CHAPTER XVIII

INTRODUCTION TO CICADA PSYCHOLOGY

INTRODUCTORY

" He who enters on the study of animal behavior in the right spirit will strive to avoid both the narrowness of the laboratory worker and the superficial emotionalism of the nature-lover. That he will always adopt the proper attitude between these extremes is not to be expected of human nature, but it is possible to cultivate a critical and catholic spirit. If I decline to join the ranks of those whose only ambition is to describe and measure the visible movements of animals, and am willing to resort to a comparative psychology in which inferences from analogy with our own mental processes shall have a place, I do this, not because I believe that the former course would be altogether unfruitful or uninteresting, but because the latter seems to me to promise a deeper and more satisfactory insight into the animal mind."

WHEELER, *Ants*, 1910, p. 507.

IT has been often remarked that " all instincts centre about alimentation and reproduction, and that in these processes themselves we have the most typical instincts " (Wheeler, 1910). With this in view we are impelled to remark that the ancients, in contrasting the behaviour of the ant with that of the cicada were right with that innate rightness which is born of contact with the soil itself. Here is a contrast than which no greater exists in the comparative psychology of the insect world. Ants, with an adaptability and plasticity rivalling that of man, are dominant organisms pushing the tentacles of their colonization into every conceivable niche of terrestrial organic nature and adapting to their use food-stuffs of bewildering variety, the exploitation of which demands a complexity of behaviour only exceeded by that of man himself. Cicadas, on the other hand, morphologically specialized to subsist throughout a long life-cycle on one abundant and ever-present diet, the sap of plants, " toil not neither do they spin "—in the organismal battle with " refractory matter " they are little more than civilians. So far as their contacts with it are concerned the environment of the long nymphal instars is incredibly uniform ; that of the adults hardly less so. Cicada feeding, without even that element of complexity introduced by restricted food-plant preferences, is simplicity itself, " avec son rostre, fine vrille, elle met en perce une pièce de sa cave inépuisable " (Fabre). We shall not then expect any high degree of behaviouristic development associated with alimentation

in the cicades. Whatever is complex or interesting in their behaviour is more directly in the service of reproduction. The adults are devoted wholly to Apollo and to Eros, and the chief problem furnished by their activities concerns the rôle of the song.

THE SENSATIONS OF CICADAS

VISUAL

The large and protuberant compound eyes are among the most striking features of cicada anatomy, while the ocelli, as shown by the frequent enquiries of children concerning them, are considerably more conspicuous than in most other insects and often remind one superficially of the eyes of Attid spiders.

That cicadas have keen eyesight is shown by their dodging tactics when approached in full view. Unless too startled they will repeatedly sidle round the branch or stem on which they happen to be sitting, keeping always on the side opposite to the observer, even though occasionally the support is too narrow to hide the insect, even then, from view. This behaviour has been noticed in *Melampsalta cruentata*, *M. strepitans*, *M. cingulata*, *M. cauta*.

Apparently no experiments on the sight of cicadas are recorded, but the evidence from field experience is strong. A frontal approach to within striking distance is with most species a matter for extreme caution. Alarm is apparently indicated very soon, by cessation of the song. If, however, one stalks the singing insect in such a manner as to remain hidden from it by its support, one may make a great variety of noises at a distance of a foot, and even shake the branch on which it rests, without causing any change in the song nor other intimation that one's presence is perceived. Rapping of the support, however, causing a vibration which, probably, can be *felt* by the insect, produces not only cessation of song but immediate flight. This experiment has been performed on *Melampsalta strepitans*, and without the shaking, numerous times on *M. cingulata* (see also Potter, 1897).

A sensory reaction of a visual nature is seen in the attraction of cicadas to light. In our experience this is of very rare occurrence and has been observed only twice (*Melampsalta cauta* and *M. ochrina*). Moulton (1923), however, finds it a sufficiently abundant phenomenon in the Malayan subregion to be of value in collecting. In the Museum of the Boston Society of Natural History there is a female *Tibicen linnei* taken at light. Rendall (1897) has caught cicadas at light in Nyasaland and the West Indies, while other records include *Pycna antinorii* in equatorial Africa (Lethierry, 1880); *Dundubia* spp. in Java (Koningsberger, 1915); an undetermined species in Afghanistan (Hay, 1840); *Ioba leopardina* in South Africa (Marshall, 1897); *Melampsalta omar* in Sokotra (Ogilvie-Grant *in* Kirkaldy, 1903a); *Ueana dahli* in the Bismarck Islands (Kuhlgatz, 1905); *Proarna hilaris* and *Zammara* sp. in Porto Rico (Wolcott, 1923); species of Cicadatra and Melampsalta in Palestine (Haupt, 1927).

NOTE.—The belief of Aristotle and of Nigidius that cicadas are short-sighted or blind, was apparently based on observation of *Tibicen plebeia*, which seems, under certain circumstances, to lack the wariness so characteristic of most cicadas. The relevant passage in Aristotle as interpreted by Gaze, is as follows (*Hist. Anim., lib.* V, cap. 30):

"Si quis digitum contrahens, ac remittens subinde appropinquet, magis expectant, quam si ilico extendat; et quidem transire in digitur alliciuntur; quod enim oculis hebetes sunt, quasi frons aliqua moveatur, digitum ita admotum conscendunt."

Krumbach (1917) notices this behaviour in *Tibicen plebia*.

AUDITORY SENSATIONS

The experimental evidence that cicadas possess a highly developed sense of hearing is scattered and in places conflicting; but on the whole, cumulatively convincing. It has been greatly strengthened by the discovery (Vogel, 1922, 1923) of an extremely complicated chordotonal organ which is believed to serve this sense.

The denial of the ability of cicadas to hear was based largely on the supposed absence of a suitable organ, Swinton's (1877b) claim that the "mirror" formed an auditory tympanum having been almost entirely ignored. The chief positive evidence for such deficiency was found in the experiment of Fabre (ed. 1921, p. 264) who noticed that the song was not in any respect altered or disturbed by the discharge of two cannon beneath the trees in which the executants, probably *Tibicen plebeia* or *Cicada orni* or both these species, were perched.

The first published observation that cicadas are attracted by certain sounds is apparently that of Solier (1837, p. 214) who had the habit brought to his notice by Boyer, and confirmed the latter's observations. Solier's note is so interesting that we quote rather fully:

"Lorsqu'on entend chanter une Cigale, on s'en approche en sifflant d'une manière un peu tremblotante, à peu près comme elle, mais de façon cependant à dominer son chant. L'on remarquera d'abord qu'elle descend à reculons un petit espace de long de la branche où elle se trouve, comme pour se rapprocher du siffleur, et qu'elle s'arrête ensuite. Si on lui présente doucement une canne, en continuant toujours de siffler, elle s'y pose et redescend lentement, encore à reculons; elle s'arrête de temps en temps, probablement pour écouter, et finit enfin, attirée par cette musique inaccoutumée, à arriver jusqu'à l'observateur. De cette manière, mon ami en a fait placer une sur son nez, où elle continuait à chanter en même temps qu'il sifflait à l'unisson."

The cicada was *Tibicen plebeia*.

Abeille de Perrin (1896) remarks that the Provençal gamins are thoroughly familiar with this method, which, " est certainement traditionnel." Solier and Boyer were themselves Provençals. The boys " placent derrière l'insecte chantant une longue tige de roseau (*Arundo donax*) et sifflent un air quelconque qu'ils ont soin de ne pas interrompre."

The next account comes from Chili (Lataste, 1895a, 1895b) where also the method is apparently of juvenile origin. The species concerned is *Tettigades chilensis* (*Cicada rubrolineata*), and of this only males were found to be attracted. The procedure in this instance consisted in clapping the hands with a rhythm more or less similar to that of the song.

" Des vos premiers battements de mains vous les voyez venir voltiger autour de vous et s'abbatre en plus ou moins grande nombre sur votre personne. Là, parfois, elles reprennent leur chant ; mais, d'autres fois, elles se taisent et restent immobiles, comme hypnotisées " (1895a, p. 4).

The cicadas sometimes flew up as many as nine at a time. It was found that persons with white clothes or with a white cloth thrown over the shoulder, attracted more than those with dull-coloured apparel.

Lataste took up the problem in a scientific manner. He made a machine, which, with the aid of a watch movement, produced at will either sounds, more or less like those of the cicada, or silent but visible vibrations. This was designed to ascertain whether the insects were drawn to the sound or to the movement ; but unfortunately they remained entirely insensible to this instrument.

He then had an assistant clad in obscure vestments hide under the bushes and clap his hands, while the author, dressed in white, stood in the open and made the same motions silently. A cicada flew at once to the aide and perched on the bush which hid him. But on the aide ceasing to clap, and Lataste clapping himself, the cicada flew at once to the latter. Lataste concludes :

" De l'ensemble des observations qui précèdent, je crois pouvoir conclure que la Cigale, accourant au battement de mains (ou au chant d'un autre individu de son espèce) se rend au bruit, les indications de la vue n'intervenant qu'après coup et seulement pour préciser celles de l'ouïe."

He believes that the song acts as a signal to both sexes, attracting them as to a rendezvous, where the one may find the other.

Giard (1895) remarks on Lataste's communications made to him by letter and discusses the question whether insects really hear, or merely feel vibrations. He decides, with Pierre Bonnier and other physiologists, that no invertebrates " ont le sens des perceptions

musicales," but instances the classical case of the cithara-contest between Eunomus and Ariston, when a cicada lit on the broken string of the former's instrument, and commencing to sing, gave him the victory (see Chapter II for an account of this contest).

Giard goes on to cite Moufet (1634) concerning the excitement produced in cicadas by groups of labourers " bavardant " and singing during their midday rest. He further mentions that according to Semon " cucuyos " in South America are attracted by hand-clapping, and suggests, we believe entirely without plausibility, that these cucuyos are " les Fulgores."

Horváth (1896a) was concerned to test on *Tibicen plebeia* in Southern Austria (Fiume) Lataste's Chilian experiments. Under the stimulus of hand-clapping this species was found to behave exactly as under that of whistling as reported by Solier, with whose work neither Horváth nor Lataste was apparently familiar. Moreover, the European species proved " si impressionée qu'on peut même modifier un peu le rythme de son chant. J'ai observé plusieurs fois qu'en laissant des intervalles un peu longs entre les battements, la Cigale émettait simultanément trois ou quatre accords avec des intervalles exactement aussi longs."

The effect on *Tibicen plebeia* remained the same even when the experimenter was hidden behind the trunk of the tree.

Cicada orni required much more patience to make it descend.

Annandale (1900) and Skeat (1900) describe a regular practice among the natives of the northern portion of the Malay Peninsula. For half an hour after sunset several men gather round a brightly burning wood fire, one of them holding a lighted torch. The others clap their hands at regular intervals, and the cicadas, **Pomponia intemerata** (Walk.), apparently attracted by the noise and guided by the light, fly down and settle upon the people as they stand by the fire. Annandale was at pains to ascertain whether possibly it was only the light which drew them, but upon his ceasing to clap, only one settled on his own coat, and ten on that of his friend who kept up the noise. Attempts later in the evening were unfruitful. The attracted cicadas filled the scene with the noise of their stridulating added to that of the hand-clapping.

The children are said to have a game (Annandale) in which cicadas are called to them without the aid of light at all ; but they sing, as they clap, a nursery chant calling on the insects to come from the trees.

Fruhstorfer (1902) describes a " cicada-clapper " made of a split piece of bamboo which is used by the Siamese for the same purpose.

Swinton (1880, p. 228) states : " Carriage bells evoke snatches of recital from *Tibicen plebeia*, *Tibicina haematodes*, and *Cicada orni*," even after the close of their diurnal activity.

Pead (1910) notices that in the Transvaal *Platypleura stridula*

is attracted by the noise of a circular ripsaw. The males call loudly as though in rivalry with the instrument.

Gadd (1908b, p. 144) quotes an oral communication from the well-known Russian Hemipterist, Oshanin, that in Turkestan cicadas are attracted to the post-wagons by the noise of the bells on the horses' harness.*

Finally Leydig (1902, p. 112) instances the effect on *Tibicina haematodes*, of a military drum.

"Wenn bei Würzburg die Trommler der Garnison auf ihrem Übungsplatz wirbelten, sich der Chorgesang der Cikaden in den benachbarten Weinbergen zu einem Heidenlärm steigerte, doch sofort wieder verstummte beim Eintreten einer Pause von Seiten der übenden Trommler."

Iris Myers (15 December 1921 ; unpublished note) found that a male of *Melampsalta cutora* confined in a small box made vigorous efforts to escape, but became quiet eventually. In the evening, whenever its song was imitated by whistling, it began again to flutter inside the closed box.

We shall show later that a number of species, especially in New Zealand, *M. cingulata*, sing in chorus—an accomplishment which presupposes the ability to hear.

From the above observations, made on a considerable number of cicada species in different parts of the world, we may legitimately conclude that cicadas hear. Vogel (1923 ; also our Chapter V) has suggested from the varying lengths of the scolopales in the auditory organ of the cicadas that these structures may, in a way analogous to that of the fibres of Corti in the human ear, give to the cicada a definite power of sound-analysis ; but since the variation in length is less than that observed in the human structures, the range of hearing in cicadas is probably less than in men. This would explain the great specificity displayed by cicadas in their attraction to sounds and their indifference to noises of a lower pitch than that of their song. We are now in the midst of so many "ifs" that we are tempted to add one more and to suggest that the sound-organs of every species are attuned especially to the song-notes peculiar to that species.

In a later section we shall see that considerable evidence for such hypotheses is to be adduced from a consideration of the behaviour of the two sexes.

OTHER SENSATIONS

In dealing with the sense-organs of cicadas we have seen that while the most highly developed are the eyes, ocelli and auditory

* In this connection a quotation by Burton (*Anatomy of Melancholy*, Vol. III, p. 229, edition 3 vols., Lond., 1886) from Calcagninus is interesting : "Bees, . . . though they be flying away, when they hear any tingling sound, will tarry behind."

organs, there exist also supposed tactile hairs at the tip of the labium in nymph and adult, and a number of rather specialized sensillae on the under surface of the flagellar segments of the antennæ. The latter are considered by Berlese (1909) to be olfactory, but we have no experimental evidence as to their function in Cicadidae. The antennæ are relatively poorly developed, while the sensory pits themselves are very much more primitive than the complex corresponding organs in some other Auchenorrhyncha, notably the Fulgoroidea. We are therefore justified in assuming that the sense served by the antennal organs is a relatively unimportant one in the cicada economy.

The sensations of cicadas may then be arranged in the following order of intensity :

visual, auditory

tactile, olfactory

Thus it appears that from a functional point of view the sensory equipment and probably the sensations of cicadas are more like those of man than are those of most other insects whose behaviour has been studied. Faced with the manifestations of a necessarily incomprehensible contact-odour sense in ants, the observer is inevitably more or less at a loss. The simpler, or rather more familiar type of sensory equipment seen in the cicadas may lead to a greater risk of anthropomorphic interpretation ; but surely also to a possibility that such an explanation is less radically wrong.

Ashton (1924), having caught an emerging *Tettigarcta*—the primitive soundless cicada—and taken it to his hotel, found several more specimens of this rare insect in the room "possibly attracted, as some insects are known to be, by emanations of scent which attract the opposite sex." The sex of none of the examples is noted, but the visitors came during dusk or darkness and we think were more probably attracted by light.

CHAPTER XIX

THE BEHAVIOUR OF CICADAS

WE have seen from the foregoing that the sensations of cicadas are predominantly visual and auditory, and that their sensory equipment is, in these two directions, very highly developed. It remains to discover what part is played in the life of the organism by these and lesser elements of the peripheral nervous system.

NYMPHAL BEHAVIOUR

The behaviour of the nymphs on hatching shows every sign of purely instinctive activity. Snodgrass (1921b, p. 408) has well-remarked an interesting reversal of instinct in the newly-hatched young.

"The creatures are too small to be followed with the eye as they drop, and so their actual course and their behaviour when the ground is reached are not recorded. But several hatched indoors were placed on loose earth packed flat in a small dish. These at once proceeded to get below the surface. They did not dig in, but simply entered the first crevice that they met in running about. If the first happened to terminate abruptly, the nymph came out again and tried another. In a few minutes all had found satisfactory retreats and remained below. The avidity with which they dived into any opening that presented itself indicates that the call to enter the earth is instinctive and imperative with them once their feet have touched the ground. See, then, how within a few minutes their instincts shift to opposites. On hatching, their first effort is to extricate themselves from the narrow confines of the egg nest. It seems unlikely that enough light can penetrate the depths of this chamber to guide them to the exit, but once out and divested of their encumbering embryonic clothes they are irresistibly drawn in the direction of the strongest light, even though this takes them upward, just the opposite of their destined course. But when this instinct has served its purpose and has taken the creatures to the port of freest passage to the earth, all their love of light is lost or swallowed up in the call to re-enter some dark hole, narrower even than the one so recently left by such physical exertion."

As Marlatt (1907, p. 112) has observed, the young nymphs

deliberately loose their hold of the branches and drop to the ground, be it many feet below. In the littoral species, *Melampsalta leptomera*, we have seen the insects actually burrowing in the sand, and thus disappearing from view with great celerity, but as both Marlatt and Snodgrass remark, there is a tendency to choose a crevice or to descend at the side of a plant stem.

Very little is ascertained of the behaviour of nymphs underground. Judging from captive examples of *M. leptomera* there are intervals of wandering and burrowing through the soil and periods of rest in smooth-walled cells excavated round a favourite sucking point on the root of a plant. The eyes are unpigmented and probably not functional, but the antennæ are much larger than in the imago.

In Chapter X we have described the peculiar towers of mud pellets constructed by the last instar in *M. septendecim* and in Burmese *Pomponia*, and others, apparently as waiting-places preparatory to emergence. The subject is, however, obscure. Snodgrass (1921b, p. 382, fig. 1) describes chambers apparently serving the same purpose in more normal individuals of *M. septendecim*. These are subterranean, but separated from the air by about a third of an inch of earth which forms part of the original surface. Fabre has found a similar practice in a European species and there is a possibility that it is widespread throughout the family. Froggatt (1896) has, however, several times discovered a single nymph under stones, enclosed in a stout clay cell, at the base of which was a small reservoir of water.

The emerging nymphs, now equipped with well-pigmented eyes and functional fore-tarsi are apparently driven by an urge to climb. We have already noticed a case in which numerous nymphs of *M. septendecim* were said to direct their course through long grass towards the invisible stumps of a tree which had been cut down during their development underground (Claypole, 1883).

Apart from the above isolated and unconfirmed story, there is nothing so far observed in the behaviour of the nymphal stages to indicate any other element than one so simply instinctive as to be almost explicable by the theory of tropisms.

ADULT BEHAVIOUR

As oviposition, "sleep," attraction to light and to sounds and feeding-habits have been already described, there remains as the chief subject of the following paragraphs the behaviour of both sexes in relation to mating and to song.

We must first, however, mention a habit very rare in Cicadidae but well-developed in one or two species. Most cicadas, when disturbed, show themselves among the most wary of insects, taking to flight with disconcerting celerity. Among the New Zealand

forms, however, *Melampsalta leptomera* "feigns death" in the approved fashion, folding wings and legs and dropping to the ground, to lie motionless upon its side. In one instance five examples —3 males and 2 females—all acted in this way as did a number of others found on the same day (31st December, 1923). In fact only one specimen refused to behave thus. This was a female which began to flutter violently as soon as the marram-grass clump was disturbed. On other occasions it was found that a singing male would fly when an attempt was made to catch it, but those reposing in the depths of the marram tufts invariably dropped motionless to the ground, even in hot and clear weather, immediately the clump was disturbed. The effective stimulus is possibly the contact of the adjacent stems, when the culms are roughly parted, rather than an auditory one. If this be so, then support is given to Holmes's (1903) theory that the death-feigning instinct has a thigmotactic origin. The same authority claims that in all invertebrates a contact-stimulus is essential to the feint. This would certainly appear to be the case in *Melampsalta leptomera*. Whether the other cicadas which are usually more "wary" would behave similarly could they be administered a contact-stimulus is difficult to ascertain. Annandale and Matsumura (1907) describe *Huechys sanguinea*—a red and black, evil-smelling form, as lying perfectly motionless in the bottom of the net. Most other cicadas, of course, flutter with great violence under such circumstances.

Scott (1852) remarks that *Cystosoma saundersi* is made to drop to the ground by shaking the bough on which it is singing; and may then be picked up. Froggatt (Goding and Froggatt, 1904, p. 660) makes a similar observation concerning the allied *Chlorocysta vitripennis*, while *Mardalana congrua* (*Chlorocysta macrula*) is said to be sluggish and easily captured in the daytime. *Platypedia vanduzeei* occurs on low plants and drops to the ground when disturbed (Van Duzee, 1920a, p. 117).

Gadd (1908b) describes what appears to be a death-feint in the grass-frequenting species, *Cicadatra querula*, *C. atra*, and *C. hyalina*. If disturbed they slip into the grass and remain motionless, but if then taken into the hand they begin to move. Our *Melampsalta leptomera* will allow itself to be rolled sometime in the hollow of the hand before stirring a leg.

Lyle (1911) netted one female of *Melampsalta montana* which lay quiescent, with folded wings. We do not know how general the habit is with this species. With the exception of *M. montana* all the species of which this behaviour has been recorded frequent herbage or low bushes.

The sound-organs of cicadas are used not only for the sustained musical performances which have rendered these insects famous, but also for ejaculatory purposes which may first engage our attention. Most cicadas when caught emit a discordant and often piercing note

which may be justly described as a "shriek" or a "squawk." Detained in the net, in the hand or in the beak of a bird they will often keep this up for a considerable time. *Huechys sanguinea* alone is recorded (Matsumura, Annandale) as uttering no sound when captured. Yet of this species Mr. Muir informs me that it "shrieks" when captured by king-hunters.

This alarm cry is highly characteristic and almost irresistibly suggestive of terror. It is entirely different from the song of the same species. A similar short, sharp note is uttered by some species when, on too near an approach, they take to flight. Gadd (1908a) observed that *Cicada orni*, *Cicadatra hyalina*, and *Tibicen plebeia* all emitted a special note as they took flight.

The true song is almost always delivered from a position of rest, usually perched in the sun, on the trunk of a tree, or the surface of a rock, according to the species. In exceptional cases of brilliantly hot weather, *Melampsalta sericea* will sing even from the surface of a road. The association between singing and sunshine is usually very close, but *M. scutellaris* will perform in the densest shade, and *M. cruentata* in the depths of a rush or grass clump quite out of sight. *Okanagana vanduzeei* sings just within the mouth of its hole (Van Duzee, 1914b).

If disturbed to a slight extent, *M. cingulata* will continue to sing while crawling on the tree-trunk, progressing usually backward. Gadd (1908b) has noticed the same habit in *Cicada orni* and it is characteristic also of *M. strepitans*. A captive *M. leptomera* used to sing continually while crawling about its cage.

Actual singing in flight is extremely rare and has never entered our experience. Moulton (1912a) mentions a species of *Maua* which was heard on one occasion to continue its song for a few moments in flight, while Kuhlgatz (1905) on the authority of Dahl, states that *Ueana dahli* in the Bismarck Archipelago, is silent when perched, but sings on the wing. Pead (1910) finds that in the Transvaal, *Taipinga consobrina* male is very active before the emergence of the female, *singing only on the wing*, or seldom or never at rest. After the females have appeared the males sing stationary. Esaki (1922) has recorded that *Melampsalta sachalinensis*, in the far north of the Japanese Empire, often sings in flight.

Cicadas are essentially diurnal—the maximum activity and especially the singing of the majority of the species occur during the hottest hours of the day. When a cloud momentarily obscures the face of the sun it is frequent for many species, especially those which sing in chorus, to cease their song till all is clear again. Howard (1905, pp. 337–339) describes somewhat similar results on Orthopteran song and quotes Scudder to the effect that *Scudderia curvicauda* has a day tune and a night tune. When a cloud passes over the sun all the insects in the vicinity change immediately to the night song, to resume the diurnal notes just as suddenly when the cloud has gone.

Milde (1866, p. 12) notices that cicadas cease singing under a dull sky and remarks that wet weather renders their sound-organs unusable—a naive explanation. We have found *Melampsalta muta, ochrina, cauta, scutellaris*, and *cingulata* all singing in actual though warm rain.

Gadd (1908a) notes that *Tibicen plebeia* begins to sing about 8 a.m. in the Crimea, but if the temperature be high it may commence two hours earlier. These observations agree with those of Fabre on the same species in the south of France.

Some species sing only or chiefly at dawn and sunset, e.g. *Quesada gigas* in South America (Delétang, 1919, p. 39); while the Bornean *Pomponia imperatoria* begins its exceptionally loud note in the evening with such regularity that the Malays (Beccari, 1904, p. 11), call it the "6 *o'clock cicada.*" Curiously enough, according to im Thurn (1883) in British Guiana an undetermined cicada is there also known as "Six o'clock" from a similar habit.

Melampsalta cingulata in New Zealand begins to sing usually just before dawn. This is our largest New Zealand species, with a habit of singing distinctly in chorus and producing a noise compared by the Maori with the crackling of a reed fire. The sound swells as the first rays of the sun strike the tops of the beeches, until soon the whole forest is blazing with light and with sound. I. H. Myers has an interesting note on the preliminary "tuning-up" of this species. At 3.40 a.m. a number of cicadas was emitting not the usual song, but a short, scratchy interrupted note "as if making repeated attempts to strike the right key."

In New Zealand the songs usually cease at dusk or some half-hour after sunset, reminding one of the poem by an unknown Japanese poet quoted by Hearn (1900):

> Lo! on the topmost pine, a solitary cicada
> Vainly attempts to clasp one last red beam of sun.

We have, however, a number of records of singing at night. Sometimes (*Melampsalta scutellaris*) there will be a sudden outburst —two phrases of the normal song—then silence again. This is quite distinct from the cry of alarm indicating seizure by some nocturnal enemy (Fabre). We have heard *M. muta* singing its accustoned song in bright moonlight at 10 p.m. in February.

M. cauta is usually the last to cease singing in the evening, and we have even heard its note after darkness has fallen.

In South Africa *Ioba leopardina* is reported to sing at night occasionally (Pead, 1910), while Johnston remarks the same of an undetermined species in equatorial Africa (1886, p. 222). According to Scott (A. W., 1852) the Australian *Cystosoma saundersi* sings only in the brief twilight and occasionally in day time, in hot sultry weather just before a thunderstorm.

Davis (1894a, 1894b) states that *Tibicen linnei* will sing on warm nights. Hueber (1903) found in Germany that *Tibicina haematodes* sings sometimes in still, warm nights. Milde observes the same in unspecified forms in the Tyrol (1866).

Hopkins (1898) thus describes a midnight chorus of *Magicicada septendecim.*

"One male in an apple tree near the house suddenly called out as if disturbed or frightened. His neighbours in the same tree were thus apparently awakened. One started the familiar song note, which was at once taken up by numbers of other males, and, like the waves from a pebble dropped into still water, the music rapidly spread until it reached the edge of the thick woods, where it was taken up by thousands of singers, and the concert was in as full blast as it had been the previous day. This continued a few minutes, until all had apparently taken part, and the song had reached its highest pitch, when it began to gradually subside, and in a short time silence again prevailed."

St. George (1920) and McAtee (1921) record similar cases.

Delétang (1919) on one occasion heard both *Quesada gigas* and *Fidicina opalina* singing vigorously on a warm moonlight night, "hasta que, desaparecida la luna, todo entró en silencio," a remarkable observation to be compared with the notes on cessation of song when the sun is obscured by a cloud.

All the foregoing records of cicadas singing during the night are recognized by the observers concerned as exceptional, save only the case of *Cystosoma* which is apparently a truly crepuscular species. *Tettigarcta* also is probably entirely nocturnal since Ashton (1924) found it flying only at dusk, and hidden during the day beneath bark, in a very moth-like manner.

Annandale (1900), however, would seem to indicate that a considerable number of the Malayan species sing at night, while Moulton (1923) mentions the frequency with which they are taken at light, like moths. Annandale speaks of a tremendous din which commences soon after dark and is produced largely by the smaller cicadas, like *Pomponia intemerata.*

Banks (1904) remarks that Philippine cicadas "almost invariably reserve their serenade till the falling of darkness."

St. George (1920) has made observations on the relation of temperature to song in *Magicicada septendecim.* He found that adults began to sing when the temperature reached 60–66° F. Continuous concerts were heard only on nights when the temperature was high, e.g. on two successive occasions, 62–74° F. McAtee (1921) confirmed this at the same time.

In New Zealand it appears clear that time of singing is influenced by illumination and by temperature; for while there are practically no songs in the dark

"and they are more vigorous on bright days, yet when a cold wind

blows from the sea or the mountains, as occasionally happens in summer, the cicadas are silent, except in sheltered places, however bright the day. For instance, on a certain February morning, choruses of *M. cingulata* began suddenly at 4.5 a.m. in the bright moonlight preceding the dawn. By the time the sun rose at 5 a.m. the bird-songs could scarcely be heard above the hissing and cracking. . . . On the following day, after a sudden change in the weather and a much cooler night, there was no singing until 7.30 a.m., and then only on the hillsides in the full sun. On cold, dull or rainy days we hear no songs, though, if the weather is warm, there is practically no intermission on a dull day, and not much more on rainy days except during very heavy showers, when the songs cease. It is on clear, late midsummer days that the noise is at its height ; but if a sudden sharp wind arises, or a cloud temporarily obscuring the sun makes the air cooler, the effect is immediate : the songs die away and silence prevails, save for the belated chirp of some tardy individual, who soon perceives the change in the weather and ceases his tune " (Iris Myers and J. G. Myers, 1924, pp. 421–422).

In the only case in which we were able to make observations in this matter, it was found that the first notes of a newly-emerged adult (*M. leptomera*) were markedly different from the normal song of the species. The first song differed in rhythm—irregular and varied groupings of the notes, and in a " tentative " placing of the accents. It was uncertain and faltering, broken occasionally by staccato notes. This gave place to an intermediate form, with a rhythm of triplets very pronounced, a varying number of triplets being followed by an accented staccato note and then further triplets. Later in the same morning the insect achieved for the first time the typical song of the species, but still later occasionally reverted to the intermediate variation.

Besides the characteristic abdominal sound-organs there are, as we have seen, in the subfamily, Tettigadinae, two stridulatory surfaces on the mesonotum. The operation of these has never been observed in nature, but they are apparently rubbed by the bases of the tegmina. A third subsidiary method of sound-production calls for comment before we pass to the rôle of the song. This is the " wing-clicking " so noticeable in *M. cingulata* and its relative *M. strepitans*, and probably referred to in *Magicicada septendecim* by McAtee (1921) where he remarks :

" Another common note produced by the cicadas is a clicking note. It is given rapidly and the end of the abdomen of the insect is depressed with each click ; one individual I noted lifted the wings and swiftly depressed them at each emission of the sound. The note is quickly taken up by nearby cicadas and a clicking chorus is soon under way."

Similarly in the Transvaal *Taipinga consobrina*, Pead (1910) remarks, in addition to the chirp, a quite different sound—a click repeated five or six times in rapid succession, and, he suggests, produced by " wings and legs as in many Orthoptera." Davis (1919b, p. 207) records an apparently similar wing-noise in *Okanagana canadensis*.

In *M. cingulata* and *M. strepitans* we have observed that this clicking is produced almost certainly by the wings, and since *it is effected by the female as well as the male*, it cannot be associated with the usual sound-organs.

We are now in a position to review the evidence for a connection between the song and the assembling and mating of the sexes.

On the basis of the following observations, Darwin (1871, pp. 350–352) drew evidence for his sexual selection theory from the behaviour of the cicadas.—Hartmann in *Magicicada septendecim* " observed the females coming around the drumming males " ; while in *Tibicen pruinosa* he " several times noticed the females to alight near a male while he was uttering his clanging notes."

Darwin goes on to say :

" Fritz Müller writes to me from S. Brazil that he has often listened to a musical contest between two or three males of a cicada, having a particularly loud voice, and seated at a considerable distance from each other. As soon as the first had finished his song, a second immediately began ; and after he had concluded, another began and so on. As there is so much rivalry between the males, it is probable that the females not only discover them by the sounds emitted, but that, like female birds, they are excited or allured by the male with the most attractive voice."

Such is the first evidence for and first statement of, a very important explanation of cicada song.

Hudson (1920), a staunch supporter of the sexual selection theory in its original connotation, observes New Zealand cicadas and remarks :

" The singing is undoubtedly attractive to the female, and close observation of the insects . . . often discloses the fact that the keenest rivalry exists between two or more males to captivate a female by means of their music. It is impossible to assign any other use to these complicated organs, and the instinct to use them, than that here indicated.

Potter (A.T., 1897) observing some of the same species—probably *M. cingulata*—was convinced that the females seek the males. He watched a solitary male singing and saw another cicada advance from another part of the tree with slow, jerky gait, stopping now and then, passing and repassing the singer, and finally resting beside him. In all such cases the visitor proved to be a female.

When females were near, a singing male often became restless, walking backwards, forwards, or sideways, and giving a sharp flutter of the wings as though to attract their attention.

Marshall (1896) makes observations on certain species in Mashonaland which are word for word so similar to those of Potter just quoted as almost to suggest that the former had copied them from Marshall. The latter comments :

" that these performances are intended for the female is well illustrated by an instance I saw only yesterday. A male cicada was singing on a small branch, and on another parallel branch about six inches away was a female. When I first observed him, the former was sitting quite still, but he gradually worked himself up, and began walking up and down and all around his branch, occasionally giving a sharp flutter with his wings ; but the female remained impassive. He got so excited that on three occasions he even took short flights of a few feet from his branch. I watched with interest to see if he would settle on the other one. But no ; in each case he returned to his own and recommenced his serenading which seemed to me significant. The female eventually got tired of him and adjourned to a neighbouring tree ; whereupon he became quiescent, though he still continued calling. . . .

" One day I came across a most unusual concourse of one species, there being about sixty specimens on a single small bush. With one sweep of the net I caught two males and five females, and I then stood for a few seconds watching where the remainder were settling. Meanwhile the two males in my net were screeching vigorously, and I noticed two cicadas fly round successively and settle momentarily on the net. These I marked down, and on catching them found them to be both females."

Swynnerton (1922) and Loveridge (1922) describe the courting of *Monomatapa insignis* in Tanganyika Territory. The former writes :

" I saw the cicadas courting also on vertical twigs though the horizontal position was much more usual. The male always headed in the same direction as the female. The stridulation was distinctly to charm the female into acquiescence, for the male continued it steadily, his whole body vibrating, until at last he came round and gently attempted copulation. . . . In one case definitely I noted two males courting one female, the three of them shoulder to shoulder round a small vertical twig, and both males calling simultaneously—as was evident from the strong vibration of both. On the female's flying off, as she did after I had already seen her sex, the males continued to call and in doing so moved opposite each other into the position usually taken by a courting pair. I did not see females coming to calling males."

Pead (1910) in the Transvaal, after describing the clicking sound subsidiary to the song in *T'aipinga consobrina*, describes

" a male on the ground within half an inch of a female, courting his mate by producing this click repeated a large number of times . . ." The " females appear to be discovered by the males as soon as they emerge ; for when I have found the female and male together, on each occasion I have found the nymph-case from which the former has emerged within a few inches ; also she is sluggish and inactive, and may easily be taken in the hand . . . As many as fifteen males may at times be counted within a foot or two of a female, all competing by their call for her favours ; but two or three will be found in quite close proximity to her, within an inch or two."

Mr. Wm. T. Davis writes (*in litt.*, 18 December, 1925) :

" I can state that I have seen cicadas fly to a singing individual of their kind. If a male flies to a singing male, as they do sometimes, one male will butt the other."

From the Crimea comes a description of similar behaviour on the part of (?) male cicadas.

Gadd (1908b, p. 142) sometimes saw two or three *Cicada orni*, near together, maybe in feeling of jealousy, begin to fight with the fore feet, beating one another on the back. (Close translation by Mr. Christoff.)

Turning now to recent work on the New Zealand species, we quote first an observation sent by Miss Marion Shaw (24 February, 1922) of Auckland, with a female *M. cingulata :*

" When I caught it, it was answering a male cicada. The female makes a noise like a clock ticking [wing-clicking]. I was listening to it calling to the male when suddenly the male cicada came and alighted at the female's side. . . . The female called the male ; because the male was a little distance away singing, the female did not answer it for a good while, and when it had been answering, the male flew to the female, and then I tried to catch them both, but only caught the female." (Miss Shaw was only about twelve years old when this observation was made. We reproduce her note and interpretation exactly.)

To cut a long story short, we have, firstly, found it to happen very frequently in all the commoner forms, on tracing a male by its song, to find closely adjacent, a female of the same species. In the case of *M. subalpina* we counted this to occur in 75 per cent of the captures. Secondly the respective behaviour of the sexes as described in so many citations above—the females fidgeting, wing-flapping, wing-clicking or passing and repassing singing males, has been repeatedly confirmed in *Melampsalta muta*, *M. cingulata*, and *M. strepitans*. Sometimes the female is impassive as in

Monomatapa : thus in *M. cingulata* a male was singing some six inches from a female. He approached, and receded, still singing. The female flew away ; the male continued to sing. In respect to another species, *Melampsalta muta*, we select the following note :

" Male singing round about female, in a dozen different positions all in about same radius of female, the male seeming very restless. A few yards away another pair was behaving similarly. The female flew away and immediately the male alighted on the spot she had left."

More often the female was the restless one. We select a few cases :

(1) A *M. strepitans* was seen on a bare log in a prominent position in full sun pawing as it were with its tarsi but not singing. It was watched closely for several minutes. About the middle of the period it clicked its wings slowly and audibly four times at the same rate as the wing-clicking which accompanied the song of the male. The insect was caught and found to be a female. A male was singing nearby but had ceased on our approach.

(2) A male *M. cingulata* was singing on a *dead* karaka trunk, alone. Suddenly a female flew up and alighted about four inches below him. He continued to sing in very much the same place. She moved quickly *down* the trunk some two feet, walking directly backward—then up again—sometimes with a little sideways sidle. This went on for a quarter of an hour. Then the female rapidly approached to within two inches. As she did so the male stopped wing-clicking but continued singing. When she was closest the male rapidly crawled some inches further up the trunk. The female crawled down backward after a few minutes and finally flew away 25 minutes after first alighting.

(3) Two *M. sericea*, a male and a female, were perched fairly high on a telegraph post. The male was singing vigorously. The female was still or occasionally crawling slowly around in close proximity to the male.

To sum up, it appears that cicadas of many different species observed in many parts of the world exhibit behaviour which is essentially similar and which seems to indicate some connection between singing and mating. In seeking to compare this behaviour with that of apparently soundless Homoptera we are at a loss for observations. Almost the only one is that of Buckton (1890, I, p. XVII) on **Cicadella viridis** (Jassoidea) :

" The male *Tettigonia* (*viridis*) assiduously follows the female, keeping at a respectful distance of perhaps half an inch behind her. He chases her up and down the stalks and appears to be very attentive in courtship."

In those other singing insects, the saltatorial Orthoptera, there are numerous descriptions of " courtship " associated with song, notably in the work of Scudder* and of Fulton. The former describes what appears to be answering stridulation between the sexes in *Melanoplus femur-rubrum*, as does also Folsom (1906, 105–106) in the katydid, *Microcentrum laurifolium*. We have seen that *Melampsalta cingulata* and *M. strepitans* females are able to make a wing-clicking sound like that of the males, while the members of the subfamily Tettigadinae possess a special accessory stridulating organ common to both sexes. There is some evidence that the male is attracted by the female's wing-clicking in the two above New Zealand species. To compare with the converse, where the female is apparently attracted by the song of the male, we may instance the behaviour of **Liogryllus campestris** (L.) as experimentally investigated by Regen (1912). The author by the most ingenious and controlled employment of phonograph records of the song, and of males enclosed in various ways, with females in which the auditory organ had been destroyed in the last nymphal instar, and with females possessed of all their faculties, proved conclusively that the song serves to attract and to orientate the female towards the male.

One of the most obvious analogies of cicada music lies in the songs of birds, concerning the rôle of which several theories are in the field. We shall briefly discuss these with reference to their applicability to cicada music. There is firstly the sexual selection theory in its original connotation, stressing above all an active choice on the part of the female, with the assumption of an æsthetic element. At the opposite extreme is the " joy of life " hypothesis to which Fabre subscribes in a striking passage (ed., 1921, p. 265) :

" Est-ce que l'insecte a besoin des effusions retentissantes, de ces aveux loquaces pour déclarer sa flamme ? Consultez l'immense majorité, que le rapprochement des sexes laisse silencieux. Je ne vois dans le violon de la Sauterelle, dans la cornemuse de la Rainette, dans les cymbales du Cacan, que des moyens propres à temoigner la joie de vivre, l'universelle joie que chaque espèce animale célèbre à sa manière."

In quoting this same passage Berlese (1912–25, II, p. 462) remarks :

" Non la gioia di vivere ma è : *Amor che all' uom musico farsi insegna*. Probabilmente ogni espressione musicale non e altre che l' alta affermazione, in faccia a tutto il mondo, della maturanza genitale."

Modern workers, and notably Julian Huxley, present another explanation for those dances and posturings of Phasianid,

* S. H. Scudder, 1893. " The Songs of our Grasshoppers and Crickets " ; *23rd Ann. Rept. Ent. Soc. Ontario* (1892), 62–78.

Limicoline and other birds and of attid spiders which constitute the strongest experimental evidence for the sexual selection theory as originally stated. They believe that the sight of such acts excites in the female the emotion appropriate to the consummation of mating.

Finally, the work of Eliot Howard (1920)—a monument of patient observation—throws great light on the phenomena of song in the Passeres which are the song-birds *par excellence*. This observer believes that the male of practically every species repairs first in spring to the nesting area, which is nearly always different from the winter feeding grounds, and having pegged out as it were a claim, defends it from all other males of the same species, at the same time by his song advertising to them that the place is occupied, and to the females that a sexually mature male with a nesting territory secured is eligible for matrimony. This explains the continuance of song after the mating, or even nesting, and in migratory species the singing of the males long before females arrive in the neighbourhood.

This " territorial " theory of Howard, combining as it does several features of previous hypotheses and adding a conception, that of territory, based on the closest observation, indicates the direction in which progress will probably be achieved.

All the above theories include elements and aspects of truth. Some are more true for some groups of animals than for others. All break down as soon as fanatical exponents seek to apply any one of them *in toto* to all the phenomena of courtship. Julian Huxley has shown that the territorial factor is of far less importance in these species with precocious young. The essence of " territory " lies in the need for a pegged-out claim in close vicinity to the nest, to supply food for young which must be tended for a long, naked period in the nest, by parents which are often greatly over-worked. In birds with precocious young the parents are absolved from such duties and the emotional element in courting procedure takes precedence, and becomes, as in the grebes, penguins, etc., more nearly reciprocal not only in physiology but in outward behaviour.

The concept of territory can hardly apply at all in the case of the cicadas, and here, as we have seen, reciprocal " courting " may also take place as in the birds above-mentioned.

In conclusion, we would present the following provisional hypothesis for the phenomena of song and mating in cicadas.

Firstly, we may assuredly believe with Fabre, that the song is an expression of " la joie de vivre," just as we may agree that " the morning stars sang together, and all the sons of God shouted for joy." But such an affirmation no more constitutes a scientific hypothesis than Job's poetry expresses an astronomical fact.

We have seen that cicadas are highly specific in their choice of perching-places, whence the male pours forth a song which in its

character, is always closely peculiar to the species concerned. We think firstly with Lataste that the song serves the purpose not only of attracting females to males, but also of drawing together individuals of both sexes for mating.

There is considerable experimental evidence for such a conclusion. Cicadas feed on the sap of plants and are apparently never restricted to specific food-plants. There would seem to be room for a device to bring individuals together, for cicadas are not abundant insects: we must not be misled by the exceptional swarms of the periodical cicada; cicadas are, moreover, not conspicuous, but usually very much the reverse. If it is asked why the cicadas should be furnished, for assembling purposes, with the most complex sound-producing apparatus in the animal kingdom, while other Homoptera, so far as we know, possess no special means for ensuring this result, we should reply:

(*a*) The " season " of the imaginal cicadas is much shorter than that of any other Homoptera, enduring sometimes only a few weeks. It is, moreover, shortest in those forms which are attracted the most easily and in the greatest numbers by artificial sounds. Thus Annandale (1900) states that the season for the edible species in the Malay Peninsula lasts not much more than one week. This is surely a significant fact. In many cases—perhaps in all—the future of the species for a very long period depends on the reproductive activity of this short interval of imaginal life.

(*b*) Cicadas are insects of powerful flight and we know no other factor than song which would explain their restriction to definite plant associations and to definite stations within those associations. In other insects this may be accomplished by restricted food-plant preferences, by feeble locomotory powers in one or both sexes, or the meeting of the sexes may be ensured by an excessive abundance of individuals.

The first rôle of the song is, then, we think, an assembling one. Once the sexes are in moderate proximity the well-developed visual powers of cicadas come into play and the assembling function of the song may be supposed to cease. Does the music then lose all further biological significance? We think not. If the observation of mating birds leads to the conclusion that the song or the display, as the case may be, operates to arouse in one or both sexes the emotions necessary for the consummation of the sexual act; then, however much we may deplore the assumption of the same psychical elements in organisms so diverse in nervous organization as insects and birds, we are irresistibly impelled to apply the same explanation to the cicadas. Just as no one save a Loebian of the most fanatical type can describe the note of a cicada seized by a bird as other than a " terrified squawk," so no unbiased observer watching the behaviour of mating cicadas can fail to be impressed with the evidence that the insects are labouring under the strongest

emotions, expressed in the one and accentuated in the other, in reciprocal fashion, by the wing-clicking and fidgeting of the female and by the song of the male. We believe that, like ants (Wheeler, 1910), cicadas

" show unequivocal signs of possessing both feelings and impulses . . . they experience both anger and fear, both affection and aversion, elation and depression in a simple, blind form, that is, without anything like the complex psychical accompaniment which these emotions arouse in us."

In conclusion, Berlese's theory, that the song is an advertisement of sexual maturity is, perhaps, correct as far as it goes, but if we add the word " merely " it becomes dogmatically inadequate.

CHAPTER XX

CICADA SONG

" Nemini denique cicadarum cantus insuavis videtur, nisi qui ab animo vel corpore ipsius aegrotat, & propterea sanae musicae sanus esse arbiter non potest."
(MOUFET, *Ins. Theatr.*, 1634, p. 130.)

ALTHOUGH the songs of Cicadas are remarkably constant specifically, forming perhaps the best single character for species recognition, yet they are no mere mechanical products ground out to a pattern pre-determined to a specific standard by the structure of the sound-organs in the species concerned. The sound-organs themselves are superficially as much alike as a number of violins collected at random ; the songs are as diverse as the tunes which may be produced from the musical instruments by different players. In other words, as we have noticed in a previous publication, cicada music depends far more upon the player than upon the instrument.

Every cicada with which we are familiar may be recognized with certainty by its song. Yet, within specific limits, there is not only considerably individual variation, but also considerable difference in the sounds emitted by the same individual on different occasions. We have already mentioned the extreme case, in the loud sharp shriek of a captive specimen.

The individual player obtains the chief modification in the sounds, by manipulating the opening between the abdomen and the opercula which cover the cavity at the base of the venter. In *Melampsalta cingulata*, for instance, the song is loudest when the abdomen is stretched upward and the space between opercula and abdomen is at its widest. This space acts merely like the horn of a wind-instrument, to amplify the sound. The abdomen, in this position is usually described as swelling. We are not at all sure that any actual dilation occurs, but only that the appearance of such is simulated, in dorsal view, by the rising of the abdomen from the level of the opercula. The observations of Hingston (1922), however, lead us to admit the possibility that the mesenteric sac becomes expanded with gas, thus swelling the abdomen and supplying a resonator to increase the sound still more. We are nevertheless not prepared to admit that such swelling takes place, as so many observers believe, by entrance of air into the sac through any of

the spiracles. We have at times ourselves observed an apparent swelling of the abdomen. A few field notes on the different species are quoted :

Melampsalta scutellaris : The abdomen rests on the support until singing begins, when it commences to stretch so that it is straight along the main dorsal line, or pushed even dorsad of the latter. This stretched position is maintained during the whole time of singing. It is noticed in this species that the last abdominal segments are rather close together in repose, and extensible to a greater degree than in other cicadas. During singing these are extended to the utmost and the abdomen appears somewhat inflated. A slight rising and falling corresponds with the rise and fall of the music and is undoubtedly the cause thereof, by regulating the opening guarded by the opercula.

Melampsalta ochrina : The abdomen is held in precisely the same position as in the preceding species, but is entirely immobile. The rising and falling movements and in consequence the differences in the pitch are entirely lacking. It is interesting that the continuous note of *M. scutellaris* when held in the hand, is produced with the abdomen motionless, and resembles the normal song of *M. ochrina* save that the tempo is considerably increased.

M. cruentata : The position of the abdomen is that of *M. ochrina*, and is maintained with similar rigidity throughout the song. The wings are very slightly spread, or perhaps merely relaxed.

The New Zealand species may, then, be divided into those which, like *M. cingulata*, *strepitans* and *scutellaris*, modify the extent of the opercular opening while singing, and thus also the note ; and those, which, like *M. ochrina* and *cruentata*, retain this opening unaltered during the performance.

Fabre has shown that *Tibicen plebeia* (ed., 1921, p. 254) and *Tibicina haematodes* (p. 259) belong to the first class and *Cicada orni* (p. 256) and *Cicada* (?) *pygmaea* Ol. to the second. Swinton (1880) makes similar observations on the three former species. From Lyle's (1913) description it appears that *Melampsalta montana* behaves as a member of the first class, while Gadd's (1908a) notes place *Cicadatra hyalina* into the second.

Goding and Froggatt (1904, p. 616) describe *Melampsalta mneme* (*Pauropsalta leurensis*), as singing with the tip of the body depressed and the wings drooped, while *Cyclochila australasiæ* (p. 570), holds the wings similarly but raises the apex of the abdomen.

A very interesting feature of cicada song is the ability of some species to sing strictly in chorus. In New Zealand this is especially noticeable in *M. cingulata*. In 1922 (see Myers & Myers, 1924) we were not convinced of this, but have since established it to our satisfaction and have found references to a similar habit in various exotic species. Thus McAtee (1921) notes that *Magicicada septendecim* like *Melampsalta cingulata* emits not only its ordinary note

in chorus but also the peculiar clicking note produced probably by the wings. Gadd (1908a) remarked *Cicada orni* singing in unison, but adds that when they had been disturbed, the singing for some time was independent. Mathew (1875) observes of *Quesada gigas* in Central America :

" These cicadae must be able to keep time with marvellous regularity, for the noise they make . . . is evidently the combined efforts of a whole colony, although a single insect is able to produce a very shrill cry."

Mr. Henry Ashburner, of Sydney, has made similar observations in Australia.

Weiss (1914, pp. 259–262) writes of *Melampsalta montana* and discusses its habit of singing in chorus.

" Vereinigen sich zahlreiche Individuen zu einen gemeinsamen Konzert, so fallen die Unterbrechungen des Tones und die Pausen zwischen den Tonreihen weg ; das Ganze klingt dann wie ein kontinuierlicher Ton."

According to Van Duzee (1915) *Clidophleps distanti*, in western North America, has a habit of " shrilling in unison."

Perhaps the earliest account which may be interpreted to refer to cicadas singing in chorus is that of Marcgrave (1648) concerning a Brazilian species :

" Circa vesperam in silvis et fruticetis ingens multitudo horum insectorum auditur ; arborum enim truncis assidentes ingentem excitant strepitum, qui incipit *gir*, *guir*, et mox continuatur *sis sis sis*, etc., centies vel pluries uno spiritu : ex continuato clamore denique rumpitur."

Although according to Amyot (1836) there were found among the papers of Latreille, after his death, a number of cicada songs set down in musical notation, the scientific study of cicada music dates from a very much later period. So far as published records are concerned Riley (1886) appears to have been the chief pioneer in this field. Landois (1874) must also be mentioned although his conception of sound-production in the cicadas was incorrect. Krumbach has given a good study of the commoner European species (1917).

Cicada songs have attracted much attention and have found frequent mention in the literature. We have a mass of references some of which are included in the bibliography at the end of this work. In many cases, however, the species concerned is unknown and the description, even if detailed and careful, is thus practically useless. Even when the cicada is known it is extremely difficult to codify a written account of the song. We have therefore been

compelled to let this mass of references go by the board and content ourselves with quoting a few of the more interesting, listing in the table below all those species of which relatively useful song-descriptions have been seen, and then proceeding to a brief account of the songs of the New Zealand species and our method of recording them.

Hueber (1903) remarks that all the Orthoptera make only a noise :

" während allein die Cicade einen reinen musikalischen Ton (gleich einer angeschlagenen Stimmgabel) zu erzeugen vermag, welcher nach Siebold dem zweifach gestrichenen ' E ' der neueren Klaviatur entspricht."

This is all very true, but the notes of some of the larger tropical species must be considered decidedly noisy. Thus Helms (1882, p. 141) writes of an insect which Distant (1889–1892, p. 69) thinks is probably *Pomponia imperatoria :*

" A green creature, with transparent wings a couple of inches long, sent forth piercing sounds which may be heard a mile away. It begins with a strong, trumpet-note, which has been likened to the sharpening of a steel knife on a grindstone, but infinitely more penetrating."

Beccari (1904, p. 11) writes that the noise of this same *Pomponia imperatoria* in the forests of Borneo is not unlike the braying of an ass in high treble, and can be heard at a distance of many hundred yards. This is one of the largest, if not *the* largest of all cicadas.

In the New World tropics the palm for noise must be conceded apparently to another huge but quite unrelated species, *Quesada gigas*, of which Mathew (1875) has given us a good account.

" Suddenly, from right above, you hear one or two hoarse, monotonous cries something like the croak of a tree-frog, and, looking upwards, wonder what it can be, but wait a moment, this is merely a signal, for the next minute everywhere above and around you these croaks are repeated in rapid and increasing succession until they merge into a long shrill whistle almost exactly similar to the whistle of a first-rate locomotive ; this continues for nearly half a minute, and then abruptly terminates, and everything for a short time becomes as still as before, but presently, similar cries will be heard in the far distance, as if in reply to those which have just died away overhead."

Jones (1884) writing probably of the same species, and likening its note to that of a locomotive states :

" So remarkable is the resemblance that once or twice since I

have returned to England I have suddenly been recalled to the tropical groves by the sound of an extra shrill railway-whistle at a distance."

This resemblance has been commented upon also by im Thurn.

Bates (1863, II, p. 142) used the same simile long before ; while Roosevelt evidently refers to this identical species in the account of the

" extraordinary screaming whistle of the locomotive cicada which I had heard . . . at Asuncion. This was as remarkable a sound as any animal sound to which I have listened, except only the batrachian-like wailing of the tree hyrax in East Africa ; . . . [it] resembles nothing so much as a small steam siren."

Of a large Himalayan cicada Hooker (1854, I, 107) writes :

" In the evening the noise of the great *Cicadae* in the trees was almost deafening. They burst suddenly into full chorus, with a voice so harshly croaking, so dissonant, and so unearthly, that in these solitary forests I could not help being startled."

In North America (Davis, 1920a) the songs of several species of *Platypedia* consist of a series of clicks, while those of *Okanagana* are loud and rattling. Concerning *O. rimosa*, Putnam (1881, p. 68) writes that the note is a

" rattling noise, exceedingly like that of a rattlesnake. This resemblance was so close that one day in 1873, in the Shoshone Mountains, I was attracted by a noise which I took to be one of those insects, and stooped to pick it up, when I suddenly discovered a large rattlesnake in its stead."

Englehardt (Davis, 1921b, p. 50) remarks similarly that the song of *O. schaefferi* " closely resembles the whirring noise produced by a rattlesnake."

Some of the best descriptions of cicada songs from a literary viewpoint are those of numerous Japanese species by the novelist, Lafcadio Hearn (1900). Where we have been able to trace the forms concerned by the Japanese names which he has given, we include them in the list which follows.

The most remarkable song appears to be that of **Tanna japonensis** (higurashi), a Japanese species of which Hearn writes :

" its wonderful cry, *Kana—kana—kana—kana—kana*—beginning almost always in a very high clear key, and slowly descending, is almost exactly like the sound of a good hand-bell, very quickly rung. The note is quick, steady, and of surprising sonority : and musical even to sweetness."

The following list includes most of the useful references to songs of species other than Nearctic or New Zealand :

Platypleura kaempferi : Matsumura, 1898.
P. centralis : Marshall, 1897
P. marshalli : Marshall, 1897.
Ioba horizontalis : Marshall, 1897.
I. leopardina : Marshall, 1897.
Koma bombifrons : Marshall, 1897.
Munza furva : Pead, 1910.
M. basimacula : Pead, 1910.
Thopha saccata : Bennett, 1860.
Cyclochila australasiae : McCoy, 1880.
Psaltoda moerens : McCoy, 1880.
Graptosaltria colorata : (aburazemi) Matsumura, 1898 : Hearn, 1900.
Tibicen plebeia : Fabre ; Krumbach, 1917 ; Solier, 1837 ; Swinton, 1880.
T. flammata : Matsumura, 1898.
Cosmopsaltria bivocalis : Matsumura, 1907.
Meimuna opalifera (tsukutsukuboshi) : Matsumura, 1898 ; Hearn, 1900 ; Fukai (1907).
Oncotympana maculaticollis (mimmin zemi) : Matsumura, 1898 ; Hearn, 1900.
Cryptotympana pustulata : Matsumura, 1898.
Pomponia imperatoria : Annandale, 1900 ; Beccari, 1904 ; ? Helms, 1882.
Terpnosia vacua (pryeri) (haruzemi) : Matsumura, 1898 ; Hearn, 1900.
Cicada orni : Fabre ; Krumbach, 1917 ; Swinton, 1880.
Taipinga nigricans : Marshall, 1897.
T. consobrina : Pead, 1910.
Monomatapa insignis : Marshall, 1897.
Quesada gigas : Mathew, 1872.
Tibicina haematodes : Fabre ; Krumbach, 1917 ; Swinton, 1880.
Melampsalta argentata : Milde, 1865, 1866.
M. montana : Lyle, 1911 ; Enslin, 1911 ; Weiss, 1914.
M. tibialis : Krumbach, 1917.
M. radiator : Matsumura, 1898.
Chonosia crassipennis : Jensen-Haarup, 1924 (song like that of corn-bunting).
Cystosoma saundersi : Scott, 1852.

In addition to the above list, *Magicicada septendecim* has been described time and time again (see Riley, 1886 ; Marlatt, 1907). The song of *M. cassini* has been distinguished almost as often from the song of its larger relative ; but especially carefully by Davis (1924a). In the works of the latter authority (1891–1925) will be found references to the songs of a very large proportion of the North American species. No man knows them better than Mr. Davis, and we hope that he may one day give us a collected account of them.

The problem of recording cicada song is a difficult one. Krumbach (1917) was led to give it up, pending the invention of a special instrument which might be contrived for the purpose. Andersen (1923), however, recorded the notes of several New Zealand species by the means which he had already practised for the birds.

The account which follows is based very largely on a previously published paper (Iris Myers and J. G. Myers, 1924) and the whole of the records, musical study and method of recording is due solely to the first of these writers.

Scudder (1893) records the stridulation of some of the Orthoptera, and for this purpose employs a special notation. Comstock (1920) describes this as follows :

" As the notes are always at one pitch, the staff in this notation consists of a single horizontal line, the pitch being indicated in a separate statement. Each bar represents a second of time, and is occupied by the equivalent of a semibreve . . . For convenience' sake he introduced a new form of rest . . . which indicates silence through the remainder of a measure ; this differs from the whole rest commonly employed in musical notation by being obliquely cut off at one end."

This rest has been employed, but with the cicadas the total problem is somewhat different. We have in some of the songs considerable variety in tune, so that the one line staff is inadequate, and it was considered best to follow the example of Andersen (1923b, pp. 765–767) and to retain the ordinary staff of five lines. Pitch is indicated in the ordinary way by means of the clef sign. The great difference in quality between the tones of the insects and those of the whistle used in the field for determination made difficult the fixing of the exact pitch of the song. The faint rapid character of some of the songs and their peculiar irreproducible timbre made them sound to the unaided ear much higher than comparison with the whistle notes showed them to be.

The songs have also definite rhythmical groupings which are obscured by the use of a bar to mark a second of time, and so the rate has been indicated separately, and the bar employed in its normal way to mark the primary accents of the rhythm. Where there is no clearly defined metrical rhythm the music is left unbarred. As in the case of bird-songs, intervals of less than a semitone need sometimes to be recorded, and these are indicated by the signs 1/2 ♯ or 1/2 ♭ before the note. The characteristic " chirring " note of some of the species is indicated by the term " vibrato " (*vib.*)

We describe below the varied songs of some of the New Zealand cicadas belonging to the widespread genus, *Melampsalta*. It is

interesting to find songs of such different types in related cicadas of this one genus.

The notes of *Melampsalta cingulata :*

A specimen caught by a sparrow was heard to give a series of staccato squawks—  —while the bird was battering it on the roof of a house.

The song, when isolated individuals are heard, sounds rather bird-like in character, though when numbers are singing a peculiar sibilant quality is noticeable. The whole forest seems to be hissing, so that two people talking to each other—or shouting, as it has to be—accuse each other of lisping, supposedly because of an illusion by which their " s " sounds appear to be absorbed. The

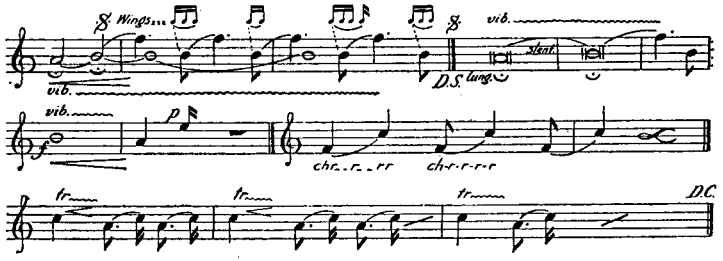

Fig. 102. *M. cingulata.*

individual song begins with a long-drawn-out vibrato note, sometimes lasting several minutes, and rising in pitch like the sound of a wheel as its rate of revolution increases : see (*a*). This first note is followed by a rise and fall of shorter notes, an interval of a major fifth above, beneath which it often seems sustained. The number of repetitions of the shorter notes varies. At the beginning of the season the first *M. cingulata* made itself heard as in (*b*), almost as if tuning-up and trying its powers. This also happens on days when an overcast sky or a sudden cold wind causes a temporary cessation of the chorus. When the sun re-emerges one or two essay their song, and gradually the whole chorus starts, and the repetition becomes endless. In this way, too, the first cicada heralds the coming dawn, before his tardier fellows join in. Often, especially on hot, sunny days, when the insects seem to be carried away by ecstasy, there is a rhythmical clacking accompaniment to the song. This accompaniment synchronises with the short note, and is caused by sudden outward jerkings of the wings, plainly visible to the observer from some distance. The song is pitched at B above middle C, the rate being about two of the short notes per second.

The song of **Melampsalta strepitans** (Kirk.) closely resembles that of *M. cingulata* in tonal quality. It is bird-like, loud and chirruping,

but not as loud as its larger relative, and is accompanied by rhythmical wing-clickings, which synchronise with the long note of each group. Its quicker rate—about four per second—and more vigorous, sprightly rhythm distinguish it clearly from the song of *M. cingulata*. Like the latter, this cicada also appears to sing in chorus.

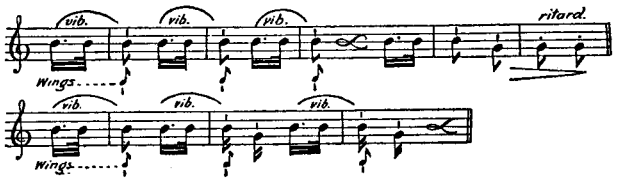

Fig. 103. *M. strepitans.*

The female of this species has been observed making the noise produced by clicking the wings.

The song of **Melampsalta sericea** (Wk.) was recorded in January, 1922, in Auckland, where it was the most common of cicadas. On the pavements in the city and on the characteristic volcanic rocks, where it is protectively concealed by reason of its harmonising dark colour, it sings its laboured, grating song. The song commences with a long-sustained note, followed by a varying number of shorter notes—sometimes only three or four, sometimes as many as twenty —of slightly lower pitch than the sustained note. After a number of the shorter notes the long note is repeated, and so the song goes on. Intent listening from near at hand reveals the presence of a

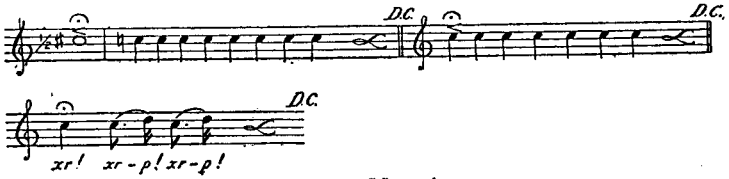

Fig. 104. *M. sericea.*

very short higher note following each of the other notes of the song. These are inaudible from a short distance. The volume of the song is less than that of its bigger relative, *M. cingulata*, and its quality is more strident, so that in consequence it is apparently higher in pitch, though really the same. The whole effect is harsh, insistent, piercing and monotonous both in rhythm and in pitch, and in the end the song becomes very irritating. Its rate is about one crotchet per second.

The song of **Melampsalta muta** (Fabr.) bears a structural resemblance to that of *M. cingulata*, which is like an embellished version of the former on a larger, more powerful instrument. It

resembles still more closely that of *M. sericea*, differing only in its quicker rate (three to four per second), its smaller volume and intensity, and less strident quality, and in the fact that the notes are staccato.

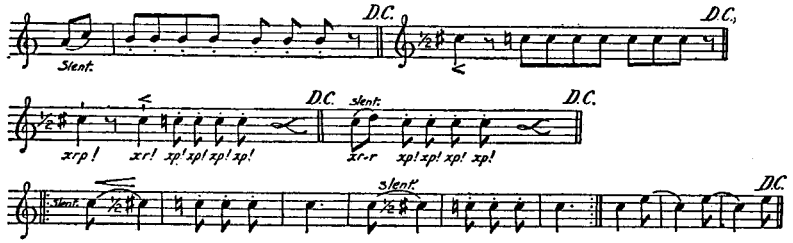

Fig. 105. *M. muta.*

When first heard from a distance the song of the little shingle-valley cicada, **Melampsalta hamiltoni** Myers, sounds very like a fainter edition of that of *M. muta*. Closer acquaintance reveals distinct differences, though a resemblance in pattern and in tonal quality remains. The song of *M. hamiltoni* is pitched slightly lower, the rhythm of the short rather staccato notes is more broken, but the tempo is very similar, being from two to three notes per second.

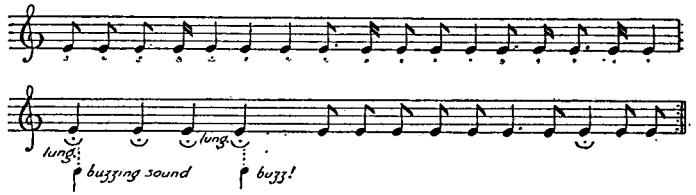

Fig. 106. *M. hamiltoni.*

A striking difference, however, is that quite often in the song a series of long-drawn-out notes is accompanied by a peculiar low buzzing sound, perhaps made by the wings.

When the wind and the sound of the waves permit we may hear from the seaside tussocks on the New Zealand coast a faint merry chirruping, rising and falling like a whirring wheel. This is the song of **Melampsalta leptomera** Myers, and if we approach sufficiently near the insect without disturbing it the whirring can be analysed into a quick succession of delicate staccato notes of the same pitch, with crescendo and diminuendo serving to give them a certain rhythm. From a little distance only the increase and decrease in intensity of sound is heard, and the song seems more varied than it really is. Its faintness and quickness make it sound very high pitched. The rate is about twelve per second.

A male *M. leptomera* reared in captivity revealed the fact of its emergence by a song more disjointed and rhythmically varied than the usual song, the variations of which depend mainly on rise and fall in intensity of sound, and not on the time relations of the successive notes. This song, (*b*), faint, and of the timbre and pitch of the normal song (*a*), was composed of a varying number of accented

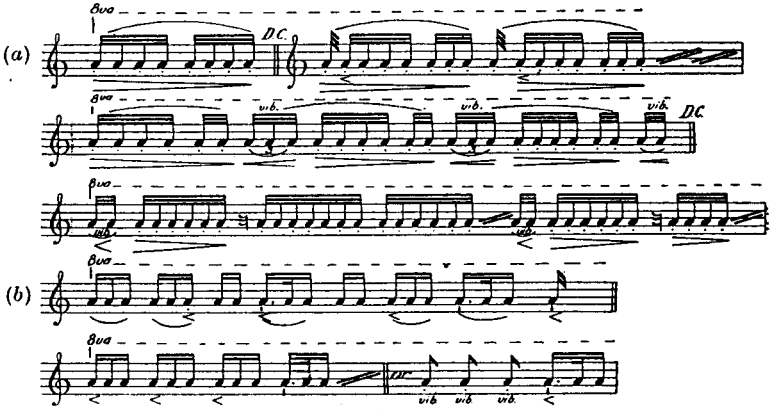

Fig. 107. *M. leptomera.*

triplets, each triplet group perhaps better expressed as an accented vibrato note, followed by a syncopated staccato phrase, the whole repeated at intervals. Later in the day, after transference of the insect to a glass vessel with sand and grass-stems reproducing in a limited way its native habitat, the normal song of the species was heard—the syncopated phrase having dropped out, and the triplets becoming merged into the rapid whirring succession of notes. The song (*b*) was heard from the same cicada several times also on the following day.

M. ochrina (Wk.) is distinguished by its rapid monotonous staccato song, strident and grating in quality and of the same

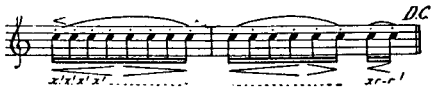

Fig. 108. *M. ochrina.*

structural type as that of the preceding species. However, it is a larger insect and the song is louder, and lower pitched. It is pitched at C and, like the *M. leptomera* song, is characterised by a rise and fall in intensity of sound, but its rate is slower (from seven to eight notes per second) and so each separate note can be distinctly heard.

The song is much less sonorous and more difficult to locate than the songs of the two other lowland forest and shrubland cicadas, *M. cingulata* and *M. muta cutora*. The rate is seven or eight per second.

M. muta var. **subalpina** (Huds.) has a song resembling that of the typical variety from which, however, it differs by the addition of several slower notes of the same or slightly lower pitch after the

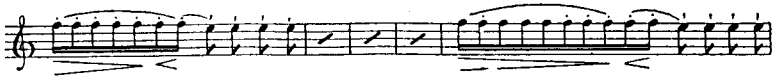

Fig. 109. *M. muta* var. *subalpina*.

rapid staccato notes. The number of shorter notes preceding the distinctive phrase varies considerably, so that sometimes the listener may have to wait several minutes before it is heard. The rate is seven or eight semiquavers per second.

M. muta var. **cutora** (Wk.) has probably one of the most beautiful of all the cicada songs. With the exception of that of *M. scutellaris* among the New Zealand species, it is the most varied in rhythm, and most nearly approaches to a sustained tune. It is more melodious and less strident in quality than the songs of such cicadas

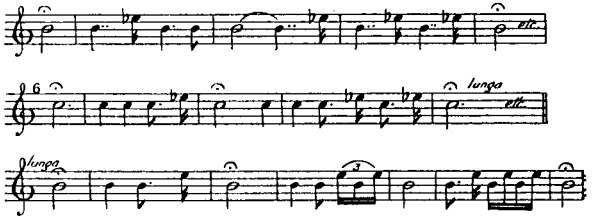

Fig. 110. *M. muta* var. *cutora*.

as *M. ochrina*, *M. sericea* and *M. cingulata*. The song begins with a prolonged note, often lasting for thirty seconds or more, followed by a group of shorter notes, which, though keeping the same metric form, are varied slightly on repetition of the phrase. The rate is about one crotchet per second.

M. cruentata (Fabr.), like *M. leptomera* a tussock-dwelling species, though unlike it, found inland as well, has from a distance a faint

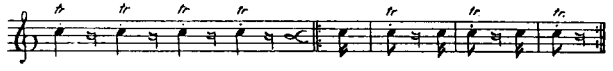

Fig. 111. *M. cruentata*.

trilling note which might easily be confused with that of the small cricket, **Lissotrachelus maoricus** Wk. Closer observation, however,

shows it to have a more grating quality than a cricket note, and to resemble in timbre the song of *M. muta*. It is different in rhythm, consisting of a phrase of a short note followed by a longer trilled note, the whole phrase repeated over and over, and this difference of rhythm enables one to distinguish it from *M. muta* when the two species are singing near to one another. The rate is about two phrases per second.

The song of the common alpine cicada, **M. cassiope** (Huds.) consists of a resonant bird-like prolonged lower note which may be vocalised as a vibrating "chur—r—r," rising in a slur to a faint very much higher note, like a shrill squeak. The second note

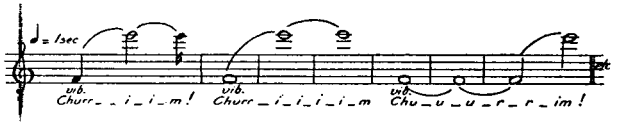

Fig. 112. *M. cassiope*.

sounds distinctly like "i—i—m," the whole phrase giving the effect of "chur—r—r———im" unmistakeably. The song is solely a repetition of these two notes, both prolonged. The time of prolongation of each varies so that there is no fixed rhythmical relation between them; for example, in the specimen given, the first "chur" was observed to last one second, the "im" $2\frac{1}{4}$ seconds, the second "chur" 4 seconds, the "im" 8 seconds, the third "chur" 10 and the "im" 2 seconds. The song produces a peculiar spatial effect, the insect being localised much nearer on the low than on the high note.

The song of that other alpine cicada, **M. mangu** (F.B.W.) is extremely low pitched—so low as to be almost imperceptible to some ears until attention is called to it. It has a very dull, toneless

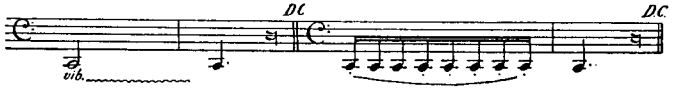

Fig. 113. *M. mangu*.

quality, and sounds rather like a buzzing wing vibration. It consists of a series of slow *vibrato* phrases of two notes of the same pitch at a rate of approximately one note in two seconds. The first, longer note of the phrase sounds, when one is nearer to the insect, more like a series of discrete notes. Because of the vague muffled quality of tone the insect is almost unlocalisable by sound. Partly because it is over two octaves lower in pitch, and partly because of the accompanying tonal quality, the song of *M. mangu* is utterly unlike that of any other cicada we have heard.

In the alpine river-beds one hears the song of **M. campbelli** Myers —slow and faint and of a muted quality rather resembling that of *M. scutellaris* (*v. infra*), of which it is occasionally reminiscent also in rhythmic structure (*c*) though quite distinct. This cicada was first heard singing when the sun was hidden by clouds. A long note, lasting 6 seconds, was followed by a monotonous, disjointed

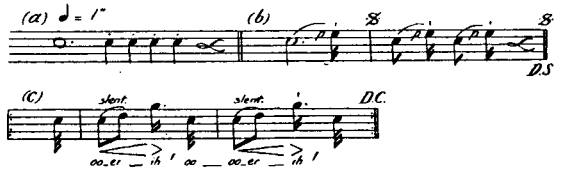

Fig. 114. *M. campbelli.*

series of staccato notes of uniform pitch, at a rate of one per second. The sun suddenly came out, and song (*a*) became more spirited, resolving itself into song (*b*), slightly rasping, varied in volume and rhythm, with a rise and fall in pitch of a major third, or sometimes a major fifth as in phrase (*c*), which was an occasional variant of the preceding phrase. This had a vocal quality which may be expressed as " oo—er—ih." Unfortunately the song was heard unexpectedly at a time when no exact means of determining pitch was at hand. It was judged to lie somewhere in the octave between C.256vs. and C.512vs

Together with those of *M. muta cutora* and *M. scutellaris*, the theme of **Melampsalta cauta** Myers is, for the New Zealand cicadas, the most deserving of the name of song. Rhythm and melody

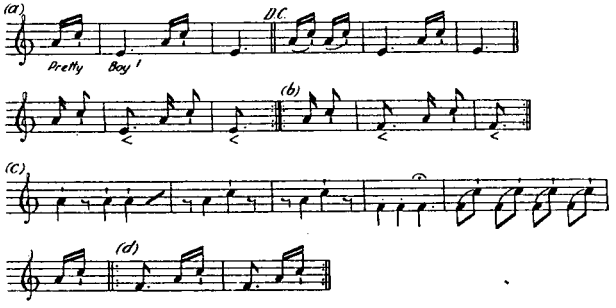

Fig. 115. *M. cauta.*

combine in all three instances to produce a definitely pleasing tune, of a musical pattern suggesting the primitive type of folk-song in which a short phrase is endlessly repeated. Andersen (1923a) actually instances a Maori *haka* song based on the rhythm and

characteristic vocalisation of a cicada song—probably of *M. cingulata*. In Maori songs of this type, melody is subordinate to rhythm ; in the three above mentioned cicada songs, they are of equal importance.

The typical song of *M. cauta* is a continuously repeated phrase of two short notes followed by a longer accented one, with a vocalisation which can be interpreted as " Pretty boy ! " The two short notes are occasionally duplicated " Pretty, pretty boy ! " The lower accented note is a minor sixth or a major fifth below the higher of the two short ones. The song usually begins, and often

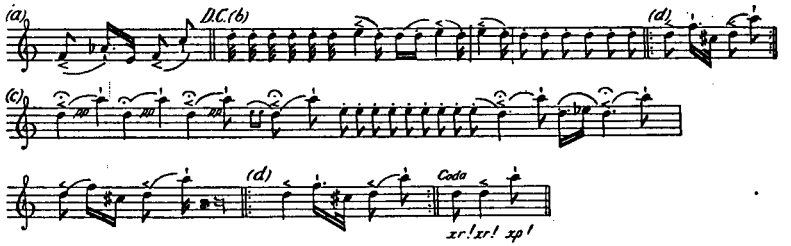

Fig. 116. *M. scutellaris.*

continues in the minor key (*a*), but if for any reason, there is acceleration, the pitch of the lower note is gradually raised a semitone, and the major key prevails (*b*). Song (*c*) is an interesting case of apparent warming-up—whether this is interpreted on a purely physiological or a psychological level. The initial note of the phrase was repeated with pauses, then the two short notes a minor third apart were heard ; the lower note of the phrase, a major fifth below the upper, was thrice repeated, a short stumbling note preceding a drawn-out note. Then with increasing precision and speed, this note was repeated with the top note of the phrase several times, and suddenly the insect took up the typical song, in the major key (*d*).

Melampsalta scutellaris (Huds.) has been described by Hudson as having " an exceedingly sad and feeble song." This insect sings in the shady parts of the forest, and so pays the least regard of any of the species to the sunshine, though that the sun does influence it is shown by the fact that on a warmer day than usual, especially if the sun is shining, the rate is increased and the sadness becomes almost cheerful. There is an almost march-like rhythm in the song, and it is the most varied of all in tune. The abdomen in this species is used very much during singing, a slight rise and fall being observed to synchronise with the rise and fall in pitch, and this is undoubtedly a factor in the variation. The song has a lack of resonance which gives it a muted quality and renders it almost

inaudible to some observers. The rate is about one phrase in two and a half seconds.

The typical phrase is the rhythmical minor one (*a*), repeated indefinitely. Two interesting examples, (*b*) and (*c*), of individual variations contain repetitions of elements of the normal song and in each case lead up to it (*d*). In song (*b*) the note E would appear to be a stage in the scalar progression to F of the normal phrase. In song (*c*) the note E occurs as an apparent variant of D of the normal phrase, and in the last bar of this song E♮ occupies in the rhythmic pattern the place of F in the typical phrase. In song (*c*) the insect, probably accidentally, supplied an excellent *coda* on taking to flight.

These two instances, together with the similar examples of initial song and " warming up " in *M. leptomera* and *M. cauta* respectively, give one the impression of an effort to approximate to a certain pattern, auditory or kinæsthetic—in short they seem to bear all the marks of practising. We have already seen that a very wide variety of cicada song is uttered by these closely related New Zealand species, the structure of whose sound-organs in no degree varies commensurately with their music—in other words the chief variable factor lies not in the instrument but in the player.

CHAPTER XXI

METHODS OF COLLLECTION, PRESERVATION AND STUDY

" Zum Schluss zeigt derselbe Herr eine aus einem gespaltenen Bambusstab bestehende Cicadenklapper vor, deren sich die Siamesen bedienen, um Cicaden anzulocken, welche in Cocosöl gebraten, von den Eingeborenen verspeist werden." (FRUHSTORFER, *Berl. ent. Zeit., S.B.*, 1902, p. 28).

WE have seen in the preceding chapter that cicadas are attracted in various countries—France, Malay Peninsula, Siam, Chili—by rhythmical sharp sounds produced either by some such mechanical device as the one described by Fruhstorfer above, or by hand-clapping which may or may not be accompanied by whistling.

These methods as employed in Chili and as used for the procuring of food in the East, form probably the most efficient quantitative procedure yet devised for capturing these wary insects, which too often elude the devices of the orthodox entomological collector. The essence of their quantitative success lies, however, in their specificity.

In Malaya (Moulton, 1923), cicadas are usually caught at night, like moths. In other regions, however, although stray individuals are occasionally attracted, such cases are far too rare to make such a method worth-while.

In China (MacPherson, 1897, p. xxix ; Dyer Ball, 1904, p. 170 ; Kershaw, 1903) and in Japan (Hearn, 1900) the favourite way of catching cicadas consists in using a long and slender bamboo pole tipped with a kind of bird-lime, made, according to Ball, of the ashes of the " Chinese fir," mixed with glutinous cooked rice and water. This instrument is pushed up high among the branches and the cicada entangled in the adhesive.

Buckton (1890) describes the boys of Foochow as using a bamboo with a cleft at the tip instead of bird-lime. The cicadas are said to be tickled like trout, until dexterously a leg is entangled in the bamboo slit.

Cockerell (W., 1925) gives a charming sketch of the Japanese " cook's boys catching cicadas with their tiny *nets* at the end of a ten- or fifteen-foot pole . . ."

The ordinary entomological collecting net is as suitable as any other means for capturing cicadas which frequent herbage and

low shrubs, and which may be caught with no more dexterity than that required for the more elusive of the butterflies. The insect is usually located by the song of the male. Once this ceases, the utmost caution is required to alarm the insect no further until a suitable position for striking can be reached. Should the attempt be unsuccessful it is often possible to follow the insect and locate it again when it has recommenced its song. Females are often found in the vicinity of the calling males ; in fact it is no uncommon occurrence to trace a song as one thinks to its author and find one's catch a female, while the male, perched on a nearby twig, makes good his escape. Females may also be " spotted " outright—an almost impossible feat with the more cryptically coloured species—or very rarely, taken by sweeping.

It is hardly necessary to add that the song of a new form should be carefully recorded before the insect is captured ; while notes should also be made on the plant-association. The latter procedure may be simplified by the numerical method elaborated by Dr. A. Dampf in Mexico.

For the large and wary tree-haunting species the collecting net is almost hopeless ; and various projectile methods must be substituted. Mr. Wm. T. Davis was, we believe, one of the first to use a catapult or " slingshot," made from the inner tube of a motor-car tyre, or from ordinary rubber bands. He also mentions the use of a shot-gun loaded with a small charge (1922, p. 37).

Mr. Raymond Beamer recommends (*in litt.*, 12 January, 1925) :

" either a 22 caliber revolver or rifle. The former is much more easily carried, but the latter will kill at a greater distance. Any gun would do, if you could procure shot shells for it. I use the 22 caliber, because 22 long shot shells may be procured in any hardware store . . . The gun, whatever kind you use, should be bored free from rifles as these cause the shot to be thrown in a ring and the specimen is too often missed. I have a seven shot, 6-inch barrel gun for my own use. I believe if I were going to purchase another I would get a single shot Stevens, long barrel, target pistol."

Cicadas are most conveniently killed in the usual potassium cyanide bottle. If this be kept reasonably clean and dry there is never the least colour change in even the greenest species.

While fully-spread cicadas occupy an excessive amount of space, and present on the wings themselves a surprising paucity of taxonomic characters, yet the closed wings hide some of the body features and the sound-organs, and the coloured axillary membranes—valuable for specific distinction—are likewise invisible under these circumstances. It is therefore essential to spread at least the wings of one side in a number of examples of each species.

Cicadas which have been relaxed and pinned some time after capture cause considerable trouble by swinging on the pins. This

is to be remedied by a tiny piece of card pushed on to the pin at the correct height and gummed to the venter of the insect. The nymphal exuviae, which form beautiful material for study, are pinned in the same way, when they are much more useful in the interpretation of skeletal structures than are the whole nymphs preserved in alcohol. The latter are hard to come by, but when procured should be preserved in 80 per cent alcohol—never dried. Eggs and newly hatched nymphs may be kept in the same way, while stems with oviposition punctures require no special treatment. Woody stems are pared of bark for an inch or so at one end and the data written on the still moist wood with an ink-pencil.

Genitalia : When pinning specimens it is advisable to draw out the pygophor of the male in some examples of a species, to its fullest extent, and disengage the ovipositor of the female from its distal sheaths.

For the proper establishment of new species it is essential to dissect out the aedeagus and mount it separately in Canada Balsam. After considerable trial I prefer not to use KOH at all, but to dissect directly in water, either fresh or relaxed material. The lateral pieces are often so tenuous as to be distorted if not destroyed by caustic, while the size of the whole structure is relatively so great that direct dissection and careful removal of muscles is a speedy and easy task.

After the usual dehydration, etc., the aedeagus and copulatory hooks must be mounted in balsam on a slip of celluloid pierced by the pin of the specimen to which they belong. We may follow Mr. F. W. Edwards's method with mosquito hypandria and leave them entirely bare of cover-slip, or we may use a cover either of glass or celluloid. If it is necessary to use the genitalic material thus mounted in a projectoscope or a photo-micrographic apparatus, one has prepared a stock of cards of the size and shape of a microscope slide, and with a strip of stout paper of exactly similar dimensions pasted on them by both ends. A circular hole of appropriate size is punched through both paper and card and the celluloid mount is then slipped in between paper and card so as to extend across the hole. The resulting combination can be handled in all respects like an ordinary glass microscopic slide.

Rearing : In keeping oviposited stems for hatching it is important to remember the long time, often weeks or months, which may elapse before the process takes place. The stems should be kept in small vials and only experience can guide one to the maintenance of optimum moisture conditions. Conditions too dry are, however, much more speedily fatal to the eggs than the reverse, and a high percentage of hatching is often achieved in stems which have become thickly covered with mould. To control the growth of the latter to some degree, the water used for moistening purposes may be slightly salted. Unless the vials are kept corked it will be found

impossible to prevent the eggs from drying up. The necessary moisture is introduced by wetting from time to time the tip of a piece of blotting-paper projecting from between the cork and the side of the vial.

In preparation for the day of hatching other vials should be prepared with sand or sandy soil in which grass or wheat seeds have been sown to supply roots for the feeding of the young nymphs, which are transferred to these on hatching and will immediately burrow for themselves. In the case of *Melampsalta leptomera* the sand may be moistened with slightly salted water from a pipette as a precaution against mould. Whether the non-maritime species would tolerate such treatment I do not know. For larger nymphs, which it was desired to keep under observation, we have used essentially the same method, with vials somewhat larger and an inch in bore. In these it is necessary to introduce from time to time fresh pieces of roots or root-stocks for the subsistence of the nymph. Success with this method depends upon using sandy soil and so adjusting the addition of moisture that a balance is achieved between evaporation and absorption and stagnation entirely obviated. Once the knack of securing this result is acquired, these breeding vials are found to be extremely simple and convenient, especially when individual treatment of nymphs is required. The small bore of the vials ensures that the insects are in view a considerable portion of the time. Natural conditions of darkness are procured by keeping the tubes in thick cylinders of brown paper, which are slid up when observations are to be made, and which serve also for the writing of data.

For the adults more spacious quarters are required and the first essential is plenty of sun. The food-plant should preferably be growing, otherwise very frequent replenishment is necessary. A convenient device consists in sleeving capaciously the branch of a tree. Neither Gadd (1908a) nor Krumbach (1917) were able to keep European species in captivity.