oviposition. I have noticed that the place for oviposition is always selected by the female with the following two considerations in view :—

1. That the eggs should be deposited under the xerophilic soil (dry soil), mesophilic soil (soil without abundance of moisture although top layer being moist), or hygrophilic soil (soil with abundant moisture), as the case may be, but usually at places where the egg-pods may not be destroyed or detected easily.

2. That the eggs should be laid at places where green vegetation as food may easily be available for the newly hatched hoppers.

As regards the first point, egg-pods have been dug out from (or the females have been watched ovipositing the eggs in) various situations, such as near or along the margins of trodden paths, field margins, near the roots of bushes and hedges, sometimes under the shaded trees and occasionally in high grass-lands, but never in the middle of the fields, gardens and nurseries, etc. The above noted places of oviposition are favourable for the newly hatched hoppers too, as they get enough food there when it is not available in the middle of the fields.

The preferences of the various species for soil conditions are given below :—

(a) Species preferring dry or xerophilic soils for oviposition :—*Hieroglyphodes assamensis*, *Hieroglyphus concolor*, *H. banian*, *H. nigrorepletus*, *Parahieroglyphus bilineatus*, *Schistocerca gregaria*, *Locusta migratoria* and *Chrotogonus concavus*.

(b) Species preferring mesophilic soils :—*Xenocatantops humilis humilis*, *Catantops splendens*, *Choroedocus insignis*, *Choroedocus* sp., *Eyprepocnemis roseus*, *Oedaleus abruptus*, *Gastrimargus transversus* and *Spathosternum prasiniferum*.

(c) Species preferring hygrophilic soil :—*Aularches punctatus* and *Poecilocerus pictus*.

(d) Species ovipositing in all types of soils :—*Ceracris deflorata* and *Phlaeoba panteli*.

The preference for the preferred soils is so great that in many cases the females were observed feeling quite miserable on unfavourable soils due to heavy weight in their ovaries. Under such conditions they either drop their eggs on the soil-surface, grass-leaves, etc., or stop taking food and ultimately die* without oviposition.

It was observed that egg-pods of species which prefer xerophilic soil are easily distinguishable morphologically from those of meso- and hygrophilic soils. The xerophilic egg-pods are simple and short, while there is a great variation in the length and shape of the meso- and hygrophilic pods. In the xerophilic pods the outer wall consists of very rough, tough, hard and cemented secreted material ; there is a hard, smooth and concave cap just above the layers of the eggs or at the apex of the pod ; in some cases above the cap, the top-section is filled with secreted material which is hard, compact and easily detachable. In the mesophilic pods the outer wall of the egg-pod is not cemented, but is rough, slightly hard and consists of a few layers of dense, laminated, secreted material, with or without a cap at the top ; the cap is usually soft and membranous when present. In the hygrophilic pods, the outer wall is usually smooth or rough, spongy or frothy, usually fragile ; it is without any cap at the top but the top-section is filled with coarsely-meshed, spongy secreted material, with septa- or hexagonal empty spaces or cells.

* Such females were dissected and it was noticed that their ovaries were laden with the matured eggs, but the alimentary canal was quite empty.

It was also observed that variation in the length of the egg-pods depends on the nature of the soil in which they are laid. Such variation was noticed in the egg-pods of the same species ovipositing in different soils, as in *Ceracris deflorata* and *Eyprepocnemis roseus*. The pods laid in different soils varied greatly in length. The females of average length of *Ceracris deflorata* were bred in the insectary in 3 different cages provided with sandy-loam, clayey soil and stony soil. The length of egg-pods was found to be 9—16 mm., 8—13 mm., and 4—7 mm., respectively.

It was further observed that soil moisture also plays some part in determining length of the egg-pod laid by a female. The pods of a few common species, namely, *Spathosternum prasiniferum*, *Phlaeoba panteli* and *Choroedocus insignis* found in the New Forest Estate, near Dehra Dun, were longer and thicker than those of the some species obtained from comparatively damper places in the Bibiwala forests near Hardwar (about 40 miles away from Dehra Dun). An experiment in the insectary also confirmed the above fact as follows :—

Three different flower-pots, with a long chimney covered with muslin cloth, were provided with 8—10 cms. thick layer of sandy-loam. Twenty average sized females of *Spathosternum prasiniferum* were kept in each pot for egg-laying. The soil of the first pot was kept without any added moisture ; of the second with a little added moisture ; and of the third very wet. The egg-pods from the first lot (without moisture) were the longest and those from the third lot (very wet soil) were the shortest, the size-range in the 3 lots being as follows :—

Dry soil : 10—17 mm. long.
Medium soil : 8—12 mm.
Very wet soil : 5—8 mm. (9 mm. in one case).

Again, the egg-pods from the light soils are larger than those from the heavy or hard clayey soils. The dimensions of egg-pod also depend to a certain extent on the carrying capacity of the female. Furthermore, egg-pods of the first oviposition are always larger and have more eggs than those of the successive layings, as noticed in *Aularches punctatus* by Katiyar (1955).

The egg-pods in the species studied were laid 5·0—12·5 cms. below the soil-surface. The depth varies from species to species, mainly depending on the length of the abdomen of the female and to some extent on the nature of the soil as well as moisture present in it.

IV.—Structure and Key to the Identification of Egg-pods of Some Indian Acrididae

Vorontsovsky (1926) classified the egg-pods of the Russian Acrididae into the following types : bag, pot, pill, capsule, etc. Zimin (1935) also working on the Russian Acrididae, classified egg-pods according to the following characters :—(i) Sculpture peculiarities of the egg-chorion. (ii) Character (physical structure) of the coagulated secretional liquids in the egg-pod and their consistency and colour. (iii) Structure and structural material of the egg-pod. (iv) Form, colour and distribution of eggs in the pod. (v) Degree of complexity of the structure of the egg-pod. (vi) Manner of closure of the exit-aperture. (vii) Number of eggs in the pod. (viii) Distance from the top of the egg-pod to the top-level of the eggs.

I have followed Zimin's classification as far as possible. In the measurements of size, the *length* is measured along the outer curvature fo the egg-pod, and *width* across the maximum diameter.

The egg-pods of the following 14 species were studied :—

Subfamily (i) *ACRIDINAE*

1. *Acrida gigantea* Herbst
2. *Ceracris deflorata* Brunner
3. *Phlaeoba panteli* Bolivar

Subfamily (ii) *CATANTOPINAE*

4. *Choroedocus insignis* Thunberg
5. *Eyprepocnemis roseus* Uvarov
6. *Hieroglyphus concolor* Herbst
7. *Hieroglyphus nigrorepletus* Bolivar
8. *Hieroglyphodes assamensis* Uvarov
9. *Parahieroglyphus bilineatus* Bolivar
10. *Spathosternum prasiniferum* Walker
11. *Xenocatantops humilis humilis* Serville

Subfamily (iii) *OEDIPODINAE*

12. *Gastrimargus transversus* Thunberg
13. *Oedaleus abruptus* Thunberg

Subfamily (iv) *PYRGOMORPHINAE*

14. *Aularches punctatus* Drury

(*a*) *Description of egg-pods and eggs.*—The characters of the egg-pods and eggs of each of the species listed above are given below briefly :—

Subfamily (i) *ACRIDINAE*

1. **Acrida gigantea** Herbst

(Text-fig. 8 *g-i*)

General : Three pods examined. Pods rough and fragile ; long, cylindrical, straight ; base round or conical ; apex flat, provided with a concave cap. Length of pod 2·8-4·4 cms., width 0·55-0·56 cm. Outer wall dirty brownish white ; internally, the frothy mass above and around eggs light brown. Outer wall consisting of compressed layers of frothy ecretion, thin near the top, thick at the base ; rough, due to the adherence of fine sand particles and bits of stones. Internally, top section filled with very finely meshed froth ; lower or egg-section surrounded by a similar thin layer of forth. A few thin layers of secreted material also lying in between eggs, with a thick frothy pad at the base of pod.

With 52-65 eggs in a pod. Eggs arranged obliquely, one above the other and sloping towards the pod-wall.

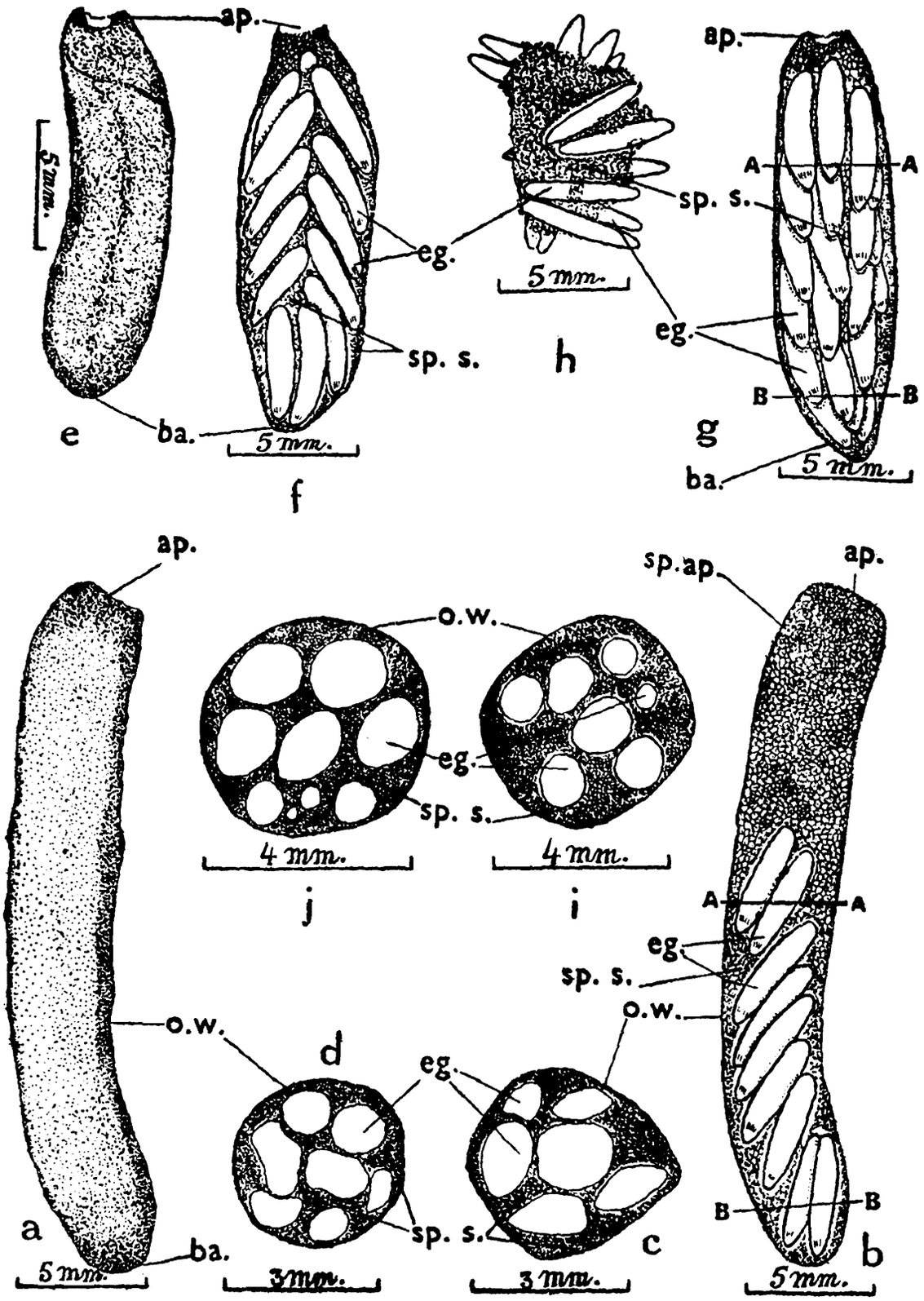
Eggs : Length, 4·5-5·25 mm. ; width, 0·5-0·75 mm. Thin, slender ; rounded at the anterior pole, subconical at the posterior.

Egg-laying : In insectary eggs laid in sandy-loam, eggs laid 5·2-8·8 cms. below soil-surface. Egg-laying observed in 3 cases only ; occurs in Dehra Dun in 3rd and 4th weeks of August.

2. **Ceracris deflorata** Brunner

(Text-fig. 2 *e-j*)

General : Eighteen egg-pods examined. Pods rough and hard ; small, cylindrical, straight or curved ; base round or semiround ; apex



TEXT-FIG. 2.—Eggs and egg-pods of *Phlaeoba panteli* Bolivar and *Ceracris deflorata* Brunner.

(*a*) Egg-pod of *Phlaeoba panteli*. (*b*) Same, with the wall partly removed from lateral side to show arrangement of eggs. (*c*) Same, transverse section across upper line (A-A) in Fig. *b*. (*d*) Same, across lower line (B-B). (*e*) Egg-pod of *Ceracris deflorata*. (*f*) Same, with the wall partly removed from the concave side to show arrangement of eggs. (*g*) Same, with the wall of the convex side removed to show arrangement of eggs. (*h*) Eggs of *Ceracris deflorata* embedded in frothy material laid abnormally on a leaf surface. (*i*) Transverse section of egg-pod of *Ceracris deflorata* across upper line (A-A) in Fig. *g*. (*j*) Same, across lower line (B-B) in Fig. *g*.

ap., apex of egg-pod ; *ba.*, base of egg-pod ; *ca.*, cap of egg-pod ; *eg.*, egg, ; *o.w.*, outer wall of egg-pod ; *sp. ap.*, spongy secretion at apex of egg-pod ; *sp. s.*, spongy secretion in between eggs.

flat, cap usually wanting but in some cases present as a thin, membranous, concave covering caused by contraction of froth when dried. Length of pod 1·45-1·85 cms., width 0·45-0·6 cms. Outer wall dirty salmon to dirty orange-pink ; internally almost all frothy mass above and around eggs orange-pink. Outer wall thin, membranous and rough, due to adherence of soil particles and bits of stones and sometimes bits of leaves and grass also. Internally, one-third of top-section filled with finely-meshed orange-pink froth ; two-thirds of the remaining lower or egg-section surrounded by coarse-meshed layers of orange-pink froth; lining of secreted material in between eggs seen only here and there ; but a thin frothy pad at base of pod always present.

With 14-22 eggs in a pod (or about 14-16 in a mass, when laid on leaves or grass). Eggs arranged in two different styles : On concave side of pod, the posterior end of eggs tending to slope towards pod-wall and anterior end of eggs meeting in middle when viewed from hollow side of pod ; on convex side of pod, eggs arranged irregularly one above the other, *i.e.*, at base a few rows of eggs arranged vertically at right angles to base ; above these the anterior end of eggs tending to slope towards pod-wall, and at top, a few eggs again lying vertically at right angles to base. (When laid on leaves and grasses, no definite arrangement of eggs seen.)

Eggs : Length, 4·5-5·25 mm. ; width, 1·0-1·45 mm. Thin, subcylindrical, straight, with both anterior and posterior ends subconical ; pale yellow to pale brown.

Egg-laying : In insectary, eggs laid in sandy-loam ; in fields in hard soil ; eggs laid 1·5-4·0 cms. below soil-surface. At times eggs deposited at random on leaves, stones or blades of grass instead below the soil ; froth whitish after oviposition, changes to orange-pink. Egg-laying occuring in Dehra Dun from 2nd week June to 3rd week August ; maximum in last week of July.

3. **Phlaeoba panteli** Bolivar

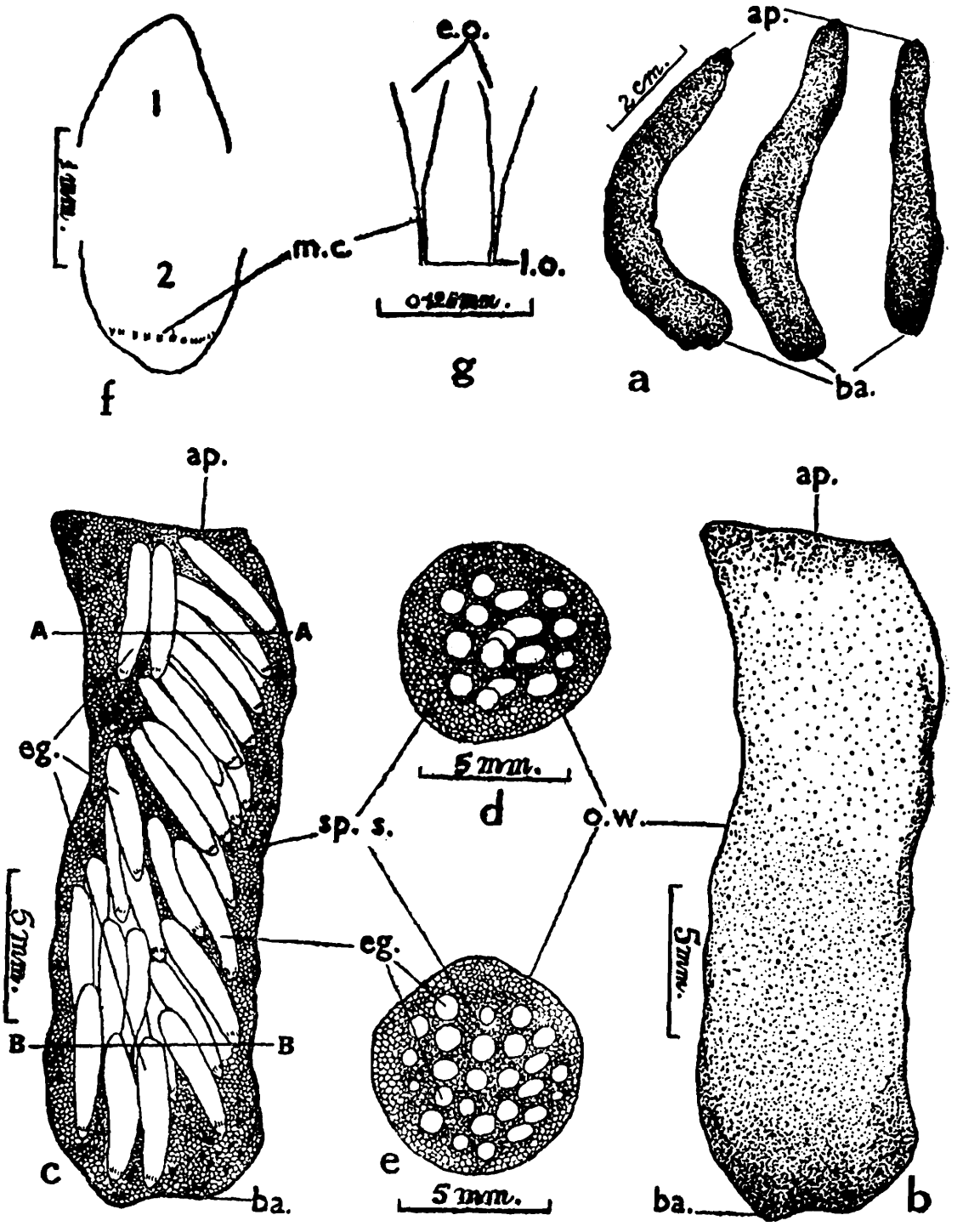
(Text-fig. 2 *a-d*)

General : Twenty-five egg-pods examined. Pods rough and hard ; elongated, straight or bent near base, sometimes near one-third the length from the top ; base round ; apex somewhat round, with no definite cap at top but only a frothy mass above eggs. Length of pod 1·9-2·85 cms.; width, 0·4-0·7 cms. Outer wall dirty brown or pink ; internally, the frothy mass above eggs pale clay yellow, below and around the eggs pinkish brown. Outer wall consisting of a compressed, thick layer of frothy secretion ; wall rough due to adherence of sand particles and bits of small stones. Internally, one-third of top section filled with thick-meshed froth with hexagonal spaces or cells ; two-thirds of the remaining lower or egg-section surrounded by coarsely-meshed thick layer of pink-froth. A thin frothy layer of secreted material lying in between eggs, with coarse-meshed froth at micropyiar end of each egg. No thick frothy pad at base of pod.

With 22-32 eggs in a pod. Eggs arranged in 2-3 rows, sloping towards the pod-wall. 8-9 eggs visible in one plane one above the other on either the concave (hollow) side or the convex (bulging) side of pod.

Eggs : Length, 4·2-5·25 mm.; width, 0·8-1·2 mm. Straight or slightly curved anteriorly ; rounded at the anterior and conical at the posterior ole ; pale to clay yellow.

Egg-laying : In insectary, eggs laid in sandy-loam ; in the field also laid in sandy-loam near roots of thorny bushes and herbs ; eggs laid 2·5-4·8 cms. below soil-surface. Eggs sometimes laid abnormally on leaves and grass. Egg-laying occurring in Dehra Dun from 2nd week May to 3rd week July.



TEXT-FIG. 3.—Eggs and egg-pods of *Choroedocus insignis* Thunberg.

(*a*) Three complete egg-pods to show variation in shape ; upper frothy portion and lower pod-portion. (*b*) Egg-pod without the upperfrothy portion. (*c*) Same, with the wall partly removed to show arrangement of eggs. (*d*) Transverse section of egg-pod across upper line (A-A) in Fig. *c*. (*e*) Same, across lower line (B-B) in Fig. *c*. (*f*) (1) and (2) Anterior andposterior poles of egg respectively. (*g*) Two micropylar canals enlarged from posterior pole of egg shown in Fig. *f*.

ap., apex of egg-pods ; *ba.*, base of egg-pod ; *ca.*, cap of egg-pod ; *eg.*, egg ; *o.w.*, outer wall of egg-pod ; *sp. s.*, spongy secretion in between egg.

Subfamily (ii) *CATANTOPINAE*

4. Choroedocus insignis Thunberg

(Text-fig. 3 *a-g*)

General : Twenty-five egg-pods examined. Pods smooth to slightly hard ; long, subcylindrical, straight, sometimes bent in middle ; base round ; apex subconical, without any cap. Length of pod, 4·8-7·4 cms. ; width, 1·1-1·35 cms. Outer wall dirty clayey due to adhering soil ; internally, apical frothy mass yellowish white, lower part (surrounding eggs) dirty yellow to light brown. Outer wall consisting of thin layer of frothy secretion ; internally, half of top section filled with coarse-meshed froth with hexa- or septagonal empty spaces or cells ; half of the remaining lower, or egg-section, surrounded by fine-meshed frothy pad ; lining of secreted material in between eggs scanty ; a thick frothy pad at base of pod always present.

With 64-95 eggs in a pod. Eggs near bottom arranged vertically at right angles to the base, with the micropylar end pointing straight down to base, above these, eggs tending to slope towards pod-wall ; and at the top, a few layers of eggs again lying vertically at right angles to base ; number both of rows and of eggs in a row variable.

Eggs : Length, 5·2-5·6 mm.; width, 0·9-1·0 mm. Thick, subcylindrical ; straight, sometimes bent slightly ; with both anterior and posterior ends rounded ; Yellow to light brown.

Egg-laying : In insectary, eggs laid in sandy-loam ; in field also in sandy-loam near the roots of the high bushes or grasses ; eggs laid 6·4-10·0 cms. below soil-surface. Egg-laying occurring from 1st week August to 2nd or 3rd week October around Rishikesh (Saharanpur District) and in Dehra Dun from 1st week August to 4th week September.

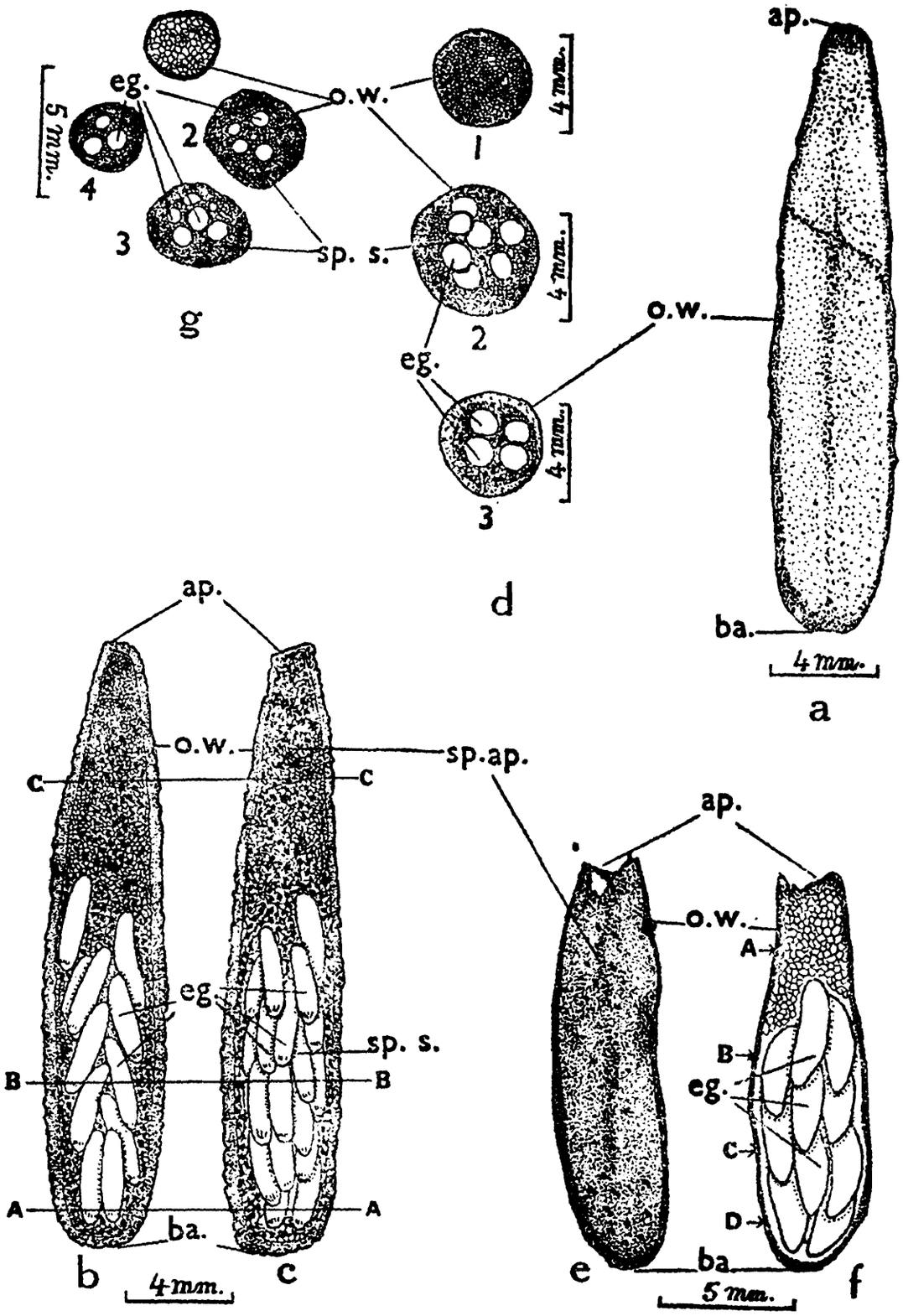
5. Eyprepocnemis roseus Uvarov

(Text-fig. 4 *a-d*)

General : Forty-one egg-pods examined. Pods rough and fragile near apex ; rough, hard near base, surface sometimes appears cork-like ; long, narrow, subcylindrical, straight or curved ; base round ; apex usually flat or subconical, without any cap. Length of pod, 2·7-3·8 cms.; width, 0·35-0·5 cms. Outer wall dirty brown or pinkish brown ; internally, frothy mass above the eggs pinkish, and below and around eggs pinkish brown. Outer wall consisting of compressed layers of frothy secretion, thin near the top, thick at the base ; rough, due to adherence of sand particles, bits of stones and sometimes bits of leaves. Internally, one-third of top section filled with fine-meshed froth ; two-thirds of remaining lower, or egg-section, surrounded by coarse-meshed frothy mass. A very thin layer of secreted material also lying in between eggs, with a thick frothy pad at base of basal eggs of pod.

With 10-18 eggs in a pod. Usually, with four basal eggs, a pair on each side ; towards the concave (hollow) side of pod, eggs arranged in groups of twos, each egg lying in a slanting position ; towards convex (outer) side, eggs arranged vertically in groups of threes in irregular rows (Text-fig. 4 *c, d.*)

Eggs : Length, 4·8-5·5 mm.; width, 1·0-1·5 mm ; subcylindrical ; straight, rarely curved ; with both anterior and posterior ends subconical; creamy white to dirty brown.

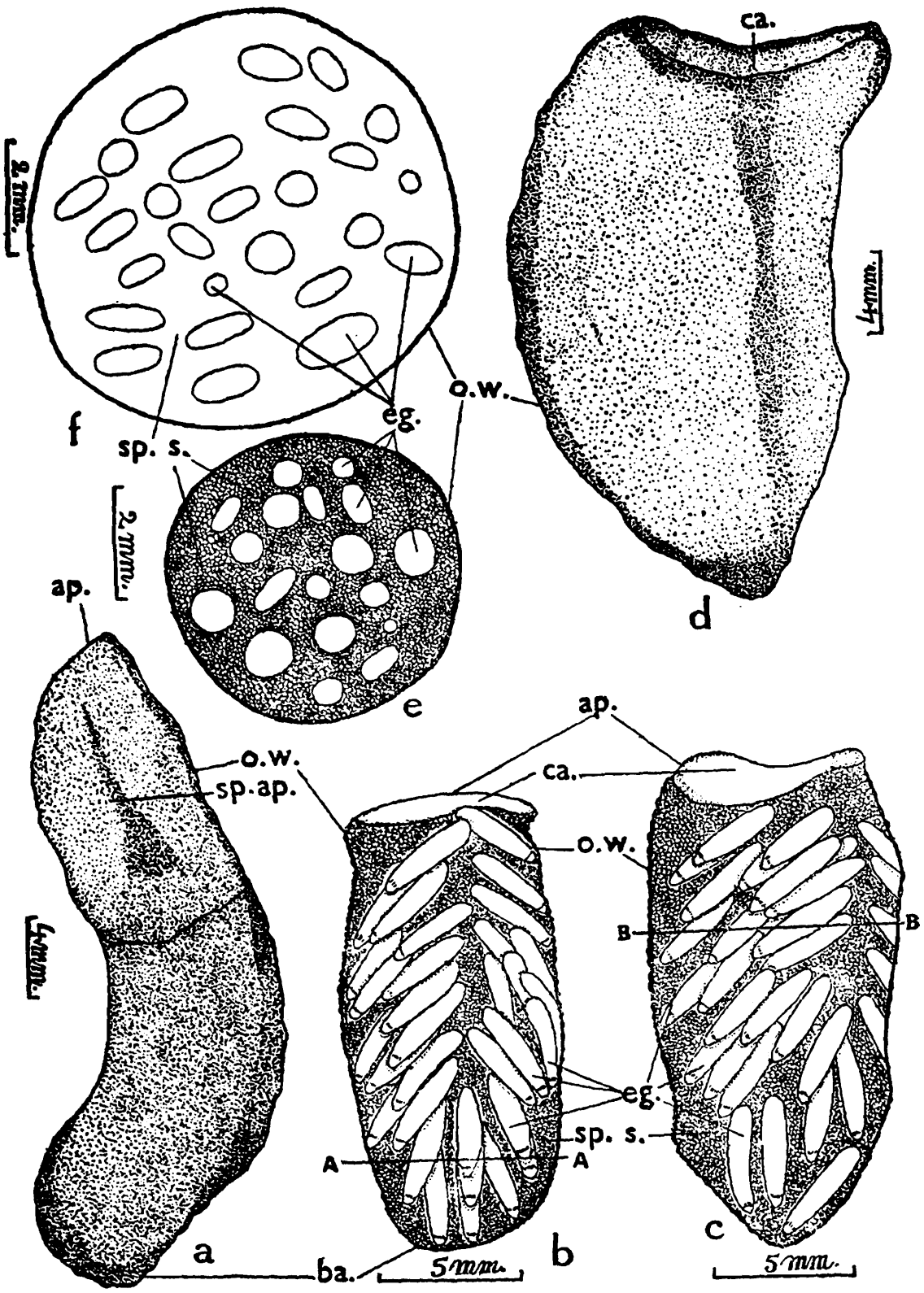


TEXT-FIG. 4.—Eggs and egg-pods of *Eyprepocnemis roseus* Uvarov and *Spathosternum prasiniferum* Walker.

(*a*) Entire egg-pod of *Eyprepocnemis roseus*. (*b*) Same, with the wall partly removed from concave side to show arrangement of eggs (cf. *c*). (*c*) Same, with the wall of the convex side removed to show arrangement of eggs (cf. *d*). (*d*). Transverse sections of egg-pod of *Eyprepocnemis roseus* : (1) Across upper line (C-C) in Figs. *b* and *c* ; (2) Across middle line (B-B) in Figs. *b* and *c* ; (3) Across lower line (A-A) in Figs. *b* and *c*. (*e*) Entire egg-pod of *Spathosternum prasiniferum*. (*f*) Same, with the wall partly removed from lateral side to show arrangement of eggs. (*g*) Transverse section of egg-pod of *Spathosternum prasiniferum*: (1) Across upper line (A-A) in Fig. *f*; (2) Across middle line (B-B) ; (3) Across another middle line (C-C) ; (4) Across lower line (D-D).

ap., apex of egg-pod ; *ba.*, base of egg-pod ; *ca.*, cap of egg-pod ; *eg.*, egg ; *o.w.*, outer wall of egg-pod ; *sp. ap.*, spongy secretion at apex of egg-pod ; *sp. s.*, syongy secretion in between eggs.

Egg-laying : In insectary, eggs laid in sandy-loam ; in field in hard soil ; eggs laid 2·5-6·7 cms. below soil-surface. Egg-laying occurring in Dehra Dun from 3rd week July to 1st week August.



TEXT-FIG. 5.—Eggs and egg-pods of *Hieroglyphus concolor* Herbst.

(*a*) Entire egg-pod. (*b*) Same, with the wall partly removed from concave side to show arrangement of eggs (cf. *c*). (*c*) Same, with the wall of convex side removed to show arrangement of eggs, (cf. *b*). (*d*) An egg-pod of abnormal size without spongy mass at apex of egg-pod. (*e*) Transverse section of egg-pod across lower line (A-A) in Fig. *b*. (*f*) Same, across upper line (B-B) in Fig. *c*.

ap., apex of egg-pod ; *ba.*, base of egg-pod ; *ca.*, cap of egg-pod ; *eg.*, egg ; *o.w.*, outer wall of egg-pod ; *sp. ap.*, spongy secretion at apex of egg-pod ; *sp. s.*, spongy secretion in between eggs.

6. **Hieroglyphus concolor** Herbst

(Text-fig. 5 *a-f*)

General : Thirty-one egg-pods examined. Pods very rough, tough and hard ; long, usually straight or bent in middle, sometimes broad (Text-fig. *d*) ; base round or subconical ; apex flat, provided with a hard smooth cap above eggs. Length of pod, 3·25-5·5 cms.; width, 0·95-1·65 cms. Outer wall dirty brown; internally, the secreted material above and around eggs dark brown. Outer wall consisting of hard secreted material, which is hard and rough due to inpregnation of small bits of stones and coarse sand. Internally, one-third of top section filled with secreted material, which is hard, compact and easily detachable; below it, with a definite hard, smooth, concave cap above the eggs ; below the cap, two-thirds of remaining egg-section surrounded by thick layers of cemented material ; a thick layer of such cemented material also lying in between eggs ; no thick pad at base of pod.

With 62-84 eggs in a pod. Eggs near base arranged vertically at right angles ; remaining eggs tending to slope towards pod-wall.

Eggs : Length, 3·6-4·07 cms.; width, 0·9-1·0 cms. Thick, subcylindrical, straight, rarely bent in middle ; anterior pole round ; posterior tapering from micropylar ring, slightly round or flat at extremity ; yellowish brown to dark brown.

Egg-laying : Both in insectary and field eggs laid in sandy-loam ; eggs laid 4·0-6·5 cms. below soil-surface. Egg-laying occurring in Dehra Dun from 3rd week July to 2nd week September (maximum in 1st week August).

7. **Hieroglyphus nigrorepletus** Bolivar

(Text-fig. 6 *a-c*)

Husain and Roonwal (1933) studied the egg-structure and micropylar apparatus of this species, while Roonwal (1945) studied other aspects in its life-history. I have studied, only the composition of egg-pod and the period of egg-laying in the insectary in Dehra Dun.

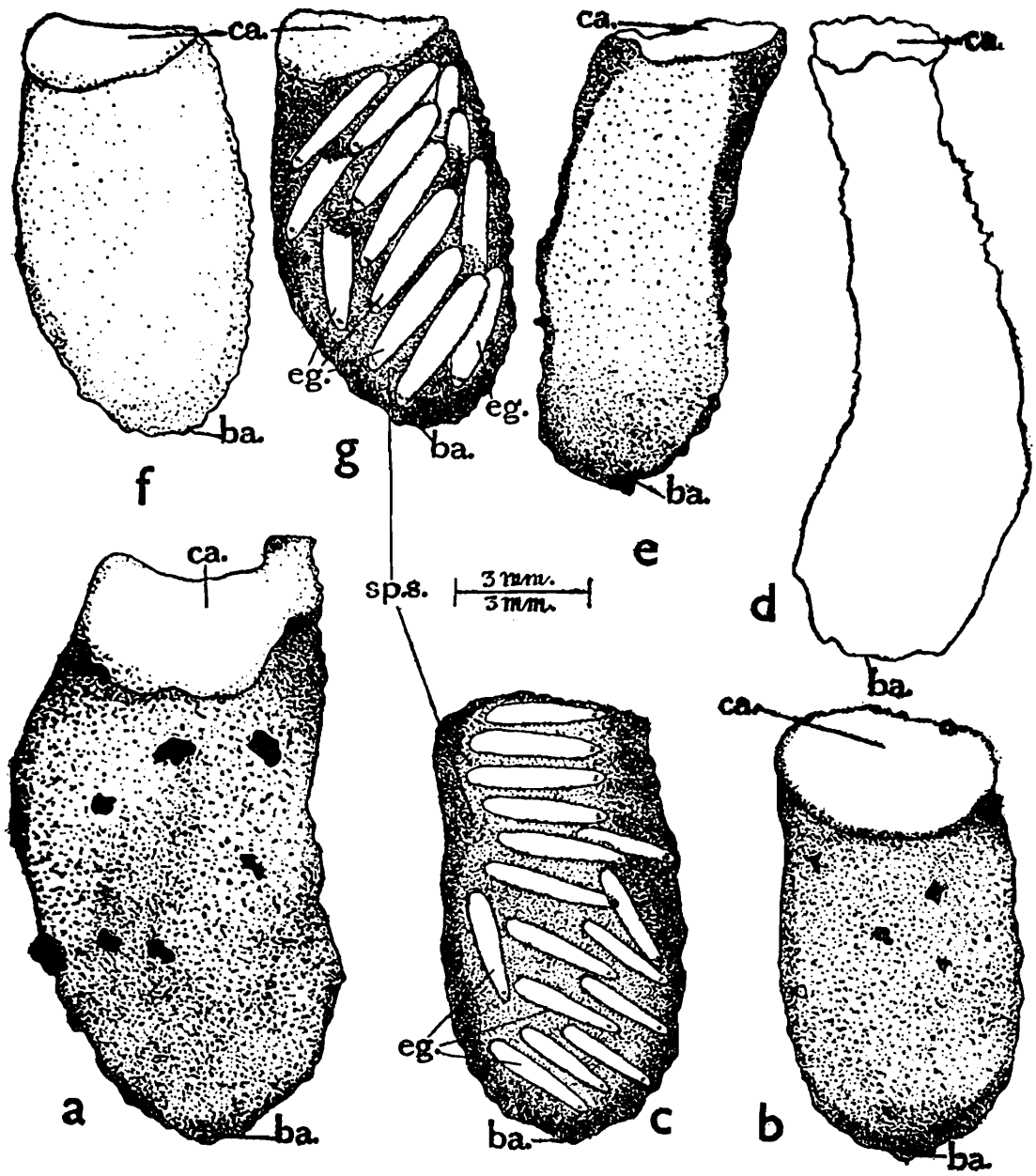
Egg-pod similar to *H. concolor* (see above), with a definite hard, smooth, concave cap ; hard cement-like, dark brown secreted material above and around eggs.

Egg-laying: In insectary, eggs laid in sandy-loam ; eggs laid 3·8-7·2 cms. below soil-surface ; sometimes dropped either on the glass chimney or on soil-surface. Egg-laying occurring in Dehra Dun from 30th July to 4th December (in 1953).

8. **Hieroglyphodes assamensis** Uvarov

(Text-fig. 6 *f-g*)

General : One egg-pod examined. Pod very rough and hard ; short, globular or broad in middle ; base round ; apex flat, provided with a hard concave cap above eggs. Length of pod 1·6-1·7 cms. ; width 0·8-1·7 cms. Outer wall sand coloured ; internally, secreted material above and around eggs dark brown. Outer wall consisting of very hard, cemented material similar to *H. concolor* in all respects, except hard mass above cap absent.



TEXT-FIG. 6.—Eggs and egg-pods of *Hieroglyphus nigrorepletus* Bolivar, *Hieroglyphodes assamensis* Uvarov and *Hieroglyphus banian* Fabricius.

(*a*) Entire egg-pod of *Hieroglyphus nigrorepletus* abnormal size. (*b*) Same, normal size. (*c*) Same, with the wall partly removed from lateral side to show arrangement of eggs. (*d*) Entire egg-pod of *Hieroglyphus banian* (from Dehra Dun). (*e*) Same, another. (*f*) Entire egg-pod of *Hieroglyphodes assamensis*. (*g*) Same, with the wall partly removed from lateral side to show arrangement of eggs.

ba., base of egg-pod ; *ca.*, cap of egg-pod ; *eg.*, egg ; *sp. s.*, spongy secretion in between eggs.

With about 28 eggs in a pod ; eggs arranged in a slanting position and slanting towards pod-wall (Text-fig. 6 *g*), with the micropylar end down.

Eggs : Length, 5·2-5·95 mm. ; width, 1·1-1·35 mm. Thick, subcylindrical, swollen in middle ; both anterior and posterior ends semi-round ; dark brown.

Egg-laying : In insectary, eggs laid in sandy-loam ; eggs laid 7·2 cms. below soil-surface. Egg-laying observed in one case only (4th August, 1953) in Dehra Dun.

9. Parahieroglyphus bilineatus Bolivar

(Text-fig. 7 *e-h*)

General : Eighty egg-pods examined. Pods very hard and rough ; short, straight globular ; base round ; apex flat, provided with a hard, smooth, concave, brown cap. Length of pod, 1·2-1·45 cms. ; width, 0·45-0·58 cms. Outer wall dirty brown ; internally, the secreted material above and around eggs dark brown. Outer wall consisting of hard secretion, very rough and cement-like due to adherence of sand and small stones and sometimes a covering of grasses and leaves. Internally, top-section (1·0-1·8 cms. above the eggs) filled with hard, compressed, densely-meshed secretion ; little more than two-thirds of the remaining lower or egg-section surrounded by a similar layer of secreted material ; a thin layer of such hard material also lying in between eggs, with a thin cemented pad at base of pod.

With 28-40 eggs in a pod. Eggs near base arranged vertically at right angles to base ; remaining eggs tending to slope towards pod-wall (Text-fig. 7 *f, g*).

Eggs : Length, 3·8-4·5 mm. ; width, 0·9-1·2 mm. Thick, subcylindrical ; usually bent in middle, sometimes near at the micropylar end ; anterior pole rounded ; tapering from micropylar region towards posterior pole ; brownish yellow to dark brown.

Egg-laying : In insectary, eggs laid in sandy-loam ; in field, in sandy soil ; eggs laid 3·0-7·2 cms. below soil-surface. Egg-laying occurring in Dehra Dun from 2nd week August to 1st week October.

10. Spathosternum prasiniferum Walker

(Text-fig. 4 *e-g*)

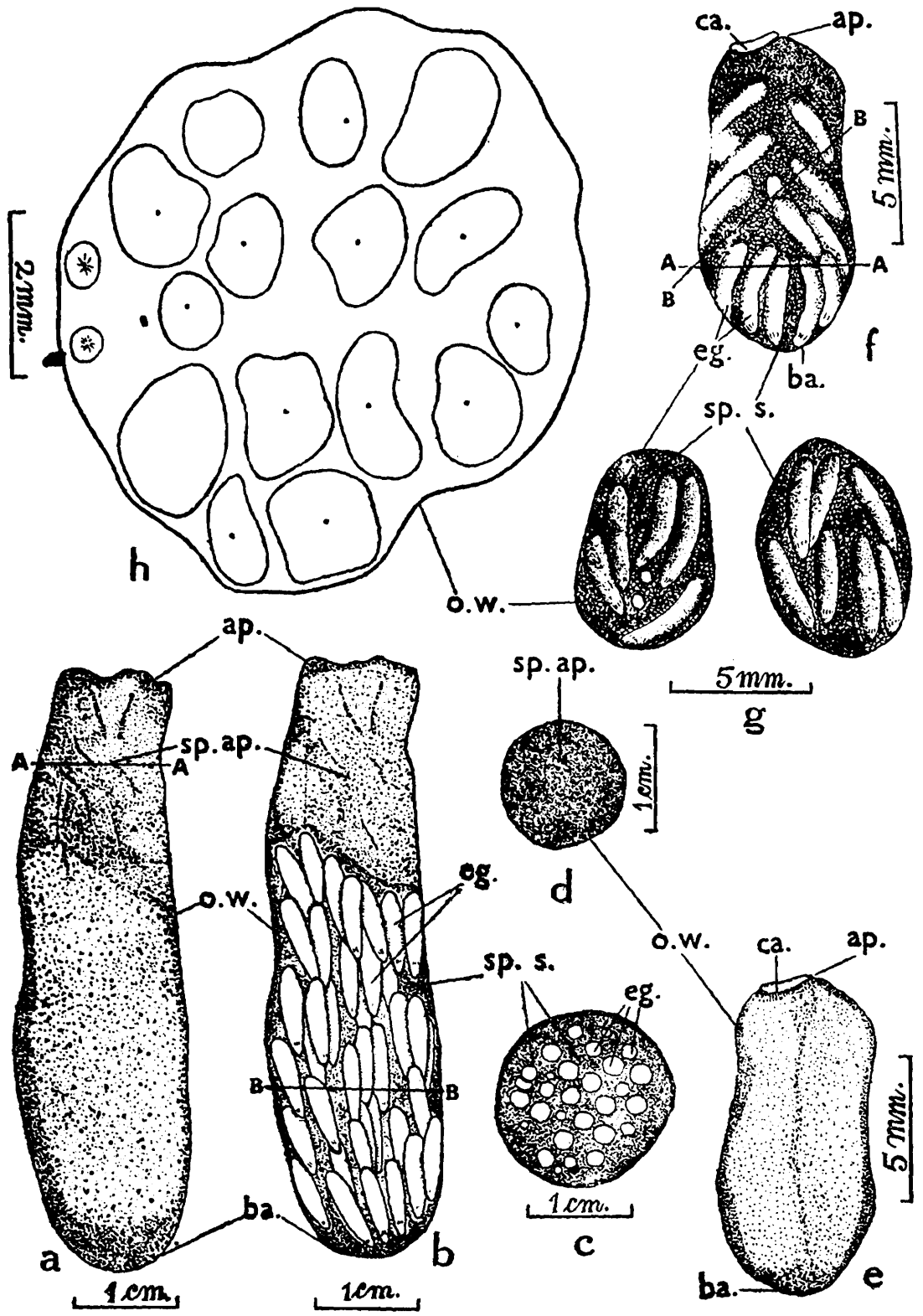
General : Fifty-five egg-pods examined. Pods rough, not fragile but spongy ; very short, irregular in shape, either straight or bent in middle ; base usually broad and round ; sometimes swollen in middle ; apex subconical or conical, provided with a thin membranous concave, ash-gray cap. Length, 0·59-1·7 cms. ; width, 0·4-0·5 cms. Outer wall earth-coloured; internally, spongy material above eggs shiny pale green, around eggs yellowish green. Outer wall consisting of compressed thin layer of spongy secretion very thin near top, quite thick at the base and rough due to adherence of fine sand particles and bits of stones. Internally, one-third of top section filled with spongy material, with clear, hexagonal spaces or cells ; two-thirds of the remaining lower or egg-section surrounded by a similar thin layer of spongy material coarse-meshed, with no clear hexagonal spaces ; lining of secreted spongy mass in between eggs seen only here and there ; but a thick spongy pad at base of pod always present.

With 17-28 eggs in a pod. On convex (outer) side, eggs arranged vertically at right angles to the base in rows of twos near base, threes in middle and again twos at upper level ; on concave (hollow) side, eggs tending to slope towards the pod-wall.

Eggs : Length, 3·5-4·7 mm. ; width, 1·15-1·35 mm. ; thin, subcylindrical, straight or slightly curved.

Egg-laying : In insectary, eggs laid in sandy-loam ; in field, in damp sandy-loam along irrigation channels and banks of canals ; eggs laid 2·0-3·5 cms. below soil-surface. Egg-laying occurring in Dehra Dun

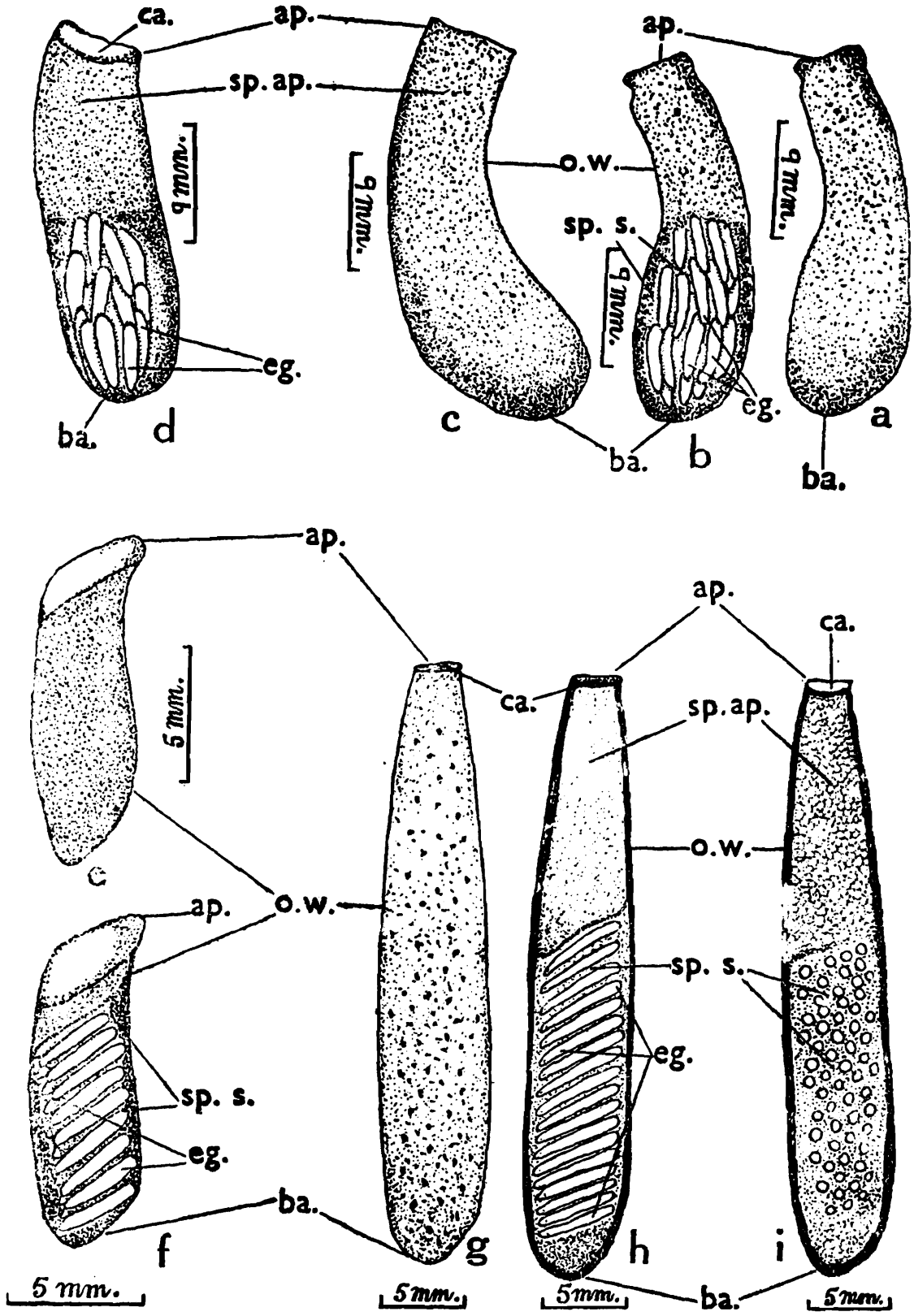
from 1st week May to 3rd week August (sometimes upto 1st week September), in insectary.



TEXT-FIG. 7.—Eggs and egg-pods of *Aularches punctatus* Drury and *Parahieroglyph u bilineatus* Bolivar.

(*a*). Entire egg-pod of *Aularches punctatus*. (*b*). Same, with the wall partly removed from lateral side to show arrangement of eggs. (*c*). Transverse section of egg-pod of *A. punctatus* across lower line (B-B) in Fig. *b*. (*d*). Same, across up per line (A-A) in Fig. *a*. (*e*). Entire egg-pod of *Parahieroglyphus bilineatus*. (*f*). Same, with the wall partly removed from lateral side to show arrangement of eggs. (*g*). Arrangement of eggs of *P. bilineatus* shown in two planes of the pod broken through the line (B-B) in Fig. *f*. (*h*). Transverse section of egg-pod of *P. bilineatus* across lower line (A-A) in Fig. *f*.

ap., apex of egg-pod ; *ba.*, base of egg-pod ; *ca.*, cap of egg-pod ; *eg.*, egg ; *o.w.*, outer wall of egg-pod ; *sp. ap.*, spongy secretion at apex of egg-pod ; *sp. s.*, spongy secretion in between eggs.



TEXT-FIG.8.—Eggs and egg-pods of *Xenocatantops humilis humilis* Serville, *Oedaleus abruptus* Thunberg and *Acrida gigantea* Herbst.

(*a*). Egg-pod of *Xenocatantops humilis humilis*. (*b*). Same, with the wall partly removed from lateral side to show arrangement of eggs. (*c*). Same, typical type. (*a*). Same, with the wall partly removed from convex side to show arrangement of eggs. (*e*). Entire egg-pod of *Oedaleus abruptus*. (*f*). Same, with the wall partly removed from lateral side to show arrangement of eggs. (*g*). Egg-pod of *Acrida gigantea*. (*h*). Same, with the wall partly removed from lateral side to show arrangement of eggs. (*i*). Vertical section of egg-pod of Fig. *g*.

ap., apex of egg-pod ; *ba.*, base of egg-pod ; *ca.*, cap of egg. ; *eg.*, egg ; *o.w.*, outer wall of egg-pod ; *sp. ap.*, spongy secretion at apex of egg-pod ; *sp.s.*, spongy secretion in between eggs.

11. **Xenocatantops humilis humilis** Serville

(Text-fig. 8 *a-d*)

General : Twenty-eight egg-pods examined. Pods rough, fragile, spongy, short, broad, straight or curved in middle (almost C-shaped) ; base round ; apex ending abruptly, flat and without any cap. Length of pod 1·7-2·8 cms. ; width 0·5-0·6 cm. Outer wall dirty clay coloured ; internally, almost all frothy mass above eggs pinkish white, and around eggs light brown to brownish ash. Outer wall consisting of thin, frothy secretion, rough, due to adherence of fine sand particles and bits of stones. Internally, half of top section filled with frothy, fragile, secretion ; half of the remaining lower or egg-section surrounded by coarse-meshed, thick, frothy pad ; lining of secreted material in between eggs almost absent.

With 23-31 eggs in a pod. Eggs usually arranged vertically at right angles to the base one above the other ; at top a few eggs tending to slope a little towards pod-wall (Text-fig. 8 *b, d*).

Eggs : Length, 3·7-4·2 mm. ; width, 0·8-1·2 mm. Thin, cylindrical, straight ; a bit swollen and round at the anterior pole, subconical at the posterior.

Egg-laying : In insectary, eggs laid in sandy-loam ; in field, in light soil under shade of trees and bushes ; eggs laid 4·5-6·3 cms. below soil-surface. Egg-laying occurring in Dehra Dun from last week August to last week October.

Subfamily (iii) *OEDIPODINAE*

12. **Gastrimargus transversus** Thunberg

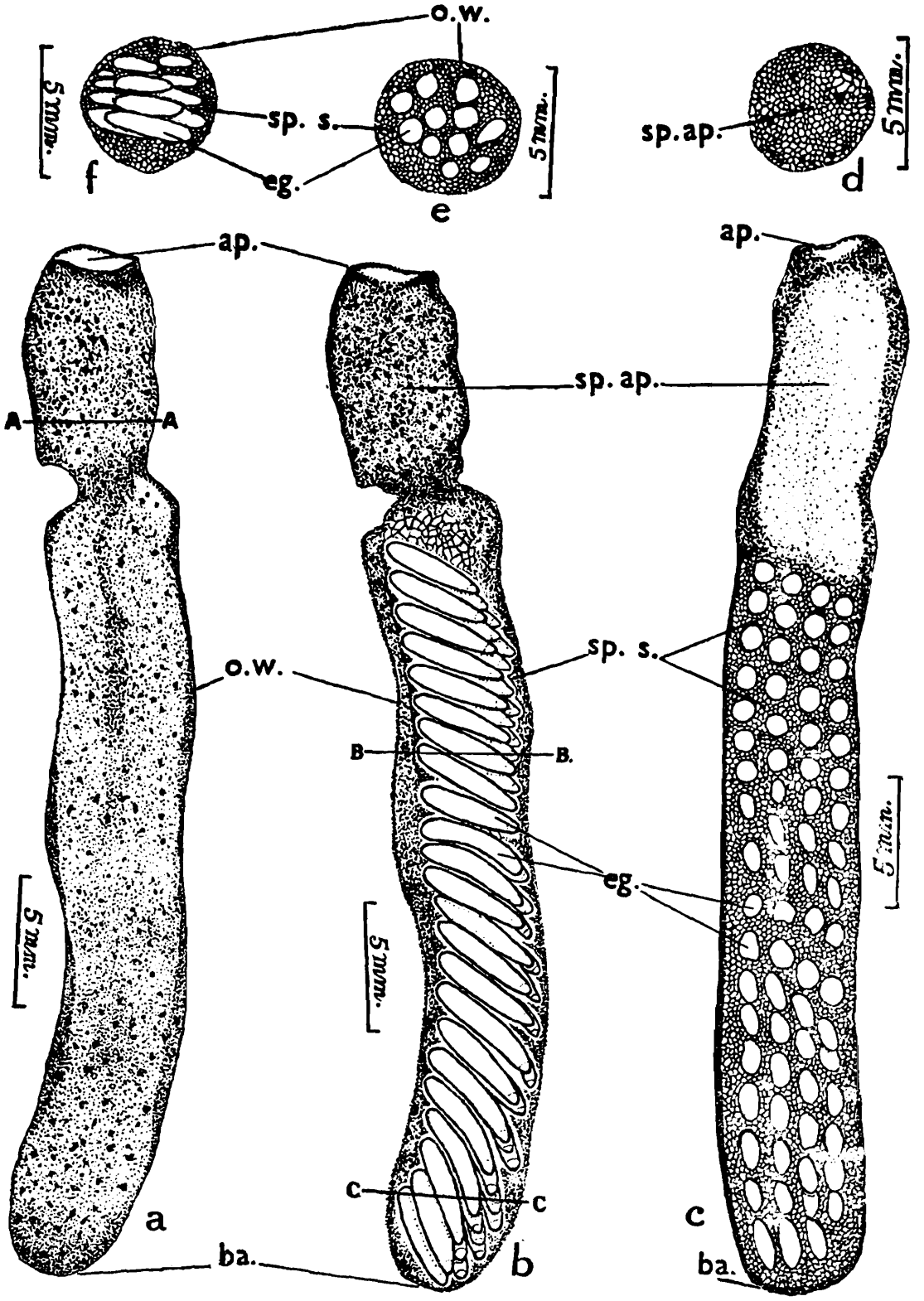
(Text-fig. 9 *a-f*)

General: Twelve egg-pods examined. Pods long, elongated, straight, sometimes bent at base ; base round ; in 9 out of 12 pods examined, a constriction present near the top; apex flat, provided with a small lid or cap. Length of the pod 3·9-4·8 cms. (in one case 5·7 cm.); width 0·45-0·6 cm. Outer wall pink to pinkish brown; internally, frothy mass above eggs, salmon white, and around eggs pinkish brown. Outer wall consisting of a compressed layer of frothy secretion, thin near the top, thick at the base ; rough, due to adherence of fine sand particles and sometimes fragments of leaves. Internally, one-third of top section filled with finely-meshed frothy secretion ; two-thirds of the remaining lower or egg-section surrounded by compressed thin layers of fragile froth.

With 69-94 (mostly 83-85) eggs in a pod. Eggs arranged obliquely one above the other, and sloping towards the pod-wall, with nearly 16-18 eggs seen on two sides only.

Eggs: Length, 4·6-5·15 mm. ; width, 1·0-1·1 mm. ; thin, straight; subconical at the anterior pole, tapering from micropylar ring to extremity at the posterior pole ; yellowish pink.

Egg-*laying* : In insectary, eggs laid in sandy-loam ; in field, in clayey soil ; eggs laid 3·8-6·4 cms. (in one case 7·5 cms.) below soil-surface. Egg-laying occurring from 2nd week June to 1st week September.



TEXT-FIG. 9.—Eggs and egg-pods of *Gastrimargus transversus* Thunberg.

(*a*). Entire egg-pod. (*b*). Same, with the wall partly removed from lateral side to show arrangement of eggs. (*c*). Vertical section of egg-pod of Fig. b. (*d*). Transverse section of egg-pod across upper line (A-A) in Fig. *a*. (*e*). Same, across middle line (B-B) in Fig. *b*. (*f*). Same, across lower line (C-C) in Fig. *b*.

ap., apex of egg-pod ; *ba.*, base of egg-pod ; *ca.*, cap of egg-pod ; *eg.*, egg ; *o.w.*, outer wall of egg-pod ; *sp. ap.*, spongy secretion at apex of egg-pod ; *sp. s.*, spongy secretion in between eggs.

13. **Oedaleus abruptus** Thunberg

(Text-fig. 8 *e-f*)

General : Five egg-pods examined. Pods rough, fragile, short ; bent at both ends ; base subconical ; apex conical or flat. Outer wall dirty yellowish ; internally, frothy mass above and around eggs yellowish white. Outer wall consisting of very thin compressed layer of fragile froth. Internally, one-third of top-section filled with finely-meshed froth ; two-thirds of the remaining lower or egg-section surrounded by thin layer of frothy secretion, lining of secreted material in between eggs wanting.

With 18-27 eggs in a pod. Eggs arranged obliquely and sloping towards pod-wall.

Eggs: Length, 3·25-4·15 mm.; width, 0·85-0·95 mm.; thin, long, slender, straight, swollen and round at the anterior pole ; tapering from micropylar ring to extremity at the posterior pole ; dirty yellowish.

Egg-laying: In field eggs laid in hard soil along edges of gardens, tennis lawns, etc. ; eggs laid 2·5-3·5 cms. below soil-surface. Egg-laying occurring in Dehra Dun from 3rd week June to last week September.

Subfamily (iv) *PYRGOMORPHINAE*

14. **Aularches punctatus** Drury

(Text-fig. 7 *a-d*)

General: Seventeen egg-pods examined. Pods very smooth, fragile, long, cylindrical ; almost all straight, sometimes bent in middle ; base wide and round ; apex usually flat, sometimes subconical and without any cap at top. Length of the pod 5·2-9·0 cms. ; width, 1·2-1·9 cms. Outer wall dirty pink ; internally, apical frothy mass pink and about 2·0-2·5 cms. high ; below this, the froth dark pink. Outer wall consisting of thin, smooth layer of froth. Internally, approximately one-third of top-section filled with fragile frothy material composed of hexa- or septagonal empty spaces or cells ; two-thirds of the remaining lower or egg-section surrounded by very thin coarsely-meshed froth with clear empty spaces. A thin layer of secreted material also lying in between eggs, with a thick frothy pad at base of pod always present.

With 96-120 eggs in a pod. Eggs arranged vertically at right angles to the base, and lying one above the other (Katiyar, 1955). One or two eggs near top tending to slope towards pod-wall (Text-fig. 7 *b*).

Eggs: Length, 7·0-7·25 mm.; width, 1·8-2·0 mm. Thin, subcylindrical, straight; anterior pole round ; posterior pole tapering from micropylar ring but flat at extremity; translucent yellow in ovaries, yellow after oviposition, and later on changing to dark brown.

Egg-laying : In insectary, eggs laid in sandy-loam ; eggs laid 6·2-7·4 cms. below soil-surface ; in field also in sandy-loam, and especially damp places ; if such places not available, the female not ovipositing at all, but dying without doing so, eggs laid in field 2·5-7·8 cms. below soil-surface. Egg-laying occurring in insectary, in Dehra Dun, from 15th September to 14th October ; in the field around Dehra Dun, from 10th September to 1st October mostly during 2nd week September.

KEY TO THE IDENTIFICATION OF EGG-PODS OF SOME INDIAN ACRIDIDAE

1 (8) Outer wall composed of cemented sandy material. Pods with a definite concave cap.

2 (7) The concave cap of the pod always concealed with cemented concretion (this cap is visible when concretion is removed).

3 (4) Pods short and globular, about twice as long as wide (length, 1·6-1·7 cms.; width, 0·8 -1·0 cms.). *Hieroglyphodes assamensis* (Text-fig. 6 *f,g*).

4 (3) Pods elongate and almost cylindrical, much more than twice as long as wide.

5 (6) Eggs are arranged sloping towards the pod-wall and mostly parallel to the base near the cap. *Hieroglyphus nigrorepletus* (Text-fig. 6 *a-c*).

6 (5) Eggs are arranged vertically at right angles to base at the bottom and sloping towards pod-wall near the cap. *Hieroglyphus concolor* (Text-fig. 5 *a-f*).

7 (2) The concave cap of the pod usually well exposed (at most only slightly covered with a few soil particles adhered with secreted material); length, 1·2-1·4 cms.; width, 0·45-0·58 cm. *Parahieroglyphus bilineatus* (Text-fig. 7 *e-h*).

8 (1) Outer wall hard and rough without cemented concretions and without any definite concave cap.

9 (12) Arrangement of eggs widely differs both on concave (hollow) and convex (outer) sides of pods, though in a standard form in either side.

10 (11) Pods about 4 times as long as wide (length, 1·45-1·85 cms.; width, 0·45-0·6 cms.), each pod with 14-22 eggs. *Ceracris deflorata* (Text-fig. 2 *e- h*).

11 (10) Pods about 8 times as long as wide (length, 2·7-3·8 cms.; width, 0·35-0·5 cms.) each pod with 10-18 eggs. *Eyprepocnemis roseus* (Text-fig. 4 *a-d*).

12 (9) Arrangement of eggs similar both on concave and convex sides.

13 (24) Eggs arranged in one standard form either in an oblique or vertical style (in latter case, at most slightly different only at the upper level of eggs); without any cap.

14 (19) Eggs arranged obliquely one above the other, sloping towards pod-wall.

15 (18) Pod rough ; base round.

16 (17) Outer wall of pod dirty brownish-white; frothy mass above and around eggs light brown (length, 2·8-4·4 cms.; width, 0·55-0·65 cm.; 52-65 eggs in a pod). *Acrida gigantea* (Text-fig. 8 *g-i*).

17 (16) Outer wall of pod pink or pinkish brown ; frothy mass above eggs salmon-white and around eggs pinkish-brown (length, 3·9-4·8 cms.; width, 0·45-0·6 cm.; 69-94 eggs in a pod). *Gastrimargus transversus* (Text-fig. 9 *a-f*).

18 (15) Pod smooth ; base subconical (outer wall dirty yellowish ; frothy mass above and around eggs yellowish white ; length, 1·1-1·75 cms.; width, 0·35-0·5 cm.; 18-27 eggs in a pod). *Oedaleus abruptus* (Text-fig. 8 *e,f*).

19 (14) Eggs arranged vertically at right angles to base of pod.

20 (23) Pod throughout smooth or rough near base and smooth near apex.

21 (22) Pod throughout smooth ; outer wall dirty pink, frothy mass dark-pink (length, 5·2-9·0 cms.; width, 1·2-1·9 cms.; 81-120 eggs in a pod). *Aularches punctatus* (Text-fig. 7 *a-d*).

22 (21) Pod rough near base and smooth near apex ; outer wall dirty-clayey; frothy mass yellowish white to light brown (length, 4·8-7·4 cms.; width, 1·1-1·38 cms.; 63-93 eggs in a pod). *Choroedocus insignis* (Text-fig. 3 *a-g*).

23 (20) Pod throughout rough (outer wall dirty-clayey ; frothy mass pinkish white to brownish ash ; length, 1·7-2·8 cms.; width, 0·5-0·6 cm.; 23-31 eggs in a pod). *Xenocatantops humilis humilis* (Text-fig. 8 *a-d*).

24 (13) Arrangement of eggs not in one standard form. Provided with membranous cap.

25 (26) Eggs arranged in 2-3 rows sloping towards the pod-wall. 8-9 eggs visible in one plane on either the concave (hollow) side or the convex (bulging) side of pod (outer wall dirty brown or pink ; frothy mass above pale clay yellow and around eggs pinkish brown ; length, 1·9-2·85 cms.; width, 0·4-0·6 cm.; 22-32 eggs in a pod). *Phlaeoba panteli* (Text-fig. 2 *a-d*).

26 (25) Eggs arranged vertically at right angles to the base in 2 rows near base, threes in middle and twos at upper level on convex (bulging side), eggs tending to slope towards pod-wall on concave or hollow side. (Outer wall earth coloured ; frothy mass above eggs shiny pale green and around eggs yellowish green ; length, 0·59-1·7 cms.: width, 0·4-0·5 cm.; 17-28 eggs in a pod). *Spathosternum prasiniferum* (Text-fig. 4 *e-g*).

V—STRUCTURE OF EGG-CHORION

(a) *General*

Very little is known about the sculpturing of the egg-chorion of the short-horned grasshoppers (family, Acrididae) of India. Some suggestions for the study of the egg-sculpturing of Acrididae were made by Plotnikov (1911, 1926) and by Uvarov (1928) who remarked that sculpturing might be of considerable importance in the identification of Acrididae. Husain and Roonwal (1933) studied the micropylar apparatus and chorionic sculpturing in some Indian species. Zimin (1935, 1938) studied the chorion of some Russian species and Morales Agacino (1951) of a few Spanish species. Roonwal, who studied in detail the egg-sculpturing of the Desert Locust, *Schistocerca gregaria* Forskal (1954*b*), and of the African Migratory Locust, *Locusta migratoria migratorioides* R. & F. (1936 , 1954*a*), has concluded that there are two types of egg-walls in the Acrididae as regards chorionic sculpturing.

Chorionic sculpturing shows interesting characteristic structures which help in distinguishing eggs of different species of Acrididbe and a study of this is, therefore, of much practical value for the systematists of the family. The present account deals with the egg-sculpturing of 10 Indian species.

For this study, freshly laid eggs were cleansed with water, then treated with 1-4 per cent KOH for a few hours and washed with water. Both the anterior and the posterior poles as well as the middle portion of the egg-chorion were cut off, cleansed of yolk, etc., stained with eosin (in alcohol) and a permanent balsam mount made on a slide. The following readings of the micropylar canals have been taken for each species :— (i) Total length of micropylar canals from mouth (outer opening) to the fine pore (inner opening) ; (ii) width of the mouth (outer opening) of the canal.

(b) *Sturcture of the egg-chorion*

The egg-chorion of the following 10 species was studied :—

Subfamily *ACRIDINAE*

1. *Acrida gigantea* Herbst
2. *Ceracris deflorata* Brunner
3. *Phlaeoba panteli* Bolivar

Subfamily (ii) *CATANTOPINAE*

4. *Chorodocus insignis* Thunberg
5. *Eyprepocnemis roseus* Uvarov
6. *Parahieroglyphus bilineatus* Bolivar
7. *Xenocatantops humilis humilis* Serville

Subfamily (iii) *OEDIPODINAE*

8. *Gastrimargus transversus* Thunberg

Subfamily (iv) *PYRGOMORPHINAE*

9. *Aularches miliaris* Linnaeus (Material from Ceylon)
10. *Aularches punctatus* Drury

The following is a description of the chorionic sculpturing. The egg has been divided for this purpose into 3 parts, *viz.*, the anterior pole, the middle portion and the posterior pole.

Subfamily (i) *ACRIDINAE*

1. **Acrida gigantea** Herbst

(Text-fig. 10 *a-e*)

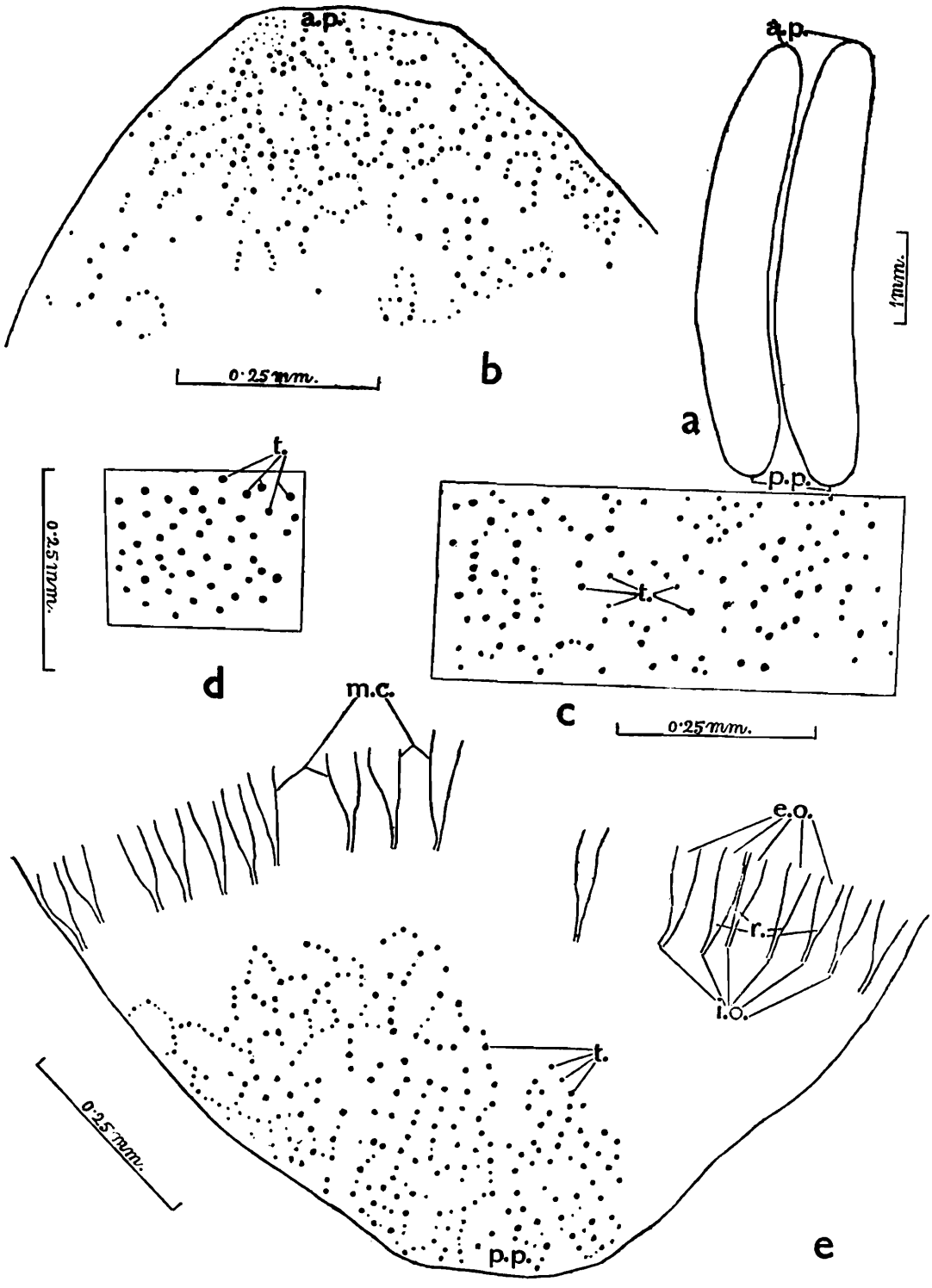
Anterior pole (Text-fig. 10 *b*).—Chorion of the anterior pole shows a large number of small round, dot-shaped tubercles, which differ greatly in size ; tubercles arranged in irregular pentagonal and hexagonal patterns, though definite ridges are absent.

Middle chorion (Text-fig. 10 *c-d*).—Middle chorion showing a number of rounded, dot-shaped tubercles but comparatively bigger than those present at either of the poles; more distinctly and sharply of pentagonal and hexagonal.

Posterior pole (Text-fig. 10 *e*).—Sculpturing at this pole similar to that of anterior pole, except that the tubercles bigger than those at anterior pole and smaller than those in the middle region. Besides this, a ring of micropylar canals ; 41-52, pipette-shaped canals present which narrow down abruptly to form a fine tubular portion. The canals measure as follows :—

Total length : 100-140μ (average 118μ).

Width of mouth: 20-40 μ (average 29μ).



TEXT-FIG. 10.—Egg-wall of *Acrida gigantea* Herbst.

(*a*). Two eggs in side view. (*b*). Surface view of the egg-wall near the anterior pole of the egg showing tubercles making polygons. (*c*). Surface view of chorion from the middle of egg showing different types of rounded tubercles. (*d*). Same, more enlarged. (*e*). Surface view of the egg-wall near the posterior pole of an egg showing the ring of micropylar canals. Note presence of tubercles.

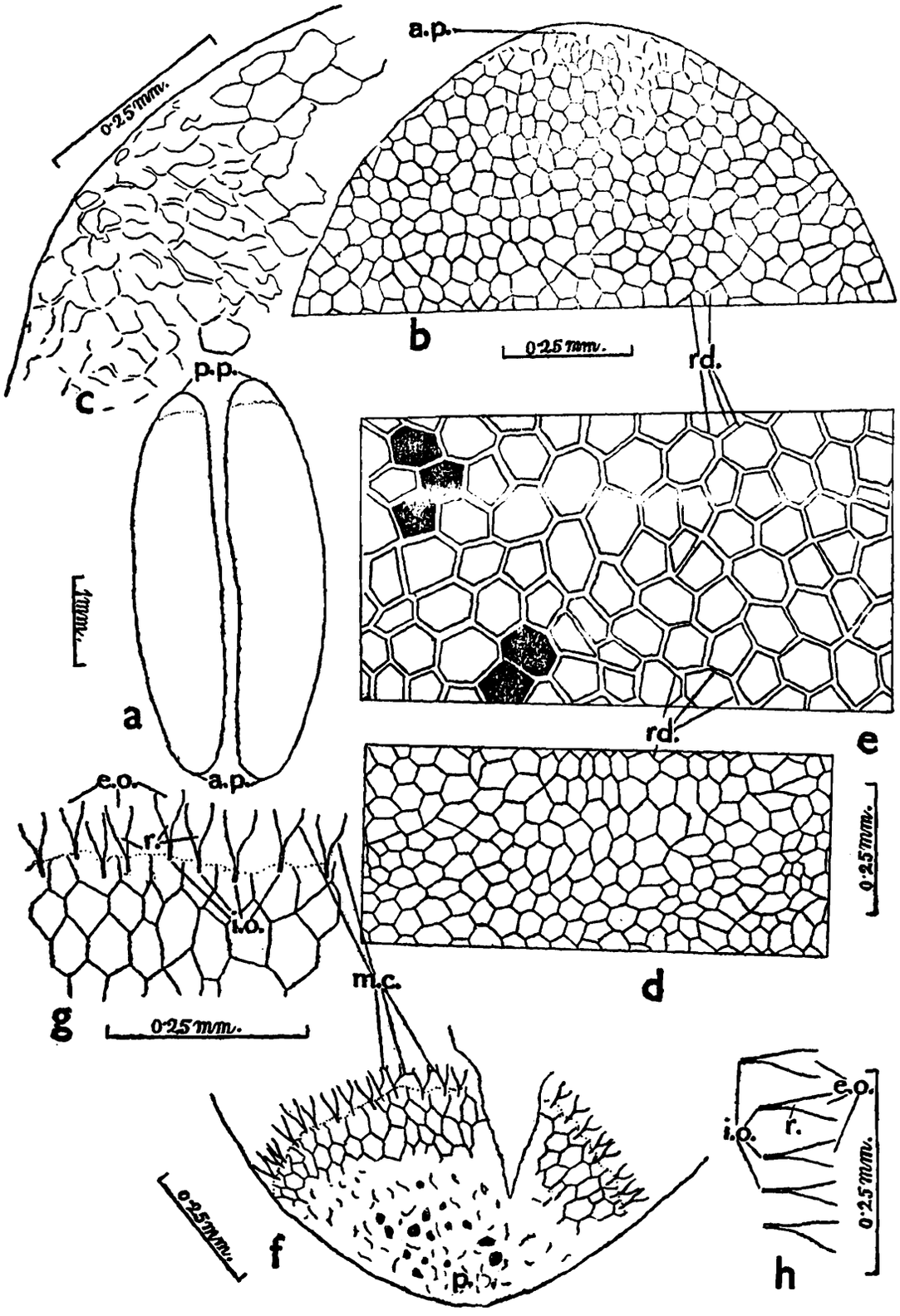
ap., anterior pole of egg ; *e.o.*, external opening of micropylar canal ; *i.o.*, internal opening of micropylar canal ; *m.c.*, micropylar canal ; *p.p.*, posterior pole of egg ; *r.*, roof of micropylar canal ; *t.*, tubercles or protuberances of endochorion of egg-wall.

2. **Ceracris deflorata** Brunner

(Text-fig. 11 *a-h*)

Anterior pole (Text-fig. 11 *b,c*).—Anterior pole presenting a mosaic pattern of pentagonal and hexagonal polygons outlined by ridges of the endochorion, but tubercles absent. At the extremity of the pole, however, no definite pattern except for a few scattered ridges or lines.

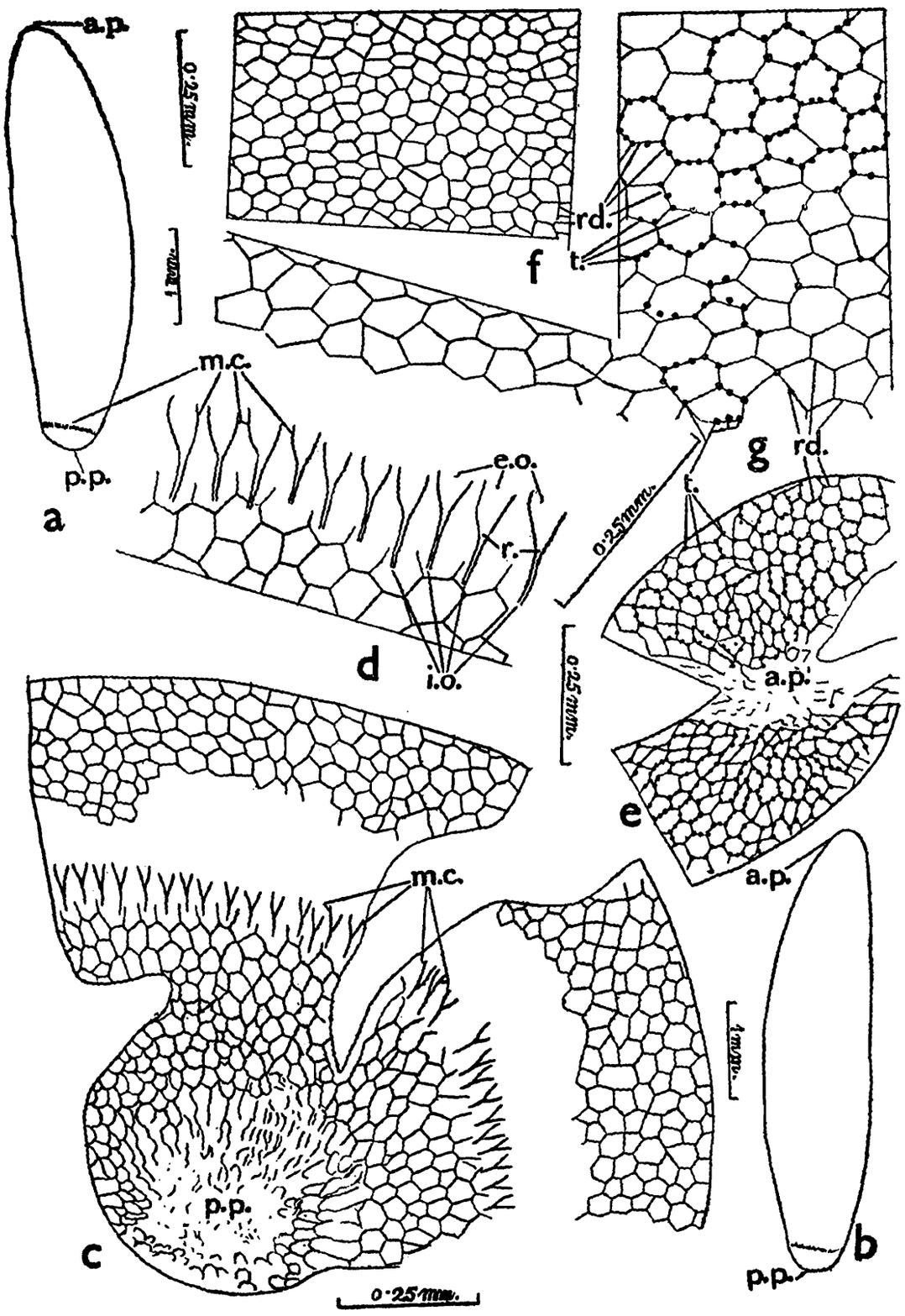
Middle chorion (Text-fig. 11 *d*, *e*).—Here again the sculpturing showing the mosaic pattern of pentagonal and hexagonal cells outlined by definite straight ridges. The spaces enclosed by the ridges appearing



TEXT-FIG. 11.—Egg-wall of *Ceracris deflorata* Brunner.

(*a*). Two eggs in side view. (*b*). Surface view of egg-wall near anterior pole of egg. Note absence of " dots " (cf. posterior pole). (*c*). Same, at anterior pole enlarged. (*d*). Surface view of the chorion from the middle portion of egg. (*e*). Same, enlarged, showing ridges and polygonous areas. (*f*). Surface view of egg-wall near the posterior pole, showing the micropylar canals and the sculpturing. Note " dots " at the pole (cf. anterior pole). (*g*). Surface view of a portion of egg-wall at posterior pole. enlarged. (*h*). Surface view of 5-micropylar canals enlarged.

a.p., anterior pole of egg ; *e.o.*, external opening of micropylar canal ; *i.o.*, internal opening of micropylar canal ; *m.c.*, micropylar canal ; *p.p.*, posterior pole of egg; *r.*, roof of micropylar canal ; *rd.*, ridges of endochorion of egg.



TEXT-FIG. 12.—Egg-wall of *Phlaeoba panteli* Bolivar.

(*a*) and (*b*). Eggs in side view. (*c*). Surface view of egg-wall near the posterior pole, showing the micropylar canals and sculpturing. Note absence of rounded tubercles. (*d*). Same, enlarged to show a few micropylar canals and their position in between egg-sculpturing. (*e*). Surface view of the egg-wall near anterior pole, showing sculpturing. Note presence of rounded tubercles and their arrangement. (*f*). Surface view of chorion from middle portion of egg. (*g*). Same, much enlarged to show rounded tubercles and ridges.

a.p., anterior pole of egg ; *e.o.*, external opening of micropylar canal ; *i.o.*, internal opening of micropylar canal ; *m.c.*, micropylar canal ; *p.p.*, posterior pole of egg ; *r.*, roof of micropylar canal ; *rd.*, ridges on endochorion of egg-wall ; *t.*, tubercles or protuberances of endochorion of egg-wall.

thick and translucent structures while the trabeculae between these thin and transparent as shown in an enlarged view in Fig. 11*e*, the thickness being shown only in a few cells shaded by small dots.

Posterior pole (Text-fig. 11*f-h*).—Sculpturing here marked by the pentagonal and hexagonal cells only near and around the micropylar canals but such cells absent beyond the mouth of the canals and at the extremity of the pole. In the latter region a few thick patches present. The micropylar canals, which number about 48-51, arranged in a ring, the distances between each two canals irregular (Text-fig. 11*f*) ; these more or less funnel-shaped with a fine tubular part. The canals measure as follows :—

Total length : 70-100 μ (average 86 μ).

Width of mouth : 20-40 μ (average 31 μ).

3. **Phlaeoba panteli** Bolivar

(Text-fig. 12 *a-g*)

Anterior pole (Text-fig. 12 *b*).—Chorion of anterior pole presenting a mosaic pattern of regular penta- and hexagonal cells outlined by ridges ; cells longer than broad towards extremity of the pole, and at pole itself only a few ridges present. Small dot-like tubercles present at each corner of the cells, and also in middle of the ridge joining two corners.

Middle chorion (Text-fig. 12*g*).—Sculpturing showing a regular pattern of hexagonal (occasionally pentagonal) cells ; cells longer than broad ; ridges thinner than those at anterior pole ; tubercles as at anterior end, but more prominent and occasionally with two tubercles between two corners.

Posterior pole (Text-fig. 12 *c-d*).—A sculpturing of hexagonal cells present near the inner openings of micropylar canals but absent near the mouth ; an smooth unsculptured area present in the level of the ring of micropylar canals. Cell ridges towards extremity of pole curved instead of straight ; at the pole only a few curved or bent ridges present ; tubercles wanting. Micropylar canals funnel-shaped and similar to those of *Ceracris deflorata* but fine tubular part longer in former ; 51-62 canals present, arranged in a ring ; measurements of canals :—

Total length : 90—120 μ (average 111 μ).

Width of mouth : 30-40 μ (average 35 μ).

Subfamily (ii) *CATANTOPINAE*

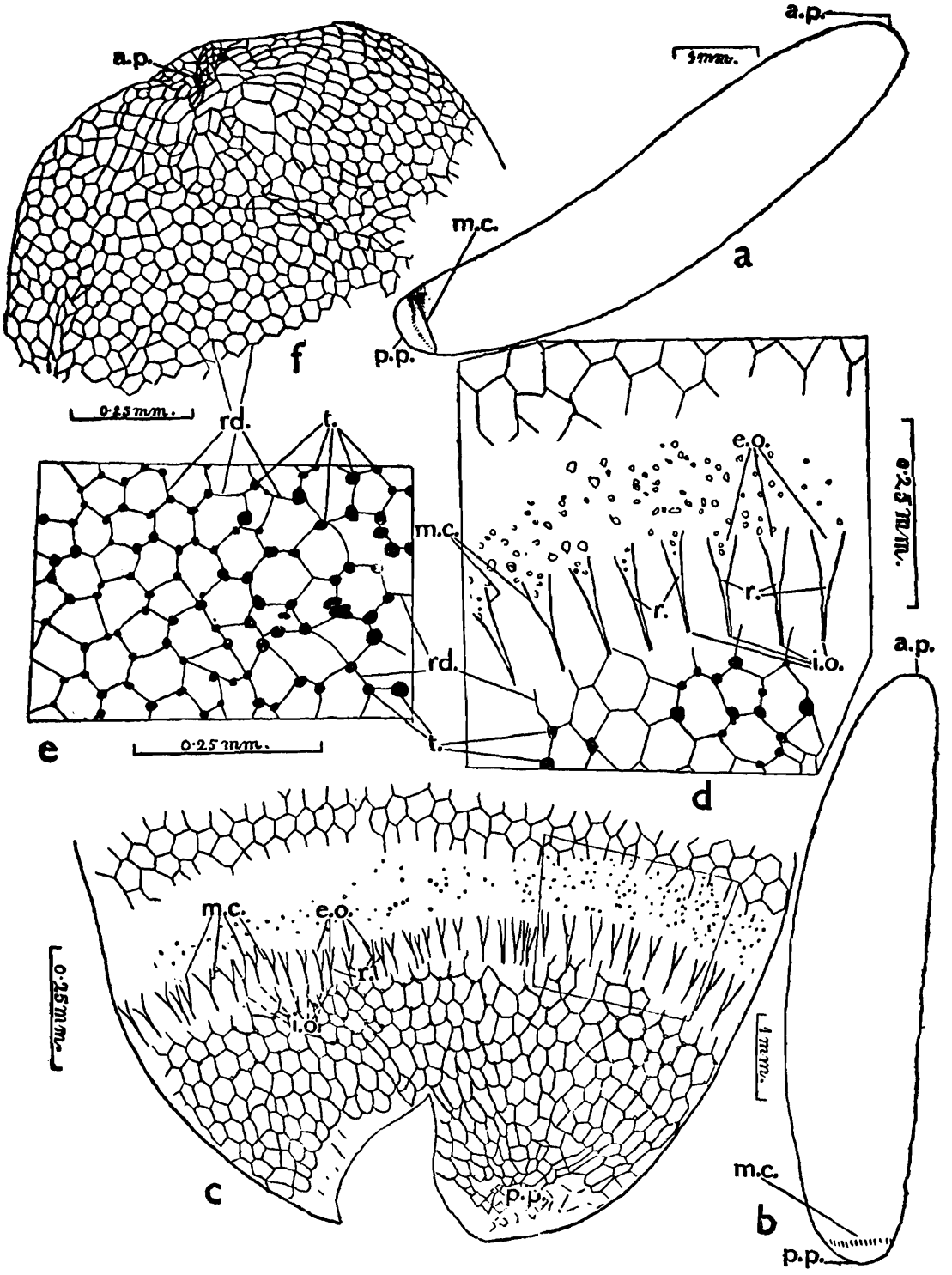
4. **Choroedocus insignis** Thunberg

(Text-fig. 13 *a-f*)

Anterior pole (Text-fig. 13 *f*).—Sculpturing at this pole presenting tetra-, penta- and hexagonal polygons, outlined by ridges. At extremity of egg only tetragonal cells present ; cells longer than broad ; at places ridges curved or bent ; tubercles wanting.

Middle chorion (Text-fig. 13 *e*).—Middle chorion also showing tetra-, penta- and hexagonal polygons outlined by straight ridges. Tubercles of irregular shapes ; oval, round dot-shaped, etc., appear thick translucent, at each corner of cells, and also sometimes within cells away from ridges.

Posterior pole (Text-fig. 13 *c*).—Sculpturing showing a mosaic pattern of penta- and hexagonal cells outlined by straight ridges near inner openings of micropylar canals, but absent near the body of canals and beyond them ; smooth unsculptured area present in the level of the



TEXT-FIG. 13.—Egg-wall of *Choroedocus insignis* Thunberg.

(*a*) and (*b*). Egg in side view. (*c*). Surface view of egg-wall near the posterior pole showing the ring of micropylar canals and sculpturing. Note presence of irregularly rounded tubercles. Dots towards external opening of the canals (*d*). Same, enlarged only a rectangular portion indicated in Fig. *c*, to show structure of tubercles and dots both at internal and external openings of the micropylar canals respectively. (*e*). Surface view of the chorion from the middle portion of egg showing ridges and tubercles of different sizes. (*f*). Surface view of egg-wall near the anterior pole, showing different sculpturing than at posterior pole. Note absence of tubercles.

a.p., anterior pole of egg ; *e.o.*, external opening of micropylar canal ; *i.o.*, internal opening of micropylar canal ; *m.c.*, micropylar canal ; *p.p.*, posterior pole of egg ; *r.*, roof of micropylar canal ; *rd.*, ridges of endochorion of egg-wall ; *t.*, tubercles or protuberances of endochorion of egg-wall.

micropylar canals as in *Phlaeoba panteli*. In former small, rounded, dot-shaped structure present in smooth unsculptured area beyond the mouth of micropylar canals, absent in latter. At extremity of pole, penta- and hexagonal cells present, longer than broad ; ridges curved. Dot-shaped tubercles thin, transparent, present at each corner of cells near inner openings of canals ; tubercles wanting at extremity. Micropylar canals funnel-shaped ; narrow down to form a fine long tubular portion ; 34-38 canals present ; measurements of canals :—

Total length : 110-150 μ (average 132 μ).

Width of mouth : 20- 40 μ (average 34 μ).

5. **Eyprepocnemis roseus** Uvarov

(Text-fig. 14 *a-h*)

Anterior pole (Text-fig. 14 *g-h*).—A mosaic pattern of small penta- and hexagonal cells ; elongated towards extremity of pole ; cells outlined by straight ridges ; ridges vary in length. Small, rounded, knob-like tubercles present within cells, visible in magnified view only.

Middle chorion (Text-fig. 14 *e-f*).—Sculpturing showing penta- and hexagonal cells similar to that of anterior pole, except that tubercles present at each corner of cells unlike at anterior pole where tubercles present within cells.

Posterior pole (Text-fig. 14 *b-d*).—A mosaic pattern of penta- and hexagonal cells at extremity of pole. An smooth unsculptured area present beyond ring of micropylar canals, only with very small granules inside and just above mouth of micropylar canals. Small, rounded, knob-shaped tubercles present at each corner of the cells at the extremity of pole ; only one or two tubercles present here and there near inner openings of micropylar canals. Micropylar canals funnel-shaped, each tapers gradually into a fine narrow pore ; 41-56 canals present, arranged in a ring ; measurements of canals :—

Total length : 120-180 μ (average 130 μ).

Width of mouth : 40-70 μ (average 48 μ).

6. **Parahieroglyphus bilineatus** Bolivar

(Text-fig. 15 *a-f*)

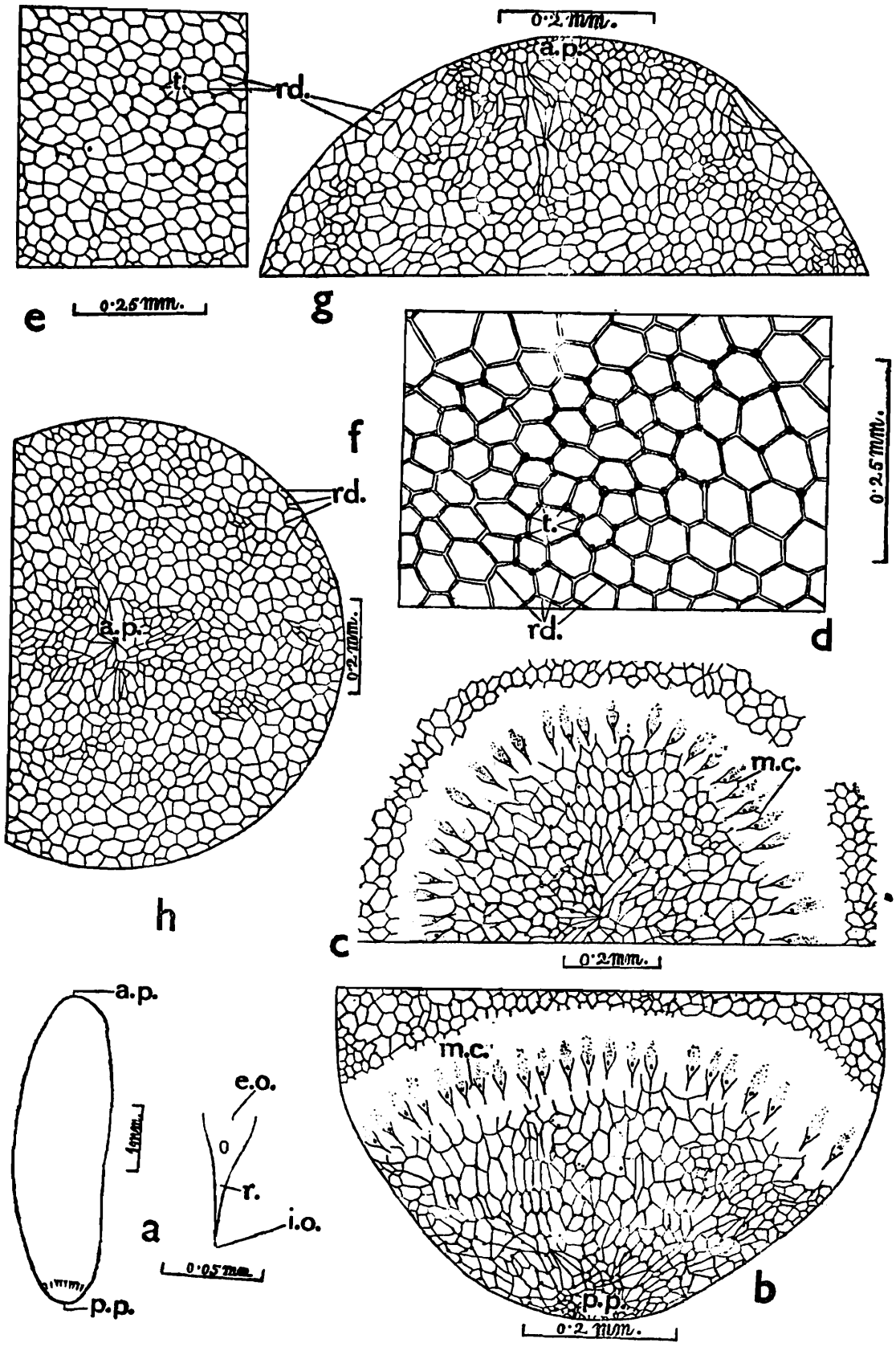
Anterior pole (Text-fig. 15 *b*).—Chorion of anterior pole showing no definite pattern of polygons outlined by ridges, but numerous, very small, dot-like, transparent tubercles scattered irregularly ; tubercles at places forming concentric or intersecting polygons.

Middle chorion (Text-fig. 15 *c*).—Here again mosaic pattern of polygons wanting as at anterior pole, but tubercles form a pattern of concentric and intersecting polygons at some places ; tubercles fewer in number than that present at both anterior and posterior poles.

Posterior pole (Text-fig. 15 *d-f*).—At this pole numerous small, dot-like transparent tubercles present in patches at extremity, a few bent or curved small lines or ridges present towards micropylar canals. Micropylar canals number 36-43 ; measurements of canals :—

Total length : 240-260 μ (average 250 μ)

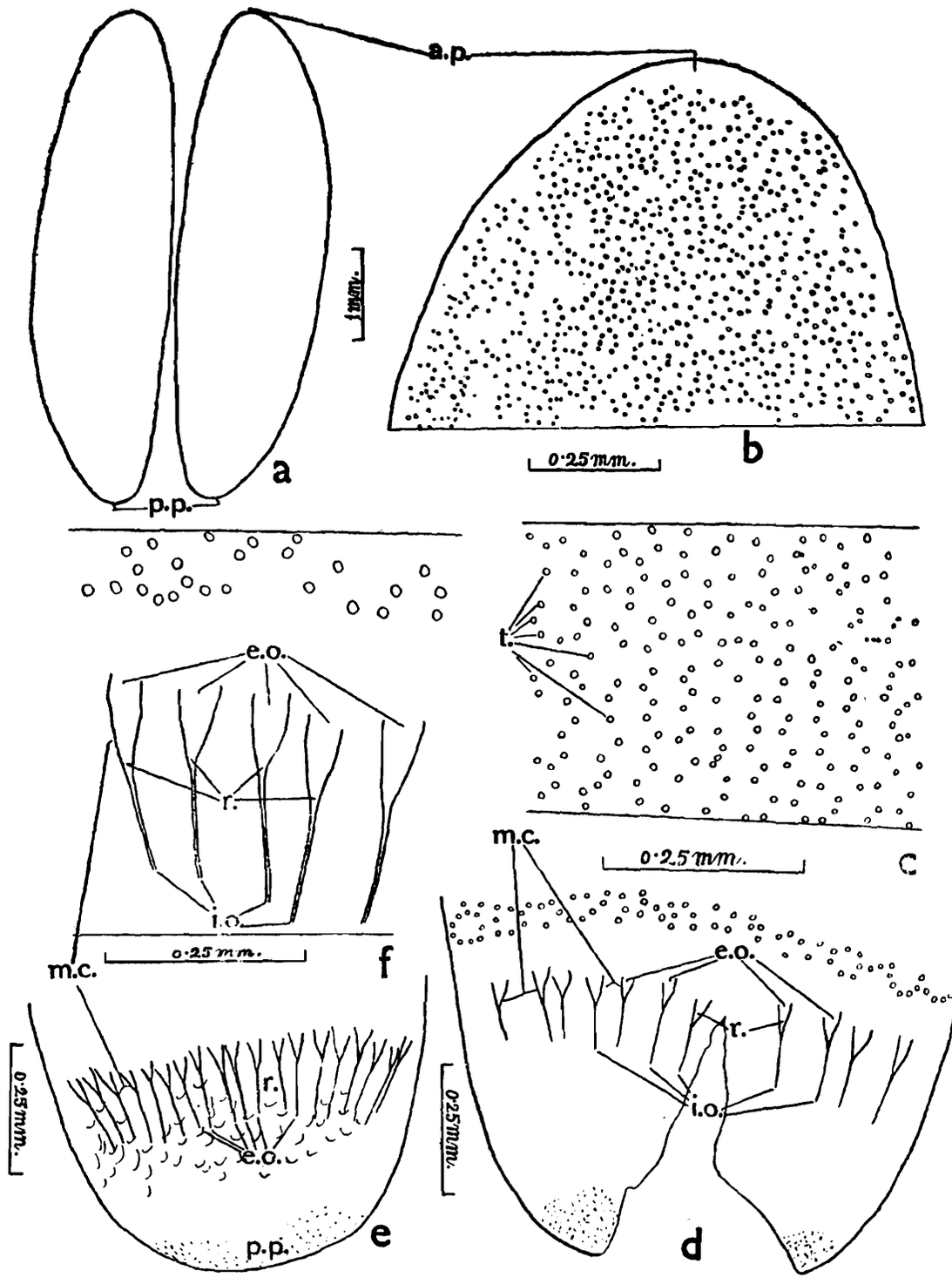
Width of mouth : 40-50 μ (average 44 μ).



TEXT-FIG. 14.—Egg-wall of *Eyprepocnemis roseus* Uvarov.

(*a*). Egg in side view. (*b*). Surface view of egg-wall near the posterior pole showing the ring of micropylar canals and sculpturing. Note presence of rounded tubercles. (*c*). Same, a portion from top. One micropylar canal enlarged. (see below). (*e*). Surface view of the chorion from the middle of egg showing ridges and tubercles at the corners of the polygons. (*f*). Same, a portion more enlarged. (*g*). Surface view of egg-wall near the anterior pole showing difference in sculpturing than at posterior pole. Note absence of tubercles. (*h*). Same, a portion from top.

a.p., anterior pole of egg ; *e.o.*, external opening of micropylar canal ; *i.o.*, internal opening of micropylar canal ; *m.c.*, micropylar canal ; *p.p.*, posterior pole of egg; *r.*, roof of micropylar canal ; *rd.*, ridges of endochorion of egg-wall ; *t.*, tubercles or protuberances of egg-wall.



TEXT-FIG. 15.—Egg-wall of *Parahieroglyphus bilineatus* Bolivar.

(*a*). Two eggs in side view. (*b*). Surface view of the egg-wall near the anterior pole showing only tubercles. (*c*). Surface view of the chorion from the middle of egg showing only circular tubercles. (*d*). Surface view of egg-wall near the posterior pole showing the ring of micropylar canals and tubercles towards external openings of the canals. (*e*). Same, another posterior pole showing a few lines near internal openings of the canals. (*f*). Surface view of 5-micropylar canals, enlarged.

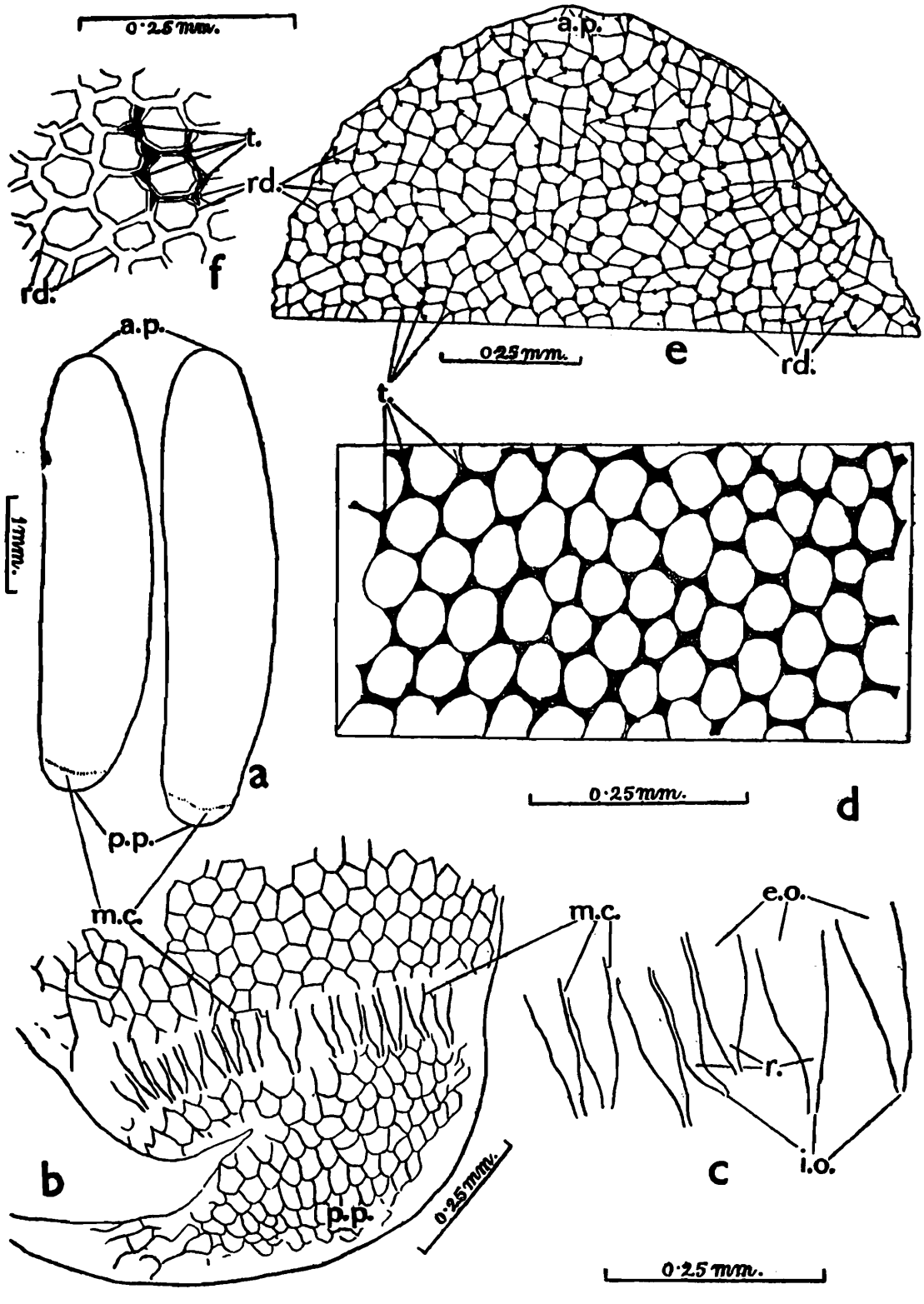
a.p., anterior pole of egg ; *e.o.*, external opening of micropylar canal ; *i.o.*, internal opening of micropylar canal ; *m.c.*, micropylar canal ; *p.p.*, posterior pole of egg ; *r.*, roof of micropylar canal ; *t.*, tubercles or protuberances of endochorion of egg-wall.

7. **Xenocatantops humilis humilis** Serville

(Text-fig. 16 *a-f*)

Anterior pole (Text-fig. 16 *e-f*).—Mosaic pattern of tetra-, penta-hexa-and septagonal cells outlined by ridges present up to extremity of pole. Small, triangular, tubercles present at each corner of cell. n

magnified view apices of tubercles join with the adjacent ones (Text-fig. 16*f*).



TEXT-FIG. 16.—Egg-wall of *Xenocatantops humilis humilis* Serville.

(*a*). Two eggs in side view. (*b*). Surface view of egg-wall near the posterior pole showing the ring of micropylar canals and the sculpturing. Note absence of rounded tubercles. (*c*). Surface view of 7 micropylar canals, enlarged. (*d*). Surface view of the chorion from the middle portion of egg, showing somewhat triangular tubercles interlacing each other on the ridges of the endochorion of egg-wall. (*e*). Surface view of the egg-wall at the anterior pole showing sculpturing different than at posterior pole. Note presence of short triangular tubercles. (*f*). Same, a portion more enlarged.

a.p., anterior pole of egg ; *e.o.*, external opening of micropylar canal ; *i.o.*, internal opening of micropylar canal ; *m.c.*, micropylar canal ; *p.p.*, posterior pole of egg ; *r.*, roof of micropylar canal ; *rd.*, ridges on endochorion of egg-wall ; *t.*, tubercles or protuberances of endochorion of egg-wall.

Middle chorion (Text-fig. 16 *d*).—Only triangular tubercles prominent ; apices of tubercles join with adjacent ones forming oval-shaped cells of dfferent diameters.

Posterior pole (Text-fig. 16 *b*, *c*).—A mosaic pattern of cells with curved or bent ridges present from inner openings of micropylar canals to extremity of pole ; triangular tubercles wanting. Micropylar canals long with no definite form ; inner openings of canals not fine and narrow as in other species of Acrididae studied above ; 38-42 canals present ; measurements of canals :—

Total length : 170-220 μ (average 186 μ).

Width of mouth : 40-70 μ (average 56 μ).

Subfamily (iii) *OEDIPODINAE*

8. **Gastrimargus transversus** Thunberg

(Text-fig. 17 *a-e*)

Anterior pole (Text-fig. 17 *b*).—Chorion of anterior pole showing on mosaic pattern of cells outlined by ridges, but only numerous dots of irregular shapes and sizes present.

Middle chorion (Text-fig. 17 *c*).—Here also only dot-like structures of various shapes and sizes present as at anterior pole, but are more prominent.

Posterior pole (Text-fig. 17 *d*, *e*).—Number of dot-like tubercles very few at posterior pole than at anterior pole ; tubercles present only near inner openings of micropylar canals. A few curved ridges or lines present here and there beyond micropylar canals upto extremity of pole. Micropylar canals neither funnel-shaped nor pipette-shaped but tapering right from mouth upto the fine narrow pore ; 36-44 canals present ; measurements of canals :—

Total length : 80-90 μ (average 87 μ).

Width of mouth : 20-30 μ (average 27 μ).

Subfamily (iv) *PYRGOMORPHINAE*

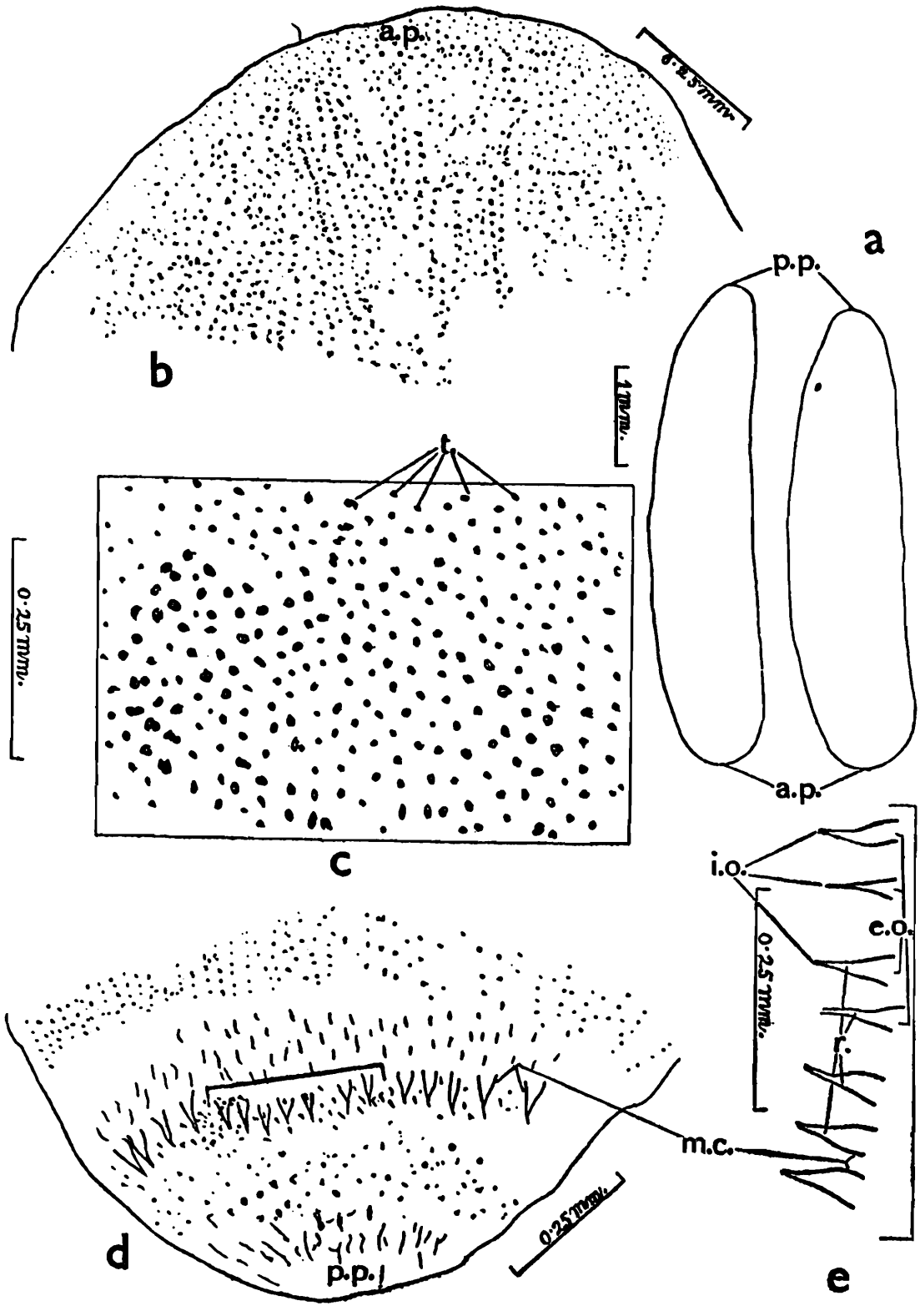
9. **Aularches miliaris** Linnaeus

(Text-fig. 18 *a-f*)

Anterior pole (Text-fig. 18 *f*).—Sculpturing presenting a mosaic pattern of tetra-, penta- and hexagonal cells outlined by straight ridges of various lengths towards extremity of pole ; ridges bent instead of straight ; no cellular sculpturing at pole.

Middle chorion (Text-fig. 18 *d*, *e*).—Here again similar cells present as at anterior pole, except that narrow spaces or trabeculae present between ridges of two adjacent cells. Long, straight, single tipped (or bent at tip) spine-like tubercles present at each corner of the cells.

Posterior pole (Text-fig. 18 *b*, *c*).—A mosaic pattern of different types of cells present right from middle of chorion to extremity of pole, very unlike other species of Acrididae studied so far ; cells vary much

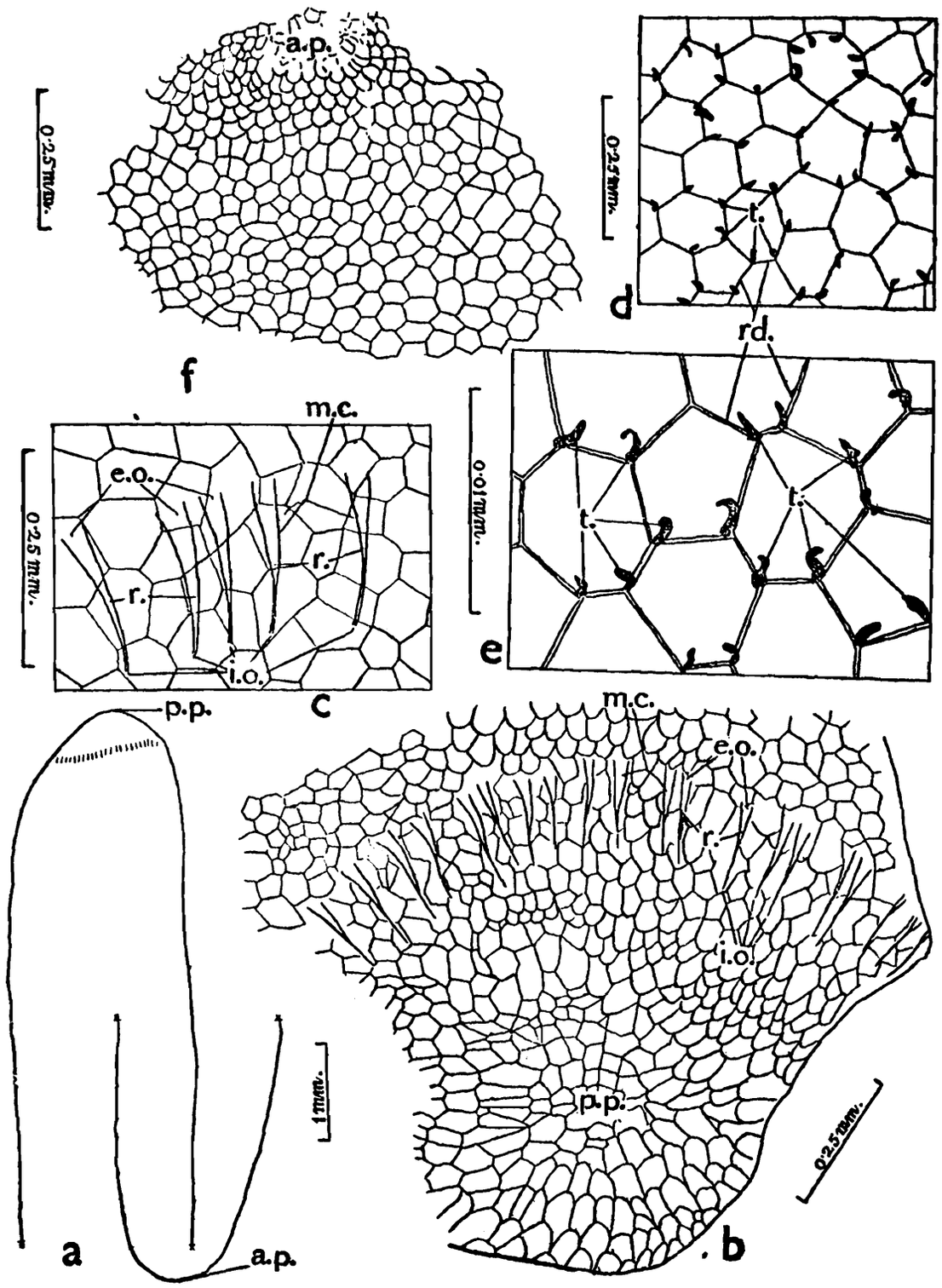


TEXT-FIG. 17.—Egg-wall of *Gastrimargus transversus* Thunberg.

(*a*). Two eggs in side view. (*b*). Surface view of the egg-wall near the anterior pole. Note only numerous tubercles. (*c*). Surface view of the chorion from the middle of egg showing irregularly distributed tubercles. (*d*). Surface view of the egg-wall at the posterior pole showing the ring of micropylar canals. Note absence of tubercles, but many noted at anterior pole. (*e*). Same, 7-micropylar canals, enlarged.

a.p., anterior pole of egg ; *e.o.*, external opening of micropylar canal ; *i.o.*, internal opening of micropylar canal ; *m.c.*, micropylar canal ; *p.p.*, posterior pole of egg ; *r.*, roof of micropylar canal ; *t.*, tubercles or protuberances of endochorion of egg-wall.

in shape and size, *viz.*, with curved and bent ridges forming oval-shapd cells near inner openings of micropylar canals ; with long and straight ridges, cells lon er than broad near extremity of pole. Micropylar



TEXT-FIG. 18.—Egg-wall of *Aularches miliaris* Linnaeus.

(*a*). Side view of an egg in two portions. (*b*). Surface view of egg-wall near the posterior pole showing the ring of micropylar canals, and the sculpturing. Note absence of tubercles. (*c*). Surface view of 5-micropylar canals. (*d*). Surface view of the chorion from the middle of egg showing typical spiniform tubercles and ridges. (*e*). Same, more enlarged. (*f*). Surface view of the portion of the egg-wall at the anterior pole of egg. Note absence of tubercles.

a.p., anterior pole of egg ; *e.o.*, external opening of micropylar canal ; *i.o.*, internal opening of micropylar canal ; *m.c.*, micropylar canal ; *p.p.*, posterior pole of egg ; *r.*, roof of micropylar canal ; *rd.*, ridges of endochorion of egg ; *t.*, tubercles of endochorion of egg-wall.

canals forming tubular structures and terminating abruptly in very fine pore ; 44-49 canals present ; measurements of canals :—

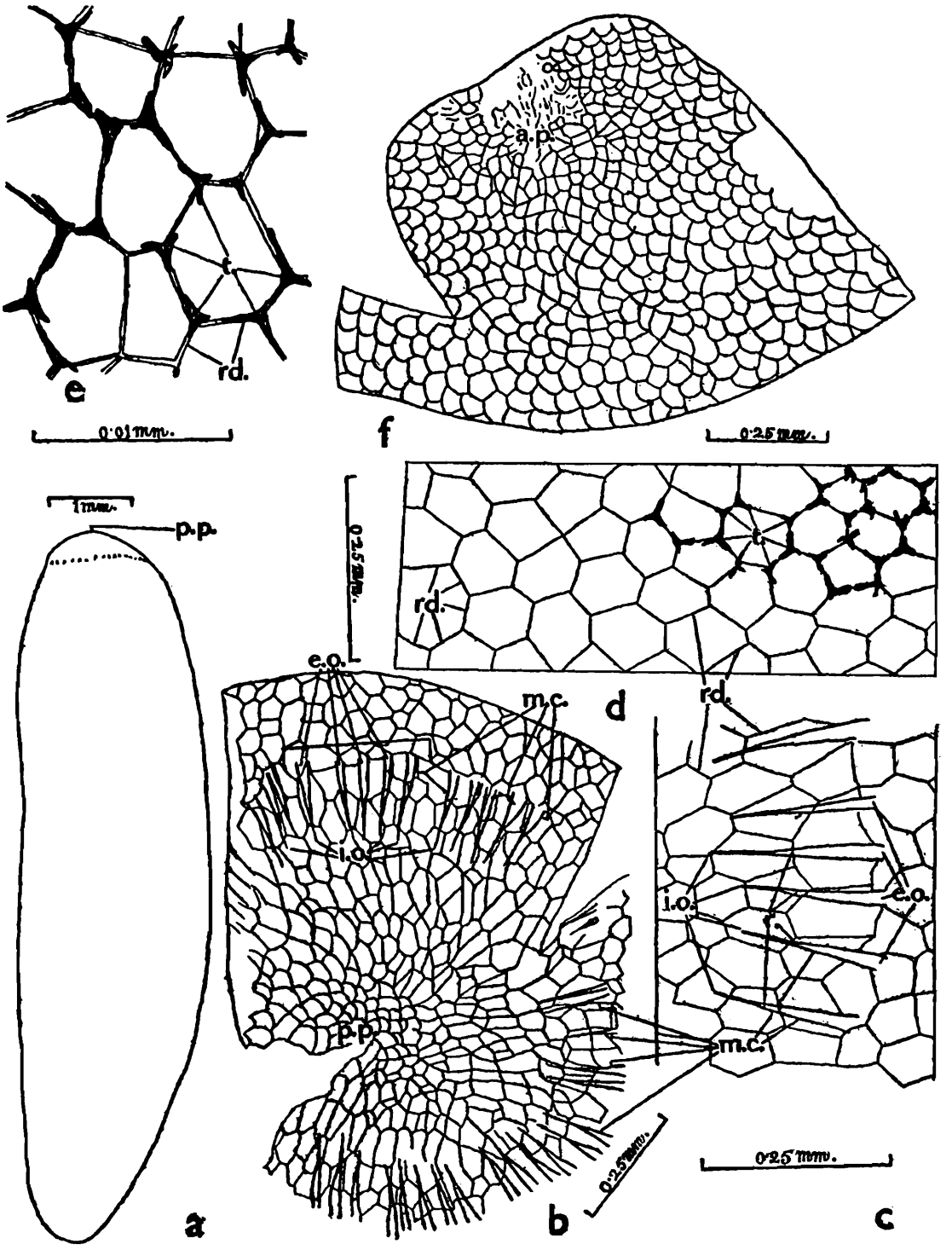
Total length : 170-190 μ (average 178 μ).

Width of mouth : 20-30 μ (average 26 μ).

10. **Aularches punctatus** Drury

(Text-fig. 19 *a-f*)

Sculpturing at both anterior and posterior poles as well as in middle chorion very similar to that of *Aularches miliaris*, but differing, firstly in structure of spines (tubercles) present in middle chorion, and secondly in number, size and shape of micropylar canals.



TEXT-FIG. 19.—Egg-wall of *Aularches punctatus* Drury.

(*a*). Egg in side view. (*b*). Surface view of egg-wall near the posterior pole showing the ring of micropylar canals and sculpturing. Note absence of tubercles. (*c*). Same, 6-micropylar canals, enlarged. (*d*). Surface view of chorion from the middle of egg showing typical trifurcated tubercles and ridges. (*e*). Same, more enlarged. (*f*). Surface view of egg-wall near the anterior pole showing different sculpturing than at posterior pole. Note absence of tubercles.

a.p., anterior pole of egg ; *e.o.*, external opening of micropylar canal ; *i.o.*, internal opening of micropylar canal ; *m.c.*, micropylar canal ; *p.p.*, posterior pole of egg ; *r.*, roof of micropylar canal ; *rd.*, ridges of endochorion of egg-wall ; *t.*, tubercles or protuberances of endochorion of egg-wall.

Middle chorion : Long and trilobed tubercles present at each corner of cells.

Posterior pole : 43-47 canals present ; measurements of canals :—

Total length : 190-230 μ (average 193 μ).

Width of mouth : 20-40 μ (average 23 μ).

VI—Summary

1. The mode of oviposition in the following 14 species of Indian Acrididae has been studied :—

Ceracris deflorata, Phlaeoba panteli, Choroedocus insignis, Choroedocus sp., *Eyprepocnemis roseus, Hieroglyphus banian, H. nigrorepletus, Parahieroglyphus bilineatus, Schistocerca gregaria, Spathosternum prasiniferum, Xenocatantops humilis Locusta migratoria migratorioides, Aularches punctatus* and *Chrotogonus concavus.*

2. The mode of oviposition falls under 3 different categories. Each of these categories is correlated with the mode of copulations (Modes I, II and III respectively, as discussed earlier).

3. An ecological study of oviposition, especially in relation to the soil, has been made in 20 species of north Indian Acrididae.

4. Detailed morphological study of the egg-pods and eggs of 14 north Indian species of Acrididae has been done, and a key to the identification provided on the basis of their characteristic descriptions.

5. A detailed study of the sculpturing of the egg-chorion of 10 species of north Indian Acrididae has been done. On this basis it is possible to distinguish the eggs of various species.

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