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THE BIOLOGY OF *CYNAEUS ANGUSTUS* LEC., A NEW STORED GRAIN PEST[1]

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In 1940 *Cynaeus angustus* Lec., a species of beetles heretofore known only to the taxonomist, became so common in stored corn that it attracted the attention of several entomologists working in the American Corn Belt. How this species, named by Leconte (6) in 1852, could remain in practical oblivion for almost a century and then within one year suddenly appear as a stored grain pest of considerable importance in hundreds of communities is somewhat of a mystery.

Prior to 1938 the only habitat recorded for *C. angustus* was the debris at the base of yucca plants in California. Then within five months it was discovered to be a pest of stored grain in Kansas, Washington, and Iowa.

Hatch (4) found specimens in a flour mill in Seattle in July, 1939. Cotton (unpublished) found it in wheat at Keats, Kansas, in October, 1939, and the writers found it in corn at Winthrop, Iowa, in November, 1939. It is presumed, however, that the species had attained wide distribution before 1939 and that its discovery as a stored grain pest awaited the extensive sampling of grain which came with the "Ever Normal Granary" program.

In 1940 and '41 this species was found in stored grain in Minnesota, South Dakota, Missouri, Nebraska, and Illinois.

By September, 1941, *C. angustus* had been recorded from forty-nine Iowa counties and undoubtedly a more intensive search would have revealed its presence in most if not all of the ninety-nine counties in the state.

MATERIALS AND METHODS

All breeding material was obtained by sifting corn taken from infested bins. Unless otherwise stated, all laboratory studies were conducted in constant temperature cabinets held at 30°C. and approximately 73 per cent relative humidity. The relative humidity in the cabinets was kept quite constant by the use of saturated solutions of NaCl.

Moisture determinations made on half-pint samples of corn (five samples) kept in wire screen containers gave an average moisture content of 13.98 per cent, a minimum of 13.44 per cent, and a maximum of 14.57

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per cent. The moisture determinations were made by a Tag-Heppenstall Moisture Meter at intervals of one to two weeks.

Studies at relative humidities other than 73 per cent were facilitated by the use of various concentrations of potassium hydroxide as given by Buxton (2). The moisture content of corn at various relative humidities was obtained by making repeated "Tag" moisture tests and the values secured are in close agreement with those reported by Alberts (1).

DESCRIPTION OF STAGES

ADULT: The newly-emerged adult is whitish, except for some dark areas. In about six to eight hours it changes to a golden-brown, and then slowly progresses through reddish-brown to brownish-black or black within four to five days. Measurements of the length of 100 individuals varied from 4.57 mm. to 6.09 mm., the average being 5.36 mm.

The following generic and specific descriptions were taken from Horn's (5) "Revision of the Tenebrionidae of America, North of Mexico":

GENUS CYNAEUS LECONTE

"The eyes are rather large and convex, deeply emarginate in front, slightly behind; inferior portion of the eye large, antennae with the third joint nearly equal to fourth and fifth; joints five to ten transverse, last joint oval. Hind tarsi slender, first joint long.

CYNAEUS ANGUSTUS LECONTE

"Thorax broad, equaling 1½ times the length, emarginate in front, sides strongly rounded, not narrowing in front, as broad as the elytra. Elytra feebly striate, striae punctured, interstices feebly convex, densely and finely punctured. Length .20–.22 inch."

EGG: The egg (Plate I, J) is somewhat obovate, whitish, shiny, somewhat translucent, and more bluntly rounded on the wider end. It is slightly convex on one side and concave on the other side. The chorion is very soft, pliable, and under high magnification usually shows the presence of fine transverse ridges and a few tiny pits. At the time of deposition, it is coated with a clear, viscid substance which glues it to the object upon which it is laid. Measurements of 63 eggs were:

Length: Maximum, 1.03 mm.; minimum, 0.73 mm.; average, 0.92 mm.

Width: Maximum, 0.48 mm.; minimum, 0.30 mm.; average, 0.42 mm.

FIRST INSTAR LARVA: Newly-hatched larvae are whitish in color and gradually change to light amber. The body segments are wrinkled with the lateral margins of the dorsal segments translucent. The larvae are wider through the middle and taper somewhat toward each end. Measurements of the length of fifty-four larvae within ten hours after hatching ranged from 1.48 mm. to 1.94 mm., the average being 1.74 mm.

LAST INSTAR LARVA: The form is elongate-cylindrical, with the dorsal thoracic and abdominal segments granular and convex above, and flattened or slightly convex below. The color is yellowish-orange or buff with the anterior and posterior margins of the prothorax and the posterior

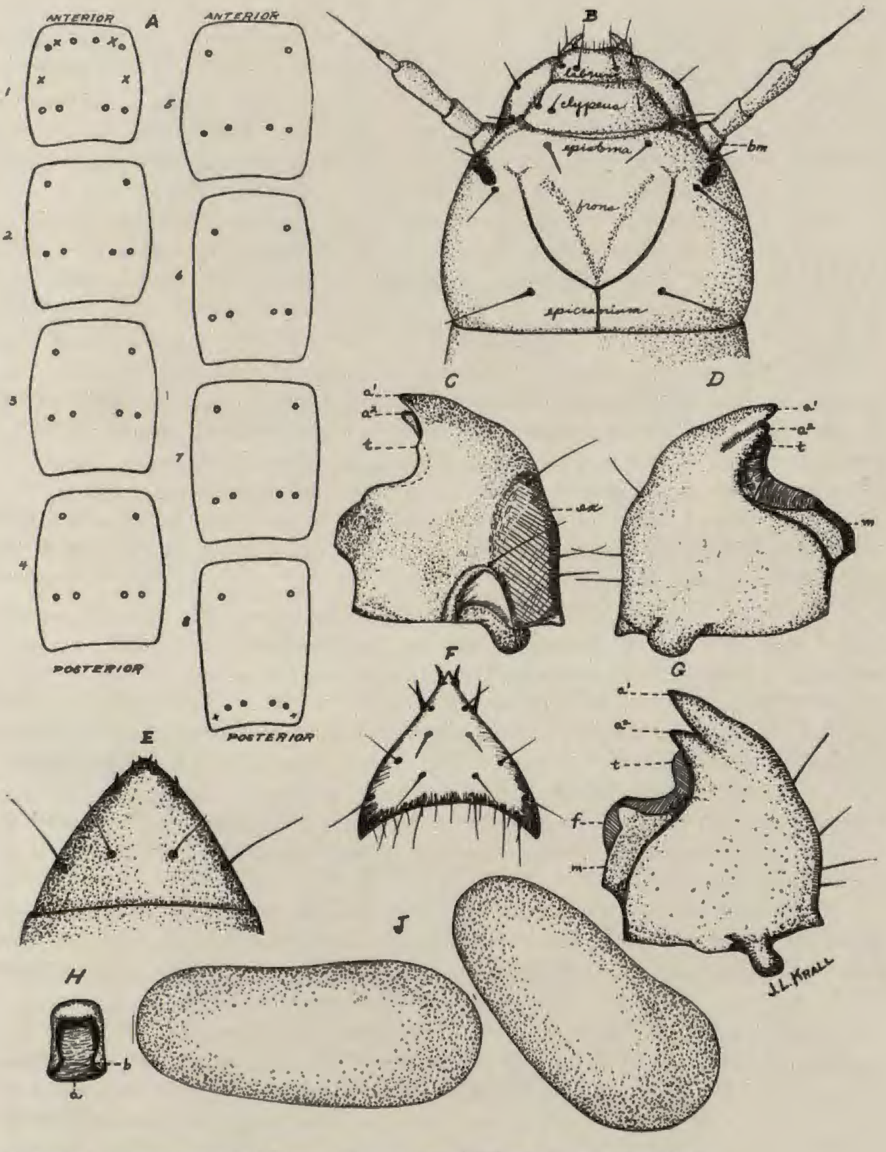

PLATE I. STRUCTURES OF MATURE LARVA AND EGGS OF *C. angustus* LEC.

A. Ventral view of abdominal segments showing setal arrangement.
B. Dorsal view of head of mature larva.
C. Right mandible; dorsal view.
D. Right mandible; ventral view.
E. Pygidium; dorsal view.
F. Pygidium; posterior view.
G. Left mandible; ventral view.
H. Hypopharyngeal sclerite.
J. Eggs.

margins of the mesothorax, metathorax, and the first eight abdominal segments slightly darker and of a different texture. When viewed dorsally, these markings give the larvae a banded appearance. The dorsal areas of the eighth and ninth abdominal segments are orange-red in color. A slight, sinuate ridge is present dorsal to the spiracles of the mesothorax, metathorax, and first eight abdominal segments. The ninth abdominal segment or pygidium is unicornute, curving sharply upward posteriorly, the apex acute and bearing a small, brownish tubercle (Plate I, E).

There are three pairs of curved, brownish, heavy, spine-like setae at or near the apex which vary from long and pointed in some larvae to rather short and blunt in others. At about the middle of the segment are four long setae arranged in an arc. A posterior view of the pygidium (Plate I, F) shows the arrangement of five pairs of long setae and the vestiture of the ventral margin composed of setae of varying lengths. The ventral surface of the ninth abdominal segment bears a pair of ambulatory warts. The setal arrangement on the first eight ventral abdominal segments is diagrammatically shown in Plate I, A. The x's represent locations of setae which are present on some larvae and absent on others. The circles represent setae which are found to be constant in number and arrangements on all larvae examined and are quite long, especially those nearest the lateral margins.

The head (Plate I, B) is of the prognathus type. It is convex on the dorsal side and lateral margins, and the epicranium is divided into two parts by a longitudinal suture. The area of the frons is marked off by a suture which is about as long as its greatest width. The V-shaped, pigmented marking in the frons has its apex at the point of contact between the frontal and epicranial sutures. The dorsal setae of the head are shown in this figure. Their location and number are constant except on the anterior margin of the labrum where they are numerous and variable in number. The labrum covers the apices of the mandibles. The clypeus is trapezoidal in shape.

The antennae are contiguous to the base of the mandibles and the basal membrane (bm) is well developed. Each antenna is composed of three segments and a hair-like seta which arises from the apex of the third segment. The first two segments are orange-red in color, except their distal ends which are quite clear and membranous. The second segment is about twice as long as the first and clubbed; the third is slightly shorter than the first, much narrower, and cylindrical. There may or may not be a few very short setae on the distal ends of segments two and three.

The mala of each maxilla bears two rows of well developed, heavy, curved setae on the inner margins. The maxillary palps are three-segmented and the labial palps two-segmented.

The mandibles (Plate I, C, D, G) are apically bifid (a^1, a^2) with an additional tooth (T) between the apex and the molar (m). The basal half of the external surface of the mandibles is flattened (C [ex.]). The molar of the right mandible, D (m), is depressed, marked with narrow, transverse ridges and slopes downward from the excavated portion of the mandible, and then drops away abruptly. The molar of the left mandible, G (m), is also depressed and appears to have a ridge running diagonally across it. The flange (f) of the dorsal surface of the left molar fits against the dorsal surface of the molar of the right mandible. Four setae are present on or near the flattened area of each mandible, the arrangement and comparative lengths of which are shown in C (ex).

The hypopharyngeal sclerite (Plate I, H) is roughly rectangular in shape and excavate above. The sides (b) recurve over at the smooth anterior margin (a). In some cases the anterior margin is serrate, which may be due to chipping off of the edges in chewing.

PRE-PUPA: Pupation is preceded by a short, quiescent, pre-pupal stage of one to two days' duration. During this period the segments of the body telescope together and the head and thoracic segments curve downward towards the ventral surface.

PUPA: The pupa (Plate II, A) is crescentric in shape, whitish in color, and bears seven pairs of lateral projections from each side of the first seven dorsal abdominal segments. On the posterior margins of the first pair are brownish, sclerotized tubercles. These tubercles are present on both the anterior and posterior margins of the second through the sixth pairs, whereas on the seventh pair they are present only on the anterior margins. There are two, jointed, diverging, protuberances from the posterior margin of the last dorsal abdominal segment.

The sex of the insect may be determined readily in the pupal stage. The last abdominal segment forms a cup-like depression on its ventral surface, in which are located the structures for determining the sex. The structure in the male pupa (Plate II, C) is bi-lobed with each lobe being rounded and slightly convex, whereas the lobes are more divergent and each bears a nipple-like projection at its apex in the female (B).

Thirty-five pupae of each sex were measured to determine the length. The males varied from 4.57 mm. to 5.84 mm., the average being 5.04 mm. The length of the females ranged from 4.57 mm. to 6.10 mm., the average being 5.17 mm.

LIFE HISTORY AND HABITS

Like most of the stored grain pests, *C. angustus* is probably semitropical in its origin and therefore breeds continuously so long as the temperature is favorable. There is no apparent diapause or other provision to enable the species to endure long periods of dormancy. However, this species is able to withstand rather long periods of inactivity at moderately low temperatures in both the larval and adult stages.

ADULT ACTIVITIES

The adult beetles are very active and are fairly strong fliers. They are to a large extent nocturnal and when abundant can be collected in large numbers in light traps. During the day, however, they are negatively phototropic and tend to hide below the surface of the grain.

No attempt was made to determine the maximum or average length of adult life, but it was noted that many individuals lived at least 100 days and some lived for as long as six months under laboratory conditions. It seems probable, therefore, that in nature some adults may live for a year or even longer.

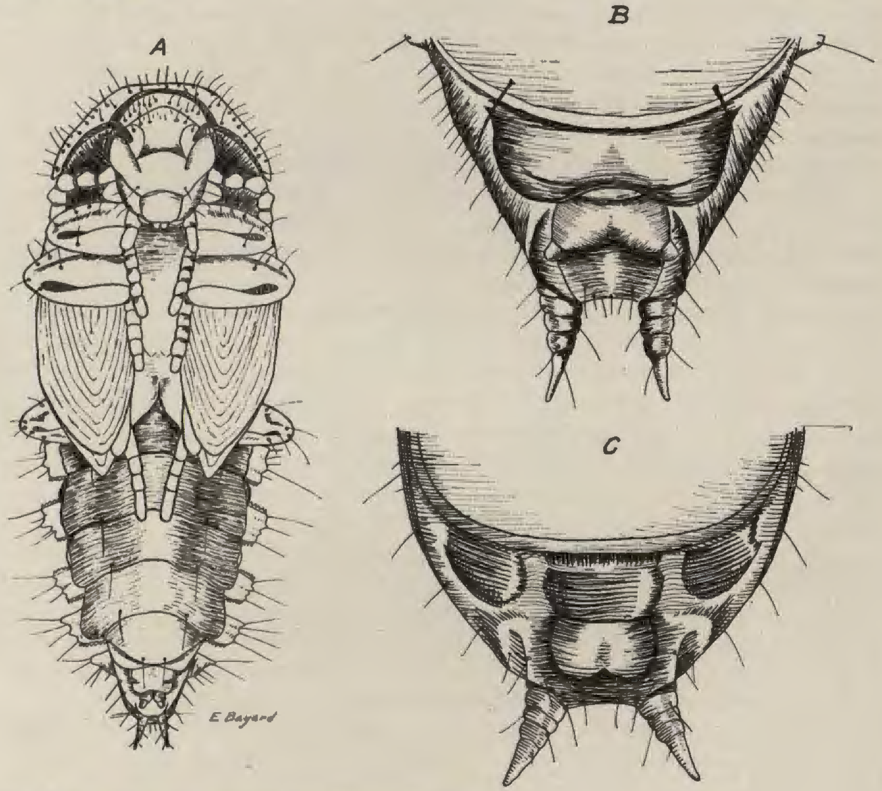

PLATE II. Pupa and Pupal Sex Characters
A. Female pupa; ventral view.
B. Female pupa; terminal segments.
C. Male pupa; terminal segments.

SEX RATIO

As no very reliable external characters for separating males and females were found, it was necessary to examine the internal genitalia to determine the sex. The genitalia of 932 adults were extracted. Of these, 49.8 per cent were females and 50.2 per cent males.

PREOVIPOSITION

Repeated observations showed that eggs were generally deposited within five to seven days after emergence.

Before depositing eggs, the female used her long, flexible ovipositor as a probe to seek a favorable location for placing the eggs in the food material. The two long setae, one on each side of the pore, were the structures used to find a suitable place. When a satisfactory location was found, the beetle remained quiet for one or two minutes while the egg was deposited.

OVIPOSITION

The eggs generally were placed in protected places. Of ninety-eight eggs found on shelled corn, seventy-two were on the glume, twelve in cracks in the kernels, eleven in the dent, and three were glued to the smooth side. More than half of the eggs were found singly, but in a few cases groups of two or more were found together.

In corn of 17 to 18 per cent moisture, females deposited from four to five eggs per female per day. Assuming 4.5 eggs per day as average and 80 to 100 days as the normal egg laying period, each female may be expected to produce from 360 to 450 eggs, discounting mortality.

INCUBATION

When adults were left on cornmeal and allowed to deposit eggs for 6 hours, thirty-one eggs hatched in 74.5 hours. In another instance when adults were allowed to remain on the medium for 12 hours, seventy-five larvae hatched in from 87 to 92.5 hours. Of this number, sixty-three hatched in 87 hours, six in 88.5 hours, one in 90.5 hours, three in 91.5 hours, and two in 92.5 hours. These observations indicate an incubation period of about three or four days. During the developmental period the eggs became almost amber in color and the reddish eye spots were discernible several hours before hatching.

LARVAL INSTARS AND LENGTH OF LARVAL LIFE

Newly-hatched larvae were segregated in small vials which contained just enough yellow cornmeal to cover them. These were kept in a desiccator containing distilled water which gave a relative humidity of about 100 per cent. Each larva was examined daily, and as soon as a larva molted the old cornmeal was removed and fresh meal substituted. In all, twenty-two adults were reared in this manner. Sixteen, or about three-fourths of the larvae, had nine instars, five had ten, and one had eleven instars. The total length of larval life varied from forty-six to fifty-five days, which in the light of more complete studies on ecology and nutrition seems to be about average but does not represent either extreme. The minimum length of larval life observed at 30°C. was 22 days and the maximum 92 days. Overcrowding tends to greatly lengthen larval life and in many cases prevents pupation.

FEEDING

The feeding activities of the adults and larvae were not confined to one kernel of corn, and both the adults and larvae moved about freely in the cultures. In most cases larvae entered the dent end or the germ area of the kernel and the germ and endosperm were preferred as food.

When only sound, hand-picked kernels were available, the larvae always attacked the germ by chewing a more or less circular hole through the pericarp.

PLACE OF PUPATION

With few exceptions, the mature larvae either selected or provided a sheltered location for pupation. Hollow kernels or pieces and foreign materials in the grain were often utilized and in most cases the openings were plugged with frass. In some cases, the pupal cells were excavated in the accumulated layer of frass in the bottom of the culture jars. To facilitate the collection of pupae for experimentation, sheets of cardboard were introduced into cultures of cracked corn containing last instar larvae. Many larvae used fine cracked corn to build an oval cell between two sheets of cardboard. In wheat, pupation generally occurred in cells constructed in the spaces between the kernels. This manner of pupation was common where the food medium did not provide sheltered facilities.

DURATION OF PUPAL STAGE

The length of the pupal period was determined by placing seventy-six mature larvae in separate vials and then making regular daily observations from the time of pupation until the adults emerged. The length of the pupal stage, at 30°C., varied from four to six days and averaged five days.

NATURAL CONTROL

PARASITES AND PREDATORS: Although it is probable that some parasitic insects attack this species in one or more of its life stages, none were observed during the course of this investigation.

PROTOZOA: An undetermined protozoan (order Microsporidia) was found to be a common parasite of *C. angustus* in many infestations in the field and it gave considerable trouble in laboratory cultures.

Microscopic examination of insects in diseased cultures showed varying degrees of infection. Solid black areas which cover from one-third to one-half or more of the body area of a larva indicated a heavy infection, while a light graying in the region of the posterior mid-dorsal line indicated a light infection.

Many diseased larvae molted from one instar to the next and some were even able to transform to the pupal stage. Although death frequently occurred in the pupal stage, a few adults were able to emerge. Some of these adults had blackened areas visible through the body wall of the ventral abdominal segments, and sections which were cut through these areas showed that the "cysts" were partially imbedded in the body wall.

Eighty-five heavily infected larvae which were segregated on corn all died before transforming to the pupal stage. These larvae were very active at first but they became sluggish shortly before death. Larvae which died of the disease remained flaccid for a short time but became quite hard within one or two days. The "cysts" were found only in the adipose tissue of the larval, pupal, and adult stages (except as mentioned above).

The incidence of the disease apparently is not influenced by temperature or moisture conditions. Infected larvae were found in corn of low moisture content as well as in corn of high moisture content and at temperatures which varied from 20°C. to 30°C.

CANNIBALISM: The presence of chewed pre-pupal larvae, pupae, and parts of adults in cultures indicated that some cannibalism occurs. In one instance four adults were observed feeding on a living larva in a jar of dry cornmeal. The first adults to emerge often fed on helpless pupae even though an abundance of meal was available for food.

Observations seem to indicate that cannibalism occurs most frequently in food of low moisture content.

ECOLOGY AND NUTRITION

INFLUENCE OF VARIED GRAIN DIET: As corn, wheat, barley, and oats are the most important grains grown in Iowa, all four were tested to determine their suitability for rearing *C. angustus*. Nine bottles, 2¾ x 5¾ inches (to the shoulder), were filled with each type of grain. In order to maintain similar biotic conditions, a layer of soaked grain one inch deep was placed in the bottom of each rearing bottle and 200 cc. of dry grain was added on top of the wet grain. Twenty-five first instar larvae then were placed in each container.

The layer of soaked grain in each bottle which soon sprouted, molded, and decayed, gave moisture to the adjacent dry grain so as to form a moisture and fungus gradient with the dry grain. The larvae, therefore, were able to select the stratum (within limits) most suitable for their development.

These experiments were disturbed as little as possible until pupation began to occur, at which time and every two days thereafter the grain in each jar was examined carefully and the newly-emerged adults were removed. The number of living adults reared from each lot of twenty-five first instar larvae and the per cent mortality are given in Table 1 and the emergence records of adults in days are given in Figure 1. In general, *C. angustus* larvae developed just as well on oats and barley as they did on corn, but development on wheat was somewhat inferior to that on the other grains tested.

INFLUENCE OF CORN MOISTURE CONTENT: Four experiments were set up in the course of the study to determine the effect of corn moisture content on the rate of reproduction and survival. Experiments A, B, and C were started on corn of known moisture content but no attempt was made to maintain the various moistures at a constant level. Quart fruit jars, filled three-fourths full of corn, were used as rearing containers. Each jar was fitted with a tin lid which had a screen-covered opening ½ inch square in the center.

In experiment A, jars of corn of 9.8 per cent, 14.10 per cent, 17.8 per cent, and 20.9 per cent moisture content were used. Twenty-five adult

TABLE 1

NUMBER OF ADULTS REARED AND THE PERCENTAGE OF MORTALITY OBTAINED WHEN TWENTY-FIVE FIRST INSTAR LARVAE WERE RELEASED IN JARS CONTAINING 200 CC. OF VARIOUS KINDS OF GRAIN

Jar No.	Wheat		Barley		Oats		Corn	
	Live Adults Reared	Percentage Mortality	Live Adults Reared	Percentage Mortality	Live Adults Reared	Percentage Mortality	Live Adults Reared	Percentage Mortality
1	5	80.0	20	20.0	19	24.0	14*	41.7
2	10	60.0	22	12.0	18	28.0	18	28.0
3	13	48.0	15	40.0	17	32.0	12	52.0
4	10	60.0	19	24.0	21	16.0	11†	50.0
5	13	48.0	18	28.0	9	64.0	11	56.0
6	18	28.0	17	32.0	19	24.0	18	28.0
7	15	40.0	5	80.0	8	68.0	17	32.0
8	10	60.0	18	28.0	20	20.0	15	40.0
9	17	32.0	15	40.0	17	32.0	19	24.0
Total	111	....	149	....	148	....	135	....
Average	....	50.7	....	33.8	....	34.2	....	38.9

* In jar No. 1, one larva was accidentally killed.

† In jar No. 4, two pupae and one larva were accidentally killed.

beetles were placed in each jar and allowed to remain sixty-four days after the experiment was started. The newly-emerged adults were removed at irregular intervals over a period of 159 days. The results are given in Table 2.

Although the larvae in each jar of corn were not counted, it should

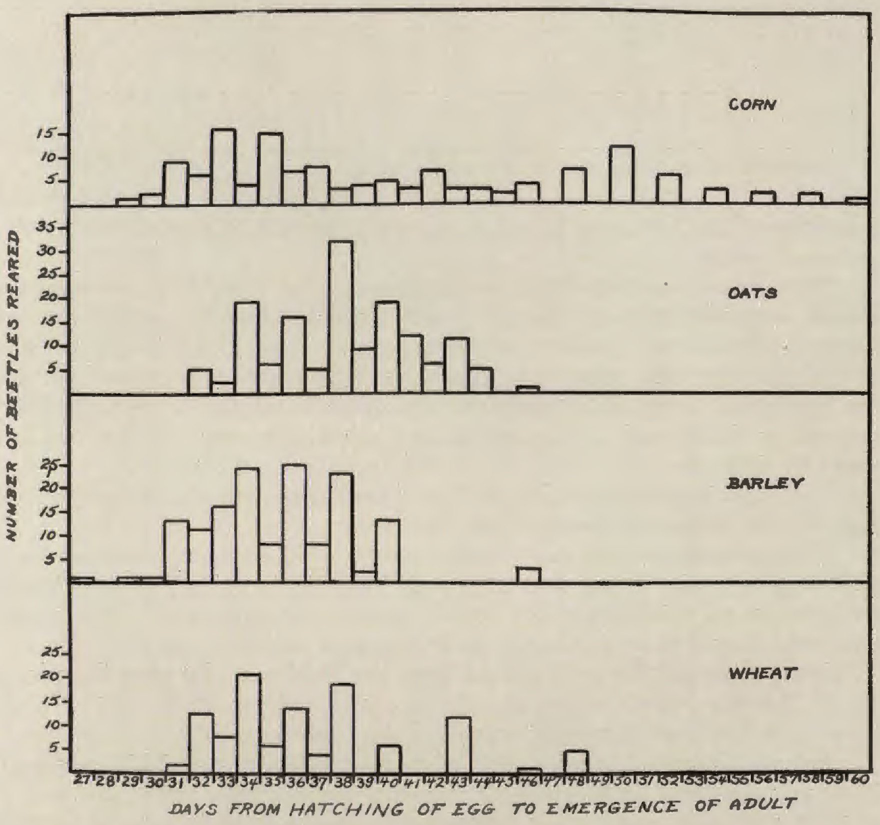

FIG. 1. Record of emergence of *C. angustus* Lec. reared on various grains.

be noted that early in the experiment, larvae were most abundant in those jars which contained corn of 17.8 per cent and 20.9 per cent moisture content. Corn of higher moisture content was very favorable for the development of the larvae until the action of fungi and bacteria caused an accumulation of free water and possibly fermentation gases. The free water trapped and killed many larvae in these and other cultures. No protozoan disease was observed.

In experiment B, the moisture content of the corn was 10.03 per cent, 14.28 per cent, 17.38 per cent, and 18.70 per cent. Three jars of corn of each moisture were used. Twenty adults were placed in each jar and after two weeks they were removed and the sex ratios determined. After pupa-

TABLE 2

NUMBER* OF INSECTS REARED TO ADULT STAGE ON CORN OF DIFFERENT MOISTURE CONTENT (TWENTY-FIVE ADULTS USED TO START EACH CULTURE)

Jar. No.	Moisture Content of Corn at Start of Experiment			
	9.8 Per Cent	14.1 Per Cent	17.8 Per Cent	20.9 Per Cent
1	56	301	0	0
2	79	137	13	0
3	92	194	12	0
Total	227	632	25	0

* Numbers shown do not include original twenty-five adults.

tion started the corn was sifted at weekly intervals to remove all newly-emerged adults.

After the experiment had been in progress for forty days, some of the larvae were infected with the protozoan parasite. In order to salvage the desired information (relative abundance), a count of all stages present in each jar fifty days after the experiment was begun was substituted for the final adult count. The experiment was then continued to permit observations on the spread of the protozoan disease. The results obtained are given in Table 3.

The high mortality in the 18.70 per cent corn was caused at least in part by an excessive amount of free water.

The percentage of diseased larvae in the 17.38 per cent moisture corn was very low, but larval mortality was high. This probably was due to some increase in infection but largely due to overcrowding. Free water was not a factor as it was in the 18.70 per cent moisture corn.

Many more adults were reared from the 10.03 per cent corn than from the 14.28 per cent corn. Undoubtedly the crowded conditions in the latter corn were the most important cause of the high mortality.

In experiment C, one jar each of corn of 9.80 per cent, 13.80 per cent, 16.66 per cent, and 19.50 per cent moisture content was used. Instead of adult beetles, fifty first instar larvae were placed in each jar. At weekly intervals, the jars were aerated and as adult beetles appeared they were removed. The results are given in Table 4. The corn of low moisture content was not favorable for the development of the larvae. The results seem to indicate that the elimination of overcrowding induced normal pupation, and that with proper aeration larvae developed normally in corn of high moisture content.

In experiment D, corn of 10.72 per cent, 14.07 per cent, and 16.72 per cent moisture content was used, and these moisture levels were maintained with only very slight fluctuation by means of KOH solutions in desiccators. Changes in the moisture content of the corn during the seventy-eight day period were insignificant.

A total of 255 first instar larvae were used in these experiments. Of this total 55, segregated 5 to a bottle, were used on the 10.72 per cent corn;

and 100, segregated 10 to a bottle, with each of the other two moistures. At the time the experiment was started, each larva was supplied with 10 cc. of food material. The desiccators were opened daily to supply fresh air. After pupation started, the contents of each jar of corn were examined and adults removed every two days. The results are tabulated in Table 5 and the daily emergence of adults is shown in Figure 2. The average length of the developmental time was 61 days on the 10.72 per cent corn, 55.4 days on the 14.07 per cent corn, and 51.7 days on the 16.72 per cent corn.

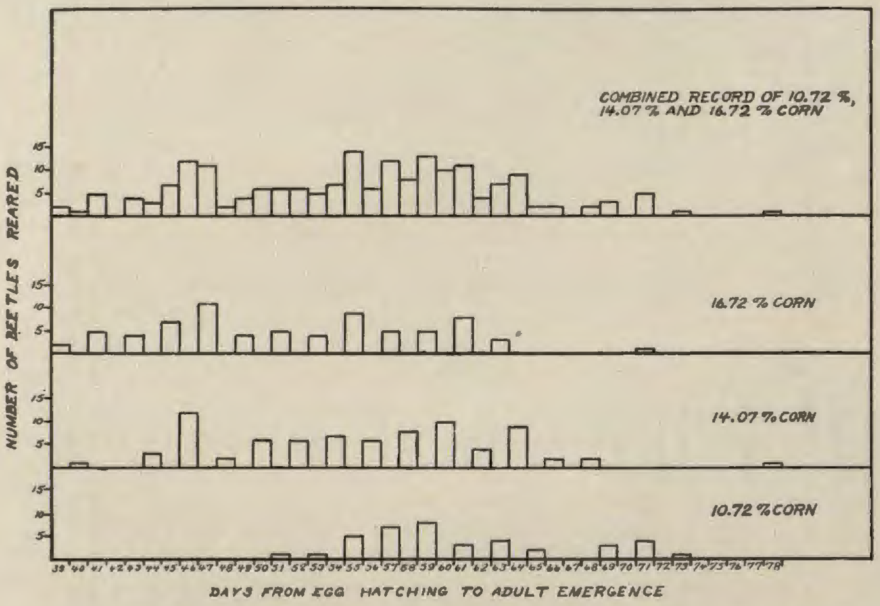

FIG. 2. Record of emergence of *C. angustus* Lec. reared on corn of various moistures.

INFLUENCE OF SOUND AND BROKEN KERNELS: The ability of *C. angustus* to attack sound corn was questioned, so an experiment was set up in which each kernel was carefully examined for soundness before the experiment was started. Thirty-five first instar larvae were placed on 350 cc. of this corn which contained 11.17 per cent moisture. At the same time thirty-five larvae were placed in a like volume of cracked corn. This moisture was maintained with a gain of only 0.1 per cent in ninety-three days.

The corn was aerated daily, and after pupation started it was examined every two days to remove the adults. On the sound corn sixteen adults were reared from the thirty-five larvae; the mortality being 54.3 per cent. The cracked corn produced twenty-five adults and a mortality of 28.5 per cent. The emergence data are given in Table 6. A few larvae were lightly infected by the protozoan, but no dead larvae were found in

TABLE 3

REARING RECORDS OF *C. angustus* ON CORN OF DIFFERENT MOISTURE CONTENT

Moisture Content of Corn (Percentage)	Jar No.	Number of					Percentage of Larvae Infected With Protozoa*	Total Mortality (Percentage) †
		Females Placed in Jar	Various Stages Present*	Living Larvae Present*	Days for First Emergence	Living Adults Removed		
10.03	1......	9	170	170	57	87	31.2	....
	2......	14	327	326	50	78	28.5	....
	3......	8	176	175	50	77	30.9	....
Total......	....	31	673	671	....	242	....	64.0
14.28	1......	7	248	240	48	86	22.1	....
	2......	11	530	528	48	32	33.5	....
	3......	8	425	423	48	29	34.5	....
Total......	....	26	1200	1191	....	147	....	87.8
17.38	1......	7	485	477	43	70	8.9	....
	2......	10	692	692	55	27	3.9	....
	3......	8	556	552	44	72	9.6	....
Total......	....	25	1733	1721	....	169	....	90.2
18.70	1......	9	618	603	45	9	17.3	....
	2......	10	739	718	45	13	21.7	....
	3......	10	613	589	46	41	20.2	....
Total......	....	29	1970	1910	....	63	....	96.8

* These figures are based on counts made fifty days after the experiments were started.

† Based on the number of living adults reared from the total number of various stages counted fifty days from the time the experiments were started.

TABLE 4

DEVELOPMENT OF FIFTY FIRST INSTAR LARVAE ON CORN OF DIFFERENT MOISTURE CONTENT

Jar No.	Percentage Moisture Content at Start	Percentage Moisture Content 97 Days Later	Number of Adults Emerging at Various Times (Days From Hatching)									Total Adult Emergence	Percentage Mortality
			39	40	46	47	53	54	60	67	74		
1.......	9.80	13.00	......	......	......	......	1	......	7	3	1	12	76.0
2.......	13.80	13.93	1	......	17	......	28	......	2	......	......	48	4.0
3.......	16.66	16.21	2	......	11	......	26	......	2	......	......	41	18.0
4.......	19.50	Soaked	......	19	......	26	......	3	......	......	......	48	4.0

TABLE 5

SUMMARIZATION OF DATA OBTAINED IN REARING *C. angustus* ON CORN MAINTAINED AT A DEFINITE MOISTURE CONTENT

	Moisture Content of Corn					
	10.72 Per Cent (5 larvae/jar)		14.07 Per Cent (10 larvae/jar)		16.72 Per Cent (10 larvae/jar)	
Jar No.	Reared Adults	Percentage Mortality	Reared Adults	Percentage Mortality	Reared Adults	Percentage Mortality
1	3	40.0	10	00.0	7	30.0
2	4	20.0	10	00.0	7	30.0
3	4	20.0	9	10.0	9	10.0
4	3	40.0	5	50.0	9	10.0
5	5	00.0	9	10.0	8	20.0
6	2	60.0	9	10.0	9	10.0
7	3	40.0	7	30.0	7	30.0
8	5	00.0	6	40.0	3	70.0
9	3	40.0	9	10.0	7	30.0
10	3	40.0	5	50.0	7	30.0
11	4	20.0	...	...	...	...
Total	39	...	79	...	73	...
Average	...	29.0	...	21.0	...	27.0

the culture. Sound corn not only increased larval mortality but also lengthened the developmental period from about sixty to almost eighty days.

DEVELOPMENT ON CORN COB: Corn cobs cleaned to remove all particles of corn and cut into small pieces were slightly moistened and placed in quart fruit jars. Several adult beetles were introduced into each jar and left there for a period of two weeks. From these cobs, four adult beetles were reared from the egg to the adult stage. Three of the beetles emerged in sixty-seven days and the other in ninety-seven days. Although many larvae were present on the cobs during the early part of this experiment, only a few of them were able to complete their development.

FOOD PREFERENCE: In an experiment to obtain some data on food

TABLE 6

DATA SHOWING THE INFLUENCE OF SOUND AND BROKEN CORN KERNELS ON THE RATE OF DEVELOPMENT OF *C. angustus*

Kind of Corn	Number of Larvae Started	Number of Adults Emerging at Various Times (Days From Hatching)											Percentage Mortality
		45	50	55	60	65	70	75	80	85	90	95	
Sound kernels	35	....	....	....	1	1	2	1	7	2	1	1	54.3
Broken kernels	35	1	1	3	11	4	2	3	....	....	....	....	28.5

preference, corn, wheat, oats, and barley were placed in stratified layers in a museum jar. This jar was then laid on its side and two hundred beetles caged in it for thirty-four days. The beetles were able to move freely over the surface of the various grains and to select their own breeding medium. At the end of the thirty-four day period, comparisons of the amount of frass and the number of larvae in each grain were made. Corn ranked highest. It contained twice the amount of frass and twice the number of larvae found in barley, which ranked second. Wheat and oats were considerably lower than barley both in the amount of frass and in the total number of larvae found. This apparent preference for corn is borne out by the

TABLE 7
STORED GRAIN PESTS ASSOCIATED WITH *Cynaeus angustus* IN SIXTY-SEVEN BINS OF STORED SHELLED CORN

Associated Insects	Number of Samples in Which Found	
	March, 1941	August, 1941
Rust-red flour bettle	32	23
Flat grain beetle	28	13
Foreign grain beetle	27	10
Saw-toothed grain beetle	12	18
Hairy fungus beetle	5	9
Cadelle	5	2
Granary weevil	2	1
Rice weevil	2	......
2-banded fungus beetle	2	1
Yellow meal worm	1	......
C. angustus alone	27	32

records of field collections, which show that the insect has been found most frequently in corn.

ASSOCIATION WITH OTHER INSECTS: In Commodity Credit Corporation storage bins, the random distribution of the pest and the uniformity of distribution within the bins seem to indicate that the delivery of infested grain from farm storage was the most common source of infestation. Insects were found at all levels from the floor to the surface.

A study of field records shows that C. *angustus* may occur alone or associated with other stored grain pests as listed in Table 7. The frequency of the occurrence of these other species in association with C. *angustus* is in direct proportion to their relative abundance in the field. These associations, therefore, appear to be incidental and not in any sense obligatory in nature. As might be expected, the rust-red flour beetle, flat grain beetle, saw-toothed grain beetle, and other species of the bran beetle group were found associated with C. *angustus* irrespective of the moisture content of the grain. The foreign grain beetle, hairy fungus beetle, two-banded fungus beetle, and yellow meal worm were most frequently encountered in moist grain.

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A COMBINED FIELD AND LABORATORY PROCESS FOR THE ESTIMATION OF PLASMA ATABRINE LEVELS IN FIELD TROOPS FROM SINGLE SAMPLES OF URINE

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It is now generally accepted that the most reliable index to the protection afforded by a suppressive atabrine regimen is the atabrine concentration in the plasma. There are several well-recognized laboratory methods for the accurate determination of plasma atabrine levels, but the prerequisite for all is a meticulous routine for handling the blood immediately after it has been drawn. For this reason it usually is not feasible to attempt to separate plasma from the blood of troops in the field. In addition it usually is inexpedient to attempt to transport them to the laboratory for the drawing of the blood. The only body fluid whose use might eliminate the objection to plasma is urine. If urine possesses properties that reliably reflect the plasma atabrine level, then a procedure utilizing such properties has a definite place in estimating the degree of chemical protection against malaria being afforded by suppressive atabrine, as well as the effectiveness of "atabrine discipline."

Most field tests for atabrine in urine are qualitative, and of these some are not too reliable. Even quantitative data on only the atabrine concentration of single voidings of urine are of little value as indices to plasma levels, a conclusion reached by several other workers and substantiated by us. The atabrine content of 24-hour collections of urine likewise is no fair index to the plasma level, to say nothing of the inexpediency of making such collections from field troops.

The British (1), however, have developed a field method for the indirect determination of plasma atabrine (mepacrine) concentration from single samples of urine. In making the determination it is necessary first to make quantitative tests for urinary ammonia and atabrine, and to substitute the values obtained in a formula involving urinary ammonia, urinary atabrine, and a constant. Urinary ammonia determination, however, is not a process so simple as to lend itself readily to field practice. In a previous report (2) of the same series of investigations appeared the following statement: "The figures for titratable acidity are parallel to those for ammonia. It is attractive on theoretical grounds, however, to suppose that the mepacrine excretion is related to that of the ammonia . . .,

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rather than the more indefinite concept 'titratable acidity'." Since the determination of titratable acidity is so comparatively simple, we ventured to undertake an investigation of its relation to urinary atabrine, and the possiblility of using such data in the estimation of plasma atabrine.

GENERAL METHODS

Plasma atabrine (A.P.) was determined by the Brody and Udenfriend method (3), and the values expressed in micrograms per liter. The procedure described in the report was closely followed with the exception that 8 ml. of di-sodium phosphate solution, made by dissolving 32 gm. of the salt in 3,000 ml. of distilled water, was mixed with 5 ml. of plasma in a 60 ml. glass stoppered bottle before delivering 30 ml. of ethylene chloride down the inside of the bottle from a 100 ml. burette. The original procedure was to add 3 ml. of 0.2 M Na_2HPO_4 and 30 ml. of ethylene chloride to the plasma. The change was made only after a series of tests showed that the modification produced consistently higher and more uniform recoveries. Urinary atabrine (A.U.) was determined by the same general method except that only 0.5 ml. of urine was tested and a wash of 10% NaOH was utilized to remove atabrine degradation products.

Titratable acidity (T.A.) was obtained by direct titration of 10 ml. of urine with N/10 NaOH solution from a burette, using 0.7 ml. of 0.02 per cent phenol red as indicator. The urine in all cases was freshly passed, and collected in most cases between 0800 and 1100 hours. T.A. was expressed in terms of the number of ml. of the hydroxide required to raise the pH of the urine to 8.4. It is realized that the colorimetric method is inferior to the glass electrode, and that potassium oxalate should have been added to the urine before titration for slightly more accurate determination of the T.A., but the glass electrode was not available, and the actual objective was a field-laboratory process for spot-testing military organizations on suppressive atabrine with the field procedure as simple as possible.

The problem involved determinations of plasma atabrine (A.P.), urinary atabrine (A.U.), and titratable acidity of urine (T.A.). The blood was taken in the morning sometimes between breakfast and noon, and the urine at the next voiding thereafter. About 20 ml. of blood was drawn into a 30 ml. syringe and transferred to an oxalated 20 ml. screw cap test tube for the first centrifugation. There were two to six tests on a few subjects at intervals of no less than a week, but most of the data were obtained from different individuals. The subjects were supposed to have started suppressive doses of 0.1 gm. atabrine daily about 15 February, 1945, or upon arrival in the theater later. A few were patients who had not been taking atabrine for two days to several weeks. Tests were first made about a month after suppressive atabrine was instituted and continued during the next four months. The subjects were instructed not to take atabrine in the morning before blood and urine were collected. Hence the plasma levels may be considered "minimal."

RESULTS

The most significant result of the study was the development of the empirical chart to be described later. It is based on data comprising the plasma atabrine levels, urinary atabrine levels, and T.A. of the urines in 216 cases presented in Table 1. It is to be noted that A.P., A.U., and T.A. values extend over a wide range. When plasma levels (A.P.) were plotted on the ordinates and corresponding urinary levels (A.U.) on the abscissas in the manner of a correlation chart, the widely-scattered points demonstrated the lack of any considerable degree of correlation. The ratio of A.U. to T.A. was also plotted against A.P., but here again the broad scattering of the points indicated the lack of any striking correlation, rendering it futile to attempt to discover a constant for introduction into a formula for the calculation of A.P. from A.U. and T.A. in the manner of the British (2) who were able to calculate A.P. from the formula

$$\text{A.P.} = \text{K} \times \frac{\text{A.U.}}{\text{NH}_3\text{U}}.$$

Another method of attack was planned to explore further the possibility of utilizing urinary data for estimating plasma levels. First a factor (F) was derived from each of the 216 sets of data (A.P., A.U., and T.A.) according to the following formula: $\text{F} = \frac{\text{A.U.}}{\text{T.A.} \times \text{A.P.}}$. The F-values were found to range from 6 to 888. Then a graph was prepared in which each A.U. was plotted against its corresponding T.A., and the corresponding F-values recorded at the points of intersection. An eye scanning of the graph revealed a remarkable gradation of F-values in that a straight line swinging upwards from the base line with the point of origin as a fulcrum would traverse more or less steadily ascending F-values. Once this sort of pattern was discovered in the arrangement of the F-values, an eye grouping of the F-values as they seemed to fall into common zones became possible. At first it appeared that the pattern might be reduced to a simple succession of sectors with regularly ascending mean F-values, but closer inspection revealed that the factors did not exactly fall into groups having such a simple arrangement. In the first place, a separate zone had to be delimited in the middle proximal region of the sectors for twenty-six factors which fell into a group (Group J) with a mean of about 52. In the second place, it was finally discovered that unless the distal ends of the sectors were drawn to swing upwards, the A.P.'s calculated from high A.U.'s were inordinately lower than the direct A.P.'s. The result was the Empirical Chart (Fig. 1) which depicts the distinctive zones, each comprised of a group of factors in more or less close proximity to their mean (F_m). The chart shows only the outlines and F_m values of the areas, but may be easily reconstructed by plotting the A.U.'s and

T.A.'s arranged in groups in Table 1, with the F's recorded at the intersection points.

Zones A-I are sectors with their respective F_m's ascending as follows: A—16, B—20, C—38, D—48, E—56.5, F—74, G—89.5, H—138, and I—252.

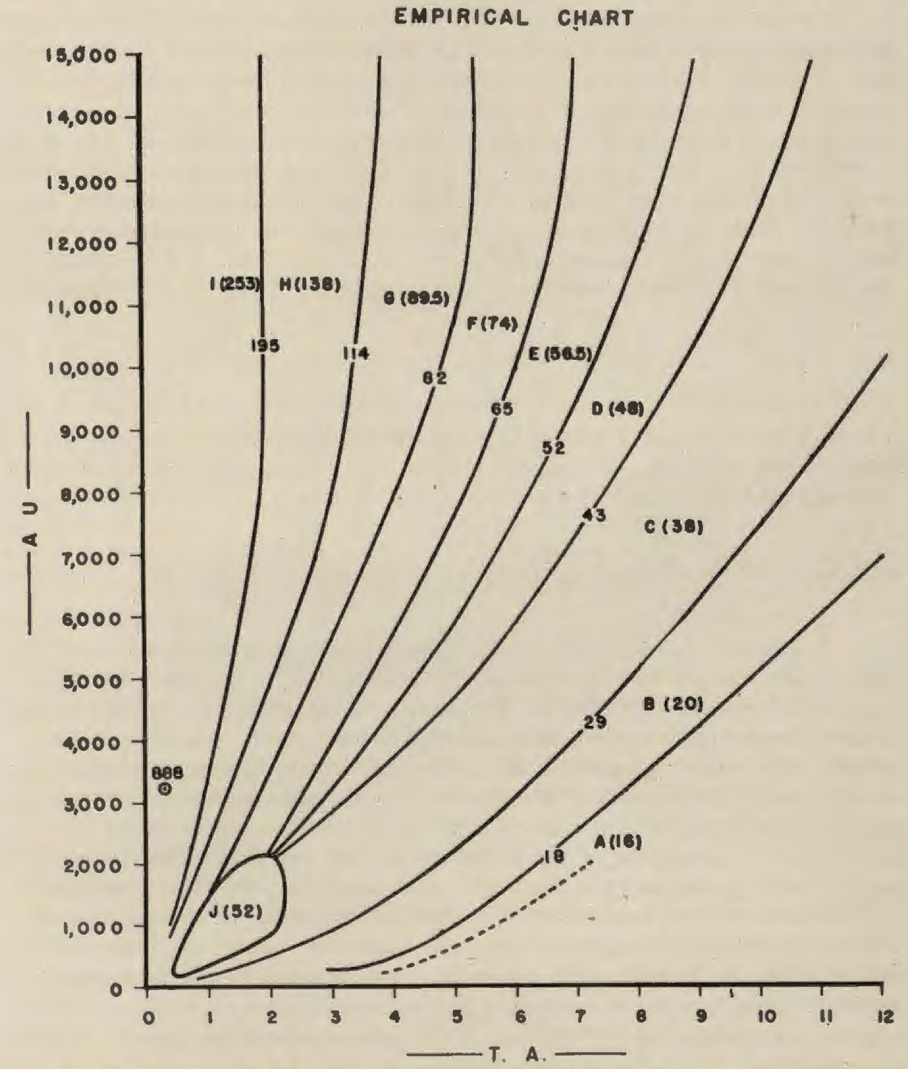

FIG. 1. The Empirical Chart. Urinary atabrines (A.U.) plotted on ordinates and titratable acidities (T.A.) on abscissas. Numbers appearing beside zone designation and on separating lines represent factors (F_m).

The proximal zone, J, has a mean of 52. There is a heterogeneous group of factors below Zone A which we have designated A_1 in Table 1 without ascertaining the mean. Far to the left in Zone I appears a ringed point with a factor of 888. It is not included in the F variables from which F_m of

Group I was calculated Its principal significance is that it shows how rapidly the F-values rise as the points of intersection approach the vertical axis. The chart is strictly empirical and, while orderly, could probably not be described by a mathematical formula.

A friendly critic who reviewed the tables commented upon the disparity between certain F-values in a few of the groups; e.g., the extreme case in Group J in which the range is from 33 to 111. Considerable disparity is to be expected among variables which evaluate almost any biological process. It is attributable, of course, to individual differences among subjects and to variability in physiological states. Some of the disparity, no doubt, is attributable to minor technical errors which are either inherent in the techniques for atabrine determination or other uncontrollable circumstances. The technical errors should cancel out to a considerable degree when the means of the F's are figured. On the other hand, some of the groups (A, B, D, E,) are remarkably homogenous.

FIELD AND LABORATORY PROCEDURES

The rationale of the process for the estimation of plasma atabrine levels prevailing in military units consists of the determination of titratable acidity and atabrine concentration of the urines of subjects obtained by random sampling, the location of the points of intersection of T.A. abscissas and A.U. ordinates in the particular zones of the Empirical Chart (Fig. 1), and the substitution of A.U.'s, T.A.'s, and F_m's in a formula. The two phases of the process in actual practice, the field and the laboratory, will be described separately.

FIELD PROCEDURE

At the military installation the determination of the titratable acidity of the urine of each subject is made by a colorimetric method, and an accurately measured sample of each urine prepared for subsequent atabrine analysis in the laboratory. The materials necessary for the field practices are listed in Table 2.

It is presumed that the organization being surveyed has been on suppressive atabrine long enough to establish the maximum attainable plasma level in each soldier. It is to be emphasized that the men are not to take atabrine previous to the urine collection on the day the survey is made. It is our practice to collect the urines sometime after breakfast, which in most cases is the second voiding.

Arrangements for spot-checking an organization are made with its commanding officer through the base surgeon. The commanding officer is approached with the proposal that the check be made so that he may know how effective is his atabrine discipline. If he agrees to make the test, as is the case almost without exception, he is instructed how it is to be conducted, that no atabrine is to be given the troops that morning, and that they are not to be warned beforehand that the test is to be made. The subjects are taken strictly by roster, taking every fifth or tenth man. No individual selections or exemptions are to be made. One usually has no way of knowing for sure, but it is likely that in most cases the instructions are followed. It is recommended that one officer and one enlisted man constitute the personnel of the team representing the laboratory at the installation.

The soldier fills a 22 ml. screw cap vial with his urine, under observation, and a key number previously assigned to him is written on the vial with a wax pencil. Ten ml. of this urine is pipetted into each of two 20 ml. screw cap test tubes. Just enough N/10 NaOH solution to precipitate the phosphates is pipetted into one tube of urine, and it is placed alongside the pH 8.4 color standard in the comparator block.

To the other tube of urine is added 0.7 ml. of 0.02 per cent phenol red (the stock phenol red solution diluted 1:10 with distilled water), and the tube agitated until the mixing of indicator and urine is complete. N/10 NaOH solution is carefully buretted into the mixture, which is shaken frequently. After a shade of red approximating the color standard has been reached, the tube is placed in the comparator block alongside a tube of distilled water. More and more NaOH is buretted into the mixture until the color barely matches the color standard. The number of ml. of N/10 NaOH required is recorded by the subject's name and number, and represents the T.A.-value to be employed in the formula that appears later.

During preparations for the field trip, the required number of screw cap 1 oz. Rx bottles were brushed out with soap and water, thoroughly rinsed in tap water, allowed to stand 20 minutes in sulfuric acid-dichromate cleaning solution, then thoroughly rinsed first in tap, afterwards in distilled water, and finally dried in the hot air oven. The caps were given thorough washing in soap and water, thoroughly rinsed in tap and distilled water, and dried by standing on towels in the open air. Then 20 ml. of ethylene chloride and 3 ml. of O.2 M Na_2HPO_4 solution were buretted into each bottle, the caps screwed on tightly to prevent leakage, and the bottles packed in the original cardboard containers. After the titration is completed in the field, 0.5 ml. of the urine is delivered from a 0.5 ml. Ostwald pipette into the prepared Rx bottle, the cap is screwed on tightly, and the bottle shaken violently for a minute. The bottles are packed in the original containers and sent to the testing laboratory by the most rapid available means of transportation.

LABORATORY METHODS

The laboratory part of the procedure consists of testing for atabrine content the 0.5 ml. of urine mixed in the field with 20 ml. of ethylene chloride and 3 ml. of di-sodium phosphate solution. In the laboratory the content of each Rx bottle is poured into a chemically clean 60 ml. glass stoppered bottle. The Rx bottle is rinsed with exactly 10 ml. of ethylene chloride, and the content added to that of the 60 ml. bottle. The procedure from here on is exactly like that for urine in the Brody-Udenfriend method (3), including the alkali wash. The atabrine concentration of the urine is expressed in micrograms per liter and appears in the formula as A.U.

CALCULATING THE PLASMA LEVEL

The estimation of the atabrine concentration of the plasma (C.A.P.) is derived from a formula employing the three values previously obtained for the titratable acidity (T.A.) and atabrine (A.U.) of the single sample of urine, and the mean factor (F_m) of the zone in the Empirical Chart (Fig. 1) where the T.A. abscissa and the A.U. ordinate intersect. The formula is written as follows:

$$\text{C.A.P.} = \frac{\text{A.U.}}{\text{T.A.} \times F_m}$$

When the intersection point falls on a line separating the zones, or about an eighth of a zone's breadth below it, the F-value on the line is substituted in the formula.

The following example from a sample of urine recently collected from a patient in the hospital serves as an illustration of the application of the formula:

(1) The A.U. value was 1,320

(2) The T.A. value was 3.5

(3) A horizontal line through 1,320 and a vertical line through 3.5 intersect in Zone C, whose F_m is 38.

(4) Therefore, $\text{C.A.P.} = \frac{1,320}{3.5 \times 38} = 9.9$ micrograms per liter. It so happens that the A.P. value by direct determination in this case was 10 micrograms per liter.

THE PROOF OF THE VALIDITY OF THE METHOD

When plasma atabrine concentration is calculated solely from urines collected in the field, there is of course no way of comparing C.A.P.'s with the actual plasma concentrations (A.P.'s). One way to test the validity of urine testing is to assume that the 210 cases comprising most of Table 1 represent the members of a military organization that had been surveyed. First, it is necessary to set up an arbitrary but fair standard evaluating the differences between C.A.P.'s and A.P.'s. It appeared *a priori* that when the A.P. ranged from 4–19 micrograms per liter, a deviation of 4 micrograms per liter by the C.A.P. would be allowable. The other ranges and deviations considered allowable were as follows: 20–24, 5; 25–29, 6; 30–34, 8; 35–39, 11; 40–59, 15; 60 and above, 20. A careful inspection of the table disclosed that 35 out of the 210 cases, or 16.67 per cent, exceeded these limits. In other words, if a fair approximation to the actual plasma levels were desired for each of 210 individuals, it would be obtainable in about 83.33 per cent of them solely on the basis of urine testing.

The present objective, however, was evaluating "atabrine discipline" in organizations; hence the data must be analyzed from an entirely different standpoint. As implied before, the checks of C.A.P. with A.P. were satisfactory in 175 cases. If it be assumed that an A.P. of 14 is "protective" (a point we do not desire to discuss here), and hence satisfactory, then it is necessary to know (1) how many C.A.P.'s were under 14 when the A.P. was 14 or above, and (2) how many were 14 or over when the A.P. was under 14. Frankly, the analysis is academic and involves hair-splitting, but it is only fair that it be made since organizations are rated on the number of satisfactory tests.

Only 5 of the 210 subjects (Nos. 9, 13, 15, 202, and 203) fell into the former category. Of these, the A.P. of one was but 14. The C.A.P.'s of four were 13, one was 10. Six (Nos. 16, 39, 44, 198, 207, 210) fell into the second category, but in all these the A.P. was actually only slightly below 14. Thus when the five of the first category are subtracted from the six of the second category, the organization received credit for one more satisfactory plasma level than it deserved, which in all fairness is not undesirable. When technical errors are taken into consideration, all eleven sets of data should have been reported as "fairly satisfactory," because a very small per cent of subjects probably fail to build up levels of 14 consistently. On the other hand, it would probably have been fair to classify the twenty cases in which both A.P. and C.A.P. were below 14 as unsatisfactory. In the case of urine testing alone, however, we have adopted the policy of rating C.A.P.'s of 9 or below as unsatisfactory, 10–15 as fairly satisfactory, and above 16 as satisfactory.

How does the urine testing work out in actual practice? Table 3 records the results obtained in three different military outfits which we have selected for discussion because one (Org. I) represents an outfit whose A.P.'s and C.A.P.'s are amazingly close, another (Org. II) whose checks are about average, and a third (Org. III) that gives the least satisfactory checks of the six for which we have obtained both A.P.'s and C.A.P.'s.

The mean A.P. and C.A.P. values for Org. I with nineteen subjects are identical. The mean of the deviations, stated positively, is 1.9, and the mean error, i.e., the ratio of the mean deviation to the mean A.P., is 8.5 per cent. There is but one C.A.P. in this group (No. 15) whose deviation exceeds the limits of its allowable range, as previously described, but in this case the C.A.P. of 21 is satisfactory. Atabrine discipline in this organization is highly rated on the basis of urine tests alone.

The results for Org. II with twenty cases show slightly more irregularity. There is a difference of 2.9 between the means of the observed and calculated values. The mean of the deviations stated positively is 5, and the mean error 21.5 per cent. There are four C.A.P.'s which deviate from their corresponding A.P.'s beyond the allowable limits: No. 7 is raised from an "unsatisfactory" A.P. to a "fairly satisfactory" C.A.P., No. 30 from "fairly satisfactory" to "satisfactory," while in Nos. 34 and 37 the ratings remain unchanged. There is one exceedingly unsatisfactory level, No. 20. On the basis of urine tests alone the organization receives a fairly satisfactory rating, a conclusion supported also by the A.P.'s.

The results in Org. III are disappointing in a way, yet even here the test served its purpose very well. The difference between the mean A.P. and the mean C.A.P. is 4.6, which is rather large. The mean deviation was 6.6, and the mean error 23.2 per cent. The reason the mean error is comparable to that for Org. II is the higher mean A.P. There are nine C.A.P.'s (Nos. 41, 42, 45, 48, 52, 53, 54, 56, and 57) whose deviations from the corresponding A.P.'s exceed the allowable limits, but in only one case (No. 52) was the rating changed. On the basis of the urine tests alone eighteen of the nineteen levels are satisfactory and one fairly satisfactory, which corresponds very well with the A.P. ratings of seventeen satisfactory and two fairly satisfactory. The organization receives a high rating.

DISCUSSION

The process described gives results that serve as a fairly reliable index to the plasma atabrine concentrations prevailing in an outfit, and hence to the status of atabrine discipline. When one considers individual differences and differences in physiological states among people, the variability among the factors (F) composing the groups in Table 1, the steep rises between the mean factors (F_m) of certain contiguous zones of the Empirical Chart (Fig. 1), and the possibility of small technical errors, on the one hand, and the amount of reliable information about plasma atabrine that the urine test provides, on the other hand, it becomes evident that casual criticism of the imperfections of the results should be restrained. It should be kept in mind that the application of the process is to group testing, not individual testing. For its intended purpose the procedures outlined in this report are not only practicable, but yield results fairly comparable with those obtained from plasma testing.

Much could be said in favor of the application of the test to individuals for the purpose of getting information about their plasma levels. As previously stated, in five out of six cases of Table 1 the deviation of calculated value from observed value was within the allowable limits, which certainly should prove satisfactory for most clinical purposes. The deviations in most of the remaining 16.67 per cent of the cases were not so great as to negate their value altogether. Urine testing for individuals is not to be recommended, however, when plasma testing can be done.

The question naturally arises: What should be done about the soldier whose C.A.P. falls somewhat below, say, 14? As previously emphasized it is not the purpose of the test to find that soldier. It might well be that this particular soldier's A.P. is as high as that of another soldier whose C.A.P. is 14 or slightly above, but there will be approximately as many in which the reverse circumstance occurs. If pressed for an answer to the question, however, it would be that a sample of blood should be drawn from the soldier and the plasma level determined as soon as possible after the low C.A.P. was discovered, and if the A.P. confirms the C.A.P., then the soldier should be questioned about his atabrine regimen. With these precautions the soldier will not be dealt an injustice. If the questioner is satisfied that the soldier is taking his atabrine as prescribed, then he may be instructed to increase his dosage so much as to attain a protective level. In general, the plasma level is in direct ratio to the dosage.

It appears that the method is practically useless for estimating very high levels such as result from therapeutic doses; e.g., in one case where a plasma level of 134 micrograms of atabrine per liter was obtained, the calculated level was 45. The same is true for high A.P.'s on a suppressive regime, for the chart shows sixteen A.P.'s ranging from 30–36, having a mean of 32.4, as against corresponding C.A.P.'s ranging from 20–27, with a mean of 23.3. In addition to these appear the following still higher A.P.'s with their corresponding C.A.P.'s: 42 and 27; 56 and 27; 64 and 44. (Another instance recently came to hand of a nurse on suppressive atabrine with an A.P. of 75 and a C.A.P. of 32.) In each of the entire nineteen cases, however, the organization would have received credit for a soldier with a satisfactory plasma level. On the other hand, the chart shows the following A.P.'s and C.A.P.'s in very close agreement: 38 and 34: 32 and 32; 35 and 32; 36 and 32; 44 and 42. It is possible that not all the cases on suppressive atabrine with the wide discrepancies are due to imperfections in the Empirical Chart, for we have obtained similar contrasts in subjects who, when later questioned, admitted having taken atabrine from 1 to 4 hours before the blood was drawn. Under such conditions the A.P. always greatly exceeds the C.A.P. Seldom does an A.P. under 30 appear with a C.A.P. over 30 (*see* Nos. 145, 183).

SUMMARY

A method of estimating atabrine concentration of the plasma from a single sample of urine is described. It involves an empirical chart based upon data obtained from testing urines of 216 subjects for titratable acidity and atabrine concentration, and blood plasma for atabrine concentration. Plasma level may be estimated from titratable acidity and atabrine concentration of urine when the latter two values are plotted on the chart and the factor at the point of intersection substituted in a formula.

There is also described a combined field and laboratory procedure for obtaining the urine data, and methods of evaluating them. The process is applicable to group testing of military organizations to ascertain the status of atabrine discipline, and to verify protection against malaria conferred upon troops by regular suppressive doses of atabrine.

ADDENDUM

A.P., A.U., and T.A. were determined for one hundred miscellaneous personnel after this report was submitted. All but six of the sets of data yielded F-values that were comparable to those already obtained; but these exceptions require special mention, since they concern areas in the

Empirical Chart where no F-values had previously been located. They are shown in semi-tabular form:

A.U.	T.A.	A.P.	F
600	6.0	4.0	25
617	5.9	4.0	26
640	7.2	4.0	22
1,440	6.4	4.0	56
2,160	8.8	10.0	25
3,520	12.8	5.0	55

It is notable that all these F-values fall into the A_1 Zone of the chart. There appear in Group A_1 of Table 1, however, under items 5 and 6, two inordinately high F-values, 25 and 22, respectively, at about the intersections where these newer values begin to appear. It is apparent in the A_1 Zone that when the T.A.'s are 5.9 or higher and the A.U.'s are in the neighborhood of 600 or higher, much higher F-values would have to be used in calculating approximately correct A.P.'s.

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TABLE 1

DATA ON 216 CASES. URINARY ATABRINE (A.U.) EXPRESSED IN MICROGRAMS PER LITER, URINARY TITRATABLE ACIDITY (T.A.) EXPRESSED IN ML. OF N/10 NaOH, PLASMA ATABRINE (A.P.), AND CALCULATED PLASMA ATABRINE (C.A.P.) EXPRESSED IN MICROGRAMS PER LITER, GROUPED ACCORDING TO THE ZONES OF EMPIRICAL CHART (FIG. 1) INTO WHICH THE FACTORS (F) FALL

GROUP A_1

No.	A.U.	T.A.	A.P.	C.A.P.	F
1.....	120	4.7	4	....	6
2.....	360	5.6	5	....	13
3.....	320	6.6	5	....	9
4.....	480	5.3	8	....	11
5.....	600	6.0	4	....	25
6.....	640	7.2	4	....	22

Number in group......6

GROUP A

No.	A.U.	T.A.	A.P.	C.A.P.	F
7.....	160	2.5	4	4	16
8.....	560	4.5	8	8	16
9.....	1,160	5.3	14	13	16
10.....	1,600	6.3	14	15	18

Number in group......4 Mean (F_m)......16.5

GROUP B

No.	A.U.	T.A.	A.P.	C.A.P.	F
11.....	80	0.9	4	4	22
12.....	360	1.6	12	11	20
13.....	400	2.1	14	10	14
14.....	480	2.3	8	10	26
15.....	880	3.5	21	13	12
16.....	1,200	4.2	11	14	27
17.....	1,800	5.5	16	16	21
18.....	2,680	6.7	24	20	17
19.....	3,000	7.0	18	21	23
20.....	3,360	7.0	30	24	16
21.....	3,800	6.8	23	28	24
22.....	4,000	8.3	32	25	15
23.....	4,560	7.6	28	30	21

Number in group......13 Mean (F_m)......20

TABLE 1—*Continued*

Group C					
No.	A.U.	T.A.	A.P.	C.A.P.	F
24	176	1.0	6	5	29
25	280	1.3	6	6	36
26	1,320	3.5	10	10	38
27	1,440	2.4	14	16	43
28	1,600	2.9	14	15	40
29	1,680	2.6	21	16	31
30	1,800	4.0	12	12	38
31	1,840	2.4	21	20	36
32	1,840	2.4	21	20	36
33	1,840	2.6	16	18	44
34	1,840	3.3	20	15	28
35	1,860	3.6	14	14	36
36	1,900	2.5	32	20	24
37	1,980	2.5	22	21	36
38	2,000	2.2	32	22	28
39	2,200	4.2	13	14	41
40	2,240	2.8	20	21	40
41	2,480	4.6	11	13	49
42	2,560	2.6	26	24	38
43	2,640	2.7	25	26	39
44	2,760	4.8	12	15	50
45	2,880	3.9	20	19	37
46	3,200	3.6	24	24	38
47	3,375	4.4	34	20	23
48	3,420	5.0	24	18	29
49	3,520	4.9	20	19	36
50	3,600	5.1	18	19	40
51	3,600	4.5	20	21	40
52	3,600	4.4	16	22	51
53	3,760	4.5	32	21	26
54	4,000	5.2	20	20	38
55	4,400	5.4	22	21	39
56	4,400	5.2	22	22	38
57	4,480	5.4	20	22	41
58	4,500	5.5	15	22	56
59	5,100	7.1	26	19	28
60	5,100	5.8	20	23	44
61	5,450	5.8	20	25	47
62	6,375	7.5	23	22	37
63	7,200	9.4	22	20	35
64	7,280	7.4	32	26	31
65	7,280	7.2	20	27	51
66	7,280	7.2	20	27	51
67	7,920	9.1	20	23	44
68	8,000	9.2	28	23	31
69	8,200	8.8	20	25	47
70	10,200	11.2	28	24	32

Number in group......47 Mean (F_m)......37.6

TABLE 1—*Continued*

GROUP D

No.	A.U.	T.A.	A.P.	C.A.P.	F
71....	2,320	2.2	24	22	44
72....	2,700	2.6	26	21	40
73....	2,940	2.9	20	21	50
74....	3,360	3.5	20	20	48
75....	3,520	3.7	20	20	48
76....	3,560	3.2	23	23	49
77....	3,760	3.9	18	20	54
78....	4,080	4.0	24	21	43
79....	4,590	4.7	21	20	47
80....	4,680	4.5	30	22	35
81....	4,740	4.5	18	22	59
82....	4,880	4.4	20	23	55
83....	4,880	4.7	20	22	52
84....	5,280	5.2	24	21	42
85....	6,000	5.4	30	23	37
86....	6,240	6.1	24	21	43
87....	6,700	5.8	23	25	50
88....	7,680	6.5	24	25	49
89....	12,000	9.0	22	28	61

Number in group......19 Mean (F_m)......48

GROUP E

No.	A.U.	T.A.	A.P.	C.A.P.	F
90....	3,760	3.2	20	21	59
91....	3,960	3.2	28	22	44
92....	4,160	3.4	25	22	49
93....	4,460	3.5	16	24	80
94....	4,635	3.8	27	22	45
95....	4,890	4.0	22	22	56
96....	5,200	3.8	24	24	57
97....	5,200	4.0	27	23	49
98....	5,760	4.2	24	24	57
99....	5,760	4.3	22	24	61
100....	6,560	4.6	24	25	59
101....	6,720	4.7	24	25	60
102....	6,720	5.0	26	24	52
103....	7,200	5.4	22	24	61
104....	7,840	5.8	25	24	54
105....	7,920	5.8	20	24	68
106....	8,000	5.7	24	25	58
107....	8,426	6.0	22	25	64
108....	13,760	7.1	38	34	50

Number in group......19 Mean (F_m)......56.5

TABLE 1—*Continued*

Group F					
No.	A.U.	T.A.	A.P.	C.A.P.	F
109....	2,100	1.3	25	22	65
110....	2,320	1.7	18	18	76
111....	2,500	1.8	17	19	80
112....	2,560	2.0	20	17	64
113....	2,640	1.8	15	20	91
114....	2,640	2.0	16	18	83
115....	2,640	2.0	16	18	83
116....	2,720	1.7	29	22	55
117....	2,900	1.9	19	21	80
118....	3,040	2.0	18	21	84
119....	3,520	2.2	30	22	55
120....	3,600	2.1	28	23	61
121....	3,760	2.7	20	19	70
122....	3,920	2.3	24	23	71
123....	4,000	2.3	24	24	72
124....	4,400	2.6	26	23	65
125....	4,480	2.7	20	22	83
126....	4,880	2.7	22	24	80
127....	5,355	3.3	24	22	68
128....	6,000	3.7	17	22	95
129....	6,000	3.8	30	21	53
130....	6,240	4.1	24	21	64
131....	6,480	3.4	24	26	79
132....	6,640	3.6	36	25	51
133....	6,800	3.5	28	26	69
134....	6,880	4.2	16	22	102
135....	7,200	4.2	28	23	61
136....	7,920	4.4	28	24	64
137....	8,059	4.4	24	25	76
138....	8,400	5.3	22	21	72
139....	8,557	4.6	20	25	93
140....	9,600	5.7	20	23	84
141....	10,340	5.1	24	27	84
142....	14,400	6.1	32	32	74
143....	14,680	6.2	35	32	68
144....	15,000	6.0	30	34	80
145....	16,000	6.8	24	32	98

Number in group......37 Mean (F_m)......74

TABLE 1—*Continued*

GROUP G

No.	A.U.	T.A.	A.P.	C.A.P.	F
146....	900	0.4	24	25	94
147....	1,520	0.8	28	21	70
148....	1,600	1.0	15	18	107
149....	2,080	1.0	20	23	104
150....	2,880	1.5	20	22	96
151....	2,950	1.5	21	22	94
152....	3,000	1.3	20	26	115
153....	3,120	1.4	24	25	93
154....	3,440	1.5	26	26	88
155....	3,540	1.5	15	26	157
156....	3,920	1.6	34	27	72
157....	4,160	1.7	42	27	58
158....	4,400	1.9	28	26	83
159....	4,500	2.3	22	22	89
160....	5,280	2.7	26	22	75
161....	5,940	2.9	36	23	57
162....	6,000	2.7	23	25	95
163....	6,400	2.7	24	27	99
164....	6,480	2.7	56	27	43
165....	6,500	2.8	18	26	129
166....	7,100	3.6	24	22	82
167....	7,280	3.5	32	23	65
168....	8,500	3.8	25	25	89
169....	9,560	4.4	32	24	68
170....	10,800	4.0	26	30	104
171....	13,120	5.0	26	29	101

Number in group......26 Mean (F_m)......89.5

GROUP H

No.	A.U.	T.A.	A.P.	C.A.P.	F
172....	1,680	0.7	24	17	100
173....	2,300	0.8	24	21	119
174....	2,360	0.9	16	19	164
175....	2,880	1.1	22	19	119
176....	3,060	1.0	21	22	146
177....	4,160	1.6	20	19	130
178....	4,480	1.3	24	25	144
179....	4,560	1.5	19	22	158
180....	7,600	2.5	25	22	122
181....	8,640	2.8	28	22	110
182....	15,200	3.5	36	32	120
183....	16,000	3.7	19	34	227
184....	17,200	3.0	44	42	130

Number in group......13 Mean (F_m)......138

TABLE 1—*Continued*

Group I

No.	A.U.	T.A.	A.P.	C.A.P.	F
185....	2,040	0.6	10	13	340
186....	4,650	1.0	18	18	258
187....	5,520	1.3	14	17	303
188....	5,600	1.3	23	17	190
189....	7,840	0.7	64	44	175

Number in group......5 Mean (F_m)......253

Group J

No.	A.U.	T.A.	A.P.	C.A.P.	F
190....	160	0.5	6	6	53
191....	240	0.5	8	9	60
192....	640	0.6	32	25	33
193....	600	1.3	10	9	46
194....	800	1.3	12	12	51
195....	900	1.9	10	9	47
196....	960	1.6	13	12	45
197....	960	1.6	12	12	50
198....	1,005	1.4	11	14	65
199....	1,040	0.9	18	22	64
200....	1,050	2.0	8	9	63
201....	1,200	1.4	20	17	45
202....	1,260	2.0	17	13	38
203....	1,380	2.0	20	13	34
204....	1,380	1.7	16	16	51
205....	1,440	1.6	24	17	38
206....	1,480	2.0	14	14	53
207....	1,500	1.4	13	21	82
208....	1,440	1.0	26	28	55
209....	1,600	2.1	15	15	50
210....	1,600	1.2	12	26	111
211....	1,880	2.1	16	17	56
212....	1,920	1.5	29	25	43
213....	1,920	1.6	27	23	45
214....	1,680	1.3	34	25	38
215....	1,840	2.1	22	17	40

Number in group......26 Mean (F_m)......52

Group Misc.

No.	A.U.	T.A.	A.P.	C.A.P.	F
216....	3,220	0.3	12	12	888

TABLE 2

NECESSARY SUPPLIES FOR FIELD PROCEDURES OF AN ATABRINE SURVEY*

Medical Supply Cat. No.	Item	Unit	No. Required
97535	Chest, field, plain	ea.	1
40990	Burette, 25 ml.	ea.	2
40563	Vial, 22 ml.	ea.	36
44230	Support stand, small	ea.	1
41750	Clamp, adjustable	ea.	2
44385	Test tube, screw cap, 15 x 125 mm.	ea.	100
44140	Stopper, rubber, solid, No. 1	ea.	2
17500	Indicator set, phenol red	set	1
43790	Pipette, volumetric, 10 ml.	ea.	10
43780	Pipette, volumetric, 5 ml.	ea.	2
43660	Pipette, Ostwald, 1 ml.	ea.	1
43730	Pipette, serological, 1 ml.	ea.	1
44420	Test tube support, wood	ea.	1
76300	Pencil, wax, red	ea.	1
79460	Rx bottle (vial) 1 oz., with screw cap (containing 3 ml. phosphate buffer and 20 ml. ethylene chloride)	doz.	35
71780	Towel, hand	ea.	6
14340	N/10 Sodium Hydroxide solution (allow 15 ml. per determination)	....	....
NS	Comparator block	ea.	1
NS-4	Pipette, Ostwald, ½ ml.	ea.	10

* These are the materials actually taken on a field tour during which approximately 400 samples of urine were collected.

TABLE 3

COMPARISON OF DIRECT AND INDIRECT PLASMA ATABRINE CONCENTRATIONS IN INDIVIDUALS OF THREE MILITARY ORGANIZATIONS

Org. I. A Q. M. Truck Co.			
Number	A.P.	C.A.P.	Deviation
1	24	24	0
2	20	23	3
3	28	29	1
4	25	26	1
5	20	23	3
6	24	24	0
7	24	24	0
8	20	22	2
9	28	23	5
10	13	14	1
11	20	17	3
12	22	24	2
13	24	23	1
14	20	21	1
15	28	21	7
16	32	32	0
17	14	17	3
18	18	19	1
19	21	19	2
Mean	22.4	22.4	1.9

TABLE 3—*Continued*

Org. II. A Q. M. Truck Co.			
Number	A.P.	C.A.P.	Deviation
20	4	1	3
21	20	20	0
22	32	24	8
23	34	26	8
24	24	21	3
25	32	24	8
26	18	21	3
27	8	13	5
28	16	20	4
29	20	16	4
30	15	20	5
31	26	24	2
32	22	20	2
33	26	24	2
34	44	22	22
35	20	16	4
36	26	24	2
37	32	22	10
38	20	22	2
39	20	22	2
Mean	23	20.1	5

Org. III. A Q. M. Truck Co.			
Number	A.P.	C.A.P.	Deviation
40	29	23	6
41	28	21	7
42	28	20	8
43	24	25	1
44	24	22	2
45	34	24	10
46	42	37	5
47	25	24	1
48	34	23	11
49	28	27	1
50	32	26	6
51	20	23	3
52	14	19	5
53	32	25	7
54	42	26	16
55	12	15	3
56	40	27	13
57	14	21	7
58	37	24	13
Mean	28.4	23.8	6.6

A DISEASE OF CORN IN THE RIO GRANDE VALLEY OF TEXAS[1]

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In the spring of 1945, G. E. Altstatt[7] observed abnormal conditions of sweet corn growing in the Lower Rio Grande Valley Experiment Station grounds. The plants observed were light yellow and streaked, and excessively stooled. At the time, this condition was thought to be due to unfavorable soil conditions or lack of water. The experimental plots were under irrigation.

Later, on June 20, I. E. Melhus, of the Iowa State College, visited the Texas station in order to study a collection of corn varieties which were being grown for him. In his material he found two plants which suggested a virus disease. The next day he and J. R. Wallin, in company with E. V. Walter, visited several fields and found the disease in each field, including two fields on the station grounds. In some of these fields the disease was prevalent and destructive. Sweet corn showed the most injury. Walter reported that he had observed this abnormal condition in 1942 and had sent descriptions of the primary symptoms to Washington, D. C. Because of the destructiveness of the disease, a description and record of the results of a survey on the United States side of the Rio Grande River are here recorded.

The symptoms manifested on the different corns were similar to malformations caused by some viruses and insects. Three different virus diseases have already been described on corn. No attempt has been made so far to determine the identity of the disease herein described. The purpose of this short article is to describe the symptoms and destructiveness of the disease as it occurred in the Rio Grande Valley of Texas.

SYMPTOMS OF THE DISEASE

Usually one or two symptoms characterized the disease. Affected plants show abnormal nodal bud extension. In every case where the

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[7] Altstatt, George E., A New Corn Disease in the Rio Grande Valley, *Plant Disease Reporter*, 29 (20), June 15, 1945, pp. 533–34.

TABLE 1

COMPARATIVE SYMPTOMS OF CORN VIRUS DISEASES

A COMPARISON OF THE SYMPTOMS OF THREE KNOWN VIRUS DISEASES AND THE DISEASE OBSERVED IN THE RIO GRANDE VALLEY

	Streak	Mosaic	Stripe	Disease Observed in Rio Grande Valley
Stalks	Internodes somewhat shortened.	No evidence of stunting until after ear development. The internodes above the ear are markedly shortened.	Internodes somewhat shortened.	Dwarfed above primary ear. Latent bud development into side branches, some several feet long.
Leaves	Narrow broken to wide chlorotic stripes varying in length along the veins.	Mottled but not striped or streaked.	Narrow to broad yellow streaks. Distinctly colored, often dark red.	Sometimes the leaves are light yellow or streaked. Occasionally red or bronze at tips and along edges, but no mosaic evident.
Vector	*Cicadulina mbila*	*Aphis maidis* or *Peregrinus maidis*	*Peregrinus maidis, Ashm.*	Unknown—possibly *Peregrinus maidis, Aphis maidis*, or *Cicadulina mbila*. All of these occur in this area.
Described from	South Africa	Hawaii	Trinidad	Lower Rio Grande Valley
Source of description	Storey[*] [†]	Kunkel[‡] [§]	Briton-Jones[‖]	....
Fertility	....	....	Tendency towards sterility.	No tendency towards sterility.

* H. H. Storey, "Streak Disease, an Infectious Chlorosis of Sugar Cane not Identical With Mosaic Disease," *Imp. Bot. Conference 1924 Rept. of Proc.*, 1925, pp. 132–44.

† H. H. Storey, "The Transmission of Streak Disease of Maize by the Leafhopper, *Balclutha mbila* Naude.," *Ann. Appl. Biol.*, 12:422–439, 1925.

‡ L. O. Kunkel "A Possible Causative Agent for the Mosaic in Corn," *Bul. Hawaiian Sugar Planters Ass'n., Exp. Sta., Bot. Series* 3:44, 1921.

§ L. O. Kunkel, "Corn Mosaic of Hawaii Distinct From Sugar Cane Mosaic." *Phytopath.*, 17:41, 1927.

‖ H. R. Briton-Jones, "Stripe Disease of Corn" (*Zea Mays*—Trinidad). *Trop. Agr.* 10:119, 1933.

disease could be identified, this was true. In general appearance these plants were bushy; often, but not always, dwarfed; frequently light green in color; occasionally the tips and edges of the leaves were red or bronze and sometimes the leaves were streaked with etiolated bands of varying widths. Occasionally the leaves were small, both in width and in length, but otherwise healthy in appearance.

The most characteristic symptom in all cases was the marked growth of shoots from the axillary buds, from all nodes below the ear shoot node. Frequently the lateral branches grew to be two to three feet long, terminated by male and female flowers. The latter usually developed some seeds.

With regard to the shortening of internodes, there was often a marked variation in the length, depending on the period of development at which the infection occurred. In plants affected early, all were shortened from the base to the tassel. Plants affected later showed internode shortening only above the primary ear, and late-infected plants showed no shortening.

Secondary symptoms in the leaf comprise changes in color, shape, and size. Leaves which became diseased at an early stage in the development of the plant were often narrower in relationship to the length than in normal plants. These leaves might be streaked, bronzed, or reddened, but these symptoms were not constant and often varied with the condition of the plant at the time of inspection. The leaves enclosing the ear were often narrowly lanceolate rather than broadly so. Frequently leaves on the ears were reduced in length, but this was not a constant symptom.

When plants were infected late in their development the side branches were still present but less marked than in the plants infected early. Occasionally, seed on the primary ears filled imperfectly, leaving wide spaces between the rows of kernels. On maturation these kernels sometimes appeared to have a loose pericarp rather than one which adhered tightly to the endosperm. This imparted a silvery appearance to the kernel which is quite distinct from the normal grain.

The symptoms that were apparent on the ears were not marked. Plants infected at an early age produced no marketable ears, while those infected later did produce some marketable corn. The ears on the abnormal side-branches were small and imperfect. In a few cases plants infected very early seemed to be killed by the disease.

The symptoms of the three major corn virus diseases and those of the disease noticed in the Lower Rio Grande Valley fields are given in Table 1.

SUSCEPTIBILITY OF DIFFERENT CORNS AND DISEASE DISTRIBUTION IN THE VALLEY

The disease was found on dent, popcorn, and sweet corn in the Valley and was most prevalent on the crop planted during the months of January and February. The two most important dent varieties, Tuxpan and Mesquitelena, were found to be infected. Likewise several varieties of sweet

FIG. 1.—Plant of R 30 x 763 stripped of leaves to show ear shank extensions as compared with normal plant. (Courtesy E. V. Walter, United States Department of Agriculture.)

FIG. 2.—Plant of White Tuxpan showing abnormally shortened nodes above primary ear and relatively small tassel. Note streaking in leaves. (Courtesy E. V. Walter, United States Department of Agriculture.)

corn seemed to be susceptible. Corn planted in March showed less infection and that planted in April was practically free. The disease was found to be present throughout the Valley from the westernmost extension in Hidalgo County, east to Blue Town in Cameron County, and north to Raymondville, in Willacy County. It was most prevalent in the vicinity of Weslaco and Santa Rosa. In the Weslaco area all types of corn seemed to be seriously damaged. At Santa Rosa the most serious damage was on popcorn.

PROBABLY NOT SEED TRANSMITTED

It was thought possible that the causal agent might be seed-borne. To answer this question seeds from infected plants were planted at Lafayette, Indiana, and at Weslaco, Texas. In no case did any of the plants from seed produced by diseased plants show the disease.

GENERIC CLASSIFICATION OF NORTH AMERICAN TINGOIDEA (HEMIPTERA-HETEROPTERA)[1]

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In any taxonomic group it is necessary periodically to redefine generic limits in order to keep abreast of changes which are constantly occurring with the descriptions of new species. The present status of the family Tingidae is such that without a representative collection of named specimens for comparison it is difficult to make accurate determinations. Rather than describe new genera, this paper attempts to clarify existing ones, and it is hoped that the accompanying keys will facilitate generic classification of species collected in the region considered here.

For the sake of convenience the geographic boundaries for this study have been set to include the continent of North American and the islands of the Carribean Sea, with the Panama Canal serving as the arbitrary southern border.

Revisions in classification cannot satisfactorily be undertaken within definite geographical boundaries unless all the members of the group to be revised are located within that area. That phase of the problem must be attacked on a world-wide basis. Therefore no attempt has been made to disentangle such confusions as exist in genera like *Tingis, Leptopharsa, Teleonemia, Monanthia,* and others of which the boundaries have become distended beyond the limits of practicability. That task remains for the monographers of the separate genera. Some of these problems will be presented here with the hope of future solution, but their disposal cannot be attempted in this study.

REVIEW OF LITERATURE

The first North American species of Tingidae were described by Fabricius in 1794, thereby antedating the family itself by thirty-eight years. These species were *Acanthia gossypii,* now included in the genus *Corythucha,* and *Acanthia sacchari,* now *Teleonemia,* both distributed throughout the west Indies and Central America and extending into South America and into southern United States. Thus the tingids had an early taxonomic start on this continent. Fabricius also described the genus *Tingis,* type of the family, ten years later. The first of the Piesmidae from North America was described by Say in 1831 as *Tingis cinerea,*

[1] Doctoral thesis No. 778, submitted August, 1945.

[2] For a number of years it has been the privilege of the author to work with Dr. Carl J. Drake in the taxonomy of Tingoidea and to publish jointly with him various papers in that field. It was at his suggestion and under his supervision that this investigation was undertaken, and it was facilitated by the use of his tingid collection, personal library, and card index of references. The author wishes to express her deep appreciation to Dr. Drake for his fine cooperation throughout the course of this research.

and the same year this pioneer American entomologist, considered the father of taxonomic entomology in America, also described *Tingis mutica,* now *Leptoypha; T. plexus,* now *Physatocheila; T. ciliata* and *T. arcuata,* both *Corythucha.* The first really extensive work on the tingids of the Western Hemisphere was done by Stål (1860 and 1873) who described twelve of the present North American genera, among other extra-European ones, and presented an excellent key to the genera.

Champion (1897–1898) in his study of Central American insects contributed greatly to the knowledge of Tingidae in that area. Although he included no generic key he did present a number of keys to species, and perhaps his greatest contribution was the inclusion of excellent illustrations of most of his species. Eight of the genera in North America were described by him. Thirteen other genera have been described by a total of ten different authors, six of whom, like Stål and Champion, were Europeans. This situation has changed greatly, though, and for some years American tingid taxonomy has been firmly established in America. Since 1916 twelve genera and a great many species have been described from North America by Drake alone or with co-workers. This number does not include his many exotic forms. Other American hemipterists who have worked with the tingids in this area include Uhler, Heidemann, Osborn, Van Duzee, McAtee, Parshley, Gibson, Barber, Blatchley, and Torre-Bueno.

In 1886 in his check-list of Hemiptera, Uhler listed eleven genera and twenty-four species of Tingoidea in North America. By 1917, when Van Duzee published his catalog of Hemiptera, 24 genera and 76 species were recorded from the area north of Mexico. In 1926 Blatchley listed just from eastern North America 73 species divided among 22 genera, almost as many as were given nine years earlier for a much larger area. From the whole of North America, Blatchley stated that more than 120 species were then recognized, but he gave no number for the genera into which they were divided. In their catalog of genera of the Western Hemisphere, Drake and Poor (1937) listed 52 genera containing an aggregate of approximately 424 species. Since of these four lists only Uhler's concerns an area of the same extent as that considered here, with its 47 genera and 301 species, it is impossible to make a direct comparison among all the figures, but it is clearly evident that a tremendous amount of growth has occurred in the knowledge of this group of insects.

Since the publication of Stål's key (1873), there have been several others designed for different parts of this area. Provancher (1886) considered the tingids of Canada; Summers (1891), those of Tennessee; Osborn and Drake (1916), of Ohio; Barber (1922), of New Jersey; Parshley (1923), of Connecticut; Blatchley (1926), of eastern North America, and Froeschner (1944), of Missouri. No keys to the tingids of the entire North American area have been published heretofore.

For regions beyond the boundaries of North America some of the outstanding works of a catalog nature have been those of Spinola (1837), Amyot and Serville (1843), Fieber (1844 and 1861), Puton (1899), Horvath (1906), and Oshanin (1908) for the palearctic regions; Walker (1873) for the insects in the British Museum; Reed (1900) for Chilean, Berg (1879 and 1884) and Pennington (1921) for Argentine, and Monte (1942) for Brazilian Tingoidea. There are many taxonomists notable for their descriptive works but an enumeration of them will not be attempted here.

The biology of the lace bugs will not be reviewed in this study but a few references to works of this nature are included in the appended bibliography. Economically the tingids have assumed importance as plant feeders only in a few instances, and those seem to occur largely in the warmer climates. Vegetable crops (Jones, 1915; Cotton, 1917 and 1919; Wolcott, 1923; and Monte, 1943) and cotton (Fenton, 1934) have been most seriously affected by feeding of these insects.

GENERAL DISCUSSION

MATERIALS AND PROCEDURE

The specimens examined in the course of this study are in the Drake Collection, undoubtedly the most complete in the world for North American Tingoidea. Of the 301 species recognized at present from this region, 254 are represented in this collection. It was thus possible for the author to examine this number of species as well as many others from the same and related genera in other regions. In only six genera of those considered here were no North American species studied. In each of these, except in the fossil genus *Eotingis*, exotic species of the same genus were examined to supplement the information obtained from figures and descriptions of the missing species. In addition to *Eotingis* the only other genus of this group not represented in the Drake Collection is *Zetekella*, the unique specimen of which, deposited in the U. S. National Museum, was examined by the author at the time it was described by Dr. Drake. Fortunately a number of the missing species are those described and figured by Champion (1897-1898) and a study of these figures and others was most useful.

Except for some of the larger and more confused genera the accompanying diagnoses were written to include the North and South American species of the genera in question, with the complete range of variation represented. The key, however, is limited in scope to North America because without the inclusion in it of genera endemic to South America, it could be of no use in determining material from that region. In the preparation of the key, a table of characters was filled out for each genus during the course of examining its species. The greatest handicap in depending on figures and descriptions for the species not represented in the collection was the failure of these sources to reveal certain characters included in the routine diagnosis. These omissions increased the hazards of preparing the key, for one cannot safely include in a section of the key pertaining, for example, to the open or closed condition of the bucculae any genus about which this condition is not known. Therefore diagnostic characters had to be limited to those about which complete information was available. These tables of characters were sorted according to their affinities and differences and a diagnostic key prepared from them. This key was checked with the specimens and revised several times. It is hoped that its weaknesses, inevitable from the variable nature of its subject material, will be lessened by the supplementary illustrations.

Genital characters were omitted entirely from the key because of the difficulty in finding consistent and outstanding differences without dissection. Also, it was possible to postpone until far into the key the necessity for turning the specimens over to examine rostral canal, bucculae, and orifice. In this way the annoyance of finding the critical feature concealed by the point on which the insect is glued may be somewhat alleviated. It was necessary, however, to include some antennal characters, another source of disappointment when one has a mutilated specimen to identify. In those cases, however, a trial of both members of the couplet will usually remedy the difficulty, though it is necessarily easier to identify a complete specimen. The fossil species are separated from the others immediately, in order to avoid the need of observing characters often obscured in them.

DIAGNOSTIC CHARACTERS

Some of the characters used in former keys of the Tingidae have become quite useless for separating certain groups because of their increased variability with the description of new species. For example, Stål's characterization of *Acalypta* as having bucculae open in front (1873) and Westwood's as having elytra meeting in a straight suture (1840) are no longer key characters for the genus. Both Stål (1873) and Summers (1891) separate *Teleonemia* from other genera by the single row of cells in its costal area, whereas there are now species with as many as three rows there. Other characters, such as the transverse carinae interrupting the rostral canal of *Gargaphia*, used by Stål (1873), Provancher (1886), and Summers (1891), remain as valid as ever. Some features which at the outset of this study seemed to hold great promise as diagnostic characters turned out to be of little or no value whatever in generic separations but rather to be of only specific significance. An example of this is the hypocostal ridge which is more than uniseriately areolate in only three genera, *Acalypta*, *Corythaica*, and *Stephanitis*, and even those genera contain some species with but one row of cells there. However, because it has not often been included in descriptions this is an uncertain character in those species of which no specimens were seen.

Another character which proved of little or no value in a diagnostic key is the placement of the coxae. In all but a few genera the distance between the procoxae and the mesocoxae is considerably greater than the distance between the meso- and metacoxae, and the mesocoxae are placed farther apart than either of the other two pairs. In *Acalypta* the position of the coxae varies with the elytral length, as does also the convexity and length of the pronotum. This is an interesting relationship, hitherto unreported, since in the brachypterous forms the pronotum is reduced in height and length, possibly because of a reduction in underlying muscles, and shortening occurs ventrally between the pro- and mesocoxae. *Acalypta* is the only genus in this region which shows this correlation so clearly.

The shape of the head does not vary greatly within the subfamilies though there is variation in the location, shape, and size of the antenniferous tubercles and in the size, shape, and number of spines. In the Cantacaderinae the head is long, extending considerably beyond the eyes and insertion of antennae and it often bears more than five spines, but in the Tinginae it is distinctly shorter and has no more than five spines, sometimes less. The spines may be long, slender, and sharp, or they may be appressed to the surface of the head, contiguous throughout (*Corycera*) or at their apices, or reduced to mere tubercles between these extremes. The antennae, always with four segments, offer many possibilities for variation in length, thickness, shape, and texture. The bucculae in some species are widely separated, showing the insertion of the clypeus between, in some contiguous at the base and emarginate anteriorly, and in others they may be completely fused, long or short, directed straight downward or produced forward and visible in front of the head from above.

Great variation occurs among species in the shape and depth of the rostral channel and in the height and extent of the bordering laminae which sometimes completely close the channel posteriorly and sometimes terminate individually, thus leaving the channel open behind. The length of the rostrum is not always correlated with this open or closed condition of the channel, for in some species the rostrum extends well onto the abdomen in spite of the presence of a continuous carina across the apex of the channel, though in that case the terminal lamina is very low. A study of the relation between rostral length and food plants would be very interesting as a clue to the variations in this structure. The degree of distinctness of the orifice, located between the mesopleura and metapleura, is another useful character in classification. In some species such an orifice is not discernible whereas in others it is quite distinct and may even be margined with protruding or somewhat inflated lips. In regard to the legs one may conclude that in general they conform quite well to the form of the antennae; in species with long slender antennae the legs are likely to be long and slender too, and in those species with thick antennae one may often, though not always, expect to find the legs similarly formed.

One of the most useful characters in separating genera is the paranotum (referred to by Stål as lateral margin of pronotum) which may be obsolete, costate, carinate, or foliaceous and explanate or reflexed in various ways. It offers perhaps the greatest number of possible variations of all the morphologic characters and has been used extensively in classification. A heretofore undescribed feature of the paranota has been used for the first time in the following key; it is called here the "*basal fold.*" *Corythucha* and *Corythaica* both have this peculiar fold, illustrated in

Figures 2c and 3, at the calli. The degree of elevation, extension, and inflation of the collar or hood is another useful taxonomic character. There is sometimes uncertainty as to the distinction between collar and hood, though in their extremes they are clearly separable. A slight tectiform elevation of the collar without an accompanying forward extension is considered not to constitute a hood, but if the elevation is bulbous or projects over the base of the head it becomes a hood. This is purely an arbitrary distinction; the interpretation varies among authors. Other pronotal variations include the convexity of the disk, length and shape of posterior process, number, length, and height of carinae and distinctness of calli.

The elytra, called hemielytra or hemelytra by many authors in reference to the position of the Tingoidea in the order Hemiptera, show little affinity with the conventional hemipterous fore-wing except in the macropterous piesmids with their membranous sutural area. In the Serenthiinae the elytra are almost coleopteroid in appearance, smoothly convex over the abdomen and protruding little beyond it. At the other extreme are found *Aristobyrsa* and *Stephanitis* species with elytra widely divaricating apically, broadly expanded laterally, highly bulbous medially, widely areolate throughout, and extending far beyond the limits of the abdomen. The costal area (costal membrane of Stål) varies from costate to widely foliaceous, but the actual number of rows of cells within it is seldom of generic value and in some groups not even of specific constancy. Its shape and the degree to which it is reflexed are ordinarily far more reliable taxonomic characters. The subcostal area (costal of Stål) may be narrow or wide, flat, oblique, vertical, or even sloping outward with its base concealed by the overhanging discoidal area, which in turn may be long or short, impressed, flat, or bulbous, with margins straight, sinuate, or obliterated. In the accompanying key the length of the discoidal area is given as related to the length of the entire elytron in order to give a definite criterion of measurement. The elytra may overlap when at rest so that the sutural areas are connivant and the apices jointly rounded or they may divaricate to different degrees.

The areolation of the pronotum and elytra is another highly variable attribute. Some species are almost coriaceous throughout with very small cells bounded by thick veins or even with a pitted homogeneous surface, whereas others are distinctly lacy with very large hyaline cells bounded by delicate veinlets. A rather common condition of areolation includes a gradation from punctures on the pronotal disk to small cells of fairly uniform size on collar, paranota, posterior process of pronotum, and discoidal and subcostal areas of elytra, to larger cells in the costal and sutural areas. In some species, however, the areolae are of practically uniform size throughout.

POLYMORPHISM

The presence of polymorphism in some genera of Tingoidea increases both the difficulties and interest in classification. Among the North American species sexual dimorphism is found in the genus *Melanorhopala*, in some species of which the antennae differ in length and thickness between the sexes. There are in this region, moreover, numerous cases of macropterous and brachypterous forms with sometimes an intermediate form within the same species. In some genera there is a definite majority of one form with only occasional specimens of the other collected, as in *Acalptya*, for example, with its great preponderance of brachypterous specimens, and *Amblystira* and *Corythucha* with reverse proportions. In the majority of genera only the long-winged form is known and it is questionable whether the short-winged form has ever developed among them or whether their environment is unfavorable for its survival. This type of dimorphism among the Tingoidea would be an interesting and as yet little touched field for research.

HOST PLANTS

The host plant records appearing in this paper have been obtained either from published data or from labels on specimens in the Drake Collection. Their inclusion here is with full realization of possible error, for many of the records may be of plants which merely were serving as resting places when the tingids were collected from them. Since it is difficult to judge from the records which plants are actual hosts and which are purely accidental, both types are doubtless included here. It is unfortunate that more complete records of host plants are not available because such a knowledge would contribute materially to a better understanding of some of the closely related species.

BIBLIOGRAPHIC NOTES

With each genus in the following section will be given the complete generic synonymy as it is now recognized, and any references to monographic works or keys to the species within that genus. Other papers of interest from the generic point of view will also be listed, but no attempt will be made to include bibliographic references for individual species beyond the type of the genus. The appended bibliography includes, in addition to those references cited in the text, various other works of importance in tingid taxonomy. It is by no means a complete list of titles concerning North American Tingoidea.

CLASSIFICATION

SUPERFAMILY TINGOIDEA REUTER, 1912

The laciness of the elytra and pronotum of these Hemiptera is their most conspicuous character, though in some cases the arcolae are so small and the bordering veinlets so heavy that their appearance is coriaceous rather than lacy. Except in certain piesmids the ocelli and clavus are absent and no membrane can be distinguished on the elytra. Plant-feeders with legs adapted for running, these Hemiptera have four-segmented antennae with the third segment usually the longest and slimmest. Even in the short-winged forms the abdomen is covered by the elytra.

Long considered as distinct families with no relationship indicated, the Tingidae and Piesmidae were finally incorporated into the superfamily Tingoidea by Reuter in 1912. The two families, though less easily distinguished now than at the time of their establishment, may be separated by the following key.

KEY TO THE FAMILIES OF TINGOIDEA

Pronotal lunate cavities visible beneath paranota; jugae produced forward in slender processes .... Piesmidae.
No pronotal lunate cavities visible; jugae not produced beyond tylus........ Tingidae.

FAMILY PIESMIDAE AMYOT ET SERVILLE, 1843

The most outstanding character which separates this family from the Tingidae is the presence, in all species known, of a peculiar pair of hollow apophyses in the prothorax, the lunate openings of which are visible only from the ventral side, between the prosternum and the paranota. The other end of the cavity is marked, in various degrees of distinctness, by a carina, bulla, callus, or depression between the pronotal carinae and the paranota, on the anterior third of the pronotum. McAtee (1919a, p. 83) refers to these external indications of the closed end of the apophyses as "lateral carinae," a rather confusing use of the term because of the presence of three other longitudinal carinae in some species, the outer pair of which would also be the lateral carinae. His other term, callosities, would seem preferable, since they seem to be correlated with the calli of the Tingidae.

The other family characters are less reliable because of their variability. Only in the macropterous forms are the ocelli and clavus usually distinct and the membrane of the elytra present. The development of the jugae is a distinguishing feature, however, with the piesmids having them produced forward, whereas in the tingids the tylus protrudes beyond the jugae. Also the genital segment is quite different in the Piesmidae.

At present there are but two genera in the Piesmidae, *Piesma* and *Mcateella* Drake, the latter of which is limited to Australia and South America. *Mcateella* is easily distinguished from *Piesma* by its shorter jugae and its smaller number of elytral areas (interstitial and brachial combined into discoidal; cubital and subcostal scarcely distinct).

GENUS *PIESMA* LE PELETIER ET SERVILLE

1825 *Piesma* LE PELETIER DE SAINT-FARGEAU et AUDINET-SERVILLE, Ency. Méth. 10:653.
1832 *Zosmenus* LAPORTE, Mag. Zool., p. 49. (*Zosnanus* on p. 47)
1833 *Aspidotoma* CURTIS, Ent. Mag., 1:196–197.
1835 *Zosmerus* BURMEISTER, Handbuch Ent. 2:262.
1895 *Agrammodes* UHLER, Bul. Colo. Agr. Exp. Sta. 31:56.
1919 *Piesma* McATEE, Bul. Brooklyn Ent. Soc. 14:80–93.

Head with eyes protruding, jugae projecting beyond tylus in slender processes; ocelli present in macropterous forms; antennae far apart, with stalk of segment I exposed and slender, the rest eccentrically bulbous; segment II ovoid, shorter than I; III slender, sometimes longer than IV which is fusiform; bucculae widely separated at apex. Rostral channel with low laminae; rostrum short and stout. Hypocostal ridge minutely uniseriate.

Pronotum somewhat truncate anteriorly and posteriorly, closely pitted, convex, especially on humeri; paranota explanate anteriorly, not produced forward. Scutellum exposed by lack of posterior process of pronotum. Elytra in macropterous forms with sutural area reticulate only at base, membranous apically, the membrane divided by longitudinal veins; brachypterous forms with six more or less well defined areas: costal, subcostal, cubital, brachial, interstitial, claval, and sutural (terminology of elytral areas from McAtee, 1919a, p. 84).

Generotype, *Piesma (Acanthia) capitata* (Wolff), 1804.

Piesma is represented in North America by eleven species and two varieties, one species of which is a fossil, *P. rotunda* Scudder from Colorado. *P. cinerea* (Say) is one of the most widespread of the Tingoidea, extending from Long Island to Oregon and from Canada to Argentina. McAtee (1919a) described eight species in this genus: *brachialis, ceramica, depressa, explanata, incisa, patruela, protea* and *rugulosa,* all from western United States. He also presents a key to the species and a discussion of the genus. The remaining American species in the genus is *costata* (Uhler) from Colorado.

The genus *Piesma,* with largely chenopodiaceous host plants, is probably much more widely represented in South America than present records indicate, with *cinerea* the only species so far recorded from there. In the Eastern Hemisphere there are about a dozen species, none of which is cosmopolitan.

FAMILY TINGIDAE LAPORTE, 1832

This family was divided by Stål (1873) into divisions, now known as subfamilies, which may be separated by the following key.

KEY TO THE SUBFAMILIES OF TINGIDAE

1. Scutellum exposed; clavus more or less distinct .... Cantacaderinae.
   Scutellum concealed, clavus not apparent .... 2.
2. Elytral areas, except costal, indistinct .... Serenthiinae.
   Elytral areas distinct .... Tinginae.

SUBFAMILY CANTACADERINAE (STÅL), 1873

The North American genera in this subfamily have the following characteristics in common: head long, extending far beyond eyes and insertion of antennae; rostrum long, extending on venter; rostral channel open behind; orfice distinct; collar wide and reticulate, not swollen into a hood or produced antrorsely; pronotum without posterior process, scutellum exposed. Elytra ovate, with clavus more or less distinct, discoidal and subcostal areas elongate.

KEY TO THE NORTH AMERICAN GENERA OF CANTACADERINAE

1. Bucculae contiguous anteriorly; seven long spines on head; pro- and mesocoxae much farther apart than meso- and metacoxae; paranota angulate; clavus very distinctly differentiated .... *Phatnoma*
   Bucculae open anteriorly; at least some of head spines reduced to tubercles or absent; coxae equidistant longitudinally; paranota rounded; clavus indistinctly differentiated 2
2. Elytra with prominent transverse nervures on discoidal and subcostal areas, costate marginal veins of discoidal area sinuate at points of juncture of these nervures; frontal spines reduced to tubercles, basal ones absent.... *Eocader*
   Elytra without prominent transverse nervures, marginal vein of discoidal area laminate-areolate; five stout frontal spines, basal pair reduced to tubercles .... *Zetekella*

GENUS *PHATNOMA* FIEBER

1844 *Phatnoma* FIEBER, Ent. Monog., pp. 30, 57.
1919 *Phatnoma* GIBSON, Trans. Amer. Ent. Soc. 45:181–185 (Key).

Head long, with seven long frontal spines, stout at base, attenuate; antenniferous tubercles spiniform extrorsely; antennae long, very slender, at least as long as head and pronotum together; bucculae contiguous at apex. Laminae of rostral canal, including bucculae, with margins almost level; venter grooved medio-longitudinally for reception of rostrum; distance between pro- and mesocoxae much greater than between meso- and metacoxae. Hypocostal ridge uniseriate.

Pronotum with three foliaceous, uniseriate carinae, median percurrent on collar and pronotum, lateral arising behind collar, subparallel; disk transversely convex, punctate, bisinuate posteriorly; scutellum triangular, raised in a tubercle posteriorly. Elytra ovate, rather finely reticulate, rounded separately at apex, with prominent transverse ridges on discoidal and sutural areas; clavus trapezoid, outer edge distinct and very straight; costal area explanate, slightly reflexed, margin rounded; subcostal area obliquely sloping, at least as wide as discoidal; discoidal area with anterior three-fourths of outer and posterior three-fourths of inner marginal vein uniseriately carinate; sutural areas narrow, overlapping.

Generotype, *Phatnoma laciniata* Fieber, 1844.

This genus is represented in the Western Hemisphere by eight species, three of which are North American: *annulipes* Champion—from Mexico, Guatemala, Costa Rica, and Panama, as well as from Venezuela and Peru in South America; *marmorata* Champion—from Costa Rica, Panama, and Trinidad (also Brazil); and *ovata* Champion—from Mexico and Guatemala. Two other Panamanian species, described by Gibson as *filetia* and *spinosa*, were found by Drake (1922a) to be synonymous with *marmorata* Champion.

From other parts of the world about seven species of *Phatnoma* have been recorded, from India, Africa, Formosa, Fiji, and Australia. No one species is common to both hemispheres, however.

Little is known about the host plants of this genus, though one specimen of *marmorata* has been collected on cultivated pineapple in Trinidad and one *annulipes* was found in Washington, D. C., on "orchid packing" from Venezuela.

GENUS *EOCADER* DRAKE AND HAMBLETON

1934 *Eocader* DRAKE and HAMBLETON, Rev. Ent. Rio de Janeiro, 4:436.
1940 *Montea* BRUNER, Mem. Soc. Cubana Hist. Nat. 14:246, p. 43.
1944 *Eocader* DRAKE, Bol. Ent. Venezolana, 3:141.

Head long, with frontal spines reduced to tubercles or lacking; eyes prominent; antennae with segment III very long and slender, IV fusiform; bucculae not contiguous at apex. Rostral canal very shallow on prosternum, not apparent beyond; coxae widely separated laterally, close longitudinally. Hypocostal ridge uniseriate.

Pronotum short and wide, truncate anteriorly and posteriorly; paranota narrow, rounded, wider anteriorly; one to three carinae, median percurrent on collar and pronotum; scutellum triangular, raised posteriorly. Elytra obovate, abruptly widened near base, gradually narrowing apically, rounded together behind; costal area widest near base, margin smoothly rounded; subcostal area wide, obliquely slanting; discoidal area with marginal veins costate, sinuate between points of juncture with prominent transverse veins in discoidal and subcostal areas; sutural area very narrow and contiguous in brachypterous form, narrow and overlapping in macropterous.

Generotype, *Eocader vegrandis* Drake and Hambleton, 1934.

There are but two species of this genus so far recorded, the generotype, from Brazil, and *bouclei* (Bruner), type of the synonymous *Montea*, from Cuba. The latter species is well figured with the original description (Bruner, 1940); only the generotype was examined by this author.

Eocader bouclei was collected on the bark of *Casuarina*.

GENUS *ZETEKELLA* DRAKE

1944 *Zetekella* DRAKE, Bol. Ent. Venezolana, 3:140, Fig. 1.

Head long, with five stout frontal spines and indications of a reduced basal pair; eyes small. Rostral canal laminate. Coxae about equidistant.

Pronotum short, convex, truncate anteriorly and posteriorly, tricarinate; median carina percurrent on collar and pronotum, lateral carinae short, distinct posteriorly; paranota wide, rounded, slightly reflexed. Scutellum small. Elytra ovate, slightly overlapping behind but rounded separately; clavus rather indistinctly differentiated; costal area explanate, uniformly rounded; subcostal area wide, separated from discoidal by laminate-areolate vein.

Generotype, *Zetekella zeteki* Drake, 1944.

This monotypic genus at present is represented by a single specimen from Panama, deposited in the U. S. National Museum. Like *Eocader*, it is very much smaller than *Phatnoma;* unlike *Eocader*, it has wide paranota and lacks the characteristic transverse veins of discoidal and subcostal areas of elytra. Its subfamily structures separate it readily from *Acalypta*, which it resembles in general habitus.

Zetekella is the only cantacaderine genus recorded solely from North America, and considering the location of Panama this distinction will undoubtedly be short-lived. There are, however, two other genera in the subfamily which occur in South America only and are therefore not included in the preceding key. They are *Nectocader* Drake, distinguished by its five-carinate pronotum and its marginal border of cells on the costal area of elytra, and *Stenocader* Drake and Hambleton, with its distinctive tuberculate margins of elytra and paranota and its five-carinate pronotum.

There are about eight other genera in the subfamily Cantacaderinae, found in various parts of the Eastern Hemisphere, including the type genus, *Cantacader* Amyot and Serville. *Phatnoma* is the only one with world-wide distribution.

SUBFAMILY SERENTHIINAE (STÅL), 1873

None of the genera usually included in this subfamily is found in North America. There is, however, one North American genus which might be classified here in part, but which also fits into the Tinginae. In *Acalypta* the macropterous form has elytra separated fairly distinctly into areas, but the brachypterous form has, like the Serenthiinae, only the costal area distinct and the others practically indistinguishable. The fact that a single species could be placed in either of two subfamilies, depending upon whether one has the brachypterous or macropterous form, clearly demonstrates the weakness of this subfamily division. *Acalypta* will be discussed below with the subfamily Tinginae.

SUBFAMILY TINGINAE (STÅL), 1873

Head short to moderately long, with five spines or less; bucculae long or short, fused, contiguous or separated anteriorly; rostrum long or short; rostral channel shallow to deep, open or closed behind. Pronotum with collar or hood; unicarinate to tricarinate; paranota obsolete to foliaceous, explanate to reflexed; posterior process short to long. Elytra without visible clavus; costal, subcostal, discoidal, and sutural areas distinguishable.

It is this subfamily which contains by far the majority of species of Tingidae throughout the world. In North America there are now recognized in it 43 genera and 283 species. These genera may be identified by means of the following key.

KEY TO THE GENERA OF TINGINAE

1. Fossil forms 2
   Non-fossil forms 4
2. Costal area regularly biseriate areolate at base; antennae as long as head and thorax together 3
   Costal area broad, irregularly areolate; antennae almost as long as entire body .... *Eotingis*
3. Paranota with one row of cells; elytra broadening apically .... *Tingis*
   Paranota not visible beyond margin of pronotum; elytra obovate, tips overlapping .... *Monanthia*
4. Pronotum with a posterior median vesicle connected with the hood by the foliaceous median carina 5
   Pronotum without a posterior median vesicle 7
5. Paranota with several rows of moderately large cells; lateral carinae lacking (Fig. 1) .... *Dicysta*
   Paranota with one row of extremely large cells 6

6. Lateral carinae very strongly foliaceous and incurved above, forming two concave shells attached to crest of pronotal disk and to bulbous posterior process; hood small, tectiform .... *Galeatus*
   Lateral carinae absent or reduced to a single large cell, attached basally to pronotum and posteriorly to posterior vesicle; hood large, more or less globose, extending over head but not over disk of pronotum............ *Aepycysta*
7. Elytra very broadly expanded, explanate, about three times as broad as pronotum 8
   Elytra not three times as broad as pronotum... 9
8. Bucculae widely separated anteriorly; elytra broadly and separately rounded behind; discoidal and subcostal areas inflated together in large bulbous vesicle; antennae and legs with long fine hairs which are somewhat curled distally; margins of pronotum and elytra setose; paranota explanate, broadest anteriorly and arcuately produced forward .... *Aristobyrsa*
   Bucculae closed in front; elytra subtruncate at apex; discoidal area flat, subcostal area narrow; margins glabrous; paranota uniformly narrow. .*Eurypharsa*

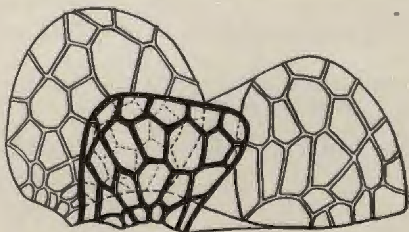

FIG. 1. Lateral view of hood, median carina and paranota, *Dicysta*.

9. Paranota explanate throughout, much broader anteriorly and produced arcuately forward, lateral margins parallel, divaricating anteriorly or distinctly concave medially; without basal fold 10
   Paranota, if explanate and produced forward, with lateral margins convex or divaricating posteriorly 11
10. Discoidal area closed behind; elytra slightly overlapping .... *Pleseobyrsa*
    Discoidal area open behind; elytra contiguous in a straight medial line. . . *Allotingis*
11. Antennae extremely long, longer than entire insect, segments I, III, and IV all much elongated 12
    Antennae not longer than entire insect...14
12. Paranota very wide, bulbous, reflexed high over disk of pronotum and incurved at distal margin; with bulbous hood and median carina high......
    .... *Phymacysta (vesiculosa)*
    Paranota not curved over pronotal disk 13
13. Paranota narrow and vertical or obsolete; head with three spines; collar not vesiculate .... *Tigava*
    Paranota evenly rounded, somewhat reflexed, uniformly biseriate areolate, the areolae rather large; one erect spine on head; with bulbous hood. *Macrotingis*
14. Paranota complete, margin equipped with spines (not including the serrate margins of such species as *Phymacysta praestantis* nor the tiny tuberculate-based hairs of *Stephanitis blatchleyi*) 15
    Paranota lacking, interrupted, or without spiniferous margins, though sometimes with marginal hairs 17
15. Collar without hood, subtruncate anteriorly; paranota explanate, uniseriate areolate, edged with large spines (Fig. 2a) .... *Acanthocheila*
    Hood covering head; paranota wide, edged with small spines....................16
16. Head with five long slender spines; hood globose, rounded at apex; costal area not sharply reflexed at base; paranota (Fig. 2b) not undulating at base and without basal fold .... *Caloloma*
    Head without visible spines; hood compressed laterally at apex; costal area sharply reflexed at base; paranota undulating basally and with a non-areolate basal fold at calli (Fig. 2c) .... *Corythucha*
17. Paranota uniseriate and explanate at humeri, wider anteriorly, tri- to quadriseriate and reflexed downward almost vertically there, with margins directed ventrad .... *Hybopharsa*

Paranota expanded laterally or reflexed upward, not directed vertically downward 18

18. Paranota present only as small ear-like flaps on humeri; discoidal area open behind ....*Pseudacysta*

Paranota lacking or not limited to humeri 19

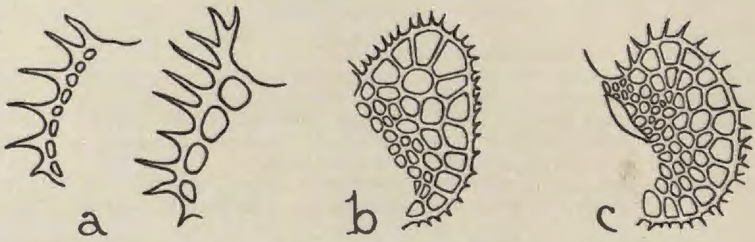

FIG. 2. Paranota: a. *Acanthocheila*, b. *Caloloma*, c. *Corythucha*.

19. Paranota with basal fold opposite calli (Fig. 3); hood reaching at least to second segment of antennae, compressed laterally at anterior end, acute apically; eyes visible from above on either side of hood ....*Corythaica*

Paranota without basal fold anteriorly, or if present, without hood reaching beyond head..20

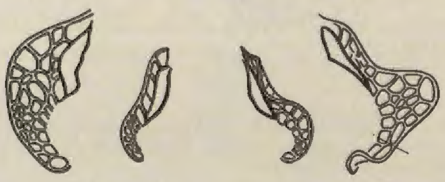

FIG. 3. Paranota, *Corythaica*

20. Paranota reflexed so that distal margin is innermost above disk of pronotum and in contact with disk or carinae; if subvertical and not reaching as far mediad as lateral carinae, then lateral carinae obsolete on disk and discoidal area abruptly curved outward beyond middle (Fig. 6a) 21

Paranota not reflexed over disk of pronotum 25

21. Paranota with a sharp longitudinal crease outermost for entire length, distal half folded back over basal half and margin resting on pronotum (Fig. 4) .... *Leptodictya*

FIG. 4. Paranota, *Leptodictya*

Paranota not creased longitudinally, but bulbous or appressed to pronotum from base 22

22. Lateral carinae exposed and free for part of their length on disk................23

Lateral carinae lacking or not exposed and free on disk........................24

23. Paranota appressed to pronotal disk, touching lateral carinae anteriorly.... .... *Physatocheila*
Paranota high, bulbous, posterior end in contact with lateral carinae; hood rounded at apex, somewhat compressed laterally (Fig. 5a) ....*Calotingis*

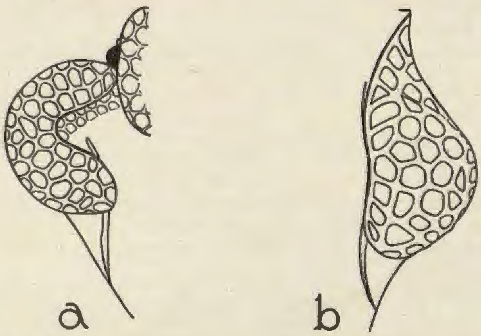

FIG. 5. Paranota: a. *Calotingis*, b. *Dichocysta*.

24. Paranota bulbous, margin closely appressed to margin of lateral carinae over entire length of disk (Fig. 5b).......................................*Dichocysta*
Paranota completely reflexed, extending mediad beyond lateral carinae, sometimes reaching middle; or if narrow, lateral carinae obliterated on disk and outer discoidal margin abruptly produced laterad on posterior half (Fig. 6a) .... *Monanthia*
25. Rostral channel interrupted at meso-metasternal suture with transverse laminae sometimes converging medially (Fig. 6b) ....*Gargaphia*
Rostral channel not interrupted by transverse laminae.......................26

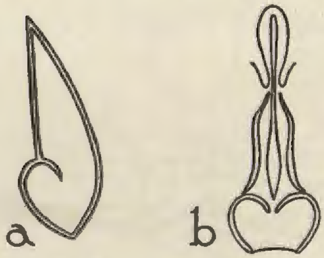

FIG. 6. a. Discoidal area, *Monanthia*. b. Rostral channel, *Gargaphia*.

26. Paranota lacking, costate or narrow and reflexed subvertically................27
Paranota explanate or somewhat broadly reflexed.............................34
27. Discoidal area reaching beyond middle of elytra.............................28
Discoidal area not reaching middle of elytra.................................32
28. Paranota obsolete or costate on humeri, costate or occasionally narrowly areolate at calli; lateral carinae obliterated on disk and sometimes on posterior process ....*Leptoypha*
Paranota reflexed vertically or appressed to pronotum; carinae complete........29
29. Anterior margin of pronotum medially convex, sometimes collar swollen into hood or raised tectiformly; lateral carinae somewhat farther apart on disk than on posterior process; elytra elongate, somewhat constricted beyond discoidal area and broadly rounded together behind ....*Teleonemia*
Anterior margin of pronotum truncate or concave, carinae usually parallel; elytra obovate or ovate 30

30. Antennal segment III thick throughout; elytra with areas, except costal, indistinctly separated in brachypterous form, sometimes more clearly defined in macropterous .... *Alveotingis*
Antennal segment III slender at base; elytra with areas distinct 31
31. Antennal segment III thickened on apical half .... *Hesperotingis*
Antennal segment III thickened only at apex, if at all .... *Melanorhopala*
32. Collar truncate at apex, not raised 33
Collar raised and produced arcuately forward over head, reaching anterior margin of eyes, highest anteriorly .... *Dyspharsa*
33. Paranota carinate and suberect anteriorly; five spines on head; median carina distinctly upraised on collar .... *Tingis* subg. *Tropidocheila*
Paranota completely lacking or costate; head with anterior spines lacking, basal ones lacking or tuberculate, sometimes with interocular ridges; median carina no higher on collar than elsewhere .... *Amblystira*
34. Antennae slender, with segment III obliquely truncate at apex, IV articulated just below apex (Fig. 7); pronotum vesiculate 35
Antennae with segment IV articulated at apex; with or without hood 38

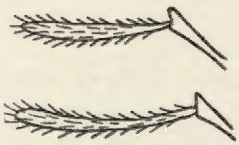

FIG. 7. Antennal segment IV, No. 35.

35. Hood long, extending from near anterior margin of head to beyond middle of posterior process, slightly constricted laterally at middle where only base of median carina remains foliaceous; lateral carinae completely concealed from above by hood (Fig. 8) .... *Megalocysta*
Hood not extending caudad of disk; lateral carinae visible from above 36

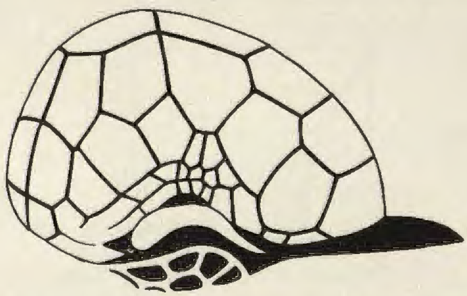

FIG. 8. Lateral view of hood, carinae and paranota, *Megalocysta*.

36. Discoidal area reaching beyond middle of elytra; median carina angularly upraised on disk; marginal veins, antennae and legs pilose .... *Stenocysta*
Discoidal area less than half the length of elytra; median carina not angularly raised on disk 37
37. Paranota wide, suberect, much wider just anterior to humeri, as wide as dorsal surface of hood; margins costate and thickly covered with short curved hairs; lateral carinae curved and leaning mediad behind disk, sometimes contiguous with median carina at middle of latter; hood somewhat compressed laterally .... *Pachycysta*
Paranota less than half as wide as dorsal surface of hood, evenly rounded, not pilose, lateral carinae subparallel (converging somewhat on disk in South American species) .... *Ambycysta*
38. Collar not, or scarcely, inflated into hood; paranota narrow, rarely more than uniseriate at humeri, sometimes obsolete opposite calli 39

Collar inflated into hood, from small to large; paranota usually with more than one row of cells at humeri, sometimes with basal fold or long bulbous cell at calli 41
39. Head without spines but sometimes with interocular grooves and ridges; antenniferous tubercles somewhat spiniform laterally and produced forward; discoidal area usually broader than either costal or subcostal ....*Atheas*
Head with spines 40
40. Paranota entirely explanate or only at calli and costate elsewhere; head with five spines, the anterior three sometimes enlarged and appressed together, forming a horn-like projection directed forward; costal area entirely costate to biseriate areolate and broadened gradually from base; widest part of discoidal area wider than adjacent sections of subcostal and costal areas, sometimes slightly raised at apex ....*Corycera*
Paranota present only on humeri and collar or complete and slightly reflexed; costal area rather abruptly broadened at base, explanate, wider than subcostal or discoidal areas ....*Acysta*
41. Orifice distinct; bucculae contiguous or fused anteriorly; head spines from none to five 43
Orifice indistinct; bucculae separated or contiguous anteriorly; one pair of head spines between eyes at their anterior margin....................42
42. Hood shorter than broad, subtruncate anteriorly and not covering base of head; antennae thick, pilose, with all segments equally stout; bucculae open in front ....*Dictyonota*
Hood highest anteriorly, produced over base of head, anterior margin bisinuate; antennae with III distinctly the slenderest; bucculae open or closed in front ....*Acalypta*
43. Median carina high; paranota rather wide, explanate, or somewhat reflexed upward; discoidal area often bulbous or tectiform at outer margin; elytra divaricating apically 44
Median carina uniformly low (uniseriate); paranota rather narrow, reflexed; discoidal area not greatly raised laterally but flat or impressed longitudinally.45
44. Hood acute at apex, longer than broad; paranota sometimes almost explanate ....*Stephanitis*
Hood globose or nearly so; paranota reflexed to the greatest extent terminally ....*Phymacysta*
45. Discoidal area more than half as long as elytra....................*Tingis* subg. *Tingis*
Discoidal area not over half as long as elytra....................46
46. Rostral channel with laminae parallel, not constricted on mesosternum.... ....*Leptopharsa*
Rostal channel distinctly constricted on mesosternum....................*Vatiga*

GENUS *ALVEOTINGIS* OSBORN AND DRAKE

1916 *Alveotingis* OSBORN and DRAKE, Ohio Biol. Survey, 2: 245.

The three genera, *Alveotingis, Hesperotingis,* and *Melanorhopala,* share the following characters:

Head squarish with five spines, basal pair appressed; antenniferous tubercles large, swollen; bucculae wide, contiguous at apex; antennae with segment III, at least at apex, as wide as IV. Rostral channel widening posteriorly, terminating on metasternum, there cordate and open behind. Orifice distinct, margins expanded. Legs slender. Hypocostal ridge uniform, distinct, with one row of regular, fairly large cells.

Pronotum with collar wide, areolate, truncate, or sinuate anteriorly, not produced forward; disk coarsely punctate, shiny, convex in macropterous forms but almost flat in brachypterous; posterior process long and acute; paranota narrow, uniseriate, reflexed vertically or appressed to pronotum; three complete, low carinae, costate to uniseriate, lateral ones practically parallel, curling outward anteriorly to end on calli. Elytra ovate, the tips overlapping and rounded together in macropterous forms; costal area evenly rounded, with regular, uniform cells, usually in one row.

Alveotingis has antennae stout, segment III thickest and uniformly wide, hirsute. Collar slightly vesiculate at rear. Elytra distinctly convex, areas but slightly differentiated, the boundaries almost imperceptible in the brachypterous forms; overlapping and rounded together apically in both macropterous and brachypterous forms, the areolae of approximately uniform size, large, the nervures heavy.

Generotype,*Alveotingis grossocerata* Osborn and Drake, 1916.

This genus is in rather an intermediate position with the brachypterous form fitting into the subfamily Serenthiinae and the macropterous into the Tinginae. Because of its proximity to *Hesperotingis* and *Melanorhopala,* both of which are unquestionably in the Tinginae, it will be considered in the latter subfamily in this paper.

Alveotingis, according to present knowledge, is limited to North America, with its three species, *brevicornis* O. and D., *minor* O. and D., and the generotype, all from northeastern and midwestern United States.

GENUS *MELANORHOPALA* STÅL

1873 *Melanorhopala* Stål, Enum. Hemip. 3:130.

In addition to the characters shared with *Alveotingis, Melanorhopala* has the following:

Antennae long, at least half the length of rest of insect, segment III narrow at base, becoming abruptly clavate at apex (except in *infuscata,* where it remains slender throughout). Collar slightly vesiculate posteriorly. Elytra with areas distinct, discoidal area slightly impressed, outer margin uniformly convex, inner sinuate; overlapping and jointly rounded at apex in macropterous forms, contiguous with divaricating acuminate tips in brachypterous.

Generotype, *Melanorhapala (Tingis) clavata* (Stål), 1873.

This genus, like *Alveotingis,* is strictly North American in distribution. The variability of the type species is attested by the fact that it has been described under five different names, three of them by Stål himself. The other valid species in the genus are *balli* Drake, from Colorado, and *infuscata* Parshley, from Virginia and the District of Columbia. *M. clavata,* as one might expect from its confused history, is much more widespread, extending from Manitoba, Wyoming, and Colorado to Maine, Massachusetts, and Long Island.

GENUS *HESPEROTINGIS* PARSHLEY

1917 *Hesperotingis* PARSHLEY, Psyche, 24:21, Fig. 3.

In addition to the previously mentioned attributes, *Hesperotingis* possesses the following:

Antennae incrassate, at least as long as head and pronotum together, segment III becoming thicker on apical half. Collar with very slight posterior expansion or none at all. Elytra convex but with areas distinctly defined by moderately costate veins; tips slightly divaricating in brachypterous forms but not angulate; discoidal area with both outer and inner margins somewhat sinuate.

Generotype, *Hesperotingis antennata* Parshley, 1917.

With seven species and two varieties, all from the United States, this genus is the largest of the threesome. The localities are obvious for *illinoiensis* Drake, *floridana* Drake, and *mississippiensis* Drake; *antennata* is from northeastern United States, its variety *borealis* Parshley, from the District of Columbia and Missouri; *duryi* Osborn and Drake, from Texas and Florida; *duryi* var. *confusa* Drake, from Texas; *fuscata* Parshley, from Colorado and Kansas; and *occidentalis* Drake, from Colorado.

These three genera seem to differ principally in degree of the same characters. The third antennal segment is swollen only at the tip, if at all, in *Melanorhopala;* on the apical half in *Hesperotingis,* and throughout in *Alveotingis;* the elytra are slightly impressed in the discoidal area in *Melanorhopala,* more convex but with areas still distinct in *Hesperotingis,* and very convex with almost indistinguishable areas in *Alveotingis;* the amount of swelling of the collar increases likewise from *Alveotingis,* through *Hesperotingis* to *Melanorphopala,* as does the length of legs.

GENUS *TELEONEMIA* COSTA

1864 *Teleonemia* COSTA, Ann. del Mus. Zool. Napoli, 2:144.
1868 *Tingis* subg. *Amaurosterphus* STÅL, Hemip. Fabr. 1:92.
1873 *Tingis* subg. *Americia* STÅL, Enum. Hemip. 3:131.
1898 *Teleonemia* CHAMPION, Biol. Centr.-Amer., Rhynch. 2:34.
1918 *Teleonemia* DRAKE, Ohio Jour. Sci. 18:324.

Head quadrangular, with antenniferous tubercles at apex of head somewhat swollen; with from two (*schwarzi*) or three (*atrata*) to five spines, varying in length, diameter, and slope; bucculae open or closed at apex, not protruding forward nor visible from above; antennae variable, short to long, slender to heavy, usually pilose; segment I subequal to II or as much as twice as long; III fairly slender to as thick as other segments; IV fusiform to subfiliform. Rostrum varying in length from very short (reaching procoxae) to moderately long (reaching middle of abdomen); rostral channel shallow to moderately deep, narrow to wide, open behind, the laminae subparallel to divaricating posteriorly. Orifice distinct. Legs moderately long and slender. Hypocostal ridge uniseriate.

Pronotum with disk very convex, coarsely pitted or areolate; collar truncate or produced forward anteriorly, the projection not reaching beyond middle of eyes and sometimes inflated into small hood; tricarinate, carinae complete, though sometimes indistinct, costate or laminate, usually uniformly high, uniseriate, or higher only on summit of disk; median carina percurrent on collar or hood, lateral carinae arising at impressed calli; posterior process of pronotum long, acuminate; paranota narrow, from obsolete to uniseriate, reflexed vertically, not explanate.

Elytra elongate, parallel-margined, or widest either opposite discoidal area or near apex; costal area narrow, reflexed subvertically at base, costate, or with one to three rows of small areolae, or with a single row of somewhat larger ones; subcostal area narrow, of uniform height, subvertical; discoidal area no less than half the length of elytra, subangulate mediad, subparallel to sinuate laterad (indistinct from sutural area posteriorly in *lanceolata* and *picta*); sutural areas completely overlapping and usually jointly rounded behind; cells of sutural area and sometimes of costal area slightly larger than remaining reticulation.

Generotype, *Teleonemia funerea* Costa, 1864.

From the above generalization of the characteristics of North American species of *Teleonemia,* it may be seen that some characters are too variable within the genus to be of value in generic separation. In this category are the length of rostrum and antennae, the number and size of head spines, the open or closed condition of bucculae, and the shape of the rostral channel. There are other consistent features, however, which serve to set this genus apart from its close allies. The narrow, subvertical paranota and elongate elytra, with discoidal area surpassing middle, will separate *Teleonemia* from all but *Alveotingis, Melanorhopala,* and *Hesperotingis.* These genera are very close to *Teleonemia* but it is hoped that they can be separated with the foregoing key.

Teleonemia is distributed throughout the world, with by far the majority of species in the Western Hemisphere; more than 40 are recorded from South America, 32 from North America, and 9 others from Africa, Asia, and the Pacific area; none is recorded from Europe. The North American species follow: *albomarginata* Champion—Trinidad, Panama, Guatemala; *atrata* Champion—Panama, Guatemala, Brazil; *barberi* Drake—Arizona, Texas; *belfragii* Stål—Florida, Mississippi, Alabama, Texas (on *Callicarpa americana*); *bierigi* Monte—Costa Rica; *bifasciata* Champion—Central America, West Indies (on *Lantana* sp.); *consors* Drake—Arizona; *cylindricornis* Champion—Honduras, Guatemala, Mexico, Jamaica, Mississippi, Illinois; *forticornis* Champion—Panama, Peru, Argentina; *huachucae* Drake—Arizona; *inops* Drake and Hambleton—Honduras; *jamaicans* Drake—Jamaica; *lanceolata* (Walker)—Central America, West Indies, South America (on *Cucurbita moschata*); *monile* Van Duzee—California; *montivaga* Drake—California (on *Penstemon*); *nigrina* Champion—Guatemala, north to Utah, east to the Carolinas (on *Eriogonum*); *notata* Champion—Guatemala, Panama, West Indies (on *Adenostegia filifolia* and *A. pilosa*); *novicia* Drake—California, Arizona; *ochracea* Champion—Panama; *picta* Champion—Panama; *pilicornis* Champion—Guatemala; *prolixa* (Stål)—Mexico, Central America, West Indies, South America; *rugosa* Champion—Guatemala, Honduras, Panama; *sacchari* (Fabricius)—West Indies, Florida, California, Brazil (on *Lantana camara*); *sandersi* Drake and Hambleton—Honduras; *schildi* Drake—Costa Rica; *schwarzi* Drake—California, Arizona, Mexico (on *Hymenoclea salsola*); *scrupulosa* Stål—Central America, Mexico, West Indies, South America, Florida, Texas, Hawaii (on *Lantana camara, Callirhoe involucrata*): var. *haytiensis* Drake—Haiti, Cuba; *sidae* (Fabricius)—West Indies; *validicornis* Stål—Panama, South America (on *Mucherium* *oblongfolium*); *variegata* Champion—Honduras, Guatemala, Mexico, Arizona; *vidua* Van Duzee—California.

GENUS *TIGAVA* STÅL

1860 *Tigava* STÅL, Rio Hemip. 1:63.

Head quadrangular, with three spines, basal and median; antenniferous tubercles short, swollen; antennae extremely long, longer than entire body; segment I usually at least half as long as pronotum, II short, III and IV very long and slender; bucculae closed at apex, not produced forward. Rostrum rather short, rostral channel wider on metasternum, closed behind. Orifice sometimes distinct, sometimes indistinct. Legs long and slender. Hypocostal ridge uniseriate. Genital segment in male usually as broad as preceding segments or even broader; in female sometimes produced in large lobes.

Pronotum with convex, coarsely punctate disk; collar truncate or sinuate anteriorly, sometimes slightly swollen into small hood; tricarinate, carinae low, costate to uniseriate-foliaceous; median carina percurrent on collar, lateral sometimes obsolete on disk; calli distinct; paranota obsolete, costate, or narrow foliaceous, reflexed subvertically; posterior process long, acuminate, areolate.

Elytra elongate, usually somewhat broader at apex, overlapping and jointly rounded behind; costal area narrow, usually uniseriate, subvertical at base; subcostal area narrow, subvertical, uniformly high; discoidal area less than half the length of elytra, posterior margin short, oblique, sometimes incomplete laterad; sutural area long, broad, with larger areolae apically.

Generotype, *Tigava praecellens* Stål, 1860.

The extremely long antennae of the members of this genus distinguish it readily from all other genera. Even without the antennae, however, they can be distinguished from their nearest ally *Teleonemia*, by the shorter discoidal area and closed rostral channel.

Tigava contains eleven South American species, one from Africa, one from Australia, and two from North America. The latter species are *convexicollis* Champion, from Panama and Brazil, and *pulchella* Champion, from Mexico and Cuba. Neither of these Central American species has been examined by this author, but both are well illustrated with the original descriptions (Champion, 1898, Pl. 2, Figs. 26 and 29). A number of South American species were examined and compared with the abovementioned descriptions and figures, in the preparation of the foregoing characterization of the genus.

The Australian representative, *Tigava unicarinata* Hacker, has recently been transferred to a new genus, *Tigavaria* Drake. This genus differs from *Tigava* by having, as its specific name indicates, only a median carina on the pronotum and also by having a biseriate, instead of a uniseriate, hypocostal ridge. Another new genus, *Idiostyla* Drake, has been erected for *Tigava anomae* Drake and Hambleton and *T. rollinae* Drake and Hambleton, both from Brazil. The African species, *T. ugandana* Drake, has quite indistinct laminae of the rostral channel.

GENUS *MONANTHIA* LE PELETIER ET SERVILLE

1825 *Monanthia* LE PELETIER et SERVILLE, Ency. Meth. 10:653.
1874 *Dictyla* STÅL, Öfv. Vet.-Ak. Förh. 3:57.
1906 *Monanthia* HORVATH, Ann. Mus. Nat. Hung. 4:97.
1922 *Monanthia* DRAKE, Mem. Carnegie Mus. 9:354.

Head with three, four, or five spines, anterior pair present, basal pair or median sometimes rudimentary or lacking; bucculae contiguous at apex. Antennae shorter than pronotum, I little longer than II, III longest and slenderest; IV fusiform. Rostrum of moderate length, rostral channel with laminae from rudimentary to foliaceous, open behind. Orifice not distinct. Fore- and mesocoxae farther apart than meso- and metacoxae. Hypocostal ridge uniseriate.

Pronotum with disk transversely convex, pitted, sometimes covered by paranota; with one or three low uniseriate carinae, lateral ones evident only on long, acuminate posterior process; paranota reflexed against pronotum, narrow or wide, flat, bulbous or humped; collar wide, areolate, raised at middle either tectiformly or convexly, anterior margin truncate or concave.

Elytra ovate, obovate, or oblong, overlapping and jointly rounded behind; costal area with one or two rows of cells; subcostal area finely areolate, upper margin slightly sinuate to deeply emarginate; discoidal area approximately half the length of elytra, outer margin sometimes upraised in one or two places, bowed outward to varying degrees posteriorly; sutural area no narrower than discoidal area.

Generotype, *Monanthia* (*Tingis*) *rotundata* (Herrich-Schaeffer), 1839.

The genus *Monanthia* obviously needs revision, but this will require a study of the complete cosmopolitan genus. Since it was one of the pioneer genera in the family, a progenitor of the family in fact, and has never had very strict boundaries, it is perhaps reasonable that it has been the repository of a great variety of species during the past 120 years. An examination of its history reveals more than 100 names which have been transferred elsewhere from *Monanthia*, and a number of genera formed directly from its ranks. The variety of characteristics found in the genus makes it an ideal one to work within because its species can be separated easily, but this same feature makes it equally difficult to separate from other genera. There are in the literature surprisingly few actual descriptions of *Monanthia* as a complete genus, rather there seems to be an assumption that everyone knows what a *Monanthia* is. That has made it easier to include a greater variety of species within its limits, if limits there are.

The preceding generic description is based only upon the nine North American species. The type of the genus, *Monanthia rotundata* (Herrich-Schaeffer), differing considerably from all nine, has highly bulbous paranota with inner margins curved parenthetically over disk, two bulbous elevations of outer discoidal margin, a distinctly inflated hood and another bulbous expansion on posterior process of pronotum. In contrast to this the *echii* group is entirely non-bulbous, with no hood (just a wide collar), narrow, appressed paranota and only the slightest indication of a bulla on outer discoidal vein. A critical division of the genus may leave the North American region entirely without representation in *Monanthia*, since none of its members seems to fall into the *rotundata* group. On the other hand, it may prove preferable to maintain the genus in its present looseness.

As the genus stands now it is distributed throughout the world, with around forty species in the Eastern Hemisphere (Africa, Europe, Asia, Australia, East Indies, etc.) and about eight in South America, two of which extend into North America. Specimens have been reported in this hemisphere from no farther north than Colorado. Two species, *c-nigrum* Champion, and *monotropidia* Stål, have wide distribution and accompanying variation. Champion's species has been reported from Brazil, Guatemala, Costa Rica, Nicaragua, Mexico, and the West Indies. *M. monotropidia* extends from Argentina through Paraguay, Bolivia, Peru, Brazil, Colombia, Venezuela, Panama, Honduras, Costa Rica, and Guatemala to Mexico, and also is found in Trinidad, Jamaica, Haiti, and Cuba. *M. labeculata* Uhler, has been found in California, Arizona, New Mexico, and Colorado, while *coloradensis* Drake, so closely allied to *labeculata* as to suggest the possibility of subspecific status, is limited to Colorado. Also from Colorado is Scudder's fossil *veterna*, which fits reasonably well into the boundaries of the genus, but because of its indistinguishable paranota its determination remains somewhat questionable. *M. ehrethiae* Gibson was collected in Mexico and Texas; *ainslii* Drake and Poor, in Guatemala; and *haitiensis* Drake and Poor, in Haiti and Puerto Rico.

The only plant host records available for the North American members of *Monanthia* are: *Ehrethia elliptica* for *ehrethiae* Gibson; and for *monotropidia, Cordia alliodoa* and cotton. This last mentioned *Monanthia* species is one of the most common tingids in the neotropical region and its records appear frequently in the literature.

GENUS *PHYSATOCHEILA* FIEBER

1844 *Monanthia* subg. *Physatocheila* FIEBER, Ent. Monog. p. 80.
1861 *Monanthia* subg. *Physatochila* FIEBER, Eur. Hemip. p. 120, *Physantochila* p. 124.
1874 *Physatochila* STÅL, Öfv. Vet.-Ak. Förh. 3:56.
1904 *Phyllochisme* KIRKALDY, Entomologist, 37:280.
1906 *Physatocheila* HORVATH, Ann. Mus. Nat. Hung. 4:94 (key to palearctic species).
1917 *Physatocheila* OSBORN and DRAKE, Psyche, 24:155. (key to nearctic species).

Head short, with five curved spines; bucculae closed in front. Antennae shorter than pronotum, III slenderest, cylindrical, IV fusiform, no longer than I plus II. Rostral channel widening slightly posteriorly, open at apex, with foliaceous laminae. Orifice distinct. Procoxae separated from mesocoxae by one width, mesocoxae close to metacoxae. Hypocostal ridge uniseriate.

Pronotum rather finely reticulate, tricarinate, carinae uniseriate, of nearly uniform height, with costate margins; median carina percurrent on collar and pronotum; lateral carinae slightly converging anteriorly, arising at calli; calli almost entirely covered by paranota; collar broad, reticulate, raised medially, somewhat inflated and slightly produced forward; paranota reflexed, resting on pronotum, distal margin reaching anterior end of lateral carinae; posterior process long, acuminate.

Elytra oblong, overlapping and jointly rounded at apex, finely areolate; cells of costal and sutural areas, like those of paranota, larger than remaining cells; costal area explanate, with two or three rows of irregularly arranged cells; subcostal area subequal in width to costal, oblique, becoming lower caudad; discoidal area more than half as long as elytra, sinuate laterad, subangulate mediad.

Generotype, *Physatocheila (Acanthia) quadrimaculata* (Wolff), 1804.

In contrast to *Monanthia*, *Physatocheila*, originally described by Fieber as a subgenus of *Monanthia*, is very distinct in its limits. This is not surprising when one considers that this particular group of species was separated from its mother genus because of its distinguishable attributes. Also in contrast to *Monanthia*, the strict generic limits are accompanied by closer affinities between species. As a result of this reversal, *Physatocheila* is a genus easily separated from other genera but difficult to work within. It is distinguished from *Monanthia* by the presence of complete lateral carinae, never covered by the reflexed paranota; longer discoidal area in proportion to elytral length, without bulbous elevations; and multiseriate, less regularly areolate costal area.

This genus is represented by about thirty species from Europe, Asia, Africa, Australia, and Java, and by four North American species. It has not been recorded from South America. The North American species are: *brevirostris* Osborn and Drake, from Quebec, Massachusetts, New York, Pennsylvania, Maryland, Virginia, Ohio, and Illinois; *major* Osborn and Drake, from Illinois, Indiana, Maryland, Virginia, and the District of Columbia; *plexa* (Say), from Massachusetts, New York, Rhode Island, Pennsylvania, New Jersey, Maryland, Virginia, North Carolina, West Virginia, Tennessee, Indiana, Illinois, Michigan, Wisconsin, Ontario, Minnesota, Iowa, Nebraska, Kansas, Idaho, and Oregon; *variegata* Parshley, from New York, Alberta, Illinois, and Missouri; and *variegata* var. *ornata* (Van Duzee), from California. These species are much confused, with *ornata* first described as a distinct species but now considered a variety, and *variegata* once considered a variety of *plexa*.

Few host plant records can be found for the North American species of *Physatocheila*. Hickory, willow, and *Kalmia latifolia* have been recorded as hosts for *plexa*.

GENUS *LEPTODICTYA* STÅL

1873 *Leptodictya* STÅL, Enum. Hemip. 3:121, 127.
1897 *Leptodictya* CHAMPION, Biol. Centr-Amer., Rhynch. 2:23 (key to species).
1905 *Hanuala* KIRKALDY, Bul. Soc. Ent. France, 15:217.
1922 *Leptodictya* DRAKE, Bul. Fla. Ent. Soc. 5(3):42.
1931 *Leptodictya* and *Hanuala*, subgenera of *Leptodictya* DRAKE, Bol. do Mus. Nac. 7:120.

Head short, with five long, attenuate, often erect spines; antenniferous tubercles short. Antennae widely separated at base, very long; I no longer than hood, at least twice as long as II; III very slender, long; IV fusiform to curved filiform. Bucculae contiguous at apex, protruding forward more in some species than in others. Rostrum moderately long, rostral channel with foliaceous laminae abruptly converging cordately behind, leaving slight opening at apex. Coxae I much farther from II than II from III; legs moderately long and slender. Orifice very distinct. Hypocostal ridge uniseriate.

Pronotum with disk of varying convexity, posterior process rather long, either acute or rounded apically; tricarinate, median carina foliaceous, uniseriate areolate, complete; lateral carinae somewhat lower, parallel, complete, arising at distinct calli; collar raised medially and produced forward, never beyond apex of head, tectiform or bulbous, sometimes sharply angulate at apex and usually highest there; paranota longitudinally creased in a sharp edge and folded back, with outer margin resting on pronotal disk, projecting forward no farther than hood, with at least two rows of cells visible from above (Fig. 4).

Elytra elongate, spreading or narrowed at apex, tips divaricating, broadly or acutely rounded behind; costal area explanate, multiseriate, with four transverse, oblique veins, more or less distinctly impressed; subcostal area narrow, subvertical. Discoidal area elongate, fusiform, impressed, with inner vein strongly raised and outer vein lowering posteriorly; more or less than half as long as elytra, with a longitudinal oblique vein halving the area. Sutural areas only partially overlapping.

Generotype, *Leptodictya* (*Monanthia*) *ochropa* (Stål), 1860.

Leptodictya, except for one Japanese species of questionable generic determination, is confined to the Western Hemisphere, with the great preponderance of species described from South America, principally Brazil (about thirty species). In North America there are twelve species: *bambusae* Drake, from Puerto Rico, Cuba, and Haiti—*championi* Drake—Guatemala; *circumcincta* Champion—Panama; *cretata* Champion—Guatemala; *evidens* Drake—Panama; *fraterna* Monte—Costa Rica; *fusca* Drake—Panama; *nigra* Monte—Costa Rica; *nicholi* Drake—Arizona; *plana*, Heidemann—Gulf States; *simulans* Heidemann—Virginia, North Carolina, Mississippi; *tabida* (Herrich-Schaeffer)—Mexico, Guatemala, Texas.

The only host plants recorded for this genus are graminaceous: bamboo for *bambusae* and *simulans*, sugar cane for *bambusae* and *tabida*, corn for *tabida*, and "grass" for *plana*.

GENUS *DICHOCYSTA* CHAMPION

1898 *Dichocysta* CHAMPION, Biol. Centr.-Amer., Rhynch. 2:33.

Head quadrangular, with stout, decumbent spines; antenniferous tubercles swollen, rather far apart; antennae with I and II short and stout, III cylindrical, slenderest, rather obliquely truncate at apex, IV lanceolate. Bucculae contiguous, projecting forward only slightly; rostrum reaching end of metasternum; rostral canal with laminae parallel, open behind. Orifice distinct. Legs rather short and stout. Hypocostal ridge uniseriate.

Pronotum with disk rather highly convex, granulose; collar tectiform, produced forward obtusely, margin biconcave; paranota produced vertically from sides of pronotum, extending high over disk, curving back over lateral carinae and resting on distal margins of the latter, thus forming two bulbous processes over humeri (Fig. 5b); median carina percurrent on collar, low, costate or obsolete on disk, complete on long, acute posterior process; lateral carinae covered on disk with paranota, visible posteriorly.

Elytra obovate to subparallel-sided, very slightly constricted beyond discoidal area, overlapping and jointly rounded behind; costal area very narrow, uniseriate, subvertical at base; subcostal area biseriate, uniformly low; discoidal area over half the length of elytra, flat, with inner vein upraised and obtusely angulate, outer margin slightly convex; sutural areas completely overlapping, areolae scarcely larger than in discoidal area, largest in costal area and paranota.

Generotype, *Dichocysta pictipes* Champion, 1898.

This genus is represented only by the type species, from Panama, Honduras, Guatemala, Mexico, Arizona, and Florida; and by a variety, also from Central America. No host plants have been recorded.

GENUS *CALOTINGIS* DRAKE

1918 *Calotingis* DRAKE, Bul. Brooklyn Ent. Soc. 13: 86.
1928 *Neopachycysta* HACKER, Mem. Queens. Mus. 9: 183.
1929 *Calotingis* HACKER, ibid, 9:334.

Head with five delicate spines, the median and anterior ones converging at apex; antennae with segment I twice as long as II, IV rather stoutly fusiform, as long as I and II together, III very slender, approximately three times as long as IV; bucculae short, open anteriorly. Rostrum reaching onto metasternum; rostral channel closed behind, very broad on metasternum. Orifice distinct, margined. Legs moderately long. Hypocostal ridge uniseriate, the cells fairly large.

Pronotum with disk convex, pilose; hood oval, concealing head, somewhat compressed laterally, smoothly rounded anteriorly, with no prominent midvein; calli impressed; paranota very wide, reflexed and incurved in two hollow shells, posterior ends touching lateral carinae on disk (Fig. 5a); median carina complete from base of hood to apex of posterior process (raised in *subopaca*); lateral carinae bowed outward on disk, parallel on posterior process, covered on posterior slope of disk by paranota; posterior process not so long as wide, apex rounded-acute.

Elytra obovate, widest on basal third, overlapping and jointly rounded at apex; costal area as wide as dorsal surface of paranota, explanate, reflexed at base, widest beyond discoidal area, biseriate; subcostal area subequal to costal area, widest at apex of discoidal area; discoidal area half as long as elytra, bulbous on apical two-fifths and outer half, impressed within strongly raised inner vein; sutural area somewhat impressed, margins subparallel, cells graduating from size of discoidal and subcostal cells at base to size of costal cells at apex; costal and larger sutural cells of about the diameter of eyes.

Generotype, *Calotingis knighti* Drake, 1918.

Calotingis is most similar to *Dichocysta* Champion in that it has the paranota greatly inflated and touching the lateral carinae. In *Dichocysta,* however, the distal edge of the paranota touches the margin of lateral carinae for the entire length of the disk, whereas in *Calotingis* only the posterior ends of the paranota are in contact with the lateral carinae and the rest is open within. Also in *Calotingis* the hood is as high as the paranota and the discoidal area has a bulbous inflation, while in *Dichocysta* the hood is not bulbous nor high and the discoidal area is flat.

The only North American species in this genus is *knighti* Drake, from Texas and Mexico. There is but one other species in the genus, *subopaca* (Hacker), originally described in *Neopachycysta,* from Australia. The host plant for *knighti* is *Malvaniscus Drummondii.*

GENUS *EOTINGIS* SCUDDER

1890 *Eotingis* SCUDDER, Rept. U. S. Geol. Surv. Terr. 13:359.

"Head triangular, about equally long and broad; antennae of excessive length, almost as long as the body and very slender, the great length largely due to the prolongation of the middle joints, the last joint very delicately enlarged so as to be faintly clavate, the club very long and slender. The pronotum is short, narrowest in front where it equals the head, truncate both at base and apex. Thorax tapering forward with no vesicular enlargements. Abdomen oval. Legs very long and slender, all the femora of nearly equal length, the tibiae of similar length, the whole leg nearly as long as the tegmina. These are broad and very long, extending well beyond the body, irregularly and more or less finely and uniformly reticulate throughout, the broad costal area as irregular as elsewhere."

Generotype, *Eotingis antennata* Scudder, 1890.

This genus is limited to fossil forms, one from Europe and one, *antennata* Scudder, from the Tertiary deposit at Florissant, Colorado. Since specimens were not available for study, Scudder's original description is quoted above.

There are but four genera of Tingoidea in North America which contain fossil forms: *Eotingis, Piesma, Monanthia,* and *Tingis,* with *Eotingis* the only one limited to fossils.

GENUS *AMBLYSTIRA* STÅL

1873 *Amblystira* STÅL, Enum. Hemip. 3:119, 129.
1897 *Amblystira* CHAMPION, Biol. Centr.-Amer., Rynch. 2:29–30.

Head short, devoid of spines, or with interocular ridges, or with rudimentary basal tubercles; antenniferous tubercles not prominent; antennae with III longest and slenderest, IV fusiform to long filiform;

bucculae very short anteriorly, not projecting forward. Rostrum short, laminae low, divaricating posteriorly, channel wide on meso- and metasternum, closed behind. Coxae with I and II much more widely separated than II and III. Orifice distinct. Legs moderately long and slender. Hypocostal ridge uniseriate.

Pronotum rather uniformly punctate on collar and disk; not so wide anteriorly as head across eyes; collar truncate or emarginate in front; disk highly convex, calli distinct; paranota completely lacking or feebly carinate; posterior process moderately long, usually with apex rounded and sometimes decurved; unicarinate or tricarinate, median carina low, costate, percurrent on collar, sometimes becoming obsolete at apex of posterior process; lateral carinae complete from calli caudad, obsolete on disk, or entirely lacking.

Elytra elongate, oblong or with sinuate margins; costal area from completely absent to explanate with not more than two rows of moderately large cells; subcostal area often subequal in width to discoidal, the latter no more than half the length of elytra, sometimes raised apically, inner margin subangulate, outer straight to sinuate; sutural areas overlapping and jointly rounded behind, with cells becoming large marginally and apically in macropterous forms.

Generotype, *Amblystira (Monanthia) pallipes* Stål, 1860.

Of the seventeen species known in this genus, eleven are found in North America. None has been collected north of Mexico, or out of the Western Hemisphere. The North American species are: *amica* Drake—Haiti; *atrinervis* Champion—Mexico; *dozieri* Drake and Hambleton—Haiti; *fuscitarsis* Champion—Guatemala, Panama, Cuba; *laevifrons* Champion—Mexico; *maculata* Van Duzee—Cuba, Jamaica; *marginata* Drake—Panama, Costa Rica; *melanosoma* Monte—Costa Rica; *morrisoni* Drake—West Indies; *opaca* Champion—Guatemala, Panama; *scita* Drake and Hambleton—Costa Rica. One other species, *socia* Drake (1942) is recorded from Costa Rica, but the specimens from that locality were subsequently described as *scita* by Drake and Hambleton (1944), so the distribution of *socia* is now limited to Paraguay.

Amblystira hirta Monte, from Brazil, has been transferred to the genus *Phaeochila* Drake and Hambleton (1945), established for Monte's species.

No host plant records have been found for this genus.

GENUS *LEPTOYPHA* STÅL

1873 *Leptoypha* STÅL, Enum. Hemip. 3:121, 129.
1917 *Leptoypha* PARSHLEY, Psyche, 24:16.

Head short, sometimes with five spines, anterior three often, and basal pair occasionally, rudimentary to obsolete; antenniferous tubercles short, antennae close together at base, short, usually shorter than pronotum, III scarcely thinner than others, I and II subequal; bucculae closed anteriorly, not produced forward. Rostrum of moderate length, rostral channel broadening posteriorly, somewhat closed behind. Procoxae closer together than others but farther from neighboring pair; legs moderately long, tibiae thinner than segment III of antennae. Orifice, when discernible, long and narrow. Hypocostal ridge uniseriate. Genital segment narrower than preceding one.

Pronotum with disk highly convex, punctate, unicarinate, carina indistinct on collar; sometimes tricarinate on long, triangular posterior process; collar rather short, subtruncate anteriorly, subequal in width to head across eyes; calli impressed; paranota very narrow, carinate opposite calli, costate or obsolete posteriorly.

Elytra elongate, broadest opposite discoidal area, narrowing beyond, parallel apically; costal area very narrow, narrower than subcostal, sometimes obsolete; subcostal area sometimes subequal to discoidal in width; discoidal area more than half the length of elytra, outer margins subparallel to bowed outward posteriorly, sometimes obsolete toward apex; sutural areas completely overlapping and jointly rounded behind.

Generotype, *Leptoypha (Tingis) mutica* (Say), 1831.

This genus can be separated from *Amblystira* by its longer discoidal area in proportion to length of elytra; from *Teleonemia* by the presence of a single carina on disk of pronotum, and by its closed rostral channel. One species, *Leptoypha morrisoni,* differs from the rest in having thinner antennae and much narrower subcostal area.

Leptoypha is primarily a North American genus, with eleven species in the United States, Central America, and the West Indies. The other species are well scattered, with one in Africa, one in Australia, one in the Philippines, two in Asia and two in South America. The only North American species not examined by this author are *binotata* and *brevicornis* Champion (1897), but their descriptions and figures conform to the above characterization. The following species are recorded from this region: *binotata* Champion—Guatemala, Jamaica; *brevicornis* Champion—Mexico; *costata* Parshley—Maryland, Mississippi, Illinois, Arkansas; *drakei* McAtee—Texas, California, Arizona; *elliptica* McAtee—southern United States; *ilicis* Drake—Georgia, Florida, Texas, Oklahoma, and New Hampshire; *mcateei* Drake—Florida; *minor* McAtee—Arizona; *morrisoni* Drake—West Indies, Canal Zone, Key West; *mutica* (Say)—New York to Minnesota, south to Texas, Maryland; *nubilis* Drake—California.

The following host plants have been recorded for North American species of *Leptoypha*: *costata* on *Fraxinus caroliniana* and witch hazel; *drakei* on ash; *elliptica* on "swamp bush"; *ilicis* from "palm jungle sweepings"; *mcateei* on *Osmanthus americana; minor* on *Fraxinus berlandieri* and *Populus candicans;* and *mutica* on *Adelia acuminata, Chionanthus virginiana* and *Fraxinus* sp.

GENUS *CORYCERA* DRAKE

1922 *Corycera* DRAKE, Mem. Carnegie Mus. 9:368.

Head rather short but appearing long in species with the three anterior spines contiguous and thickened, resembling a horn directed straight forward; some species without thickened spines, basal pair short or long, appressed. Antenniferous tubercles swollen, blunt; antennae long, I longer than II, III longest and slenderest, IV slender fusiform. Bucculae contiguous; rostrum reaching metasternum; rostral channel closed posteriorly. Coxae I farther from II than II from III; legs slender, long, tibiae subequal in diameter to antennal segment III. Orifice distinct. Hypocostal ridge uniseriate.

Pronotum with disk moderately convex, coarsely pitted, calli impressed; collar raised, anterior margin truncate to concave, areolae subequal to subcostal cells; paranota narrow, explanate, with margins even, not produced forward or backward, uniseriate apically, sometimes with more cells opposite calli; median carina low, costate to finely uniseriate, complete, sometimes becoming obsolete on collar; lateral carinae costate, obsolete on disk in *panamensis;* posterior process moderately long, blunt, areolate.

Elytra oblong to constricted beyond middle, overlapping and jointly rounded behind; costal area costate to biseriate basally, triseriate beyond middle in *panamensis;* subcostal area very narrow to wider than discoidal, uniformly seriate, oblique; discoidal area more or less than half elytral length, outer margin almost straight, boundary veins upraised except in *panamensis,* apex usually somewhat raised; sutural areas completely overlapping, cells somewhat larger.

Generotype, *Corycera comptula* Drake, 1922.

Originally this genus was described for species with the peculiar horn-like process on the head, composed of the three anterior spines, thickened and contiguous. Since its original description, however, its limits have been considerably broadened to include species with no trace of the cephalic horn but with paranota narrow and explanate like those of the type. Likewise, some of the "horned" species have almost obsolete paranota, so the generic limits may be described as with either thickened head spines or narrow paranota or both. Except for the spine and paranota characters this genus very much resembles *Amblystira* Stål, *Atheas* Champion, *Acysta* Champion, and *Leptoypha* Stål.

Corycera panamensis Drake and Poor, from Panama, is the only representative of this genus in North America. It is far from a typical *Corycera,* lacking as it does the horn-like process of the head, but its paranota place it in this genus. Its host plant is not known.

GENUS *ACYSTA* CHAMPION

1898 *Acysta* CHAMPION, Biol. Centr.-Amer., Rhynch. 2:46.

Head short, with four spines; antennae long and slender, longer than pronotum, IV thicker than III, fusiform; bucculae closed in front; rostrum moderately long, rostral channel with laminae divaricating posteriorly and closed behind. Legs slender, moderately long.

Pronotum with disk highly convex, glabrous, punctate; median carina low, lateral carinae low, obsolete on disk or entirely lacking; collar areolate, truncate anteriorly; posterior process acuminate, areolate; paranota narrow, complete, or present only on collar and humeri.

Elytra oval, overlapping, separately rounded at apex; costal area wider than discoidal, margins evenly rounded; subcostal area at least as wide as discoidal, oblique; discoidal area less than half the length of elytra, closed behind; cells of discoidal and subcostal areas and of posterior process of pronotum of about diameter of segment III of antennae; cells of costal and sutural areas of about diameter of eye.

Generotype, *Acysta integra* Champion, 1898.

This genus is easily distinguished from *Atheas* Champion by its broader costal and subcostal areas, shorter discoidal area and the presence of head spines.

None of the three North American species of this genus has been available for study by this author. Fortunately, however, there are excellent figures of all three with their original descriptions, and specimens of the five South American species were examined. *Acysta integra* Champion is represented by a single specimen from Guatemala, deposited in the British Museum with the two specimens of *interrupta* Champion from Panama. The unique example of *hubbelli* Drake, from Honduras, is in the Museum of Zoology, University of Michigan.

No host records exist for these North American forms.

GENUS *PSEUDACYSTA* BLATCHLEY

1926 *Pseudacysta* BLATCHLEY, Heterop. East. N. America, p. 497.

Head short with anterior pair of short spines, bucculae contiguous in front, there emarginate. Antennae slender, longer than pronotum, III cylindrical, IV fusiform. Rostrum extending to meso-metasternal suture; rostral channel with foliaceous laminae, widening posteriorly, closed behind. Coxae with greater distance between I and II than between II and III, mesocoxae farther apart than pro- and metacoxae; legs long, slender. Orifice very distinct. Hypocostal ridge uniseriate.

Pronotum very convex on disk, narrowing abruptly anteriorly to less than width of head across eyes; collar truncate at apex, punctate equally with disk; posterior process long acuminate, punctures larger than on disk; paranota short, present only on humeri. Median carina costate, percurrent; lateral carinae obsolete.

Elytra oblong, widest opposite apex of posterior process of pronotum, overlapping and individually rounded behind; costal area wide, triseriate, posterior areolae about diameter of eye; subcostal area oblique, subequal in width to discoidal area, areolae of both very small; discoidal area open behind; sutural area with apical cells the size of larger costal cells.

Generotype, *Pseudacysta* (*Acysta*) *perseae* (Heidemann), 1908.

Pseudacysta in many respects resembles *Acysta*, in which genus its sole representative was first described. Some of its differences seem not of generic value, such as the reduction in number of head spines, shortening of paranota and absence of lateral carinae since these characters show some variation among the species of *Acysta*. Taken together, however, and added to the outstanding difference, the apically open discoidal area, they seem to constitute adequate generic distinction.

In Florida this species has been found breeding on the foliage of avocado trees (*Persea carolinensis* and *Persea gratissima*), and in New Orleans, Louisiana, it has been collected from camphor trees (*Camphora officianalis*). Other localities for *perseae* include Texas and Vera Cruz, Mexico.

GENUS *ATHEAS* CHAMPION

1898 *Atheas* CHAMPION, Biol. Centr.-Amer., Rhynch. 2:44.

Head squarish, naked of spines, with antenniferous tubercles spiniform laterad; bucculae contiguous and somewhat protruding anteriorly. Antennae rather close together, III longest, IV usually fusiform, and little longer than I (except in *flavipes* where IV is filiform and twice as long as I). Rostrum short; rostral channel widening posteriorly, closed behind, laminae from rudimentary to foliaceous. Orifice distinct. Greater distance between fore- and mesocoxae than between meso- and metacoxae. Hypocostal ridge uniseriate. Legs long, slender.

Pronotum with disk convex, coarsely pitted, impressed around shiny calli; tricarinate, median carina percurrent on pronotum and collar; lateral carinae complete from calli caudad; collar with anterior margin truncate to concave, areolae larger than on disk, width with paranota greater than that of head across eyes; posterior process from long acuminate to rather short obtuse or rounded; paranota complete from apex of collar to base of elytra, narrowest opposite humeri, there uniseriate, margins straight to concave.

Elytra oblong, overlapping and jointly rounded behind (except in *flavipes* where they are rounded separately); costal area narrower than discoidal, of nearly uniform width until beyond apex of discoidal area, there wider; subcostal area also narrower than discoidal, uniformly areolate; discoidal area elongate, at least half the length of elytra and as long as pronotum or longer; sutural area wide, areolae graduated from those at base the size of discoidal and subcostal areolae to the larger apical ones, as large as those of costal area.

Generotype, *Atheas nigricornis* Champion, 1898.

Examination of a long series of *mimeticus* Heidemann, from Mississippi, reveals much variation and raises a question as to the validity of some of the United States species. *A. annulatus* and *sordidus* Osborn and Drake, from Arkansas and Iowa, respectively, are undoubtedly synonyms of *mimeticus*. The presence of dimorphism in this group adds to the confusion, though there is less difference between the brachypterous and macropterous forms here than in some other genera. In addition to slightly shorter elytra, the brachypterous forms also have the accompanying decrease in convexity of pronotum and have slightly shorter segment III of antennae.

The following species of *Atheas* are now recognized from North America: *austroriparius* Heidemann, from Florida, Texas, Mississippi, Missouri; *exiguus* Heidemann—Florida; *flavipes* Champion—Panama, Brazil; *fuscipes* Champion—Mexico, Central America, South America; *insignis* Heidemann—eastern United States; *mimeticus* Heidemann—from

Virginia to New Mexico, and Wyoming; *mirabilis* Drake—Mexico; *nigricornis* Champion—Central America, Mexico, Arizona; *tristis* Van Duzee—Mexico. In addition to these North American forms there are five South American species, some of which differ somewhat from the above generic description. The most radical difference is found in *birabeni* Drake, with its four head spines.

The following host plant records have been found: *austroriparius* on *Desmodium* spp.; *flavipes* on *Maechaerium angustifolium; tristis* on *Aeschynomene nivea; fuscipes* on Leguminosae; *insignis* on *Stylosantnes biflora; mimeticus* on *Petalostemon purpureus; nigricornis* on *Alnus acuminata* and *Parosela citriodora.*

GENUS *DICTYONOTA* CURTIS

1827 *Dictyonota* CURTIS, British Ent. 4:154.
1874 *Scraulia* STÅL, Öfv. Vet.-Ak. Förh. 3:50.
1900 *Alcletha* KIRKALDY, Entomologist, 33:241.
1906 *Dictyonota* HORVATH, Ann. Mus. Nat. Hung. 4:36.

Head quadrangular, with two fairly stout, pointed spines between anterior margins of eyes; antenniferous tubercles very prominent, as large as spines; antennae slightly shorter than pronotum, thick, pilose, IV tapering at apex but indistinguishable in width from others. Bucculae separated anteriorly, showing insertion of clypeus; rostrum extending to end of channel; rostral channel open behind, with laminae slightly divaricating posteriorly. Coxae I closer together than others but farther from II than II from III. Orifice indistinct. Hypocostal ridge uniseriate.

Pronotum with collar raised for entire width into short hood, shorter than wide, subtruncate anteriorly and not covering base of head; tricarinate, carinae complete, uniform, uniseriate; disk coarsely pitted, shiny; paranota explanate, widest anteriorly, subtruncate there, rounded behind; posterior process triangular, reticulate.

Elytra little wider than pronotum, evenly rounded, with tips overlapping and jointly rounded; costal area of uniform width, explanate, bi- to triseriate; subcostal area vertical, uniformly biseriate; discoidal area long fusiform, impressed, well over half the length of elytra; sutural area slightly wider than discoidal. Areolae quite large and very distinct, with heavy veins, those on elytra of almost uniform size.

Generotype, *Dictyonota* (*Tingis*) *eryngii* (Latreille), 1802.

There are about twenty-four species of *Dictyonota* distributed throughout Europe, Africa, and Asia, and but one variety of a European species found in North America. This American representative is *Dictyonota tricornis* Schrank, var. *americana* Parshley, 1916. It may have been introduced along the eastern coast from Europe on broom and furze, hosts of some of the European species. Parshley considered it too different from the typical *tricornis* to bear that name alone, but not different enough to justify consideration as a distinct species. It has been reported from New England and eastern Canada.

GENUS *ACALYPTA* WESTWOOD

1840 *Acalypta* WESTWOOD, Introd. Mod. Class. Ins., Gener. Synop. 2:121..
1844 *Orthosteira* FIEBER, Ent. Mon., p. 46.
1861 *Orthostira* FIEBER, Eur. Hemip., pp. 36, 130.
1906 *Acalypta* HORVATH, Ann. Mus. Nat. Hung. 4:24.
1916 *Fenestrella* OSBORN and DRAKE, Ohio State Univ. Bul. 20:222.
1922 *Drakella* BERGROTH, Ann. Soc. Ent. Belg. 62:152.
1924 *Acalypta* TORRE-BUENO, Bul. Brooklyn Ent. Soc. 19:50, 93.
1928 *Acalypta* DRAKE, Bul. Brooklyn Ent. Soc. 23:1.

Head short, with one pair of spines arising between anterior margins of large eyes; antenniferous tubercles swollen, somewhat spiniform ventrolaterad. Antennae in brachypterous forms longer than pronotum; segment III longest and slenderest; IV thickest, fusiform. Bucculae open in front in some species, in others contiguous at base but emarginate at juncture. Rostrum long, channel narrow with areolate laminae, open behind. Orifice indistinct. Coxae variably spaced in accordance with wing length, i.e., all three pairs quite close longitudinally in brachypterous forms, anterior pair distant from middle pair in macropterous. Hypocostal ridge uniseriate or biseriate.

Pronotum with collar raised and produced forward medially, not recurved at apex; paranota explanate, slightly reflexed, quadrate; disk shiny glabrous, much reduced and hardly more than calli in brachypterous forms, convex and coarsely pitted in macropterous; posterior process of varying lengths, from obtuse to acute at apex; unicarinate or tricarinate, carinae foliaceous, uniseriate; median carina percurrent on collar and pronotum, with margin almost straight; lateral carinae, when present, arising abruptly anteriorly and gradually lowering caudad.

Elytra ovate and contiguous in brachypterous, oblong and overlapping in macropterous forms, rounded separately at apex in both; costal area explanate, abruptly widened at base to width of paranota, margins evenly rounded; subcostal area wider than costal, sometimes as wide as discoidal, widest near base, usually steeply sloping; discoidal area elongate, slightly impressed, outer margin sinuate; sutural area in brachypterous forms narrower than discoidal or subcostal.

Generotype, *Acalypta* (*Tingis*) *carinata* (Panzer), 1806.

This genus has been the scene of many changes during the 105 years of its existence, and now contains three other generic names in its synonymy, as well as many suppressed species. This is not surprising in view of its age, the extent of its distribution and its polymorphism. A great deal of work has been done on *Acalypta* and several keys to species have been published. A complete list of references to the genus and its constituents would indeed be long; only the generic synonymy and some of the keys are included above. Drake (1928) studied the genus in North America and few changes have been made since then.

Acalypta is holarctic in its distribution, with twenty-four species and two varieties reported from across the European continent and Siberia, one species from Japan and ten from North America. The first representative of the genus to be described from this continent was *Acalypta thomsonii* Stål, 1873, from South Carolina, for 43 years the sole American member of the group. Torre-Bueno's *lillianis*, 1916, was followed by *ovata* Osborn and Drake, 1916 (Ohio, Tennessee, North Carolina), which turned out to be the brachypterous form of *lillianis*. In the same year Osborn and Drake described *Fenestrella ovata* which had to be renamed (*duryi* Drake, 1930) when its genus, changed to *Drakella* because of preoccupation, finally was established as *Acalypta*. This is a good example of the hazard in repeating specific names in closely related genera. The variable and widespread *lillianis* (British Columbia to Quebec, south to Maryland and Iowa) was twice more to be described as *grisea* Heidemann, and *modesta* Parshley, thus becoming established as the most confused member of the North American *Acalypta*.

The distribution of this genus may be interpreted better when one learns that *Acalyta* species are collected largely on moss. Obviously, however, there are some gaps which may well be filled upon more intensive collecting in some regions. For instance, *nyctalis* Drake has been reported from Alberta, Canada, and from New Hampshire, rather widely separated localities. The finding of *lillianis* in British Columbia suggests that it might also be located in other regions between there and North Dakota, its nearest western record. Since the type of collecting which turns up this small tingid is quite different from ordinary tingid collecting, it is reasonable to assume that the field by no means has been exhausted.

The west coast is populated also by *vanduzei* Drake, in California; *vandykei* Drake, in California and Oregon; *mera* Drake, in Oregon and British Columbia; and *saundersi* (Downes) in Washington and British Columbia. In Montana is found *cooleyi* Drake, and the remaining species, *barberi* Drake, is a New York resident.

Many characters which ordinarily remain quite constant within a genus vary considerably in *Acalypta*. Polymorphic differences include the shape and size of pronotum and spacing of coxae, in addition to wing length and form. The open or closed bucculae and the uniseriate or biseriate hypocostal ridge seem to be specific rather than polymorphic differences. Regardless of these variabilities the genus is quite uniform in general habitus, and is distinct from *Dictyonota* because of its gradation in diameter of antennal segments; in *Dictyonota* segment III is as thick as the others. These two genera are similar in rounded form and heavy venation, which characters, with their explanate paranota and costal areas, serve to separate them from other genera. Rarely among the tingids does one find such continuity between paranota and costal area, which, with the hood, give the impression of a uniform margin around the entire insect.

GENUS *TINGIS* FABRICIUS

1803 *Tingis* FABRICIUS, Syst. Rhyng., p. 124.
1904 *Maecenas* KIRKALDY, Entomologist, 37:280.
1906 *Tingis* HORVATH, Ann. Mus. Nat. Hung. 4:61 (key to palearctic species).
1927 *Tingis* DRAKE, Ann. Carnegie Mus. 17:83 (key to S. Amer. species).

Head moderately short, with four or five spines, the frontal ones sometimes reduced; antennae in subgenus *Lasiotropis* shorter than pronotum, in subgenus *Tingis* subequal to pronotum, and in subgenus *Tropidocheila* very long and slender, much longer than head and pronotum together. Bucculae contiguous at apex; rostrum ending on sternum, not reaching onto abdomen; rostral channel widening on metasternum, open or closed behind, with foliaceous laminae. Orifice distinct in some species, indistinct in others. Coxae I and II farther apart than II and III; legs varying with antennal length. Hypocostal ridge uniseriate.

Pronotum moderately convex, coarsely punctate, with transverse indentation separating it from long, acuminate posterior process, this groove especially distinct in *Tropidocheila* species; calli transversely rather convex; collar truncate with slight tectiform elevation of median vein in *Tropidocheila,* raised and slightly produced forward in a small bulbous hood in *Lasiotropis,* and either truncate or produced forward, and tectiform or bulbous in *Tingis;* tricarinate, carinae low, costate, sometimes lower on disk, median percurrent on collar and sometimes fading on posterior process. Paranota explanate, with one or more rows of areolae in *Tingis;* rather wide, reflexed upward, pilose in *Lasiotropis;* very narrow, carinate and suberect in *Tropidocheila,* evenly rounded in all.

Elytra obovate or oblong, overlapping and jointly rounded behind in all but *Lasiotropis;* costal area with from one to four rows of cells, explanate; subcostal area oblique, from narrower to wider than costal and discoidal areas; discoidal area at least half as long as elytra in *Tingis* and *Lasiotropis,* distinctly less than half in *Tropidocheila,* outer margin straight or slightly bowed outward posteriorly, upraised, sometimes lowered apically; sutural areas completely overlapping, cells at base the size of those in discoidal and subcostal areas, becoming as large apically as costal cells. Cells of uniform size throughout, except on disk, in *beiri* and *necopina.*

Generotype, *Tingis* (*Cimex*) *cardui* (Linnaeus), 1758.

This oldest of all tingid genera has been, quite understandably, the temporary location of a great many species which later were put into other genera. In fact, there are twenty-six genera containing species originally described in *Tingis.* Since this genus was the progenitor of the entire family it is not surprising that its original description could fit almost any member of the Tingidae. It has necessarily been narrowed throughout subsequent years, but it still includes quite a variety of characters. The classification of its species has been considerably facilitated by Horvath's subgeneric divisions (loc. cit.), *Tingis, Lasiotropis* and *Tropidocheila,* to which Drake (1928c) added a fourth, *Caenotingis.* Both *Tingis* and *Lasiotropis* have areolate paranota and their collars may be somewhat bulbous and produced forward; *Lasiotropis* is well supplied on marginal veins with hairs at least as long as the diameter of an eye; *Tropidocheila* has very narrow, carinate paranota and a truncate collar; *Caenotingis* has a much larger hood than the others, extending over the head in front and onto the crest of the disk behind. Only the first three subgenera are represented in the Western Hemisphere, and only *Tingis* and *Tropidocheila,* the North American representatives, are included in the foregoing key.

Of almost ninety species throughout the world, by far the majority are from the Eastern Hemisphere, with but ten recorded from South America and three from North America. These three are: *gamboana* Drake and Hambleton, subgenus *Tropidocheila*, from Canal Zone; *necopina* (Drake), subgenus *Tingis*, from Maryland; and *Tingis florissantensis* Cockerell, a Miocene fossil from Colorado, probably belonging to subgenus *Tingis*. No host plant records are to be found for these North American forms.

GENUS *LEPTOPHARSA* STÅL

1873 *Leptostyla* STÅL, Enum. Hemip. 3:120, 125.
1873 *Leptopharsa* STÅL, ibid, pp. 122, 126.
1897 *Leptostyla* CHAMPION, Biol. Centr.-Amer., Rhynch. 2:11.
1897 *Leptopharsa* CHAMPION, ibid, p. 21.
1904 *Gelchossa* KIRKALDY, Entomologist, 37:280.
1917 *Leptostyla* McATEE, Bul. Brooklyn Ent. Soc. 12:60.
1928 *Leptopharsa* DRAKE, Proc. Biol. Soc. Washington, 41:21.

Head rather short, usually with five spines, sometimes less; antennae long, segment I from two to five times as long as II, III always long and very slender, IV variable in size and shape. Bucculae closed at apex; rostrum of moderate length; rostral channel of varying widths, open behind in some species, in others closed. Orifice distinct. Coxae I farther from II than II from III; legs slender, moderately long. Hypocostal ridge uniseriate.

Pronotum with collar raised and produced forward medially to different degrees; in some species scarcely inflated; in some the hood bulbous but not covering head or much of convex disk; in others tectiform and sharply angulate at apex. Median carina uniformly low, foliaceous, uniseriate; lateral carinae usually complete from calli back; posterior process long, acuminate; paranota usually narrow, produced evenly, uniformly reflexed upward, but not vertical.

Elytra much longer than abdomen, broadening from base, widest opposite discoidal area or near apex, overlapping somewhat and usually with divaricating apices, but sometimes jointly rounded; costal area from uniseriate to multiseriate, explanate; subcostal area narrow to as wide as discoidal, oblique to vertical, of uniform width, discoidal area acuminate at base and apex, no more than half as long as elytra, often impressed longitudinally, boundaries complete; sutural area with cells usually highly variable in size from small at base to large near apex.

Generotype, *Leptopharsa elegantula* Stål, 1873.

This large and variable genus is confined almost entirely to the Western Hemisphere, with more than sixty species from South America, thirty-three from North America, two from Australia, and one from Africa. Recently three smaller genera have been split from it, *Phymacysta* Monte, *Dyspharsa* Drake, and *Vatiga* Drake and Hambleton; a fourth, *Hybopharsa* gen. nov., is described from its ranks in this paper. Still further division is desirable because of the unwieldiness of such a large genus, and a study of the whole group of species may disclose other possible divisions.

The following are the North American species of *Leptopharsa*: *angustata* Champion—Guatemala, Jamaica, (on *Artocarpus integrifolia*); *bifasciata* Champion—Guatemala; *clitoriae* Heidemann—from Massachusetts to South Carolina, west to Arkansas, (on *Clitoria mariana, Meibomia, Lespedeza*); *constricta* Champion—Jamaica, Guatemala, Panama; *dampfi* Drake—Mexico; *dapsilla* Drake and Hambleton—Guatemala; *digitalis* Drake—Haiti; *dilaticollis* Champion—Guatemala; *distantis* Drake—Mexico; *divisa* Champion—Panama; *elata* Champion—Mexico, Guatemala; *fimbriata* Champion—Mexico; *furculata* Champion—Guatemala, Panama, (on Rubiaceae); *fuscofaciata* Champion—Panama; *gracilenta* Champion—Guatemala, Brazil, (on *Machaerium stipitatum*); *guatemalensis* Drake and Poor—Guatemala; *heidemanni* Osborn and Drake—Maryland, Ohio, New York, (on *Baptisia tinctoria*); *hintoni* Drake—Mexico, Arizona, Texas; *hoffmani* Drake—Haiti; *lineata* Champion—Guatemala; *longipennis* Champion—Guatemala; *machalana vinnula* Drake and Hambleton—Florida; *oblonga* (Say)—New Jersey to South Dakota to Arkansas to Virginia, Brazil, (on *Falcata comosa*); *ovantis* Drake and Hambleton—Guatemala, Peru; *papella* Drake—Indiana; *partita* Champion—Mexico; *ruris* Drake—Antigua; *setigera* Champion—Panama; *siderea* Drake and Hambleton—Guatemala; *tenuis* Champion—Guatemala; *unicarinata* Champion—Panama; *usingeri* Drake—Mexico; *velifer* McAtee—Arizona; *vicina* Drake and Poor—Haiti; *zeteki* Drake—Panama.

GENUS *VATIGA* DRAKE AND HAMBLETON

1946 *Vatiga* DRAKE and HAMBLETON, Proc. Biol. Soc. Washington, 59:10.

Head short, usually with two or three spines, the anterior pair and sometimes the median lacking; antennae long, slender, segment I longer than II, III longest, IV at least as long as I and II together. Bucculae contiguous at apex; rostrum extending onto metasternum, there rostral channel distinctly constricted. Orifice distinct. Coxae I and II farther apart than II and III; legs moderately long and slender. Hypocostal ridge uniseriate.

Pronotum with collar scarcely produced forward; tricarinate, carinae uniseriate and uniformly low; paranota narrow, somewhat reflexed upward, aereolate; posterior process long, acuminate.

Elytra longer than abdomen, broadening from base; discoidal area reaching no farther than middle of elytra; costal area explanate; subcostal area uniformly wide.

Generotype, *Vatiga vicosana* Drake and Hambleton, 1946.

This genus is composed of the generotype, three species and one variety transferred from *Leptopharsa* and three from *Tigava*. Only two are found in North America, both formerly as *Leptopharsa*: *illudens* (Drake) from the West Indies and Brazil; and *manihotae* (Drake) from Trinidad and Brazil (on *Manihot utilissima*).

Vatiga may be separated from *Leptopharsa* and *Tigava* by the constricted rostral channel.

GENUS *DYSPHARSA* DRAKE AND HAMBLETON

1944 *Dyspharsa* DRAKE and HAMBLETON, Jour. Washington Acad. Sci. 34:127.

Head short, with five spines, basal pair and median long, slender, appressed, anterior pair short, erect. Antennae longer than head and pronotum together, very slender, IV fusiform, slightly longer than I plus II. Bucculae closed apically; rostrum long, terminating on metasternum; rostral channel becoming broader posteriorly, closed behind. Coxae I and II farther apart than II and III; legs long, slender, tibiae not quite so thin as antennal segment III. Orifice distinct. Hypocostal ridge uniseriate.

Pronotum with disk highly convex, shiny, punctate, calli distinct; collar raised and broadly produced forward over head; median carina uniformly low, complete; lateral carinae lacking; paranota narrow, carinate; posterior process long, bifid at apex.

Elytra almost twice as long as abdomen, broadening from base, widest opposite discoidal area, then narrowing somewhat and parallel, jointly rounded at apex; costal area explanate, with three rows of fairly large cells; subcostal area subequal in width to costal and discoidal, convex-oblique. Discoidal area distinctly less than half the length of elytra, outer margin sinuate, inner broadly curved; cells about diameter of tibiae, subequal in size to cells of subcostal area, posterior process of pronotum, and hood. Sutural areas overlapping, with cells becoming larger apically.

Generotype, *Dyspharsa* (*Leptopharsa*) *myersi* (Drake), 1926a.

This genus, until recently contained in *Leptopharsa*, differs from the latter in having much reduced, carinate paranota; its hood is raised evenly and produced forward in a broad curve instead of being tectiform or vesicular as is usually true in *Leptopharsa*.

Dyspharsa is at present monotypic and is recorded only from Cuba. Host plants for *myersi* are not known.

GENUS *HYBOPHARSA*, GEN. NOV.

Head short, with five appressed spines, anterior three converging at tips; antennae longer than head and pronotum, I twice as long as II, III three times as long as IV, IV as long as I plus II; bucculae short, contiguous anteriorly. Rostrum long, reaching end of channel; rostral channel deep, bifid and open at apex. Orifice distinct, margin wide. Coxae I and II farther apart than II and III; legs with tibiae little thicker than antennal segment III, moderately long. Hypocostal ridge uniseriate. Genital segment constricted at base and rather long in male, truncate at apex in female.

Pronotum with disk very highly convex, with a transverse, bisinuate groove immediately behind crest; longitudinally impressed between lateral carinae and paranota; calli distinct, transverse; hood highest posteriorly, sloping forward, covering basal half of head, with anterior margin broadly convex; tricarinate, median carina low, slightly raised on disk, not percurrent on hood; lateral carinae low, complete from calli. Paranota narrow, uniseriate posteriorly; broader opposite calli, there reflexed downward, with only basal part visible from above and distal margin directed ventrad. Posterior process of pronotum long, acuminate, with bifid apex.

Elytra broadening from base, widest opposite discoidal area, narrower and parallel beyond, overlapping at apex and jointly rounded; costal area of uniform width, with two rows of rather large cells; subcostal area oblique, subequal in width to costal and discoidal areas, slightly inflated with discoidal area; the latter less than half the length of elytra, somewhat inflated at outer margin at widest point, with inner vein strongly raised and outer sinuate; sutural area with cells graduating in size from small at base to large at apex.

Generotype, *Hybopharsa (Leptopharsa) colubra* (Van Duzee), 1907.

This monotypic genus was separated from *Leptopharsa* because its deflexed paranota and high, transversely grooved, pronotal disk make it entirely distinct from the other species of *Leptopharsa*. Leaving it in its original genus would require much broader limits for that group than the already wide ones it has. No other genus in North America has such distinctly deflexed paranota, a character which should serve to distinguish *Hybopharsa* from all other genera.

The single species in this genus, *colubra* (Van Duzee), is from Jamaica and Cuba, and has been collected from *Eugenia rhombea* and from pimiento.

The name Hybopharsa is from the Greek hybo, meaning "humpbacked," and pharsa, meaning "part."

GENUS *EURYPHARSA* STÅL

1873 *Eurypharsa* STÅL, Enum. Hemip. 3:122, 133.

Head quadrangular, with five long, fairly slender spines, curving downward; antennae close at base, stout, longer than pronotum, III as thick as IV, pilose; bucculae broad, contiguous anteriorly; rostrum reaching metasternum; rostral canal without laminae on prosternum, broadening on metasternum, cordately closed behind. Coxae equidistant laterally, I farther from II than II from III. Orifice small, very distinct, with wide margin. Hypocostal ridge uniseriate.

Pronotum with convex, areolate disk, tricarinate, carinae uniformly low, uniseriate, median becoming obsolete near apex of rounded-acute posterior process; paranota narrow, reflexed, with evenly rounded margin and small cells; calli distinct, large.

Elytra extremely broad, almost three times as wide as pronotum, widest from middle to apex, subtruncate at apex; costal area broadening somewhat gradually from base, widest at apex, explanate; subcostal area very narrow, biseriate, subvertical; discoidal area very long, about two-thirds the length of elytra, outer margin not raised but slightly decurved; sutural area no wider than discoidal; areolae rather small throughout.

Generotype, *Eurypharsa (Tingis) nobilis* (Guérin), 1838.

This very striking genus can easily be separated from all others by its extremely broad elytra. The only other genus with that attribute is *Aristobyrsa*, easily distinguished from *Eurypharsa* by its separated bucculae, explanate paranota and bulbous discoidal area.

Only five species comprise this genus, four of which are South American and the other, *fenestrata* Champion, is from Panama.

GENUS *MACROTINGIS* CHAMPION

1897 *Macrotingis* CHAMPION, Biol. Centr.-Amer., Rhynch. 2:22.

Head short, antenniferous tubercles very short, far apart, the tylus and bucculae visible between them from above; with one erect spine; antennae extremely long, distinctly longer than rest of insect, only segment II short; bucculae closed at apex, projecting forward somewhat. Rostrum moderately long, its channel becoming broader on metasternum and closed behind. Coxae I far from II, II close to III; legs very long and slender. Orifice indistinct. Hypocostal ridge uniseriate. Male genital segment extremely broad.

Pronotum with disk convex, punctate, shiny; tricarinate, median carina foliaceous, uniseriate, lateral carinae lower, obsolete on disk; collar narrower at apex than head across eyes, inflated into small oval hood medially, projecting forward as far as middle of eyes; paranota evenly rounded, uniformly wide, biseriate, somewhat vertically reflexed, not projecting forward; posterior process long, acuminate.

Elytra elongate, much longer than abdomen, widest near apex; costal area explanate, subvertical at base, cells nearly the diameter of the eyes; subcostal area suberect, narrower than other areas, cells small; discoidal area much less than half the length of elytra, impressed, outer vein raised, subparallel, inner vein subangular; sutural area broad, overlapping but rounded separately at apex.

Generotype, *Macrotingis biseriata* Champion, 1897.

This very distinctive genus is so far extremely limited in number of species and in geographical range. There are only the two original species of Champion, *biseriata* and *uniseriata*, the former from Panama and Honduras, the latter from Guatemala, and a variety, *biseriata novicis* Drake, from Honduras. No host plant records have been found.

The extremely long antennae separate this genus immediately from any others except *Tigava* from which it is easily distinguished by its single erect head spine, its broader paranota and costal area and more divergent apices of elytra.

Specimens of *uniseriata* were not examined by this author, but Champion's figure and description were studied.

GENUS *ACANTHOCHEILA* STÅL

1860 *Acanthocheila* STÅL, Enum. Hemip. 3:119, 127.

Head short, with antenniferous tubercles widely separated and tylus visible from above; basal spines long, stout, appressed; median spine long, slender, erect, or rudimentary, or lacking; antennae moderately long, slender, pilose, I longer than II, III longest, IV fusiform. Bucculae open or closed in front; rostrum not reaching beyond metasternum; rostral channel rather broad, open or closed at apex, laminae sometimes scarcely indicated. Orifice distinct but not prominently margined. Coxae I and II farther apart than II and III; legs moderately long and slender. Hypocostal ridge uniseriate basally, costate posteriorly.

Pronotum with disk convex, shallowly pitted; calli transverse, flat, shiny; collar areolate, margin truncate, slightly sinuate or produced forward and upraised in a small hood (not in North American species); paranota explanate, sometimes reflexed, narrow, edged with large spines; median carina costate, sometimes percurrent, sometimes obliterated on posterior process; lateral carinae usually obsolete, occasionally indicated posteriorly; posterior process long, and acute, blunt, truncate, or emarginate at apex.

Elytra narrow at base, widened abruptly or gradually, subparallel-sided, overlapping, broadly and separately rounded at apex; costal area broadest beyond discoidal area, margins sometimes spiniferous; subcostal area almost horizontal in many, with cells large or small or both; discoidal area not over half the length of elytra, very flat or with tumid elevation posterolaterad, outer margins subparallel, inner margins never strongly raised, sometimes indistinguishable; sutural area partially overlapping, cells not strikingly larger than in costal area.

Generotype, *Acanthocheila* (*Monanthia*) *armigera* (Stål), 1860.

The large spines on the margins of the paranota of the members of this genus readily distinguish it from all other groups. Twelve species are recorded, all from the Western Hemisphere, and five of these are North American. They are: *armigera* (Stål)—from Texas, Mexico, Central America, West Indies, and South America; *dira* Drake and Hambleton—Guatemala; *exquisita* Uhler—Florida; *sigillata* Drake and Bruner—Cuba; *spinicosta* Van Duzee—West Indies. *Pisonia* spp. for *armigera*, and *Pisonia aculeata* for *sigillata* are the recorded hosts.

GENUS *PLESEOBYRSA* DRAKE AND POOR

1937 *Pleseobyrsa* DRAKE and POOR, Proc. Biol. Soc. Washington, 50:165.

Head with five spines, either long or reduced. Antennae usually at least as long as from apex of collar to apex of discoidal area, slender; I longer than II, III longest and slenderest, IV sometimes scarcely thicker or shorter than III. Bucculae very much reduced and widely separated anteriorly, or closed and produced forward; rostrum fairly short; rostral canal closed or almost closed at apex, widest on metasternum, rather shallow. Orifice indistinct. Coxae I farther from II than II from III; legs slender, moderately long. Hypocostal ridge uniseriate to costate.

Pronotum with disk convex, coarsely punctate; calli convex or impressed; collar truncate anteriorly or raised and produced forward in a hood, not reaching beyond the middle of eyes; paranota projecting forward no farther than apex of head, narrow behind, explanate, outer margins parallel or sinuate, rounded in front; median carina low, uniform; lateral carinae low, parallel, complete from calli, or only on disk, or entirely obsolete; posterior process long and acuminate or roundly abbreviated at apex.

Elytra abruptly broadened from base, sometimes produced forward there, overlapping slightly, broadly and separately rounded, margins subparallel; costal area broadest beyond discoidal area, sometimes equally broad at base; subcostal area oblique to subvertical; discoidal area less than half the length of elytra, not bulbous, sometimes impressed, with either outer or inner margin nearly straight; sutural area with cells becoming larger apically.

Generotype, *Pleseobyrsa boliviana* Drake and Poor, 1937.

This genus contains several species originally described in *Leptobyrsa* Stål but separated from it by its lower pronotal carinae, less globose hood, and lack of tumid elevation of discoidal area. As revised, *Leptobyrsa* no longer is represented in North America. *Aristobyrsa,* also described from *Leptobyrsa,* differs in having much broader elytra and bulbous discoidal area.

Three species of *Pleseobyrsa* are recorded from North America; *chiriquensis* (Champion)—from Panama and Costa Rica; *nigriceps* (Champion)—Guatemala and Panama; *plicata* (Champion)—Panama and South America. In addition there are six South American species.

P. chiriquensis (Champion) has been collected from avocado.

GENUS *ALLOTINGIS* DRAKE

1930 *Allotingis* DRAKE, Bul. Brooklyn Ent. Soc. 25: 269.

Head about as long as width across eyes, with two or three spines (basal pair lacking); antenniferous tubercles produced sharply forward, giving appearance of another pair of spines; antennae widely separated at base, I longer than head, subequal to IV, II short, III about twice as long as I. Bucculae broad, contiguous in front, projecting obliquely forward and visible from above. Rostrum fairly short, thick at apex; rostral channel wide, broadening convexly on meso-metasternum, closed behind, laminae low, almost costate. Coxae with wide separation between I and II, II and III close. Orifice indistinguishable. Hypocostal ridge uniseriate, narrow.

Pronotum finely punctate, with disk convex; collar broad, reticulate, truncate to slightly emarginate anteriorly; unicarinate or tricarinate, median carina low, costate, percurrent on collar; lateral carinae, if present, parallel, swollen anteriorly at calli; paranota explanate, projecting forward at least as far as anterior margin of eyes, with outer margins parallel to concave; posterior process obtuse to sinuate, no longer than disk.

Elytra long, abruptly broadened at base, not overlapping but contiguous in straight dorso-medial line, lateral margins subparallel; costal area explanate, broad; subcostal area oblique, narrower than costal and discoidal areas; discoidal area subequal in width to costal area, open behind; sutural area extending from base, uniform, uniseriate.

This genus most closely resembles *Liotingis* Drake from Brazil, and

Pleseobyrsa Drake and Poor, but is clearly separable by the contiguous alignment of its elytra and the posterior continuity of discoidal area with sutural.

Allotingis is limited to the West Indies and contains two species, *binotata* Drake and Bruner, from Cuba, and *insulicola* Drake and Poor, from Haiti. The former species has been collected from *Thrinax wendlandiana*.

GENUS *ARISTOBYRSA* DRAKE AND POOR

1937 *Aristobyrsa* DRAKE and POOR, Proc. Biol. Soc. Washington, 50:164.

Head short, with long spines; antennae longer than from apex of hood to apex of discoidal area, I much longer than II, IV no thicker than III; bucculae very short, widely separated anteriorly. Rostrum extending on metasternum; rostral channel broad, closed at apex. Orifice indistinct. Coxae I farther from II than II from III; legs slender, moderately long. Hypocostal ridge uniseriate at base, costate beyond.

Disk convex, calli rather flat; hood raised tectiformly, produced arcuately forward; median carina uniseriate, complete; lateral carinae uniseriate, arising at calli and terminating on short, obtuse posterior process; paranota explanate, much wider anteriorly, produced forward as far as anterior margin of eye, lateral margins only slightly divaricating posteriorly.

Elytra three times as broad as pronotum, abruptly widened and slightly produced forward at base, barely overlapping, broadly and separately rounded apically; costal area extremely broad, explanate, with six rows of cells at base; discoidal and subcostal areas inflated together into large ampulla, reaching almost to middle of elytra and projecting bulbously over small basal cells of subcostal area; sutural area very narrow anteriorly, very broad posteriorly.

Generotype, *Aristobyrsa* (*Leptobyrsa*) *latipennis* (Champion), 1897.

The very short and widely separated bucculae, the highly bulbous discoidal area, the extremely broad elytra and the explanate, forward-produced paranota separate this genus readily from all other genera. It differs markedly from the other species of *Leptobyrsa* with which it was originally described. There is but one species in the genus, collected in Panama, Peru, and Brazil.

GENUS *CALOLOMA* DRAKE AND BRUNER

1923 *Caloloma* DRAKE and BRUNER, Mem. Soc. Cubana Hist. Nat. 6:152.

Head short, with five very long, slender spines; antennae almost as long as from tip of hood to apex of posterior process of pronotum, somewhat pilose, segment IV clavate; bucculae contiguous anteriorly. Rostrum reaching onto metasternum; rostral canal closed posteriorly, with foliaceous laminae. Orifice distinct, with fairly wide margin. Coxae I and II farther apart than II and III. Hypocostal ridge uniseriate, cells rather large.

Pronotum with convex disk; hood globose, slightly longer than wide, reaching beyond apex of head; calli indistinct; tricarinate, carinae high, uniseriate, abruptly lowered at both ends; paranota explanate, extending forward beyond apex of hood, wider anteriorly (Fig. 2b); posterior process reticulate, triangular.

Elytra rather abruptly widened at base, outer margins parallel, tips divaricating; costal area explanate, with two to three rows of cells which become larger at widest point, beyond discoidal area; subcostal area vertical or concave, not included in inflation of discoidal area; the latter barely over half the length of elytra, distinctly bulbous, elevation occupying almost entire width; sutural area subequal in width to costal. Margins and veins of pronotum and elytra set with numerous short spines.

Generotype, *Caloloma uhleri* Drake and Bruner, 1923.

The spiniferous margins of this genus separate it from all but *Corythucha* and *Acanthocheila* among the North American tingids. The width of paranota and shortness of marginal spines distinguish it immediately from the latter, and the rounded apex of the hood from the former.

This monotypic genus was collected on Antigua Island, British West Indies. No host plant has been reported. Drake (1945) has recently questioned the distribution of *C. uhleri*, because of some typical specimens of this species in his collection from Australia.

GENUS *STENOCYSTA* CHAMPION

1897 *Stenocysta* CHAMPION, Biol. Centr.-Amer., Rhynch. 2:28.

Head squarish with five short blunt spines, antenniferous tubercles obtuse; antennae moderately long, thickly set with long fine hairs, I about twice as long as II, both short and stout, III three times as long as IV, slenderer, with IV inserted a little before apex. Bucculae closed in front; rostrum moderately long, rostral channel narrow with laminae parallel and low. Coxae I farther from II than II from III; legs rather short and stout.

Pronotum with disk moderately convex, collar inflated into short narrow subangulate hood, highest at middle, not covering head; median carina complete, percurrent on hood, upraised angularly on disk; lateral carinae complete from calli back, low; paranota evenly produced and somewhat reflexed, with three rows of fine areolae; posterior process long acuminate, reticulate.

Elytra broad, obovate, overlapping, with separately rounded apices, close together; costal area broadly explanate, narrow at base, widening rather abruptly to almost as wide as subcostal and discoidal areas together; subcostal area narrow, oblique; discoidal area wider than subcostal, more than half the length of elytra, outer margin curved farthest laterad near apex; sutural area parallel behind, with cells little if any larger than those of costal area.

Generotype, *Stenocysta pilosa* Champion, 1897.

Stenocysta is represented by the type from Panama. The genus *Zelotingis* Drake and Hambleton (1945) was erected for *S. aspidospermae*

Drake and Hambleton. In shape of antennae *Stenocysta* resembles *Megalocysta, Pachycysta* and *Ambycysta* but differs greatly in size and shape of pronotal hood.

GENUS *PACHYCYSTA* CHAMPION

1898 *Pachycysta* CHAMPION, Trans. Ent. Soc. London, p. 59.

Head with five short, blunt spines. Antennae pilose, segments I and II stout, I twice as long as II; III longest, slenderest, obliquely truncate at apex; IV subcylindrical, articulated below apex of III, with longer hairs. Bucculae open or closed in front; rostrum long, extending onto venter II; rostral channel open behind, with foliaceous laminae. Orifice distinct, margined. Coxae I farther from II than II from III; legs with tibiae the diameter of antennal segment III. Hypocostal ridge uniseriate.

Pronotum with disk highly convex; hood oval, high, reaching from anterior margin of eyes to crest of disk, narrower than head across eyes; paranota wide, suberect, not produced forward, in South American species incurved, shell-like, at distal margin; median carina foliaceous, uniseriate, with costate margin; lateral carinae foliaceous, uniseriate, leaning inward toward median carina; posterior process long, acute.

Elytra widest across discoidal area, then slightly narrowed and parallel, apices separately rounded; costal area no wider than discoidal, widest beyond discoidal, inner vein sinuate; subcostal area suberect, narrow; discoidal area impressed, less than half the length of elytra, boundaries upraised, outer margin sinuate, inner arcuate; sutural areas overlapping, cells no larger than in costal area. Veins, legs, and antennae covered with short, curved hairs.

Generotype, *Pachycysta diaphana* Champion, 1898.

This genus shares with *Stenocysta, Megalocysta,* and *Ambycysta* the obliquely truncate third antennal segment, with the apical segment attached below the apex. Its costate, pilose margins, high hood and very wide, reflexed paranota distinguish it from all three, however. Of the four species in the genus three are South American and one, *schildi* Drake, is from the West Indies, Costa Rica, and Venezuela. No host plants have been recorded.

GENUS *MEGALOCYSTA* CHAMPION

1897 *Megalocysta* CHAMPION, Biol. Centr.-Amer., Rhynch. 2:5.

Head with five blunt spines, basal and median appressed. Antennae with segment I stouter and longer than II; III very long, slender, somewhat curved, obliquely truncate at apex; IV longer than I plus II, articulated just below apex of III, subfusiform, curved, pilose. Bucculae fused anteriorly, produced forward; rostrum reaching onto abdomen; rostral channel subparallel, laminae uniformly high, open behind. Orifice distinct, with rather broad margin. Coxae I and II farther apart than II and III; legs long, slender, tibiae subequal to antennal segment III in diameter. Hypocostal ridge uniseriate.

Pronotum with disk convex, mostly covered by hood (Fig. 8); the latter extending from anterior margin of eyes almost to apex of posterior process, obovate, slightly constricted at middle; paranota explanate anteriorly, very slightly reflexed posteriorly, uniformly wide, with margin evenly rounded; median carina foliaceous only in small, semicircular, basal piece at middle of hood, costate from end of hood to apex of posterior process; lateral carinae arising at calli, foliaceous on disk, costate posteriorly, very close to median carina and completely concealed from above by overhanging hood; posterior process long, covered except at blunt apex by hood.

Elytra gradually widening on basal third, then parallel-margined, overlapping and separately rounded at apex; costal area explanate, narrower than discoidal, biseriate anteriorly, triseriate posteriorly, inner margin sinuate; subcostal area subvertical, rather uniform; discoidal area almost half the length of elytra, impressed, tectiform laterad; sutural area somewhat impressed.

Generotype, *Megalocysta pellucida* Champion, 1897.

The tremendous hood on this genus separates it immediately from all others. Three species described in *Megalocysta* have been transferred by Drake and Hurd (1945) to the new genus *Ambycysta* because of their very different hoods. From the time of its original description until now the generotype has been considered to be without lateral carinae and with no foliaceous area of the median carina. A careful cleaning of Champion's cotype has revealed these structures hidden by exudation at the base of the hood. They still are not visible from above because of the overhanging hood.

M. pellucida Champion, from Panama, is the sole representative of this striking genus.

Megalocysta is somewhat similar in appearance to the South American *Ulocysta*, but the latter lacks the characteristic antennae, has no lateral constriction in its long hood and no lateral carinae beneath it.

GENUS *AMBYCYSTA* DRAKE AND HURD

1942 *Megalocysta* MONTE (in part), Rev. Brazil. Biol. 2:301.
1945 *Ambycysta* DRAKE and HURD, in press.

Head with five blunt spines; antennae with segment III somewhat thickened and obliquely truncate at apex, IV subcylindrical, curved, articulated just below apex of III; bucculae open or closed in front; rostrum long; rostral channel open behind. Orifice distinct. Coxae I farther from II than II from III; legs long and slender. Hypocostal ridge uniseriate.

Pronotum with hood reaching from apex of head no farther than slightly beyond crest of disk, bulbous, narrower in front; paranota less than half as wide as dorsal surface of hood, slightly reflexed, not produced forward, margin evenly rounded; median carina foliaceous, lowering posteriorly, uniseriate; lateral carinae converging on disk or subparallel; posterior process long.

Elytra wider than pronotum, overlapping, rounded separately at apex, outer margins subparallel; costal area explanate, reflexed at base; subcostal area subvertical; discoidal area less than half as long as elytra, impressed, outer margin no higher than inner; sutural area slightly impressed.

Generotype, *Ambycysta* (*Megalocysta*) *championi* (Drake), 1922b.

This genus differs from *Megalocysta*, from part of which it was described, principally in the visibility of its carinae and its smaller hood. It differs from *Pachycysta* Champion in having narrower, less reflexed paranota, and from *Stenocysta* in having a larger hood and shorter discoidal area. Three species comprise *Ambycysta*, two from South America, and *gibbifera* (Picado), from the West Indies.

GENUS *PHYMACYSTA* MONTE

1942 *Phymacysta* MONTE, Pap. Avul. Dept. Zool. São Paulo. 2:106.

Head with or without spines. Antennae long, I sometimes longer than IV, much longer than II; III very slender, distinctly longer than tibiae; IV long, slender fusiform. Bucculae contiguous apically; rostrum moderately long, rostral channel with a narrow opening behind, laminae foliaceous, most widely separated on metasternum. Orifice distinct. Coxae I and II more widely separated than II and III; legs with femora and tibiae equal in diameter to antennal segments I and III, respectively. Hypocostal ridge uniseriate.

Pronotum with disk convex, often pilose, sometimes covered by hood; collar inflated into bulbous hood, sometimes covering head or disk or both; paranota broad, reflexed, spreading upward or open-bulbous, not projecting forward farther than apex of hood; median carina high, extending from base of hood to apex of long, acuminate posterior process; lateral carinae carinate in *vesiculosa*, lacking in *magnifica*, absent on disk in *mcelfreshi* and abbreviated to a short, high triangular tooth in the other species.

Elytra spreading from base, apices divaricating, rounded separately, widely reticulate; costal area explanate, narrow (uniseriate) at base, widest at middle, inner vein deeply sinuate beyond discoidal area; subcostal area narrow or wide, oblique, vertical or even sloping outward from costal vein; discoidal area less than half the length of elytra, often higher laterad and either bulbous or tectiform there, inner vein sometimes inconspicuous; sutural areas but slightly overlapped.

Generotype, *Phymacysta* (*Leptosyla*) *tumida* (Champion), 1897.

This genus was erected by Monte for seven species of *Leptopharsa* Stål, one of which is a synonym (*cubana* Drake = *malpighiae* Drake). One more species is added here, *mcelfreshi* (Drake), also from *Leptopharsa*. Six of the seven species now contained in *Phymacysta* are found in North America, with only *magnifica* (Drake), from Brazil and Paraguy, excluded; but none extends farther north than Mexico. They are: *malpigheae* (Drake), from Cuba; *mcelfreshi* (Drake), from Haiti;

praestantis (Drake), from Mexico; *tumida* (Champion), from Guatemala, Jamaica, Haiti, and Trinidad, and also from Peru and Venezuela; *vesiculosa* (Champion), from Panama; and *walcotti* (Drake), from Haiti.

Available host records for these *Phymacysta* species are: *malpigheae* on *Malpighea urens; tumida* on *Malpighea punctifolia* and *M. glabra,* and on "weeds and cherry."

This group of *Leptopharsa* species is indeed distinct from the rest of the genus and well deserves a generic name. *Phymacysta* can be distinguished from *Leptopharsa* by having larger pronotal hood, wider paranota and higher median carina. From *Dicysta* Champion it can be separated by having but one ampulla on pronotum.

GENUS *DICYSTA* CHAMPION

1897 *Dicysta* CHAMPION, Biol. Centr.-Amer., Rhynch. 2:5.
1922 *Dicysta* DRAKE, Ann. Carnegie Mus. 13:271 (key).

Head with at least frontal spines present, sometimes reduced, covered by hood; antennae very long and slender. Bucculae in some species open at apex, in others closed, low; rostrum usually long, sometimes reaching only to meso-metasternal suture; rostral channel rather broad, posterior lamina flattened, with rostrum sometimes lying across it. Orifice usually distinct. Coxae I and II much more widely separated than II and III; legs long, slender. Hypocostal ridge uniseriate.

Pronotum with coarse or minute, widely-scattered punctures on moderately convex disk; collar swollen into bulbous hood, spherical or ovate, reaching at least to apex of head and sometimes covering disk; median carina high, joined to posterior end of hood and rising caudad, becoming swollen into bulbous vesicle on partially areolate posterior process of pronotum; this posterior vesicle sometimes larger than hood, sometimes smaller; lateral carinae lacking; paranota moderately to extremely wide, directed upward and laterad or incurved somewhat in shell-like fashion, neither so high nor extending so far forward as hood.

Elytra broad, obovate and jointly rounded behind (*aspidospermae*) or with parallel or divaricating margins and divergent apices; costal area explanate, uniseriate at base, soon widening to bi- or triseriate, widest beyond discoidal area; subcostal area becoming higher posteriorly, there sometimes swollen with discoidal area into bulbous inflation; discoidal area not more than half the length of elytra, raised laterad and caudad; sutural area with cells of approximately the same size as those in costal area.

Generotype, *Dicysta vitrea* Champion, 1897.

The genus *Dicysta* is not easily confused with any other North American genus because the only others with two bulbous medial inflations of the pronotum, *Aepycysta* and *Galeatus,* have the posterior inflation formed from the posterior process of the pronotum instead of from the median carina as in *Dicysta.*

Dicysta is composed of twelve species, two Australian, eight South American, one Central American, and the generotype, from both South and Central America. Brazil, Paraguay, and Panama are the localities recorded for *vitrea*, and Panama for *sagillata* Drake. In *vitrea* the paranota are very broad and incurved at outer margin, whereas in *sagillata* the paranota are only moderately broad and obliquely and evenly reflexed outward.

The only host records available for this genus are for *vitrea* and include *Mansoa glazionii (Bignoniaceae)* and *Adenocalymna* sp.

GENUS *AEPYCYSTA* DRAKE AND BONDAR

1932 *Aepycysta* DRAKE and BONDAR, Bol. Mus. Nac. Rio de Janeiro, 8:93.

Head and spines completely covered by hood; antennae very long and slender, segment IV slightly curved, only slightly thickened toward apex; bucculae widely separated anteriorly. Rostrum long, reaching onto abdomen; rostral channel fairly deep, open behind, laminae foliaceous. Orifice distinguishable. Coxae I farther from II than II from III; legs long, slender. Hypocostal ridge uniseriate.

Pronotum with disk only moderately convex; collar raised and inflated into large hood, as wide as long or wider, with a few very large cells; larger than disk but placed far forward over head, exposing most of disk. Paranota very broad opposite humeri, with one row of three or four very large cells; median carina high, sloping upward from hood to posterior vesicle; lateral carinae absent or composed of a single large cell, attached basally to pronotum and posteriorly to posterior vesicle; posterior process upraised and inflated into large vesicle.

Elytra obovate, with apex bluntly acuminate (*decorata*), or parallel-sided, with apices separately rounded; costal, subcostal and discoidal areas uniseriate, sutural area not more than biseriate; discoidal area more or less than half the length of elytra, raised apically; areolae extremely large throughout.

Generotype, *Aepycysta undosa* Drake and Bondar, 1932.

The very lacy species of this genus are extremely different from any other North American genus except *Galeatus*, from which they are easily distinguished by their abbreviated or obsolete lateral carinae. *Aepycysta* is composed of three species, the South American generotype and two Central American representatives: *schwarzi* (Drake), from Panama; and *decorata* Monte, from Costa Rica. The latter was collected by sweeping in grass.

A series of *undosa* specimens from Brazil contains both brachypterous and macropterous forms; *decorata* seems to be brachypterous and *schwarzi* macropterous.

GENUS *GALEATUS* CURTIS

1833 *Galeatus* CURTIS, Ent. Mag. 1:196.
1906 *Galeatus* HORVATH, Ann. Mus. Nat. Hung. 4:49.
1909 *Cadmilos* DISTANT, Ann. Soc. Ent. Belg. 53:113.
1911 *Galeatus* HORVATH, Ann. Mus. Nat. Hung. 9:337.

Head short, antenniferous tubercles small, widely separated; with five long, sharp, erect spines; antennae long, segment I more than twice as long as II, IV fusiform, only toward apex stouter than III. Bucculae widely separated anteriorly, tylus prominent between; rostrum moderately long; rostral channel with laminae uniseriate, diverging somewhat posteriorly, almost circularly continuous behind, low there. Orifice indistinct. Coxae I and II farther apart than II and III; legs long, slender. Hypocostal ridge uniseriate, basal cells large, diminishing apically.

Pronotum with disk convex, smooth, shiny, minutely punctate; calli impressed, flat; collar short laterad, raised sharply and produced acutely forward at middle into small, tectiform hood; paranota projecting forward angularly beyond head, uniformly broad, somewhat reflexed, composed of a single row of large cells; median carina of uniform height but raised from below on crest of inflated posterior process; the latter bulbous, tectiform and compressed laterally. Lateral carinae very strongly raised and curved inward above, forming two concave shells attached to crest of disk and sides of posterior vesicle, converging above median carina or hood.

Elytra narrow basally, abruptly widened and parallel-sided, broadly and separately rounded at apex; costal area broadest beyond middle, emarginate at base; subcostal area subequal to costal in width; discoidal area not more than half the length of elytra, widest posteriorly, margins irregular; costal, subcostal and discoidal areas each composed of one row of cells, sutural of two. Cells of pronotum and elytra extremely large, hyaline, with uniform veins throughout.

Generotype, *Galeatus (Tingis) spinifrons* (Fallen), 1807.

This genus is most closely allied to *Aepycysta* in having a bulbous elevation of the posterior process of pronotum, but differs markedly in having high lateral carinae and a much smaller hood.

Galeatus is primarily an Old World genus, with only two species found in North America. They are *peckhami* (Ashmead)—from northeastern United States, and *uhleri* Horvath—from New Mexico, Colorado, and Alberta. The former has been collected on *Aster macrophyllum* and *Eupatorium*.

GENUS *GARGAPHIA* STÅL

1862 *Monanthia* Subg. *Gargaphia* STÅL, Stett. Ent. Zeit. 23:324.
1873 *Gargaphia* STÅL, Enum. Hemip. 3:119, 124.
1919 *Gargaphia* GIBSON, Trans. Amer. Ent. Soc. 45:188.

Head short, usually with five spines; antennae at least as long as pronotum, I two or more times as long as II, III very slender, IV fusiform, sometimes long and curved. Bucculae closed anteriorly; rostrum not reaching beyond metasternum. Rostral channel interrupted between meso- and metasternum by a transverse carina, either continuous or separated medially (Fig. 6b); widening on metasternum and open behind. Orifice distinct. Coxae I farther from II than II from III; legs moderately long and slender. Hypocostal ridge uniseriate.

Pronotum with disk convex, calli distinct; hood small, tectiform or bulbous, reaching forward no farther than anterior margin of eyes and back not so far as crest of disk, usually longer than broad; tricarinate.

carinae foliaceous, complete, uniseriate, with costate margins; paranota evenly produced, somewhat reflexed, with rounded or angulate margin, never projecting forward; posterior process reticulate, long acuminate, sometimes blunt at apex.

Elytra narrow at base, widening gradually, margins becoming parallel, oblong, or divergent; overlapping and jointly rounded, or rounded separately, either broadly or acutely; costal area slightly reflexed at base, explanate beyond, usually more than uniseriate and wider than subcostal, widest beyond discoidal area; subcostal area narrow or wide, oblique to erect, usually of uniform height; discoidal area more or less than half the length of elytra, inner margin curved, outer curved or straight, apex acute, truncate or obliterated; sutural area with cells usually increasing in size posteriorly.

Generotype, *Gargaphia* (*Monanthia*) *patricia* (Stål), 1862.

The interrupted rostral canal serves to distinguish this genus from all others; in addition, it may be separated from its closer allies, *Corythucha* and *Corythaica*, by its shorter hood and lack of basal fold in paranota, and from *Stephanitis* by its lower median carina and level discoidal area.

About fifty-five species in the Western Hemisphere comprise this genus, with a slight majority from South America. The twenty-six North American species are: *albescens* Drake—California; *amorphae* (Walsh)—Illionis, Iowa; *angulata* Heidemann—Massachusetts to Colorado, Alabama to Minnesota; *arizonica* and *balli* Drake and Carvalho—Arizona, New Mexico; *bimaculata* Parshley—Florida; *carinata* Gibson—Arizona, South America; *deceptiva* Drake and Bruner—West Indies, South America; *gentilis* Van Duzee—Mexico; *insularis* Van Duzee—Mexico; *interrogationis* Monte—Costa Rica; *iridescens* Champion—Central America, Mexico, southwestern United States; *mexicana* Drake—Mexico, Texas; *nigrinervis* Stål—Central and South America; *opacula* Uhler—Mexico, western United States; *panamensis* Champion—Panama; *patricia* (Stål)—Mexico, Costa Rica; *shelfordi* Drake and Hambleton—Mexico; *solani* Heidemann—from Canada to Texas to Maryland; *tiliae* (Walsh)—Connecticut to Ontario, Nebraska to Florida; *tuthilli* Drake and Carvalho—Colorado; *vanduzeei* Gibson—Cuba; *valerioi* Drake—Costa Rica; *paula* Drake and Hambleton—Canal Zone; *oregoni* Drake and Hurd—Oregon; *jucunda* Drake and Hambleton—Panama.

Gibson (loc. cit.) gives a food plant index, as well as a key to species recognized at that time.

GENUS *CORYTHAICA* STÅL

1873 *Corythaica* STÅL, Enum. Hemip. 3:120, 128.
1893 *Typonotus* UHLER, Proc. Zool. Soc. London, p. 716.
1898 *Dolichocysta* CHAMPION, Trans. Ent. Soc. London, p. 56.
1919 *Corythaica* GIBSON, Proc. Biol. Soc. Washington, 32:98.
1938 *Leptotingis* MONTE, Bol. Biol. São Paulo, 3:128.
1945 *Corythaica* HURD, Iowa State College Jour. Sci., 20:79–99.

Head with no visible spines; antennae long, slender, segment I subequal to or longer than II, III very slender, IV stoutly fusiform. Bucculae rather wide, fused anteriorly; rostrum moderately long; rostral channel widening behind, closed at apex, the terminal lamina sometimes very low. Orifice indistinct. Coxae I farther from II than II from III; in brachypterous forms I and II slightly closer than in macropterous; legs moderately long and slender. Hypocostal ridge uniseriate to triseriate.

Pronotum with disk slightly or moderately convex, punctate; calli often concealed by paranota and hood; the latter wider at base, narrowing anteriorly, with acute apex surpassing antennal segment I but not wide enough to cover eyes; paranota not produced forward, narrow or wide, undulating or reflexed anteriorly, with basal fold at calli and margin rounded or sinuate (Fig. 3); tricarinate, carinae foliaceous, complete, median arched or uniform, lateral straight or sinuate; posterior process long, acuminate.

Elytra obovate or oblong, sometimes constricted at middle, overlapping and jointly rounded at apex; costal area widening gradually from base, explanate to slightly reflexed, uniseriate to triseriate; subcostal area suberect; discoidal area more or less than half the length of elytra, outer margin tectiform, bulbous or level, inner marginal vein upraised or indistinct; sutural area somewhat impressed.

Generotype, *Corythaica* (*Tingis*) *monacha* Stål, 1860.

This genus has a very confused history as a result of the variability of some of its species. It can readily be distinguished from all other genera but *Corythucha* by its long, narrow hood and the basal folds of its paranota; from *Corythucha* it is easily separated by its lack of spines on paranota and elytra. In its ranks are found the only North American species with more than two rows of cells in the hypocostal ridge, though the number is variable between species. Brachypterous, macropterous, and intermediate forms are found in this genus.

As *Corythaica* now stands there are thirteen species recognized in it, all from the Western Hemisphere. Five of these species are found in North America: *acuta* (Drake)—Montana, Colorado; *bellula* Torre-Bueno—New York, Florida; *carinata* Uhler—West Indies, Guatemala, Colorado, Texas; *cyathicollis* (Costa)—West Indies, South America; *venusta* Champion—western United States, Mexico.

A great number of solanaceous plants are recorded as hosts for *carinata* and *cyathicollis*, the latter being a pest of considerable economic importance; *venusta* has been collected from *Eriogonum* and *Salsola pestifer*.

GENUS *STEPHANITIS* STÅL

1873 *Stephanitis* STÅL, Enum. Hemip. 3:119, 123.
1903 *Cadamustus* DISTANT, Ann. Soc. Ent. Belg. 47:47.
1904 *Maecenas* KIRKALDY, Entomologist, 37:280.
1906 *Stephanitis* HORVATH, Ann. Mus. Nat. Hung. 4:54.

Head with spines present, reduced or absent; antennae very long and slender, pilose, subequal to length of elytra, with segment I much longer than II, IV longer than both together, III subequal to IV or as much as three times as long. Bucculae either fused, fairly wide and protruding slightly forward, or scarcely contiguous, short and deeply emarginate anteriorly. Rostrum rather long, sometimes extending onto venter; rostral channel rather deep, posterior lamina low or emarginate medially. Orifice distinct. Coxae I much farther from II than II from III; legs long and slender. Hypocostal ridge uniseriate or biseriate.

Pronotum with convex disk and flat calli; hood longer than wide, acute at apex, reaching forward at least as far as anterior margin of eyes and back sometimes to crest of disk; paranota wide, explanate or evenly reflexed, produced forward somewhat roundly but not beyond apex of hood; median carina high, highest opposite base of elytra; lateral carinae low, uniformly uniseriate, sometimes obsolete on all or anterior part of disk; posterior process long, acuminate.

Elytra widening from base, broadest apically, very slightly overlapping, tips divaricating, margins evenly rounded; costal area widest beyond discoidal, inner vein deeply sinuate; subcostal area usually as wide as discoidal, oblique, suberect, or bulbous; discoidal area raised tectiformly or bulbously with subcostal, sloping mediad to merge with sutural without distinct dividing vein; sutural area with cells becoming larger apically.

Generotype, *Stephanitis* (*Tingis*) *pyri* (Fabricius), 1803.

This very lacy genus somewhat resembles *Caloloma* in form of elytra but is easily distinguished from it by its anteriorly acute hood and low lateral carinae. It differs from both *Corythaica* and *Corythucha* principally in its lack of basal folds of paranota, and from *Gargaphia* in its laterally elevated discoidal area and uninterrupted rostral channel.

Horvath (1906) divided this large and somewhat confused genus into subgenera, only one of which, *Stephanitis*, is represented in the Western Hemisphere. The above description refers only to these western representatives. In North America there are four species of *Stephanitis*: *blatchleyi* Drake—Florida; *pyrioides* (Scott)—Holarctic region; *rhododendri* Horvath—United States and Europe; *translucida* (Champion)—Guatemala.

The widespread *pyrioides* is a pest of azalea, rhododendron and laurel, thus accounting for its distribution, as is also true of *rhododendri*.

GENUS *CORYTHUCHA* STÅL

1873 *Corythucha* STÅL, Enum. Hemip. 3:119, 122.
1918 *Corythucha* GIBSON, Trans. Amer. Ent. Soc. 44:74.

Head without visible spines; antennae rarely as long as hood and pronotum together, I much longer than II, III longest, thinnest, IV short, fusiform. Bucculae fused anteriorly (very short in *gossypii*); rostrum moderately long; rostral channel usually deep, with laminae foliaceous, composed of one row of usually very large cells, laminae contiguous posteriorly. Orifice either distinct or not. Coxae I much farther from II than II from III; legs moderately long. Hypocostal ridge uniseriate.

Pronotum with disk moderately to highly convex, shiny, finely punctate or smooth; calli, if not covered by hood, black and distinct. Hood somewhat globose posteriorly, narrower anteriorly, with apex sharply acuminate or blunt, extending forward at least as far as apex of antennal segment I. Paranota broadly expanded, roundly produced anteriorly, not as far as apex of hood, and posteriorly slightly over base of elytra; undulating at base and with basal fold at calli; margins evenly rounded, subparallel, spiniferous (Fig. 2c). Median carina foliaceous, either arched, sinuate, or of uniform height, complete to apex of long, acuminate posterior process; lateral carinae arising on or behind disk, foliaceous, curved and leaning outward, converging apically, gradually lowering until continuous with margin of posterior process.

Elytra somewhat rectangular, abruptly widened at base, margins parallel or slightly concave; costal area broadly explanate, sharply reflexed at base; subcostal area suberect, leaning outward from base, or oblique, outer cells smaller than inner ones; discoidal area usually not reaching beyond middle of elytra, margin indistinct mediad and caudad, raised tectiformly or bulbously laterad; sutural areas scarcely overlapping, broadly and separately rounded at apex (except in brachypterous forms); margins sometimes spiniferous.

Generotype, *Corythucha* (*Tingis*) *fuscigera* (Stål). 1862.

Despite the number of species in this genus there is remarkable uniformity among them and no subdivisions have yet been proposed. The spiny margins of paranota will immediately separate this entire genus from all other North American genera with the exception of *Acanthocheila* and *Caloloma*, the former of which has much larger paranotal spines and the latter has an oval hood and high lateral carinae.

Corythucha has the great majority of its sixty-three species in North America, with only twelve of its number endemic to South America. The following is a list of North American species: *aesculi* Osborn and Drake—Ohio, Illinois, Kentucky; *arcuata* (Say)—Arizona to Pennsylvania; *associata* Osborn and Drake—eastern United States; *baccharidis* Drake—Florida; *bellula* Gibson—Ohio, New York; *brunnea* Gibson—southern United States; *bulbosa* Osborn and Drake—Ohio, Maryland, Virginia; *caelata* Uhler—Pacific states and Mexico; *celtidis* Osborn and Drake—southeastern United States; *ciliata* (Say)—central and southern United States; *compta* Drake and Hambleton—California; *confraterna* Gibson—southwestern United States; *coryli* Osborn and Drake—Maryland and Virginia; *cydoniae* Fitch—entire United States; *decens* Stål—West Indies, Central America, Mexico, New Mexico, California; *decepta* Drake—Mexico, Guatemala; *distincta* Osborn and Drake—western United States and Canada; *elegans* Drake—New York, Wisconsin, Colorado; *eriodictyonae* Osborn and Drake—California; *exigua* Drake—North Carolina; *floridana* Heidemann—Florida; *fuscigera* Stål—Mexico, Guatemala, Arizona; *gossypii* (Fabricius)—West Indies, Central America, Mexico, southern United States, and Pennsylvania; *heidemanni* Drake—New York, Ottawa; *hewitti* Drake—Manitoba, British Columbia, Iowa, Colorado, Pennsylvania; *hispida* Uhler—California, Mexico; *immaculata* Osborn and Drake—western United States and Canada; *incurvata* Uhler—California, Arizona, Mexico; *juglandis* Fitch—central and eastern United States;

marmorata Uhler—entire United States; *mcelfreshi* Drake—Mexico; *mollicula* Osborn and Drake—Canada and northern United States; *montivaga* Drake—Montana, Wyoming; *morrilli* Osborn and Drake—West Indies, Mexico, southwestern United States; *nicholi* Drake—Arizona; *obliqua* Osborn and Drake—western United States; *omani* Drake—Arizona; *pacifica* Drake—Washington, California; *padi* Drake—northwestern United States, British Columbia; *pallida* Osborn and Drake—Ohio, Maryland, Virginia, Tennessee, Mississippi, Arizona; *pallipes* Parshley—eastern United States and Canada; *palmatis* Drake—Costa Rica; *pergandei* Heidemann—most of United States; *pruni* Osborn and Drake—eastern United States, Oregon; *sagillata* Drake—Arizona; *salicata* Gibson— Pacific states and British Columbia; *serta* Drake and Hambleton—Guatemala; *setosa* Champion—Guatemala; *sphaeralceae* Drake—California, Arizona; *spinosa* (Dugés)—Mexico, Cuba; *tuthilli* Drake—Colorado; *ulmi* Osborn and Drake—New York to Nebraska, Minnesota to Virginia; *unifasciata* Champion—Mexico, Guatemala, Panama. Varieties are not listed above.

The list of host plants for *Corythucha* is too long to be appended here. One striking feature of this list is the large number of trees included, in contrast to the herbaceous plants which predominate as hosts for the majority of tingids.

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