

## CHAPTER XII

### GENERAL RELATIONS OF CICADAS WITH OTHER ORGANISMS

Attica puella Pandion, melle nutrita garrula cum rapueris  
Cicadam, volucris cibum fers pullis,  
Garrulam garrula, bene alatum alata,  
Hospitem hospes, vernam verna,  
Nonne statim abiicies ? Neque enim fas est, nec iustum  
Perire musicos musicos oribus.

EVENUS OF MELEAGER, *Anthologia Graeca*, Aldrovandi,  
1618, p. 130.

LIKE all other organisms, cicadas are connected with other beings by the strands of the web of life in relations of varying degrees of complexity and directness. We are concerned to analyse the more salient of these relationships in the following chapters. There are many insects in which the task would be more difficult than in the Cicadidae. After a prolonged nymphal life of an almost incredible uniformity as indicated *inter alia* by the regularity of the cycle, it may be said of the imaginal existence,

La vie est brève  
Un peu d'amour  
Un peu de rêve  
Et puis bonjour.

Yet during the sum of this simple existence we shall find that direct relations subsist between these insects and a host of other creatures ranging from yeasts to man. The Cicada's activities at the urge of hunger, self-preservation and reproduction are directed so far as other organisms are concerned on the higher plants, which supply it with food, with shelter for itself, and nidus for its eggs; its sufferings result from the corresponding activities of fungi, insects, and other invertebrates, and vertebrates up to man. Far less simple are the relations with certain micro-organisms generally considered symbiotic.

Cicadas are remarkably lacking in any special means of protection against their numerous enemies. The most vulnerable period in the life-history, when the nymphs issue from the ground for the final ecdysis, is marked by a heavy mortality through the agency of birds, mammals, and other insect-eaters.

Concerning the life and relations of the nymph during its underground existence, we know next to nothing. The chief protection of the adults would seem to lie in their often extremely cryptic colouration and markings. How effective these are against human seekers is familiar to all who have collected cicadas, how efficient against natural enemies we have no experimental data to indicate. Even large, chorus-singing forms like *Melampsalta cingulata* are often difficult to perceive on the bark which is their usual resting-place; while the brilliant green shrub-haunting species like *M. ochrina*, *muta* vars. *cutora*, and *subalpina* are frequently almost entirely baffling. To one who has not collected them it must seem incredible that an insect of this size, singing vigorously and continuously, fully exposed to view less than two feet from one's nose, can yet during five minutes' intensest scrutiny, remain entirely invisible. How far the difficulty is accentuated by the possibly ventriloquial quality of the song we shall discuss in dealing with the latter. It is certainly true, however, that the song renders discovery easier than if the insect were mute, for one never locates females of these species save by accident. The cryptically coloured forms are by no means confined to the plant-frequenting species. *M. hamiltoni*, living apparently solely among grey river-bed shingle, is one of the hardest to see. One may search for hours on a bank which is sizzling with their songs, and eventually take but two or three.

Stem-perching forms endeavour constantly to keep the support between them and the observer, but the more highly procryptic green cicadas remain entirely still until one perceives them—then they are off like a flash.

Marshall (G. A. K., 1897) found several Mashonaland species to be very protectively coloured. Thus *Platypleura marshalli* (Dist.) is extremely difficult to distinguish from the bark of *Mopani* trees, to which it is confined. *P. centralis* Dist. frequents the main trunk of its special tree, the *mfuti*, the bark of which it resembles closely, the black central line simulating a crack in the scaly trunk. There is apparently some connection between restriction of ethological station and degree of protective resemblance. It is surely no coincidence that the most highly cryptically coloured New Zealand cicadas, e.g. *Melampsalta ochrina*, *subalpina*, *cutora*, *hamiltoni*, and South African species, as mentioned above, are at the same time the most restricted in ethological station. It is difficult to explain this save in teleological terms or on the basis of direct action of the environment.

We know only one cicada genus which has been advanced as an example of "warning colouration." This is *Huechys*, and especially *H. sanguinea*, which Annandale observed to fly about among the bushes during the day "unlike the majority of Malayan cicadas." This species is the famous *Chu-ki* or blistering cicada of Chinese medicine (Pl. VII, fig. C), a strikingly coloured brilliant red and

jet-black form with opaque tegmina. Numerous workers, as we shall see later, have studied its chemistry and isolated various compounds. Some have demonstrated vesicating properties and others have failed to do so. Both Annandale (l.c.) and Matsumura (1907, p. 102) noticed that when caught it lay still in the bottom of the net, while the Japanese entomologist observed that it gave off an unpleasant smell. Mr. Muir has also noticed a smell but has not found it noticeably unpleasant. Jacobi (1913, p. 47) considers it a striking case of warning colouration, and it is certainly as good as any, though no evidence is available as to its possible freedom from enemies as compared with other cicadas. There is certainly a very interesting combination of characters in this cicada—firstly: vesicating properties of its tissues; secondly, unpleasant (to man) odour; thirdly, startling colouration; fourthly, unusual behaviour in lying motionless when seized—all four of which might be explained, at least plausibly, on the "warning colouration" hypothesis. Mr. F. Muir, however, informs me that he has frequently seen this cicada in Macao carried off *shrinking* by kinghunters (Alcedinidae), while Maki records sparrows catching it in Formosa.

Both Distant (1897g) and Swinton (1880) consider the song to fill the rôle of a betrayer. The latter writer (l.c., p. 21) even describes "certain greyish insectivorous birds" as whistling in order to persuade the unwary cicada into an answering chirp and thus to indicate his whereabouts!

Distant, however (1881b), conceives the song as sometimes secondarily protective since a captured specimen of the large *Pomponia imperatoria* (West.) sent a thrill up his arm by the vibration of its powerful stridulation. He thinks a bird receiving such a shock would drop the insect. Most of the species emit a sharp alarm note when captured, the effect of which on sparrows is nil; on other enemies apparently not ascertained. These are all the purest hypotheses—all save Swinton's cunning bird, which was surely even more fanciful.

Jacobi (1907c) adds one more theory to explain the presence in the subfamily, Tettigadinae, of two pairs of sound-organs—the ordinary cicadan type, assumed to be for sexual purposes, and a stridulating apparatus consisting chiefly of a ridged area on the mesonotum—the use of which he believes to be probably protective since it is equally developed in both sexes.

## CHAPTER XIII

## CICADAS AND LOWER PLANTS

THE lower plants directly influencing the cicada economy fall into two distinct categories, parasitic, and supposedly symbiotic, to be considered in turn.

## FUNGAL PARASITES

Not long after Réaumur's classical account of the "plant worms" of the East, there appeared Watson's (1764) description of the equally intriguing "vegetable-fly" of the West Indies.

"The *vegetable fly* is found in the island Dominica, and (excepting that it has no wings) resembles the drone both in size and colour more than any other English insect. In the month of May it buries itself in the earth and begins to vegetate. By the latter end of July the tree is arrived at its full growth and resembles a coral branch; and is about three inches high, and bears several little pods, which dropping off become worms, and from thence flies, like the English caterpillar."

Watson quotes thus from the collector's account and then cites the opinion of Dr. Hill, who disposes of the whole matter by stating that cicadas are common in Martinique, whence he had specimens of the same fungus, and in their "nympha state" just before ecdysis, the mortality is great and the fungus, which Hill named *Clavaria sobolifera*, grows on the dead bodies.

"This you may be assured is the fact, and all the facts; though the untaught inhabitants suppose a fly to vegetate; and though there exists a Spanish drawing of the plant's growing into a trifoliolate tree; and it has been figured with the creature flying with this tree upon its back. So wild are the imaginations of Man; so chaste and uniform is Nature!"

It was some years before it could be shown that in this case the chastity of Nature fell somewhat short of the learned doctor's expectations; and that the fungi of the genus *Cordyceps* are really parasitic on cicadas and many other insects.

The next to deal with these fungi was de Bondaroy (1772) who figured very many infected cicada nymphs, all in the last instar, and showed also (Pl. II, figs. 12, 13) a Fulgorid from Cayenne with a new

species of white fungus depending from the abdomen of nymphs and adults alike, and appearing in no way to affect the health of the insect—a fact which becomes less extraordinary when we recognize in the mycological *sp. nov.* the waxy secretion of the Fulgorid itself.

The genus *Cordyceps* (Fries) includes chiefly fungi parasitic on insects and other arthropods, but at least two species attack hypogaic fungi. But little is known of their life-history. It appears, however, that:

"A spore, on coming in contact with a host, germinates and produces a germ-tube which penetrates the cuticle and body-wall. Inside the body-cavity this germ-tube branches, forming hyphae, which penetrate to all parts of the body. In the blood gemmae are produced: these are cells asexually produced from the ends of hyphae. They are exceedingly small and are rapidly carried in the blood-stream to different parts of the body, where they in turn give rise to hyphae. In this manner the fungus rapidly spreads and quickly kills the host. Infection of the host may occur from the germ-tube from an ascospore or from hyphae developed from conidia born by the Isarial form of *Cordyceps*. A conidium may germinate, and the subsequent hyphae live saprophytically on decaying wood or other organic matter for some considerable time. These hyphae on coming into contact with a host are capable of entering the host tissues" (Cunningham, 1921, p. 372).

"In the host the hyphae continue to develop until finally the whole of the internal tissues are replaced by the mycelium of the fungus, when it forms a hard, compact mass, the cuticle and sometimes portions of the alimentary system alone remaining unaltered. This mycelial mass is known as a sclerotium: from it, usually after a period of rest, the stromata bearing the fructification of the fungus arise. The stromata vary considerably in shape, size and number, according to the nature and habitat of the host. . . . In some species there are two kinds of fructification: the first is known as the Isarial form, and bears conidia; the second form, which appears after the Isarial (when the latter is present), bears the ascospores.—The relationship between this Isarial and the latter (or *Cordyceps*) stage is known in a few species only, and in the majority of cases is assumed merely on account of the occurrence of both forms from the same host" (Cunningham, l.c., p. 373).

Some half a dozen forms are known to attack Cicadidae, always nymphs in the last instar. Only one of these (*C. sobolifera*) is known in the *Cordyceps* stage. It is the "vegetable fly" described and figured by Watson from the West Indies.

The common New Zealand species, *C. (Isaria) Sinclairii* Berk., may possibly be the conidial stage of *C. sobolifera* (Cunningham,

l.c., p. 375), but as most of the other New Zealand species are endemic, this is improbable.

"It is a very variable form, and assumes many different shapes. The colour of the stroma ranges from white in the most immature specimens, through yellow, . . . light brown, in more mature forms becoming pink, deepening in colour with age" (Cunningham, l.c., p. 375).

This species has been recorded from nymphs regarded without absolute certainty as those of *Melampsalta cingulata* and *M. muta*

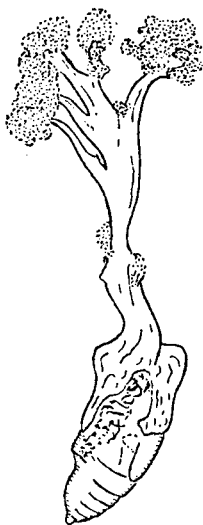


Fig. 99. Cicada nymph (*Melampsalta* sp.) from New Zealand, killed by the parasitic fungus, *Cordyceps Sinclairii* Berk.

After photo by E. Bruce Levy.

(Myers in Cunningham, l.c., p. 375). *Sphaeria Basili* Taylor and *Torrubia caespitosa* Tul. are synonyms. Figures are given by Benham (1900) and Cunningham (1921), also in our figure. Petch (1924) has since recorded it from Ceylon, and has suggested that it and all the other large-spored, cicada-attacking *Isaria* species may be the same.

Other cicada-attacking *Cordyceps* (?) include :

- (1) *Isaria arbuscula* Hariot : Mexico.  
1892, *Bull. de la Soc. Mycologique de France*, 8, p. 67 [not seen].  
1900, Beauverie and Vaney, *Ann. Soc. Linn. Lyon*, 46, 79-86, 3 figures.

- (2) *Cordyceps sobolifera* (Hill) : West Indies, Japan (Lloyd, 1915, 1916) in Watson (1764).
- (3) *Cordyceps cicadae* (Miquel), (*Isaria*).  
1838, *Bull. Sc. phys. et nat. Néerl.*, I, p. 85, Tab. 1, figure A [not seen].  
*Ann. Sc. nat.*, 2 sér., 10, pp. 377-378.
- (4) *Isaria amorpha* von Höhnel, 1909, Java.
- (5) *Isaria cosmopsaltriae* Yasuda, 1918 (*Bot. Mag.*, Tokyo, 32 : (263).

Saccard<sup>b</sup> places the genus in the family Hypocreaceae of the Pyrenomyceteae, and gives full references to the cicada-attacking species in pp. 569-577 (Vol. II, 1883). Other useful references include Cooke (M. C., 1892), C. G. Lloyd (1915, 1916), Masee (1895), Miquel (1838), Tulasne (1861-1865, III, p. 11), Hara (1921), Vuillemin (1911).

A fungus parasite of a far more anomalous nature is confined to *Magicicada septendecim*, where it attacks chiefly the males, towards the end of their life. It was first noticed apparently by Leidy in 1851 and officially described by Peck (1879) as *Massospora cicadina*, "a singular fungus unlike any other known to me." Its taxonomic position became a subject for considerable discussion, in which Thaxter and others took part, and it was not until the work of Speare (1919, 1921), especially in his second paper, that the fungus could be unquestionably assigned to the family Entomophthorales. Butler (A. W., 1886) and Marlatt (1907, p. 139) deal with this fungus from the entomological view-point. The following notes are taken chiefly from Speare.

The cicadas may fly about with the entire posterior part of the abdomen missing, and conidia or resting-spores scattering with every movement. This has excited the wonder of many observers. The conidial stage is plentiful near the beginning of the season, and the resting-spore stage towards the end. They are not found simultaneously in the same host, and in fact they impart to the latter a macroscopic appearance which differs according to the stage present. *Massospora* has been found on no other insect than the periodical cicada, solely on the imago and chiefly on the male. There is no information regarding the manner in which it passes the 16 years and 9 months' subterranean existence of its host (Speare, 1921, p. 81).

According to Cooke (M. C., 1892) the mould *Sporotrichum minutulum* Spegazzini grows on the "putrescent larvae" of *Fidicina bonaërens* Berg. There is probably nothing but saprophytism involved.

## SYMBIOTIC (?) MICRO-ORGANISMS

In 1859 (p. 208) Huxley introduced the term "pseudovitellus" for a somewhat puzzling body found in aphides and considered by him to form a supplementary yolk. Heymons (1899) devoted considerable space to a description of a peculiar structure in the egg of *Magiccada septendecim* which he was able to follow through embryonic development and into the young nymph. Practically simultaneously Pierantoni (1910) and Sulc (1911a) concluded that these structures were "mycetomes" forming dwelling-places for symbiotic micro-organisms. Later Sulc published a paper dealing more especially with true cicadas (1911b), while the chief worker in recent years has been Buchner (1912a, 1912b, 1921, 1924). We have seen that these investigators have homologised the enigmatical structures described by Huxley, Lubbock, and Heymons. We believe, however, that still earlier references are extant. Thus Dufour (1833, p. 325, footnote) writes, as we translate :

"When the cicada flies from a tree-trunk when it is surprised, or when, already captive, it is disturbed, it ejects from the end of the abdomen a yellowish excrementitious liquid, a sort of urine. A search for the originating gland showed it in both sexes, on each side and a little below the rectum ; a granular gland consisting of an agglomeration, little compacted, of some fifty yellowish or greyish sachets. The most usual shape of these seems at first sight spheroid, but on close examination one recognizes oval, round, irregular and asymmetrical forms, of unequal size. Most are sessile, but some attenuate in a kind of very short neck. In the male they look like the spermific capsules of the testicle, which they adjoin, but an attentive examination dissipates the illusion ; and they occur, moreover, also in the female. The mode of connection of the sachets, their efferent canals, their reservoir, have eluded observation. This gland has often for its axis a tracheal trunk of which the branchlets seem to form a pedicel for each sachet."

On the basis of this passage we hail Dufour as the discoverer of the Mycetome.

It is possible that the following remarks by Putius (in Zanotti, 1731, p. 82), concern the same structure : Postremo in thoracis medio rubrum quoddam punctum observare licuit quod quid sit, quidve inserviat, nec cognovimus nec statuere audemus.

So far as the Cicadidae are concerned, Sulc has studied these supposed symbionts in *Cicada orni* nymphs, while Buchner has described also those of an undetermined cicada from Japan and another from Liberia. We give a few notes on these :

(1) *Cicada orni* : There are two different symbionts, diverging completely in station and relationship. The one lives in masses in

the fat-cells, especially in the fat-body at the posterior end of the abdomen, and is a tear- or cigar-shaped yeast.

The other symbiont has a special *organ* as a dwelling-place. Embedded in the fat-tissue of the abdomen in the region of the VIIth and VIIIth segments, on each side of the body, is a mass of round, colourless globules connected in a grape-like bunch by the branchlets of the trachea from the Vth pair of spiracles, this trachea being exclusively in their service. Sulc (1910) was mistaken when he saw in each of them a mycetocyte. Buchner (1902) found a much more complex structure. Each globule is rather a mycetome which consists of a fungus-free epithelial covering and a central zone of syncytial structure containing numerous polymorphic nuclei and the fungi themselves. Small branchlets of the trachea envelope the whole and undoubtedly send tracheoles in among the symbionts through the epithelium. This condition is found in nymph and in adult.

(2) Undetermined Japanese cicada. Typical yeasts are present in the fat-tissue. The mycetome groups are also similar but differ in histological structure in that the epithelial covering is syncytial instead of cellular as it is in *C. orni*.

(3) Undetermined Liberian cicada. The fat-tissue contains no yeasts ; but as though in compensation the mycetomes harbour two different symbiotic fungi. Each mycetome has a cellular epithelial covering as in *C. orni*, but beneath this *two* zones, one within the other, each with a different fungus. The two zones are sharply differentiated and the two symbiont species are restricted to their respective zones.

In *C. orni*, where development has been followed through some at least of the nymphal stages, Buchner shows that the symbionts go through a regular and parallel change.

In the forms with two symbionts, whether one in mycetomes and the others in fat-tissue, or both in mycetomes, the fungi both enter the egg at the same time and locus and at first form a roundish fungus ball. In cicada infection must take place very early. The infection-mass is moved passively during embryonic development and at the revolution of the embryo is finally drawn out of the yolk and enclosed within the hinder part of the abdomen. At the same time it divides into two similar parts.

Heymons found these also in the ovarian egg of *Tibicina tomentosa*. It is not known when the separation of the mycetome- and fat-dwelling symbionts occurs.

Buchner regards the Psyllids and Cicadids as reaching the acme of complexity in insect-fungus symbiosis. He distinguishes between genuine symbionts, which are the forms dwelling always in mycetomes and are always present in the Cicadidae examined, and accessory symbionts, or yeasts living in the fat-tissue, and not always present—thus not essential to the cicada economy.

Systematic position of the symbiotic micro-organisms: The fat-dwelling forms are true *Saccharomyces*, and have been described by Sulc (1911b) as *S. cicadarum*. Buchner, however (1924), suggests they are more probably Ascomycetes.

The mycetome fungi are of very uncertain position. They may even be bacteria allied to *Azotobacter* (Buchner, 1921, p. 327). Sulc (1911b) described the form from *orni* as *Cicadomyces cicadarum*, while Buchner (1912b, pp. 101, 102, Taf. 9) has added *C. liberiae* and *C. minnimus* [sic], both from the undetermined Liberian cicada, and *C. sp. ?* from the Japanese insect.

Significance of the symbionts: Sulc (1911a) believes the mycetome-complex is a bactericidal organ. He thinks Homoptera are peculiarly liable to infection since their sugary excrement is a good breeding-ground for bacteria. Cases are instanced of antagonism between fungi and bacteria, and of the use of the former in medicine—against gonorrhoea and other diseases. Buchner (1912b) credits him also with suggesting an excretory function, and points out that though this might be probable for aphides and coccids in which malpighian tubules are wanting and reduced respectively, the Cicadidae and other Auchenorrhyncha show these organs well-developed.

Pierantoni credits the fungi with an enzymatic effect in breaking up sugars.

We record here, for want of a better place, the presence in *Magi-cicada septendecim* of two other kinds of micro-organisms, discovered by Cowdry (1925). Eleven cicadas out of fifty were heavily infested with peculiar organisms smaller than most bacteria and applied like *Rickettsia* in thick masses upon the epithelial surfaces; seldom were they observed in cells. The alimentary tract and the malpighian tubules were not uniformly invaded throughout, nor was there any noticeable ill-effect on the host. Cowdry would classify these with *Rickettsia*, a group of micro-organisms, somewhat ill-defined, and very resistant to cultural methods. The "genus" includes the causative agent of Rocky Mountain Spotted Fever, trench fever, Japanese river sickness, and about twenty-two others. They pass through successive generations in the eggs.

The same observer notices within the body cavities of the periodical cicadas examined, small numbers of larger true Bacteria, staining blue by Giemsa's method (*Rickettsia* stains red). These were not seen in the intestines nor in the malpighian tubules.

## CHAPTER XIV

### CICADAS AND VASCULAR PLANTS

"Nasci non possunt cicadae, ubi arbores desunt: quocirca apud Cyrenam nullae in campo sunt, cum circa oppidum ipsum multae proveniant. Oleas maxime amant, ut minus umbrosas; loca enim frigidiora aspernantur; quamobrem in opacis nemoribus esse nequeunt."

ARISTOTLE, *Hist. Anim.*, lib. V, cap. 30; T. Gaza, interpr.

In a preceding section (chap. XI) we have seen that Cicadidae, in spite of their powerful wings, are strongly restricted to definite stations, in the delimitation of which the vegetational or plant ethological factor seems predominant. Since the bulk of vegetation consists of vascular plants, such restriction implies the existence of very close relations between cicadas and these organisms. It behoves us here to attempt an analysis of this relationship.

Generalizing very broadly it appears that the local chorological, as distinct from the regional chorological requirements of cicadas are chiefly food, oviposition-hosts, and perching-places. Of these, the first and second are supplied entirely and the third largely by vascular plants.

The choice of oviposition-hosts has not been correlated with any structural variations in the ovipositor; but the oviposition of too few species has been studied to supply useful data. It would appear, however, as we have already seen, firstly that the choice is not influenced either by the taxonomic position of the host or by that of the cicada; and secondly that the oviposition hosts of a given species are distinguished by a mechanical character rather than by any other.

In support of these statements we submit a list of oviposition-hosts of *Melampsalla cingulata*, with possibly some of *M. cauta*, collected at York Bay, Wellington, New Zealand, in primitive forests—mixed rain-forest on the lower levels, passing into *Nothofagus* on the ridges and higher levels, edged with *Ulex* heath and gardens.

#### Violaceae

*Melicytus ramiflorus* Forst.

#### Pittosporaceae

*Pittosporum tenuifolium* Banks and Sol.

*P. eugenioides* A. Cunn.

## Tiliaceae

- Aristotelia racemosa* Hook. f.  
*Elaeocarpus dentatus* Vahl.

## Meliaceae

- Dysoxylum spectabile* Hook. f.

## Sapindaceae

- Alectryon excelsum* Gaertn.

## Saxifragaceae

- Carpodetus serratus* Forst.  
*Weinmannia racemosa* Linn. f.

## Myrtaceae

- Myrtus bullata* Sol.  
*Leptospermum ericoides* A. Rich.

## Onagraceae

- Fuchsia excorticata* L. f.

## Araliaceae

- Nothopanax arboreum* Forst.

## Rubiaceae

- Coprosma grandifolia* Hook. f.  
*C. lucida* Forst.  
*C. robusta* Raoul.  
*C. rhamnoides* A. Cunn.  
*C. microcarpa* Hook. f.

## Compositae

- Olearia Cunninghamii* Hook. f.  
*Brachyglottis repanda* Forst.

## Epacridaceae

- Leucopogon fasciculatum* A. Rich.

## Myrsinaceae

- Rapania Urvillei* (A. D. C.).

## Oleaceae

- Olea lanceolata* Hook. f.

## Loganiaceae

- Geniostoma ligustrifolium* A. Cunn.

## Piperaceae

- Macropiper excelsum* (Forst. f.).

## Monimiaceae

- Hedycarya arborea* Forst.

## Fagaceae

- Nothofagus Solandri* Hook. f.  
*N. fusca* Hook. f.

All the 28 species listed are indigenous woody plants—trees or shrubs; and without exception they include only plants of the forest itself or of its actual border. The total number of indigenous shrubs or trees in the vicinity, from sea-level to the top of the ridge at 1000 feet, and including plants of the open heath and cliff face, is 68. The number of forest species is 58. When one considers that many of these are extremely rare in the forest in question, in several cases represented by one or by two trees, and that no special search was made, 28 is a large proportion.

In addition the gardens of the forest edge have shown lemon and *Sophora tetraptera* J. Mull., with oviposition marks.

Outside the limits we have considered, *Melampsalta cingulata* has been found to oviposit in mistletoe, *Elytranthe tetrapetala* Forst. To give a complete list of other plants acting outside the area as oviposition-hosts would serve no useful purpose, since the cicada's eclecticism has been demonstrated. Butler (1886) and Davis (1894d) have indicated a much wider range for the periodical cicada, in whose vast irruptions, however, there probably enters a factor of competition, leading to a use of unsuitable plants. *Melampsalta cingulata*, chosen for our study, is never so excessively abundant.

This list as we have seen includes a considerable proportion of the woody plants of the vicinity, and taken in conjunction with the data supplied in chapter XI, seems certainly to indicate that the choice of an oviposition-host is guided chiefly by a mechanical factor. If it be suggested that oviposition occurs merely in the plant nearest to hand, in this case, woody plants of one kind and another, we would instance the teeming abundance of numerous other plant-types in a rain-forest so tropical in character as that of New Zealand, and their entire freedom from the ovipository attentions of *Melampsalta cingulata*.

## THE FEEDING-HABITS OF CICADAS

“Elles sont donques nourries de la rousee du Ciel, car de la rousee est faite la manne, dont le peuple Hebrieu a esté nourry au desert.”

HIEROSME CARDANUS, 1584, 1, p. 252.

Two features of cicada life, above all others, appealed to the imagination of the ancients. One was the loud and piercing song, and the other was the mysterious feeding-habits. Few popular beliefs have taken so long to die as that which attributes to the cicada a diet of dew. Even Aristotle (*Hist. Anim.*, lib. IV, cap. 7) saw nothing improbable in this “Alimentum unum et peculiare.” Pliny, of course, followed him, while Cardanus, the physician of Milan, proved logically the nourishing properties of dew in the passage quoted above. Hales, the English comparative anatomist

(1727) believed in the valuable properties of dew, which was absorbed directly by the plant.

To the question of *manna* produced by cicada feeding punctures, we shall return later, but here we are impelled to quote from Donovan, who was responsible for the charming English popular name applied to a Chinese cicada, namely, "flea-locust." Donovan writes that cicadas "had been observed to fly among ash trees, bore many holes in them, and when the manna had oozed out, return and carry it off!"

The earliest note, however, of cicadas' feeding upon something if not more substantial, at least more nutritious than the dew of heaven, seems to be an observation made by Tancered Robinson in 1683-1684, but published in 1714-1716.

"Coming near Capua, I observ'd a Species of Ash, or *Ornus* on the trunk whereof many Saccharin Concretions were visible. This proved the true *Manna*, that issues out thro' the Incisions made in this Tree by the Inhabitants of *Calabria*. Swarms of Cicada's were sucking the Body and Boughs, and perhaps by wounding them made way for fresh Manna" (p. 474).

Réaumur, somewhat later (1740), describing the rostrum, says (p. x), "Cette trompe apprend que la cigale n'est pas faite pour vivre uniquement de rosée;" and instances an observation of one of his correspondents that a cicada suddenly seized on a tree-trunk often withdrew its mouth-parts only with great difficulty.

But the dew theory migrated to America and held sway until comparatively recent years. Potter (1839) claimed that cicadas live solely on the exhalations of vegetable barks—"the insensible perspiration of the vegetable skin." Yet Hildreth (1830) saw the same species (*Magiccada septendecim*) with its "proboscis" inserted in the bark of a tree, and a drop of liquid exuded when the mouth-parts were withdrawn.

Jaeger (1834, p. 102) retained the old fetish—"they suck with their snout only the dew of leaves."

It is possible, although not proven, that we may have to recognize a difference, especially quantitative, in the feeding-habits of different species. Thus in Europe, *Tibicen plebeia*, though well-known (Fabre) to feed, appears to do so less frequently than *Cicada orni*, which was doubtless the subject of Tancered Robinson's observation. In Australia Froggatt (1903, p. 339) remarks that *Cyclochila australasiae* does not appear to feed in the adult state. In North America it is usually the periodical cicada which is given the palm for abstinence. With regard to this species there were stray observations by Riley, by Davis, and by March (1889), but it was Quaintance (1902) who proved that it fed commonly and sometimes in such numbers that the sap from the punctures streamed down the trunks and branches of the trees.

Townsend (1892) saw *Tibicen montezuma* (Dist.) almost certainly feeding on *Yucca angustifolia*. Gravely (1915) had a captive specimen of *Lemuriana apicalis* (Germ.) which fed on the sap of a piece of the tree on which it was caught. During feeding it emitted from time to time a jet of colourless liquid with considerable force from its hinder end.

This squirting of liquid surely is an indirect proof of feeding. We have observed it in *Melampsalta cingulata*. The fluid discharged is probably different from that emitted by the adult during the final ecdysis—a kind of moulting fluid (Davis, 1922, in *Tibicen auletes*; Krumbach, 1917, in *T. plebeia*).

The feeding evacuations are especially numerous in *Cicada orni* (Krumbach, 1917); in *Platypleura capitata* (Ol.), (= *Poecilopsaltria subrufa* Dist.) in India (Biscoe, 1896); and have been described by Bates (1863, p. 227) in an Amazonian species. In Australia, *Psaltoda moerens* (Germ.) feeds continually on the trunks of *Angophora lanceolata*, emitting meanwhile a spray from the anus (Froggatt, 1903, p. 340).

This habit has led in South Africa (Peard, 1917), in Mexico, and in Australia, to a belief in "rain-trees," which in the latter country are explained as follows:

"The 'rain' is caused by the micturition of countless cicadas. Walk quietly under a tree where they are, and you will experience only an April shower. Then make a noise or move suddenly, and you will be favoured by a tropical downpour" ("Vincimus," 1927).

The most copious rain-makers are, however, reported from Mexico. Dr. W. M. Mann found that in one new irrigation district a main ditch was being constructed with an angle to avoid a rain-making tree which was considered a valuable irrigation agent. An unidentified species of cicada was discovered thickly perched on this tree, busily producing the "rain." A similar case is recorded, likewise from Mexico, by Krieger (1904). This writer observed that the evacuation was performed with a chorus effect, much like that observed in the song of other species.

"Beginnt eine der Cicaden ihren Tropfen zu schleudern, so ist dies das Zeichen für die ganze Gesellschaft, ein gleiches zu tun, und in wenigen Sekunden ist die Erscheinung des Baumes, der nach Bolieben regnen lässt, fertig."

In the case of some species at least, it would appear that no very great restriction in feeding-habits is shown. Thus, *Cicada orni*, which seems in some districts to prefer ashes and olives, in others haunts pines, and Swinton (1908, p. 380) found it in Spain feeding upon especially resinous "mushroom-topped pines." He was "at liberty to pick as many of the intoxicated bridegrooms off the sticky trees" as he pleased, "for they had drunk the spirit of turpentine, which is a poison to man, long and deep."



Among some cicadas collected in Samoa by Dr. P. A. Buxton and Mr. G. H. Hopkins is a male, *Baeturia exhausta* (Guér.), with its face and mouth-parts obscured by a hardened blob of some adhesive material. It bears the label, "The value of latex to plants! This cicada tried to suck *Carica papaya* . . ." This is an interesting example of lack of discrimination in cicada feeding.

The question of food-plant preferences brings up an interesting discussion which has already been mentioned. It is important in the present study to discover why an insect chooses to feed on one plant rather than another. To an older generation the term "instinct" would explain all, and even now we must of course admit in the insect an inherited tendency to act upon certain stimuli. Our problem is to find what those stimuli are which determine food-plant preference. At the outset we are impressed with the existence of two sets of conditions—first, those which are inherent in the plant itself and are shared to a greater or less extent by the relatives of that plant, and which we may call botanical factors; and, second, those which depend primarily on external or purely physical conditions and may be termed environmental factors. The entomologist will at once recall instances in which the food-determining factors are predominantly or exclusively botanical. As examples we may cite the Pierid butterflies and Cruciferae, certain *Vanessas* and Urticaceae and *Dysdercus* and Malvaceae. The appearance of taxonomic acumen with which insects will choose for themselves, or for their morphologically often very dissimilar young, food-plants botanically related to their accustomed host has long excited interest and wonder and has been dealt with by Fabre in a very characteristic chapter on "l'instinct botanique." The modern view regards the preference as guided directly by the specific chemical—gustatory or olfactory—properties of the plants themselves.

But it has long been borne in upon the writer that the importance of environmental factors in the host-preferences of phytophagous insects is too little understood and too largely underestimated. In a study of the food-habits of the Hemiptera of New Zealand, it was found that, while cases analogous to that of the cabbage butterflies were plentiful and, in fact, the rule among the Heteroptera (phytophagous species only), they were rare in the Homoptera. The New Zealand fauna is so peculiar and apt to be a law unto itself that generalizations were considered risky. But later observations in North America, in Europe, and especially in Cuba have gone far to confirm the impression gained in the antipodes, while the recorded data are apparently not opposed to the same conclusions. For example, Metcalf (1924)\* writes of "what seems to be a rather general rule among these insects, that is, that they live in a given habitat because they find there the complex of environmental conditions required and not alone because they find some particular

food-plant growing there." Thus there is, I believe, a marked but hitherto almost unnoticed difference in this respect between the two sub-orders Heteroptera and Homoptera. In the Heteroptera general plant-feeders are rare, though their scarcity is obscured by the individual frequency of such indiscriminate feeders as *Lygus pratensis* and certain Pentatomids. The pages of Butler's monumental work on the biology of British Hemiptera-Heteroptera (1923)\* abound in cases of restricted host range; while in reference to the species-rich and largely phytophagous family Miridae (Cassidae) Knight (1923, † p. 422) states that "probably the greater number of species are limited to a single host-plant, or to a genus of plants, while a very few, such as *Lygus pratensis* Linnaeus and *Halticus citri* Ashmead, have a wide range of food-plants." In the Homoptera, on the other hand, the Cicadidae and the Fulgoroidea are predominantly general feeders, a condition in this case probably correlated with the frequent difference in host and habitat between the nymphal stages and the adult. In the Cicadellids, Aphids, and Coccids, examples of very general plant-attachments are numerous. In the latter family the case of *Platycoelostoma compressa* (Mask.) is interesting as showing the power of a purely mechanical factor. This highly aberrant monotypic representative of an endemic genus is recorded so far only on *Podocarpus totara* A. Cunn., a Taxad, and on *Dracophyllum Traversii* Hook. f., an Epacridaceous plant. It apparently does not occur on other common species of *Podocarpus*. The character common to these two unrelated plants is a finely laminate bark in a state of chronic dehiscence. The other species of *Podocarpus* show no such character. *Platycoelostoma* lives tightly compressed under the thin layers of bark. ‡

The Psyllidae tend to be more specific than other Sternorrhyncha, but perhaps the only Homopterous family which can compare with the Miridae in this respect are the Membracidae, of which Funkhouser remarks (1923, || p. 167):

"The various species of Membracidae usually confine themselves to very definite host plants and are excellent botanists. In many cases the association between the insect and its host is so characteristic that a knowledge of the one is sufficient for the recognition of the other."

The whole question, of course, may be obscured by the untrust-

\* *A Biology of the British Hemiptera-Heteroptera*. E. A. Butler, London, 696 pp. illus.

† H. H. Knight: "The Miridae" in W. E. Britton, *Guide to the Insects of Connecticut*. Part IV. "The Hemiptera": *Bull. Connecticut Geol. Nat. Hist. Survey*, No. 38.

‡ Since this was written, Mr. E. E. Green has decided to describe the *Dracophyllum* form as a distinct species,

|| "The Membracidae," in W. E. Britton, l.c.

\* The beach pool—leafhopper complex. *Ecology*, 5, pp. 171-174.

worthy nature of so many published "host-records" based on the collecting of stray individuals.

In earlier pages we have seen that cicadas will feed on a considerable variety of trees, even those in which the sap is extremely resinous. In New Zealand the exclusively tree-dwelling *Melampsalta cingulata* apparently feeds on *Pinus insignis (radiata)*; since it sometimes occurs on this introduced tree in plantations far distant from other arborescent vegetation.

The relations of Cicadidae to vascular plants are then, from the botanical view-point, extremely indiscriminate; from the ethological standpoint highly specific.

An alleged reciprocal relation between *Cicada orni* and one of its common food-plants—the European ash, *Fraxinus ornus*, merits attention here. There is a widespread belief that the dried sap exuding on the trunk and branches of this tree from the feeding-punctures of *Cicada orni* form the best "manna." Linnaeus gave expression to this opinion when he named the section of the genus *Cicada* containing the present Cicadidae, *Manniferae*. How old the story is, or how true, I have not been able to ascertain, but one of the earliest records—that of Tancred Robinson, quoted above, mentions that most of the manna obtained from this tree exudes from artificial punctures. Dufour (1833, p. 92) casts doubts on cicada agency. Yet Brandt and Ratzeburg (1833) and Ratzeburg (1839) state that the best product is obtained from cicada-punctures. Melichar (1897) seems to agree; but Judeich and Nitsche (1895, p. 1189) remark that most manna is now procured by artificial means. This product is used medicinally.

In Australia the blacks say that the manna produced by *Eucalyptus viminalis (mannifera)* is the excrement of a cicada (Bennett, 1834, p. 237). McCoy (1880) dealing with the same species of tree and probably the same cicada—*Psaltoda moerens* (Germ.)—remarks that the feeding of the insect induces "an abundant exudation of sap, which, drying in the hot parched air of the mid-summer, leaves the sugary solid remains in a gradually increasing lump, which ultimately falls off, covering the ground with a sort of white sweet manna in little irregular masses." He proceeds to a chemical examination of the product.

Froggatt, likewise in Australia, found *Melampsalta incepta* (Walk.) during one season, in such numbers on peach-tree limbs and trunk as to cause serious damage. "The whole of the trunk and the main branches of dozens of peaches were covered with little globules of dried gum . . ." (1913). The punctures passed entirely through the bark into the sapwood beneath. There was somewhat similar damage to Eucalypts.

## CHAPTER XV

### RELATIONS OF CICADAS WITH OTHER INVERTEBRATES

"Once, shrilling cicada, perched on the green branches of the luxuriant pine, or of the shady domed stone-pine, thou didst play with thy delicately-winged back a tune dearer to shepherds than the music of the lyre. But now the unforeseen pit of Hades hides thee vanquished by the wayside ants. If thou wert overcome it is pardonable; for Maeonides, the lord of song, perished by the riddle of the fishermen."

ARCHIAS OF ANTIOCH, *Anthologia Graeca (Stephanus of Philippus)*,  
tr. Paton, 1917, II, p. 121.

THE relations of other invertebrates with cicadas are, with the exception of a few possible cases of phoresy, almost entirely inimical. Nearly all the animals concerned are insects or Arachnids. We shall consider the few and doubtful others first.

Butler (A. W., 1886) records two snails, *Mesodon exoleta* Binn. and *M. elevata* Say, feeding on dead *Magiccicada septendecim*.

A freshly-emerged example of *Melampsalta leptomera* brought to me in January (1924), was found to be swarming with a large white nematode, of which over 40 were counted in the head-capsule alone. Unfortunately the cicada was dead when brought to me; so the worms may have been merely saprophagous like the snails.

The insect enemies include true parasitoids of eggs or imagines; predators feeding on adults or eggs, paralyzers of the adults and finally exploiters of the sap-flow caused by cicada feeding-punctures.

The last is a miscellaneous crowd which Fabre (ed. 1921, p. 221) has well described.

"Ils accourent, d'abord avec quelque réserve, se bornant à lécher la liqueur extravasée. Je vois s'impresser autour de la piqûre melliflue des Gûepes, des Mouches, des Forficules, des Sphex, des Pompiles, des Cétoines, des Fourmis surtout. . . . En ce coup de bandits, les plus opiniâtres sont les Fourmis. J'en ai vu mordiller la Cigale au bout des pattes; j'en ai surpris lui tirant le bout de l'aile. . . . Une audacieuse s'est permis, sous mes yeux, de lui saisir le suçoir, s'efforçant de l'extraire."

With the startling conclusion, "The song of the cicada is appreciated and listened to by other insects," Lewis (1891) describes the congregating of lacewings, *Nothochrysa gigantea*, round singing cicadas in Natal. The note that they form themselves into a rough

semicircle at a short distance around the performer's head, suggests a gastronomic rather than a purely æsthetic interest.

Froggatt (1896) records a similar occurrence in Australia, accompanied there with more violence. *Priocnemus bicolor* Smith actually seizes the cicada by the leg and shakes it until the cicada withdraws its setae and flies away, whereupon the wasp stands over the hole and drinks the exuding sap. The cicada is apparently never harmed.

The large and powerful Bembecid digger wasps of the genus *Sphecius*, are redoubtable cicada-hunters. The North American species, *S. speciosus* Dr. has been studied in considerable detail by Riley (1892) and many succeeding writers, including especially Marlatt (1907, p. 132) and Savin (1923). The latter observer found nearly 40 independent burrows within an area of about 600 square feet, near which were some trees, whence it was the custom of the wasps to fly with their paralysed but heavy and bulky prey. Some burrows were four feet long and provisioned with more than one cicada, sometimes of more than one species. The egg of the wasp is laid on the underside of the victim and the wasp grub finishes by devouring it almost entirely, subsequently spinning a cocoon. *Sphecius spectabilis* has been observed in South America to use the fairly powerful *Tettigades chilensis* A. and S., while *S. freyi* Handl. in Madagascar captures the large cicada, *Yanga brancsiki* (Dist.), (Brancsik, 1891, 1893).

The place of these wasps in that land of cicadas, Australia, is taken by the strange and aberrant Exeiridae, represented by the great Australian cicada-hunter, *Exeirus lateritius* Shuck. The habits of this giant wasp have been described by Tillyard (1926, p. 298). The burrows end in veritable catacombs in which the paralysed cicadas are laid on shelves, an egg fastened to each. "The wasp grub devours the Cicada and forms a large earthen cocoon alongside its remains. If the weather is dry, they frequently remain two or three years in the larval state inside the cocoon before pupating." Here then is an instance of facultative hypnody to be compared with the regular examples of this phenomenon shown by the cicada-egg parasites discussed in later pages.

Froggatt (1903) describes as *Priocnemus* sp. a cicada-hunting wasp which is almost certainly the *Exeirus lateritius* studied by Tillyard.

Davis (1924b, 1925) has given several instances of the introduced wasp, *Vespa crabro*, attacking cicadas in North America. Such an encounter may be the basis of the line in Theocritus (Idyll V) which has been translated, "He that would think like thee to worst his mate, a wasp against the cicada." Buxton and Hopkins noticed a cicada (*Bacturia exhausta*) as the prey of a *Polistes* wasp in Samoa.

The most redoubtable enemies of cicadas, however, appear to be Asilid flies. Poulton (1907) even suggests that the genus *Promachus* specializes in dragon-flies and cicadas, as does the Nicaraguan

kite observed (see later) by Belt. These flies are notorious for tackling prey much larger than themselves, and *Neotamus smithi* in New Zealand is no exception to the rule. Messrs. S. and C. Lindsay sent me an example (Mar., 1923) with a *Melampsalta hamiltoni* which they had disturbed, but the fly had caught first.

It is a really spectacular sight to see the giant New Zealand dragon-fly—*Uropetala carovei*—swoop and catch in mid-air our largest cicada, *M. cingulata*. It is able, somewhat more slowly it is true, to fly with its bulky prey, but it usually does not carry it far before perching to eat it. (Plate VII, fig. a.)

One of the most extraordinary cases I have seen, however, is that of *Cermatulus nasalis*, an Asopine Pentatomid. This New Zealand bug had attacked a male *Melampsalta muta* much larger than itself and "had inserted its rostrum into the end of the cicada's abdomen. The latter insect, attempting to fly, was actually swinging by its exerted extreme abdominal segments, while the bug, gripping with its claws the rough toetoe (*Arundo conspicua*) leaf, held back hard, though nearly pulled off its perch by the larger insect, which kept up a shrill screaming stridulation, very different from its normal note" (Myers, 1921a).

Ross (in Distant, 1898a) and Mrs. Monteiro (1891) describe the victim as making a similar noise when seized by a mantis, and keeping it up while being devoured.

Webster (F. M., 1897) states that a Tachinid plays havoc with the later part of the brood of *Magiccicada septendecim*. Eggs are often seen attached to the bodies and maggots found within. Yet this Tachinid seems never to have been identified.

Among the egg-parasites of cicadas are two small parasitic wasps, a *Syntomaspis* and a *Heterospilus* (Beamer, 1925) which usually attack far different insects—namely, gall-insects and wood or stem-borers respectively. The *Heterospilus* has been described by Rohwer (1925) as *H. beameri*.

Silvestri has made a very detailed study of the Chalcidids attacking cicada eggs in Europe—an investigation begun by Réaumur himself, whose parasitic "petites mouches noires et luisantes," have been identified as *Cerambycobius cicadae* (Giraud), (1871), (Silvestri, 1918). Fabre (ed. 1921, pp. 272-274) has well described the oviposition of the same species. Silvestri (1918) found that the young larva hatching from the single egg laid in the cicada cell among the ova of the latter insect, with a worm-like movement, adheres with its mouth to the surface of the host egg and sucks it dry. *Centrodora cicadae*, on the other hand, being much smaller, lays from one to three eggs in a cicada egg, and the larva feeds endophagously. *Cerambycobius* is attacked in the larval stage by a secondary parasitoid, *Homoporus fulviventris* (Walk.), (Silvestri, 1921). The larvae of *Cerambycobius* and of *Centrodora* present a striking instance of hypnody since, after devouring the cicada eggs, in late summer,

they remain without nourishment or pupation till the following July.

**Archirileya inopinata** Silvestri (1920, 1921) is an exceptionally interesting Chalcidid in that its first generation develops in the eggs of *Cicada orni* or of *Tibicen plebeia*, and the second in those of the tree-cricket, *Oecanthus pellucens*. The larva, by means of the uncinata teeth of the clypeus, will burrow in softer stems, from one egg cell to the next, devouring a number of the eggs of the second after it has finished its first supply.

Gahan (1927) has recently described as a new genus and species a remarkable Mymarid, *Idiocentrus mirus*, reared by us from the

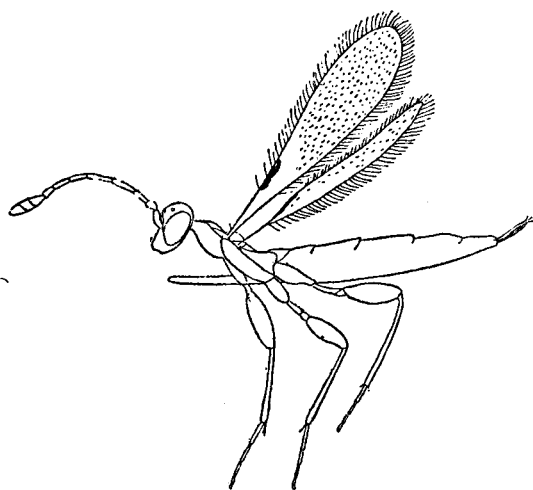


Fig. 100. *Idiocentrus mirus* Gahan. Adult female.  
After Gahan, 1927.

eggs of *Melampsalta muta* (Fabr.) at York Bay, Wellington, New Zealand. In this extraordinary little insect, of which only the female is at present known, the ovipositor is folded forward within a sheath which, formed by a modification of the basal abdominal segments, extends between the legs right to the head itself (fig. 100).

Ants, according to Musgrave, are redoubtable enemies of the emerging adults, ranging over the tree-trunks in New South Wales, in search of this defenceless prey.

There is a peculiar family of moths, the Epipyropidae, whose caterpillars, in various parts of the world, are parasitic externally on variously leafhoppers and planthoppers, and in one case, in Japan, on adult cicadas. These curious larvae, covered with a white pruinose substance, were discovered by Nawa (1903) on the

common Japanese cicadas, *Tanna japonensis*, *Oncotympana maculaticollis*, and *Graptosaltria colorata*, but most frequently on the first-named. Moths were reared, and later described by Dyar (1904) as *Epipyrops nawai*. The full-grown larva leave the host to which they have been clinging and spin cocoons on tree-trunks or leaves (see also Kirkaldy, 1903, Perkins, 1905).

The following table includes all the data we have been able to gather on the insect enemies of the Cicadidae :

| Insect enemy.                       | Cicada.                       | Stage Attacked.  | Place.      | Authority.              |
|-------------------------------------|-------------------------------|------------------|-------------|-------------------------|
| <b>ORTHOPTERA</b>                   |                               |                  |             |                         |
| <b>Mantidae</b>                     |                               |                  |             |                         |
| <i>Miomantis fenestrata</i> (F.)    | <i>Quintilia carinata</i>     | adult            | S. Africa   | Ross (Dist. 1898a)      |
| "large green mantis"                | Sp. unknown                   | "                | "           | Monteiro (1891)         |
| Locustidae (auctt.)                 |                               |                  |             |                         |
| <i>Locusta viridissima</i> (L.)     | <i>Tibicen plebeia</i>        | "                | Europe      | Fabre (1912 ed.)        |
| <b>ODONATA</b>                      |                               |                  |             |                         |
| <i>Uropetala carovei</i> White      | <i>Melampsalta cingulata</i>  | "                | N. Zealand  | Myers (see text)        |
|                                     | <i>M. subalpina</i>           | "                | "           | "                       |
| <i>Tachopteryx thoreyi</i>          | <i>Magisicada septendecim</i> | "                | N. America  | McAtee                  |
| "dragon-flies"                      | " "                           | "                | "           | Marlatt                 |
| "largest dragon-flies"              | " "                           | "                | "           | Felt (1912)             |
|                                     |                               |                  |             | Fitch.                  |
| "large Libellulæ"                   | —                             | "                | Afghanistan | Hay (1840)              |
| <b>HEMIPTERA</b><br>(Heteroptera)   |                               |                  |             |                         |
| <b>Pentatomidae</b>                 |                               |                  |             |                         |
| <i>Cermatulus nasalis</i> (Westw.)  | <i>Melampsalta muta</i>       | "                | N. Zealand  | Myers                   |
| <b>Reduviidae</b>                   |                               |                  |             |                         |
| "soldier bug"                       | <i>Magisicada septendecim</i> | eggs<br>nymphs ? | N. America  | Marlatt<br>March (1889) |
| <b>COLEOPTERA</b>                   |                               |                  |             |                         |
| <b>Carabidae</b>                    |                               |                  |             |                         |
| <i>Calosoma sycophanta</i> L.       | <i>M. septendecim</i>         | adult            | N. America  | Lacroix (1923)          |
| <b>Cicindelidae</b>                 |                               |                  |             |                         |
| <i>Mantichora mygaloides</i> Thoms. | <i>Callipsaltria longula</i>  | "                | S. Africa   | Distant (1906 b. 178)   |
| <b>MECOPTERA</b>                    |                               |                  |             |                         |
| <i>Panorpa rufescens</i> Ramb.      | <i>Tibicen linnei</i>         | (dead)           | N. America  | Malloch (1922)          |
| <b>DIPTERA</b>                      |                               |                  |             |                         |
| <b>Asilidae :</b>                   |                               |                  |             |                         |
| <i>Dasyllis grossa</i> (Fabr.)      | <i>Tibicen chloromera</i>     | adult            | N. America  | Champlin and Knoll      |
| <i>Neotamus smithi</i> (Hutt.)      | <i>Melampsalta hamiltoni</i>  | "                | N. Zealand  | Lindsay (see text)      |

| Insect enemy.                                   | Cicada.                                      | Stage<br>Attacked. | Place.     | Authority.                  |
|---|--|--------------------|------------|-----------------------------|
| <b>DIPTERA—contd.</b>                           |  |                    |            |                             |
| <i>Microstylum dux</i> Wied.                    | <i>Mogannia mandarinae</i>                   | adult              | S. China   | Kershaw<br>(Poulton)        |
| <i>M. apicale</i> Wied.                         | <i>Abroma nubifurca</i>                      | "                  | Ceylon     | Yerbury                     |
| <i>Promachus capreolus</i><br>Loew              | —  | "                  | S. Africa  | Marshall<br>(Poulton)       |
| <i>P. sokotrae</i> Ric.                         | <i>Melampsalta omar</i>                      | "                  | Sokotra    | Ogilvie-<br>Grant           |
| <i>P. anicius</i> Wk.                           | <i>Mogannia nasalis</i>                      | "                  | S. China   | Kershaw<br>(Poulton)        |
| <i>Proctocanthus nigriventris</i>               | <i>Cicada hieroglyphica</i>                  | "                  | N. America | Davis<br>(1924 b)           |
| <i>Erax interruptus</i>                         | <i>Tibicen olympusa</i>                      | "                  | N. America | Davis (l.c.)                |
| "large Asilid"                                  | <i>Platypleura centralis</i>                 | "                  | S. Africa  | Marshall<br>(1897)          |
| "Asilid larva"                                  | <i>M. septendecim</i>                        | eggs               | N. America | Marlatt                     |
| <b>Tachinidae:</b>                              |  |                    |            |                             |
| <i>Tachina</i> sp.                              | <i>Magiccicada septendecim</i> ,             | "                  | N. America | Marlatt                     |
| "Tachinid"                                      | " "  | "                  | "          | Webster<br>(1897)           |
| <b>Sarcophagidae</b>                            |  |                    |            |                             |
| Sarcophagid                                     | " "  | "                  | "          | Webster<br>(1897)           |
| <i>Sarcophaga helicus</i><br>Town.              | <i>Tibicen linnei</i>                        | adult<br>(dead)    | "          | Aldrich                     |
| <b>Cecidomyiidae</b>                            |  |                    |            |                             |
| "Cecidomyiid"<br>(larva)                        | <i>M. septendecim</i>                        | eggs               | "          | Marlatt<br>Felt (1914)      |
| <b>LEPIDOPTERA</b>                              |  |                    |            |                             |
| <i>Epipyrops nauai</i> Dyar.                    | Several Japanese<br>spp.                     | adult              | Japan      | { Nawa<br>Dyar              |
| <b>HYMENOPTERA</b>                              |  |                    |            |                             |
| <b>Chalcididae</b>                              |  |                    |            |                             |
| <i>Syntomaspis</i> sp.                          | <i>Tibicen aurifera</i>                      | eggs               | "          | Beamer                      |
| <i>Cerambycobius cicadae</i><br>(Gir.)          | <i>Tibicen plebeia</i><br><i>Cicada orni</i> | "                  | Europe     | Silvestri<br>Giraud         |
| <i>Centrodora cicadae</i> Silv.                 | <i>Tibicen plebeia</i>                       | eggs               | "          | Silvestri                   |
| <i>Archirileya inopinata</i><br>Silv.           | <i>T. plebeia. C. orni</i>                   | "                  | "          | "                           |
| <i>Lathromeris cicadae</i><br>How.              | <i>M. septendecim</i>                        | "                  | N. America | Howard<br>(1898)            |
| <i>Idiocentrus mirus</i><br>Gahan.              | <i>Melampsalta muta</i>                      | "                  | N. Zealand | Marlatt<br>Myers,<br>Gahan. |
| "mymarid, trichogrammid<br>and two chalcididae" | <i>M. Septendecim</i>                        | "                  | N. America | Marlatt                     |
| <b>Braconidae</b>                               |  |                    |            |                             |
| <i>Heterospilus beameri</i><br>Roh.             | <i>Tibicen marginalis</i>                    | "                  | "          | Beamer<br>Rohwer            |
| <b>Psammocharidae</b>                           |  |                    |            |                             |
| <i>P. bicolor</i> Smith                         | <i>Henicopsaltria perulata</i><br>and others | adults             | Australia  | Froggatt<br>(1903, 1896)    |



Fig. 101. Cicada Killer, *Sphex speciosus* Dr., from Staten Island, New York.  
Slightly enlarged

Wm. T. Davis, photo

| Insect enemy.                      | Cicada.  | Stage<br>Attacked.          | Place.     | Authority.                 |
|------------------------------------|--|-----------------------------|------------|----------------------------|
| HYMENOPTERA— <i>contd.</i>         |  |                             |            |                            |
| Exeiridae                          |  |                             |            |                            |
| <i>Exeirus lateritius</i> Shuck.   | —  | adults                      | Australia  | Tillyard<br>(1926)         |
| Bembecidae                         |  |                             |            |                            |
| <i>Sphecius speciosus</i> Dr.      | <i>Tibicen linnei</i><br>and others            | ,,                          | N. America | Marlatt<br>(see text)      |
| <i>S. spectabilis</i> Tasch.       | <i>Tettigades chilensis</i>                    | ,,                          | S. America | Jensen-<br>Haarup          |
| <i>S. freyi</i> Handl.             | <i>Yanga brancsiki</i><br>(Dist.)              | ,,                          | Madagascar | Brancsik                   |
| Vespidae                           |  |                             |            |                            |
| <i>Polistes pallipes</i> Lepel.    | <i>Cicada hieroglyphica</i>                    | ,,                          | N. America | Davis<br>(1924 b.)         |
| <i>Polistes macaënsis</i>          | <i>Baeturia exhausta</i>                       | ,,                          | Samoa      | Buxton &<br>Hopkins        |
| <i>Vespa crabro</i> L.             | <i>Tibicen chloromera</i><br><i>T. lyricen</i> | ,,                          | ,,         | Davis<br>(1924 b.<br>1925) |
| "hornet" ( <i>V. crabro</i> ?)     | —  | —                           | —          | Distant<br>(1881-1883)     |
| Formicidae                         |  |                             |            |                            |
| Ants                               | <i>M. septendecim</i>                          | eggs<br>and young<br>nymphs | N. America | Marlatt                    |
| <i>Iridomyrmex detectus</i><br>Sm. | <i>Thopha saccata</i>                          | emerging<br>adults          | Australia  | Musgrave                   |

The references to Marlatt are throughout to his bulletin (1907) on the periodical cicada ; those to Beamer (1925) and those to Poulton (1907).

No insect enemies of the nymphs during their subterranean existence seem to have been observed.

Turning to the Arachnida, we find cicadas to be such clumsy insects that even comparatively small and delicate spider webs prove death-traps. The large and bulky *Melampsalta cingulata*, caught by only one wing in the web of *Araneus pustulosus* (Walck.) is frequently entirely helpless even though the spider avoids involving it further. The smaller species, like *M. muta*, one sometimes (e.g. field-note, 26th Nov., 1922) sees properly swathed and rolled by this same spider species—a sign that it has been accepted as food. The most frequent victim, among the cicadas, is, however, *M. scutellaris*. Nine times out of ten the remains of a cicada found in a New Zealand spider web, prove to be of this species.

*M. leptomera* has been found living deep in tufts of marram grass—*Psamma arenaria*—with the large Lycosid spider, *Dolomedes imperiosus*, which would appear, to judge by the remains, to prey at least occasionally on this cicada. Bilsing (1920) records the killing of *Tibicen linnei* by *Lycosa carolinensis* Walck. in captivity. Davis (1928) found a recently-emerged seventeen-year cicada caught by a

comparatively small Thomisid spider (*Xysticus ferox* Hentz.). He also records the North American *Argiope aurantia* capturing *Tibicen chloromera*, a very powerful species.

Larval mites, adhering to various parts of the body, have been found on *Melampsalta mangu* and *M. nigra*. Dr. August E. Miller has kindly determined them provisionally as a new species of *Erythraeus*, of the superfamily Trombidioidea.

Alexander,\* discussing similar larval mites on crane-flies, is doubtful whether any injury results to the host since the acarids are usually attacked only by the anal filaments. He is inclined to see in it a case of phoresy.

The following mites have been found associated with *Septendecim* eggs in the egg-slits, and were considered by Marlatt as probable destroyers (1907, pp. 135-138, figs. 61-68):

*Oribata* sp.

*Oribatella* sp.

*Oripoda elongata* Banks.

*Oppia pilosa* Banks.

*Oribatula* sp.

*Hoplophora* sp.

*Pediculoides ventricosus* Newp. (recorded also by Silvestri in *Tibicen plebeia* (1921).

*Tyroglyphus cocciphilus* Banks.

*Iphis ovalis* Banks.

*Cheyletus* sp.

*Bdella* sp.

The arthropods and other invertebrates here discussed are nearly all injurious to cicadas. There remains a case in which, though the relationship is almost certainly not hostile, the true position is somewhat obscure. On two occasions Mr. G. F. Hill has found cicada nymphs in earth nests of termites—once in Tasmania and once in Northern Australia. The North Australian one was full-grown, and may have encountered the nest accidentally on its way to the surface for emergence. It was found at a season when this might have occurred. The other, however, in a nest of *Porotermes froggatti* Holmgr., in Tasmania, was in an early stadium, and from its position high above the surface of the ground no burrow by which it could have entered was discoverable. Needless to say the termite galleries were too small to give it passage. No roots on which it might have fed penetrated that part of the termitarium. This is a very curious case.

\* 1920, p. 732, *The Crane-flies of New York*. Part II, Biology and Phylogeny. Cornell Univ Agric. Expt. Sta. Mem. 38, pp. 691-1133, pls. 11-97.

## CHAPTER XVI

### VERTEBRATE ENEMIES

"Nulla negotio a lupis asini comprehenduntur, et facile e vita tolluntur, a meropibus apes, ab hirundinibus cicadae, a cervis serpentes; . . ."

AELIAN, *De natura animalium*, lib. VIII, 6.

#### FISHES

CICADAS have been found in the stomachs of the following fishes, in the countries named:

*Magiccada septendecim* in *Ichthaelurus punctatus* Jordan, North America (Butler, 1886; Lowe, 1902);

in *Micropterus salmoides* Henshall, North America (Butler, Lowe, l.c.);

in *Catostomus teres* LeS., North America (*ibid.*);

gen. et sp. ? in trout, Japan (Matsumura, 1898, p. 19);

*Melampsalta* spp. in trout (probably introduced brown trout—*Salmo fario* L.), in New Zealand (Hudson, 1904, pp. 98, 94).

In the last case in the list Hudson found 9 cicadas among a total of 5466 insects in 60 trout stomachs. These insects had therefore formed only about 0.2 per cent of the insect food. Fishes, of course, obtain only cicadas which, dead or alive, have fallen into the water. Butler (1886) notes that fish refused to take the hook while the periodical cicada was abundant.

#### AMPHIBIA

DAVIS (1922, p. 37) records toads as lying in wait for the nymphs of species of *Tibicen* issuing from the ground for the last ecdysis.

#### REPTILES

Reptiles of many different groups—lizards, snakes, tortoises—have been recorded to feed upon cicadas. Probably there is a greater or less departure from normal feeding-habits under the stimulus of an irruption of the periodical cicada, with its myriads of moulting nymphs and freshly-emerged adults; but among the lizards there are numerous forms well-equipped by sharpness of eye, agility of movement, and tree-haunting habits, to make the most

wary adults a not infrequent prey. Thus Distant (1906c) states that according to the observations of Dixon, the worst enemy of cicadas in India is the Agamid lizard, *Calotes versicolor*. The same authority records (1906b) tree-lizards in South Africa as extremely fond of the cicada *Pycna semiclara*; while Marshall (1897) finds that in Mashonaland, *Platypleura centralis* and *Koma bombifrons* are often caught by small lizards.

Surface (1907, 1906b) found certain Pennsylvanian snakes feeding upon the periodical cicada.

"We have found the stomach of the Copperhead snake filled with scores of these insects. These pests have afforded at least eight per cent of the food of the Copperheads which we have dissected, and no less than six specimens, out of forty-one of this reptile containing food, were found to have fed upon seventeen-year Cicadas. . . . We have also found the Hog-nosed Adder, Spreading Adder or Blowing Viper feeding upon Cicadas."

The following is a list of reptiles known to feed upon cicadas:

Ophidia:

|                                    |                                   |            |   |
|------------------------------------|-----------------------------------|------------|---|
| <i>Heterodon platyrhinus</i>       | on <i>Magiccicada septendecim</i> | N. America | — |
| (Latr.)                            |                                   |            |   |
| <i>Agkistrodon contortrix</i> (L.) | " "                               | " "        | — |

Lacertilia:

|                                |            |           |   |
|--------------------------------|------------|-----------|---|
| <i>Calotes versicolor</i> Gray | on cicadas | India     | — |
| { "small lizards" }            | " "        | S. Africa | — |
| { "tree lizards" }             | " "        |           |   |

Chelonia:

|                      |   |  |            |                    |
|----------------------|---|--|------------|--------------------|
| "common land turtle" | " | { <i>M. septendecim</i><br>(nymphs) }                  | N. America | Felt (1905)        |
| "turtles"            | " | { <i>M. septendecim</i><br>(newly emerged<br>adults) } | —          | (Surface,<br>1907) |

### BIRD ENEMIES OF CICADAS

Birds play only one direct rôle in relation with cicadas—that of destroyers. The drama which was enacted in the temple of Bellona, when the consultations of the senate, with "the wisest of the Tuscan sages" were interrupted by a sparrow which had made a cicada its prey, as described by Plutarch and quoted in chapter two, has been played again and again in new lands where colonization has deliberately or inadvertently let upon the stage that arch-villain, *Passer domesticus*. The investigations of Professor Sushkin within the last year have shown that this bird belongs more correctly with the weaver birds (Ploceidae), but it shares with the Fringillidae to which it is usually referred, a strong penchant for cicadas.

The following passage from Fabre (ed. 1921, p. 269) would appear to indicate, as might be expected, that the depredations of the

sparrow are less serious in its native home than in the regions where it has been artificially introduced:

"Le Moineau, il est vrai, s'en montre friand. De temps à autre, son plan bien médité, il fond du toit voisin sur les platanes et happe la chanteuse, qui grince éperdue. Quelques coups de bec assenés de droite et de gauche la débitent en quartiers, délicieux pour la couvée. Mais que de fois l'oiseau revient bredouille! L'autre prévient l'attaque, urine aux yeux de l'assaillant et part. Non, ce n'est pas le Moineau qui impose à la Cigale progéniture si nombreuse."

In North America, however (Webster, F. M., 1897), in Australia (Cleland, 1918), in New Zealand (Hudson, 1891), especially in the vicinity of cities, the English sparrow is a very serious enemy of the indigenous cicadas. In fact, the three authors cited regard the sparrow as the chief agent in the partial extinction of cicadas in such localities. It is, however, only fair to add, that while these birds are as plentiful as ever in the vicinity of Wellington, where Hudson's observations were made, the cicada concerned, *Melampsalta cingulata*, is still a common insect; and thus we may be in the presence of one of those restorations of balance which do sometimes occur between members of an indigenous fauna and the disturbing changes of colonization.

The methods adopted by the sparrow in tackling such a large insect are well described by Fabre as quoted above. In New Zealand we have seen this bird with a *Melampsalta ochrina* held in its beak by the tips of the closed tegmina and thus evidently seized while resting—surely an adroit feat. The sparrow was swinging the incessantly shrieking insect over its head and banging it violently and repeatedly upon the ground. *M. ochrina* is almost our most protectively coloured cicada. One may look for five minutes only two feet away from a singing male and fail to locate it. I have seen also a sparrow catch *Melampsalta muta* on the wing. An example of the latter which I had disturbed was taken in flight by a sparrow after a very short chase, but the bird had to alight immediately to deal with its bulky prize. Mr. Cockcroft has seen it capture even the much larger *M. cingulata* in the same way.

I doubt very much whether birds trace cicadas by the song as Distant and Swinton have suggested. The behaviour of sparrows where cicadas are plentiful, seems rather to consist in keeping a sharp lookout for the movements which, in hot sunny weather, are frequent among both sexes of, for instance, *M. cingulata* and *M. muta*. The observation of Swinton (1880, p. 21) that "certain greyish insectivorous birds" deliberately twittered in order to provoke a response from the cicada, reads altogether too like a fairy tale to receive serious consideration. Yet I find an observation in one of my own old notebooks (29th Oct., 1915), that the "cat stalks cicadas (*M. muta*) in the grass, by their chirping, catches and



cats them even to the wings." As I remember it now, this was quite a habit of one of our cats, and its behaviour certainly gave all the outward signs of listening rather than of searching alone.

In antiquity, however, the hereditary enemy of the sacred tettix was considered not so much the sparrow as the swallow (Plutarch, Aelian). The *puella Pandion* of Evenus is a swallow (Milde, Aldrovandi). This belief, like that which supposed a deep-seated antagonism between cuckoos and cicadas (Aldrovandi, de Gubernatis), probably had a basis of observed fact. In North America, at least, there are no fewer than 58 records of cuckoos preying upon various species of cicadas (U.S. Biol. Survey, see below).

Among "les observations de plusieurs singularitez & choses memorables" made by Pierre Belon du Mans (Petrus Bellonius) during his wanderings in the sixteenth century, none is more remarkable than his description of the boys of Crete and their aerial angling for birds with cicadas as bait. With regard to the *Merops* he writes (chap. IX, feuil. 10):

"Sa beauté exquise inuite les petits garçons de Crete à le prendre avec des Cigales, comme aussi font les grandes Hirondelles, nommées Apodes. Et pour se faire, mettēt une espingle crochue en forme d'un hameson par le trauers d'une Cigale, à laquelle ils attachent un filet, dont ils tiennent le bout. La Cigale estant ainsi attachée, ne laisse pas de voler en l'air. Adonc le Merops l'aduisant, descend de roideur, et auale la Cigale en volant: l'epingle crochue le retient à ce filet, et demeure prins par ce moyen."

Kershaw (1903) saw bulbuls in South China chasing cicadas on the wing, and suggests they were doing so in sport since they appeared always unsuccessful.

The same writer, likewise Fabre and Distant, mention the screech emitted by cicadas when caught by an enemy. This is a feature also of the New Zealand species and is probably a widespread habit. It is such a piercing and, in fact, terrified shriek and so different from the song that one finds it extremely difficult to avoid anthropomorphic implications in describing it.

That comparatively large and powerful raptorial birds do not disdain cicadas as food is well established by the data given below, and by the description of Belt (1874, p. 230):

"In April, when the cicadae are piping their shrill cry from morn-  
ing until night, individuals are often seen whose bulky bodies have been bitten off from the thorax by some bird; and the large and graceful swallow-tailed kite at that time feeds on nothing else. I have seen these kites sweeping round in circles over the tree-tops, and every now and then catching insects off the leaves, so that on shooting them I have found their crops filled with cicadae."

Mr. Outram Bangs informs me that this bird feeds very largely on dragon-flies.

Bingham (1901) describes a nest of the pigmy falcon (*Microhierax caerulescens*) in the old hole of a barbet. The end was slightly enlarged into an oval chamber containing "a fairly firm pad of chips of wood, a few leaves, with an upper stratum quite two inches thick composed almost entirely of the wings of cicadas, with a few butterfly and moth wings interspersed therein" (quoted also in Poulton, 1908, p. 291).

In the Mokohinou Islands of New Zealand (east of Auckland), Sandager (1890) observed the mackerel gull—*Bruchigavia novae-hollandiae* (*Larus scopulinus*)—to prey on cicadas—probably *Melampsalta muta cutora*.

"When the *Cicadae* make their appearance in the early part of summer they are eagerly followed in their short flights by this little gull, which may be seen busily feeding on them during the whole day for a week or two at a stretch, driving them out of the ngaio bushes and following them inland, or out over the water."

The following list, arranged according to Sharpe's *Handlist*, will supply some evidence of the great variety of birds which at some time or other prey upon Cicadidae, and of the quantity of these insects which birds will occasionally devour:

| Bird species.                                | No. of records. | Cicada species.                | Place.     | Authority. |
|--|-----------------|--------------------------------|------------|------------|
| LARIDAE                                      |                 |                                |            |            |
| <i>Larus californicus</i><br>Lawrence        | 1               | —                              | N. America | B.S.       |
| <i>L. philadelphia</i> (Ord)                 | 1               | —                              | "          | "          |
| <i>L. atricilla</i> L.                       | —               | <i>Magiccicada septendecim</i> | "          | Forbush    |
| <i>Bruchigavia novae-hollandiae</i> Stephens | —               | —                              | N. Zealand | Sandager   |
| STERNIDAE                                    |                 |                                |            |            |
| <i>Sterna hirundo</i> L.                     | —               | <i>M. septendecim</i>          | N. America | Forbush    |
| <i>S. dougalli</i> Montague                  | —               | "                              | "          | "          |
| CHARADRIIDAE                                 |                 |                                |            |            |
| <i>Oxyechus vociferus</i> (L.)               | 1               | <i>Cicada</i> sp.              | "          | B.S.       |
| FALCONIDAE                                   |                 |                                |            |            |
| <i>Buteo lineatus</i> (Gm.)                  | 2               | —                              | "          | "          |
| <i>B. platypterus</i> (Vieill.)              | 5               | —                              | "          | "          |
|  | 2               | <i>Tibicen</i> sp.             | "          | "          |
| <i>B. swainsoni</i> (Bonap.)                 | 1               | —                              | "          | "          |
| <i>Falco sparverius</i> L.                   | 1               | —                              | "          | "          |
|  | 7               | <i>Tibicen</i> sp.             | "          | "          |
| <i>F. columbarius</i> L.                     | 1               | <i>Cicada</i> sp.              | "          | "          |
|  | 1               | <i>Tibicen</i> sp.             | "          | "          |
| <i>F. melanogenys</i> Gould                  | 1               | —                              | Australia  | Cleland    |
| <i>Ictinia mississippiensis</i> (Wils.)      | 3               | <i>Cicada</i> sp.              | N. America | B.S.       |

| Bird species.                                  | No. of records. | Cicada species.            | Place.        | Authority.     |
|--|-----------------|----------------------------|---------------|----------------|
| <b>FALCONIDAE—contd.</b>                       |                 |                            |               |                |
| <i>Tinnunculus cenchreis</i> (Naum.)           | —               | —                          | India         | Distant        |
| <i>Astur badius</i> (Gm.)                      | —               | —                          | "             | "              |
| <i>Cerchneis cenchroides</i> (V. & H.)         | —               | —                          | Australia     | McCoy          |
| <i>Eltanoides forficatus</i> (L.) ?            | —               | —                          | Nicaragua     | Belt           |
| <i>Microhierax caerulescens</i> (L.)           | —               | —                          | India         | Bingham        |
| <b>BUBONIDAE</b>                               |                 |                            |               |                |
| <i>Glaucidium gnoma</i> Wagl.                  | 1               | —                          | N. America    | B.S.           |
| <i>Otus asio</i> (L.)                          | 2               | —                          | "             | "              |
| <b>NESTORIDAE</b>                              |                 |                            |               |                |
| <i>Nestor notabilis</i> Gould                  | — (Nymphs)      | —                          | N. Zealand    | Philpott       |
| <b>CORACIIDAE</b>                              |                 |                            |               |                |
| <i>Eurystomus pacificus</i> (Lath.)            | 2               | —                          | Australia     | Cleland        |
| <b>ALCEDINIDAE</b>                             |                 |                            |               |                |
| <i>Halcyon vagans</i> Vig. & Hors. kingfishers | —               | —                          | N. Zealand    | G.-Smith Falla |
|  | —               | <i>Huechys sanguinea</i>   | Macao         | F. Muir        |
| <b>MEROPIDAE</b>                               |                 |                            |               |                |
| <i>Merops apiaster</i> L. (?)                  | —               | —                          | Europe(Crete) | Bellonius      |
| <b>CAPRIMULGIDAE</b>                           |                 |                            |               |                |
| <i>Chordeiles virginianus</i> (Gm.)            | 1               | <i>Cicada</i> sp.          | N. America    | B.S.           |
|  | 1               | <i>Okanagana rimosa</i>    | "             | "              |
|  | 2               | <i>Okanagana</i> sp.       | "             | "              |
|  | 1               | <i>Platypedia putnami</i>  | "             | "              |
| <b>MICROPODIDAE</b>                            |                 |                            |               |                |
| <i>Apus melba</i> (L.) ?                       | —               | —                          | Crete(Europe) | Bellonius      |
| <b>CUCULIDAE</b>                               |                 |                            |               |                |
| <i>Coccyzus americanus</i> (L.)                | 28              | —                          | N. America    | B.S.           |
|  | 2               | <i>Cicada</i> sp.          | "             | "              |
|  | 4               | <i>Tibicen pruinosus</i>   | "             | "              |
|  | 1               | <i>T. chloromera</i>       | "             | "              |
|  | 4               | <i>M. septendecim</i>      | "             | "              |
|  | 1               | "                          | "             | Butler         |
|  | 1               | <i>Tibicen vitripennis</i> | "             | B.S.           |
| <i>C. erythrophthalmus</i> (Wils.)             | 1               | —                          | "             | "              |
|  | 1               | <i>M. septendecim</i>      | "             | Butler         |
| <i>Geococcyx californianus</i> (Less.)         | 3               | <i>Okanagana gracilis</i>  | "             | B.S.           |
|  | 3               | —                          | "             | "              |
|  | 4               | <i>Proarna</i> sp.         | "             | "              |
|  | 5               | <i>Tibicen</i> sp.         | "             | "              |

| Bird species.                           | No. of records. | Cicada species.              | Place.         | Authority      |
|---|-----------------|------------------------------|----------------|----------------|
| <b>PICIDAE</b>                          |                 |                              |                |                |
| <i>Colaptes cafer</i> (Gm.)             | 2               | —                            | N. America     | B.S.           |
| <i>C. auratus</i> (L.)                  | 2               | <i>Okanagana rimosa</i>      | "              | "              |
|   | —               | <i>M. septendecim</i>        | "              | Butler         |
| <i>Dryobates villosus</i> (L.)          | 2               | —                            | "              | B.S.           |
|   | 1               | <i>Okanagana rimosa</i>      | "              | "              |
|   | 1               | <i>M. septendecim</i>        | "              | Butler         |
| <i>Asyndesmus lewisi</i> (Riley)        | 1               | <i>Cicada</i> sp.            | "              | B.S.           |
| <i>Melanerpes erythrocephalus</i> (L.)  | 3               | <i>Cicada</i> sp.            | "              | "              |
|   | 7               | <i>M. septendecim</i>        | "              | "              |
|   | 1               | "                            | "              | Butler         |
| <i>M. f. bairdi</i> Ridgway             | 1               | <i>Cicada</i> sp.            | "              | B.S.           |
| <b>TYRANNIDAE</b>                       |                 |                              |                |                |
| <i>Muscivora forficata</i> (Gm.)        | 2               | —                            | "              | "              |
|   | 1               | <i>Cicada</i> sp.            | "              | "              |
| <i>Myiarchus cinerascens</i> (Lawr.)    | 15              | —                            | "              | "              |
| <i>M. crinitus</i> (L.)                 | 11              | —                            | "              | "              |
|   | 1               | <i>M. septendecim</i>        | "              | Butler         |
| <i>Nuttallornis borealis</i> (Swains.)  | 2               | —                            | "              | B.S.           |
| <i>Sayornis phoebe</i> (Lath.)          | 3               | —                            | "              | "              |
| <i>Tyrannus tyrannus</i> (L.)           | 13              | —                            | "              | "              |
|   | 1               | <i>Okanagana cruentifera</i> | "              | "              |
|   | 1               | <i>Tibicen</i> sp.           | "              | "              |
| <i>T. verticalis</i> Say                | 9               | —                            | "              | "              |
|   | 2               | <i>Okanagana</i> sp.         | "              | "              |
|   | 3               | <i>Platypedia putnami</i>    | "              | "              |
| <i>Myiochanes virens</i> (L.)           | —               | <i>M. septendecim</i>        | "              | Butler         |
| <b>HIRUNDINIDAE</b>                     |                 |                              |                |                |
| <i>Hirundo erythrogaster</i> Bodd.      | 2               | —                            | "              | B.S.           |
| <i>Petrochelidon lunifrons</i> (Say)    | 3               | —                            | "              | "              |
| <i>Progne subis</i> (L.)                | 3               | <i>Cicada</i> sp.            | "              | B.S.           |
|   | —               | <i>M. septendecim</i>        | "              | Butler         |
| <b>MUSCICAPIDAE</b>                     |                 |                              |                |                |
| <i>Poecilodryas aethiops</i> (Scl.)     | —               | <i>Ueana dahli</i>           | Bismarck Arch. | Kuhlgatz, Dahl |
| <i>Myiagra rubecula</i> (Lath.)         | 2               | —                            | Australia      | Cleland        |
| <b>TIMELIIDAE</b>                       |                 |                              |                |                |
| <i>Arrenga castanea</i> (W.-R.)         | 1               | —                            | Java           | Jacobson       |
| <b>TROGLODYTIDAE</b>                    |                 |                              |                |                |
| <i>Troglodytes aedon</i> Vieill.        | 4               | <i>Cicada</i> sp.            | N. America     | B.S.           |
| <i>Thyrothorus ludovicianus</i> (Lath.) | 2               | <i>Cicada</i> sp.            | "              | "              |

| Bird species.                        | No. of records. | Cicada species.               | Place.     | Authority |
|--------------------------------------|-----------------|-------------------------------|------------|-----------|
| <b>MIMIDAE</b>                       |                 |                               |            |           |
| <i>Dumetella carolinensis</i> (L.)   | 1               | —                             | N. America | B.S.      |
|                                      | 1               | <i>Cicada</i> sp.             | "          | "         |
|                                      | 1               | <i>M. septendecim</i>         | "          | "         |
|                                      | —               | "                             | "          | Butler    |
| <i>Toxostoma rufum</i> (L.)          | 1               | —                             | "          | B.S.      |
|                                      | 3               | <i>Cicada</i> sp.             | "          | "         |
|                                      | —               | <i>M. septendecim</i>         | "          | Butler    |
| <i>Mimus polyglottos</i> (L.)        | 2               | <i>Cicada</i> sp.             | "          | B.S.      |
| <b>TURDIDAE</b>                      |                 |                               |            |           |
| <i>Hyllocichla aliciae</i> (Baird)   | 2               | —                             | "          | "         |
|                                      | 1               | <i>M. septendecim</i>         | "          | "         |
| <i>H. fuscescens</i> (Steph.)        | 2               | —                             | "          | "         |
| <i>H. guttata</i> (Pallas)           | 1               | —                             | "          | "         |
| <i>H. mustelina</i> (Gm.)            | 2               | <i>Cicada</i> sp.             | "          | "         |
|                                      | —               | <i>M. septendecim</i>         | "          | Butler    |
| <i>H. ustulata</i> (Nutt.)           | 7               | <i>Cicada</i> sp.             | "          | B.S.      |
| <i>Sialia currucoides</i> (Bechst.)  | 2               | —                             | "          | "         |
|                                      | 2               | <i>Platypedia putnami</i>     | "          | "         |
| <i>S. mexicana</i> (Swains.)         | 1               | —                             | "          | "         |
| <i>S. sialis</i> (L.)                | 6               | <i>Cicada</i> sp.             | "          | "         |
| <i>Planesticus migratorius</i> (L.)  | 1               | <i>Cicada</i> sp.             | "          | "         |
|                                      | 1               | <i>Platypedia putnami</i>     | "          | "         |
|                                      | 2               | <i>Platypedia</i> sp.         | "          | "         |
|                                      | 2               | <i>M. septendecim</i>         | "          | "         |
|                                      | —               | "                             | "          | Butler    |
|                                      | —               | "                             | "          | Webster   |
| <i>Myiadestes townsendi</i> (Aud.)   | 1               | <i>Cicada</i> sp.             | "          | B.S.      |
| <b>SYLVIIDAE</b>                     |                 |                               |            |           |
| <i>Poliophtila caerulea</i> (L.)     | —               | <i>M. septendecim</i>         | "          | Butler    |
| <b>VIREONIDAE</b>                    |                 |                               |            |           |
| <i>Vireo griseus</i> (Bodd.)         | 1               | —                             | "          | B.S.      |
| <i>V. vicinior</i> Coues             | —               | <i>Tibicinoides hesperius</i> | "          | "         |
| <i>Vireosylva olivacea</i> (L.)      | 2               | —                             | "          | "         |
|                                      | 1               | <i>Cicada</i> sp.             | "          | "         |
|                                      | 1               | <i>Tibicen</i> sp.            | "          | "         |
| <i>Lanivireo solitarius</i> (Wils.)  | 1               | <i>Cicada</i> sp.             | "          | "         |
|                                      | 2               | <i>Platypedia putnami</i>     | "          | "         |
|                                      | 2               | <i>Platypedia</i> sp.         | "          | "         |
| <i>L. flavifrons</i> (Vieill.)       | 1               | <i>Tibicen</i> sp.            | "          | "         |
|                                      | —               | <i>M. septendecim</i>         | "          | Butler    |
| <b>BOMBYCILLIDAE</b>                 |                 |                               |            |           |
| <i>Bombycilla cedrorum</i> (Vieill.) | 1               | <i>Cicada</i> sp.             | "          | B.S.      |
|                                      | —               | <i>M. septendecim</i>         | "          | Butler    |

| Bird species.                             | No. of records.    | Cicada species.           | Place.     | Authority.               |
|---|--------------------|---------------------------|------------|--------------------------|
| <b>LANIIDAE</b>                           |                    |                           |            |                          |
| <i>Lanius cristatus</i>                   | 1                  | —                         | India      | Mason and Maxwell-Lefroy |
| <i>Lanius collaris</i> L. ?               | —                  | —                         | S. Africa  | Cogan                    |
| (" common butcher bird ")                 |                    |                           |            |                          |
| <i>Eopsaltria australis</i> (White)       | 1                  | —                         | Australia  | Cleland                  |
| <i>Cracticus destructor</i> Temm.         | 1                  | —                         | "          | "                        |
| <b>PARIDAE</b>                            |                    |                           |            |                          |
| <i>Baeolophus bicolor</i> (L.)            | 2                  | —                         | N. America | B.S.                     |
|   | —                  | <i>M. septendecim</i>     | "          | Butler                   |
| <i>B. inornatus</i> (Gambel)              | 1                  | —                         | "          | B.S.                     |
| <i>B. wollweberi</i> (Bonap.)             | 1                  | —                         | "          | "                        |
| <i>Penthestes atricapillus</i> (L.)       | 2                  | —                         | "          | "                        |
| <i>P. carolinensis</i> (Aud.)             | —                  | <i>M. septendecim</i>     | "          | Butler                   |
| <b>SITTIDAE</b>                           |                    |                           |            |                          |
| <i>Sitta carolinensis</i> (Lath.)         | —                  | <i>M. septendecim</i>     | "          | Butler                   |
| <b>CERTHIDAE</b>                          |                    |                           |            |                          |
| <i>Climacteris picumna</i> Temm. et Laug. | 1 (ultimate nymph) | —                         | Australia  | Cleland                  |
| <b>COMPSOTHLYPIDAE (Mniotiltidae)</b>     |                    |                           |            |                          |
| <i>Icteria virens</i> (L.)                | 1                  | <i>Platypedia putnami</i> | N. America | B.S.                     |
| <i>Helmitheros vermivorus</i> (Gm.)       | —                  | <i>M. septendecim</i>     | "          | Butler                   |
| <b>MOTACILLIDAE</b>                       |                    |                           |            |                          |
| <i>Anthus rubescens</i> (Tunst.)          | 16                 | <i>Cicada</i> sp.         | "          | B.S.                     |
| <b>FRINGILLIDAE</b>                       |                    |                           |            |                          |
| <i>Cardinalis cardinalis</i> (L.)         | 1                  | —                         | "          | "                        |
|   | —                  | <i>M. septendecim</i>     | "          | Butler                   |
|   | 3                  | "                         | "          | B.S.                     |
|   | 7                  | <i>Cicada</i> sp.         | "          | "                        |
| <i>Passerina amoena</i> (Say)             | 2                  | —                         | "          | "                        |
|   | 1                  | <i>Cicada</i> sp.         | "          | "                        |
| <i>P. cyanea</i> (L.)                     | —                  | <i>M. septendecim</i>     | "          | Butler                   |
| <i>Pipilo erythrophthalmus</i> (L.)       | 2                  | —                         | "          | B.S.                     |
|   | —                  | <i>M. septendecim</i>     | "          | Butler                   |
| <i>P. crissalis</i> Vigors                | 1                  | <i>Cicada</i> sp.         | "          | B.S.                     |
| <i>Guiraca caerulea</i> (L.)              | 1                  | <i>Cicada</i> sp.         | "          | "                        |
| <i>Passer domesticus</i> L.               | 1                  | <i>Platypedia putnami</i> | "          | "                        |
|   | 3                  | <i>Platypedia</i> sp.     | "          | "                        |
|   | 1                  | <i>M. septendecim</i>     | "          | "                        |

| Bird species.                             | No. of records. | Cicada species.              | Place.     | Authority.                |
|---|-----------------|------------------------------|------------|---------------------------|
|   | —               | <i>M. septendecim</i>        | N. America | Butler and many others    |
|   | —               | —                            | Europe     | Fabre                     |
|   | —               | <i>Melampsalta cingulata</i> | N. Zealand | Hudson, Cockcroft, Myers. |
|   | 1               | <i>M. muta</i>               | N. Zealand | Myers                     |
|   | 1               | <i>M. ochrina</i>            | N. Zealand | "                         |
|   | —               | Several spp.                 | Australia  | Cleland                   |
| Sparrow ( <i>P. domesticus</i> ?)         | —               | <i>Huechys sanguinea</i>     | Formosa    | Maki                      |
| <i>Zamelodia melanocephala</i> (Swains.)  | 1               | —                            | N. America | B.S.                      |
|   | 4               | <i>Platypedia putnami</i>    | "          | "                         |
| <i>Poocetes gramineus</i> (Gm.)           | 1               | " "                          | "          | "                         |
|   | 4               | <i>Platypedia</i> sp.        | "          | "                         |
| <i>Oreospiza chlorura</i> (Aud.)          | 1               | " "                          | "          | "                         |
| <i>Spizella passerina</i> (Bechst.)       | 1               | " "                          | "          | "                         |
| <i>S. socialis</i> (Wils.)                | —               | <i>M. septendecim</i>        | "          | Butler                    |
| <i>Astragalinus tristis</i> (L.)          | —               | "                            | "          | "                         |
| <i>Pyrrhuloxia sinuata texana</i> Ridgway | 1               | <i>Cicada</i> sp.            | "          | B.S.                      |
| TANAGRIDAE                                |                 |                              |            |                           |
| <i>Pyrranga erythromelas</i> (Vieill.)    | 4               | —                            | "          | "                         |
| <i>P. rubra</i> (L.)                      | —               | <i>M. septendecim</i>        | "          | Butler                    |
| <i>P. ludoviciana</i> (Wils.)             | 2               | —                            | "          | B.S.                      |
| ICTERIDAE                                 |                 |                              |            |                           |
| <i>Euphagus cyanocephalus</i> (Wagl.)     | 6               | —                            | "          | "                         |
|   | 15              | <i>Platypedia putnami</i>    | "          | "                         |
|   | 16              | <i>Platypedia</i> sp.        | "          | "                         |
| <i>Icterus bullocki</i> (Swains.)         | 2               | —                            | "          | "                         |
|   | 1               | <i>Cicada</i> sp.            | "          | "                         |
| <i>Icterus spurius</i> (L.)               | 4               | —                            | "          | "                         |
|   | —               | <i>M. septendecim</i>        | "          | Butler                    |
| <i>I. galbula</i> (L.)                    | —               | "                            | "          | "                         |
| <i>Molothrus ater</i> (Bodd.)             | 3               | —                            | "          | B.S.                      |
|   | 1               | <i>Platypedia putnami</i>    | "          | "                         |
|   | —               | <i>M. septendecim</i>        | "          | Butler                    |
| <i>Quiscalus quiscula</i> (L.)            | 3               | —                            | "          | B.S.                      |
|   | 1               | <i>M. septendecim</i>        | "          | "                         |
|   | —               | "                            | "          | Butler                    |
| <i>Agelaius phoeniceus</i> (L.)           | 2               | <i>Platypedia putnami</i>    | "          | B.S.                      |
|   | 3               | <i>Platypedia</i> sp.        | "          | "                         |
| <i>Sturnella magna</i> (L.)               | 3               | —                            | "          | "                         |
|   | 1               | <i>Platypedia putnami</i>    | "          | "                         |
| STURNIDAE                                 |                 |                              |            |                           |
| <i>Sturnus vulgaris</i> L.                | 1               | <i>Cicada</i> sp.            | "          | "                         |
|   | 1               | —                            | Australia  | Cleland                   |
| <i>Acridotheres cristatellus</i> (L.)     | —               | —                            | S. China   | Kershaw                   |

| Bird species.                           | No. of records. | Cicada species.                              | Place.         | Authority.    |
|---|-----------------|--|----------------|---------------|
| DICRURIDAE                              |                 |  |                |               |
| <i>Dicrurus longicaudatus</i>           | —               | —  | India          | Distant       |
| Hay                                     |                 |  |                |               |
| CORVIDAE                                |                 |  |                |               |
| <i>Amphelocoma californica</i> (Vigors) | 4               | —  | N. America     | B.S.          |
| <i>Cyanocitta cristata</i> (L.)         | 17              | —  | "              | "             |
|   | 6               | <i>Cicada</i> sp.                            | "              | "             |
|   | 2               | <i>M. septendecim</i>                        | "              | "             |
| <i>Nucifraga columbiana</i> (Wils.)     | 1               | <i>Cicada</i> sp.                            | "              | "             |
| <i>Pica pica</i> (L.)                   | 13              | —  | "              | "             |
|   | 3               | <i>Cicada</i> sp.                            | "              | "             |
|   | 6               | <i>Platypedia</i> sp.                        | "              | "             |
|   | 1               | <i>Tibicen pruinosus</i>                     | "              | "             |
| <i>Corvus brachyrhynchos</i> Brehm      | 73              | —  | "              | "             |
|   | 3               | <i>Cicada</i> sp.                            | "              | "             |
|   | 1               | <i>Tibicen pruinosus</i>                     | "              | "             |
|   | 52              | <i>M. septendecim</i>                        | "              | "             |
|   | —               | "  | "              | Kalmbach      |
|   | —               | "  | "              | Butler        |
|   | —               | "  | "              | B.S.          |
| <i>C. ossifragus</i> Wils.              | 3               | <i>Cicada</i> sp.                            | "              | "             |
| <i>C. macrorhynchus</i> Wagl.           | —               | —  | India          | Distant       |
| <i>C. orru</i> Bonap.                   | —               | <i>Ueana dahli</i> (nymphs in large numbers) | Bismarck Arch. | Kuhlgatz Dahl |

The authorities for the above data are firstly, the Biological Survey of the U.S. Department of Agriculture (B.S.) to which, through the acting chief, Dr. W. C. Henderson, I am indebted for very detailed information; and secondly, Forbush (1924), Sandager (1890, p. 289), Cleland and his associates (1918), Distant (1906c, p. 56), McCoy (1880), Belt (1874), Bingham (1901, p. 224), Philpott (1919), Guthrie-Smith (1910, p. 45), Bellonius (1555), Butler (A. W., 1886), Kuhlgatz (1905), Dahl (1899, p. 204), Jacobson (*in* Robinson and Kloss, 1924, p. 305), Webster (F. M., 1897), Cogan (1916a, p. 167), Fabre (ed. 1921), Hudson (1891, p. 51), Kershaw (1903), Falla (Myers and Atkinson, 1923), Kalmbach (1918, pp. 23, 61). In addition I am indebted to Mr. T. Cockcroft for unpublished data and to Dr. R. Friedmann for very great assistance with the nomenclature of the birds concerned.

In examining the above list one notes that the predominance of *M. septendecim* among the North American records is not so great as might be expected. We know that under special circumstances birds will often eat large quantities of insects which form no part of their normal diet; and the emergence of a brood of the periodical cicada is a very special circumstance, comparable only to the arrival of a locust swarm. Doubtless the two terns in the list were

intrigued into cicada-eating chiefly through the ease of capture and plentiful supply of the seventeen-year species which is the only one they are recorded as catching. The terns were described as dashing fearlessly into the bushes. Domestic poultry of many kinds must be added to the list of enemies of the latter species, which is subject to the onslaughts of many more or less unaccustomed insect-eaters at the time of the final ecdysis (Surface, 1907). Harlan claims that fowls indulging their taste for this cicada lay eggs with colourless yolks (1834). Marlatt (1907, p. 136) goes so far as to state that if all the enemies of the periodical cicada were known they "would doubtless include all the insectivorous birds and mammals occurring within the range of this insect." That other species when occurring in phenomenal numbers are subject to similar attacks is indicated by F. B. Scott's observations in Baluchistan (1919).

There is, however, abundant evidence in the list to show that common cicadas of more ordinary occurrence are favoured to a considerable extent as food by birds. In five continents, but chiefly in North America, some 121 species of birds are recorded as preying on cicadas, chiefly as adult insects. These 121 species are incriminated on the basis of at least 632 separate records, and are distributed among 35 families, of which the most cicada-eating species are included in the Fringillidae (14), Falconidae (12), Turdidae (10), Icteridae (8), Corvidae (8), Tyrannidae (8), Picidae (6), Paridae (5), Vireonidae (5). But the caprimulgids and the cuckoos must also be no mean cicada-catchers, as evidenced by the 41 records for *Coccyzus americanus*, and the 30 specimens of *Okanagana rimosa* found in one example of *Chordeiles virginianus*. So far as our records go, however, the American crow tops the list as a destroyer of cicadas, with over 130 records, and the following counts of single stomach contents—27, 30, 41, 25, 21, 28, 18, 33, 36—all adult cicadas, and in two other cases, 49 and 16 nymphs respectively (U.S. Biological Survey, *in litt.*, 24th November, 1925, Incl. no. 17167). Kalmbach gives additional information, especially on the feeding of the young crows. *Magicalcicada septendecim* he found sometimes (4 broods) to comprise 31 per cent of their food. A brood of seven had been fed on no fewer than 168 "pupae." The adults fed on cicadas ravenously, "most of those eaten being in the last pupal stage and probably dug out from their retreats not far below the surface of the ground" (*l.c.*, p. 23). Dahl found 23 nymphs of *Ueana dahli* in one stomach of a *Corvus orru* in the Bismarck Islands.

The cicadas represented in the above list, so far as determinable, have been drawn from all the dominant groups of the family. Large size seems to be no deterrent—perhaps to the Falconidae it is even an attraction.

According to Butler (1886) most birds eat only the softer parts, but some devour also wings, legs, and head.

## MAMMALS OTHER THAN MAN

Most of the records of Mammals eating cicadas concern *Magicalcicada septendecim* during the period of emergence. Pigs (Surface, 1907), cats (Davis, 1922), chipmunks (Surface, *l.c.*; Lowe, 1902), fox squirrels (Lowe), grey squirrels (Felt, 1912), ground hogs (Felt, 1912), skunks (Felt, 1912) have all been recorded at this unaccustomed feast. Scott (F. B., 1919) found the similar irruptions of an undetermined Baluchistan species exploited in similar fashion by dogs and cats, and this in spite of the fact that the liquid squirted from the abdomen was considerably irritant.

Butler (1886) saw the chipmunk (*Tamias striatus* Baird) climb to the topmost branches of an apple tree seeking cicadas, while young fox squirrels (*Sciurus rufiventer* Geoff.) showed a special relish for these insects.

We have already quoted a note of our own concerning a cat stalking *Melampsalta muta* in the grass, apparently locating these little cicadas by their song and afterwards catching and eating them even to the wings.

## CHAPTER XVII

## RELATIONS OF CICADAS WITH MAN

## ÆSTHETIC

"Symphonistam cupis ? Cicadam audi ; quae perpetuis repleta cantibus ne cibo vivit, et melodiâ quadâm suavissimâ Philomelam provocat."

MOUFET, 1634, *Ins. Theatr.*

FIRST, man listened to cicadas, then he ate them, thirdly discovered or imagined divers medicinal uses, and finally hailed certain species as pests of his crops. The scientific interest which has occupied already so much of our space, is merely the flowering of a long acquaintanceship.

In our second chapter we have shown that cicadas were kept by the Greeks in small cages made of rushes, for the pleasure of hearing them sing and possibly also in order to observe their mating behaviour (Moufet).

In Japan (Hearn ; Cockerell, W., 1925) they are less favoured as pets than the various musical Orthoptera, while the Latins condemned their musical performances utterly, as raucous and disagreeable. They are, however, "favourite cage pets with the Chinese" (MacPherson, 1897, p. XXIX), (Kershaw, 1903), (Staunton, 1798), (Buckton, 1890).

Whether or not the following employment should be classed as æsthetic we do not know. In South China (Kershaw, 1903) "sometimes a child is given a cicada in a twist of paper, to act as a substitute for a rattle." They are recorded as children's playthings in Italy (Buckton, 1890). In Japan, Fujita found on sale in the streets of Kobe, an ingenious toy which, when swung, emitted a sound like the song of a well-known cicada.

We consider the song of several New Zealand species, notably *M. scutellaris* and *M. cutora* to be highly agreeable, even apart from the pleasant seasonal associations which they evoke. We do not, however, go quite so far as Moufet (1634, p. 130) when he implies that one who does not appreciate cicada music must be sick either in mind or in body. Koningsberger (1915, p. 105) goes to the other extreme in characterizing the song of Javan species as "een martel-ing voor de ooren ;" and McCoy (1880) agrees concerning some Australian forms.

## GASTRONOMIC

"There is a Kind of Locust in Tonquin, in great Abundance. . . . In the Months of January and February, which is the Season of taking them, being then only seen, this Creature first comes out of the Earth in huge Swarms. It is then of a whitish Colour, having two small Wings, like the Wings of a Bee ; at its first coming out of the Earth it takes its Flight ; but for Want of Strength or Use falls down again in a short Time. . . . They are plump and fat, and are much esteemed by Rich and Poor, as good wholesome Food, either fresh or pickled."

(DAMPIER, *Voyages*, 1688 (ed. Masfield, 1906, I, p. 578).)

Even the Greeks, being of a practical turn of mind, were apparently in the habit of eating the favourite of the Muses. Aristotle (*lib. V*, cap. 30) remarks that the *telligometrae* or nymphs, *gustu suavissimae sunt antequam cortex rumpatur* ; while as to the adults, *ante coitu mares suaviore sunt ; a coitu foeminae, quippae quae ova candida, gustu habeant grate excitatae cum subuolant, quendam reddunt humorem modo aquae, quo rustice eas mingere.*

Fabre (ed. 1921, p. 247) argues at considerable length that Aristotle's praise of the nymphs just before ecdysis is merely proof that he was the victim of a practical joke at the hands of the Macedonian peasant, since in France Fabre found it next to impossible to collect a sufficient quantity before ecdysis commenced, and the result when cooked was highly uninteresting gastronomically. Aristotle "écoutait les bavardages de la campagne et les enregistrait comme documents véridiques."

Aelian in his travels was shocked to see *connexas cicadas* exposed for sale in the market-place. This people "neque cicadis etiam pareit, nec animadvertit se rem perpetrare Musis, Jovis filibus, invisam" (*lib. XII*, 6).

Cicadas of some species or another are eaten in China (Fauvel, 1876, p. 13), in the Malay Peninsula (Annandale, 1900, p. 859 ; Skeat, 1900), in Siam (Fruhstorfer, 1902), in Burma (Mason, 1860, *nymphs*), in Australia—"when no white feller here, and black feller no get bread or jam" (Bennett, 1834), in North America (Collinson, 1765 ; Sandel, 1715, *pulb.* 1906 ; Marlatt, 1907, p. 103), in a southern part of South America (Delétang, 1919), and finally, in the Congo basin (Johnston, 1884, p. 337).

The species which comes nearest to furnishing a regular and considerable article of human diet is probably *Pomponia intemerata* in the Malay Peninsula, although the season for this is short. It is attracted in quantities by a hand-clapping procedure which we shall describe later.

The "Kind of Locust" found by Dampier in Tonking, was also obtained in bulk, in this case by skimming the insects from the water of the river into which numbers of them fell.

Howard (1885) and Fabre (ed. 1921, pp. 246-247) are among the

daring investigators who have made trial of this dish. The former had freshly emerged adults of *Magicicada septendecim* fried in batter, when they were reminiscent of shrimps. But "they will never prove a delicacy," concludes Howard, though Marlatt (1917, p. 104) remarks that "theoretically the Cicada, collected at the proper time and suitably dressed and served, should be a rather attractive food." We may yet see the American product, properly organized and attractively canned, ousting the native article from the village markets of Burma and Siam.

Fabre cooked nymphs and concluded "C'est coriace en diable, pauvre de suc, un vrai morceau de parchemin à mâcher. Je ne recommanderai à personne le mets glorifié par Aristote."

Annandale (1900) remarks that cicadas cooked according to native usage in the Malay Peninsula, by boiling or frying in coconut oil, have very little flavour of any sort and what they have is vegetable rather than animal.

#### MEDICINAL

"L'explication qu'on donne des propriétés diurétiques de l'insecte est merveilleuse de naïveté. Le Cigale, chacun le sait ici, part en lançant à la face de qui veut la saisir un brusque jet de son urine. Donc elle doit nous transmettre ses vertus évacuatrices. Ainsi devaient raisonner Dioscoride et ses contemporains, ainsi raisonne encore le paysan de Provence."

(FABRE, ed. 1921, p. 249.)

On the principle evoked by Fabre in the above quotation, cicadas have long been used medicinally for diuretic and other purposes, and are still in use among the peasants of Provence. We must distinguish between the more typical cicadas thus employed and the truly vesicating *Huechys* of China.

Dioscorides (ed. 1529, *lib.* II, 56) in the first century of our era, writes, *Cicadae quae inassatae manduntur, vesicae doloribus prosunt*: while his successor, Galen, in addition recommended them *cum paribus numero piperis granis*, for colic (ed. 1550, *lib.* IX, 32). Later physicians prescribed cicadas in honeyed wine or hypocras, as a cure for bladder-stones, while one sought to improve the diuretic properties of the remedy by adding to the powdered insects the blood of a he-goat (Amyot, 1836). Cicadas mixed with oil of scorpions were used, appropriately enough as a counter irritant (Buckton, 1890). The most extensive compilation of these ancient nostrums is the work of Mufet (1634, p. 133), who cites no fewer than eleven authorities. The Arab physician, Ibn el-Beithâr (Leclerc, 1881, II, 230) prescribed cicadas after the manner of Dioscorides and Galen.

The nymphal exuviae are included in the *materia medica* of the Far East. Thus, according to Hearn (1900), they are used as a cure for ear-ache in both China and Japan. Their employment in the former country is remarked by Fauvel (1876, p. 13), Dyer Ball (1904, pp. 170-171), and Schumacher (1917b). The latter authority

states that the Chinese name for the drug is *Ch' an t'ui*. It does not appear to be mentioned in the *Pen ts' ao*. I have been enabled to examine a quantity of this material through the kindness of Mr. C. R. Kellogg, who states that several species are involved. In its marketed form the drug is considerably crushed and the fragment not amenable to specific determination. Kaempfer (1729, *liv.* I, p. 114; also cited in Cowan, p. 100) remarks that as *Semini mukigara*, these exuviae, for medicinal purposes, are sold in shops both in China and Japan. Dyer Ball gives the Chinese name as *töü shim*. Boiled in water with certain plant materials they form a bitter decoction administered to children for convulsions and fever. According to Maki, they are used also for skin wounds.

Among the Sántáls, an aboriginal tribe of India, an "ointment of cicada and mole-cricket" is given for screaming-fits (Bodding, 1927).

The remaining literature on cicadas in medicine concerns the striking red and black Oriental species, *Huechys sanguinea*. We have shown already that this was early mentioned in the great Chinese manual of *materia medica*, the *Pen ts' ao*, and in the Japanese editions known as *Honzau Kaumoku*, in the latter of which it was crudely figured. The use of *Huechys* in Chinese medicine has been treated by Schumacher (1917a) in a masterly summary, and earlier by Porter Smith (1871a, 1871b), Arnaud and Brogniart (1888a, 1888b), Cooke (1871-1872), Béguin (1874), Beauregard (1890), Fumouze (1888a-d), and Taschenberg (1909). Most of these workers did some work on the chemical and therapeutic properties of the drug, which consists of the dried bodies divested of appendages.

The *Pen ts' ao* ordered this material taken in various ways, for a considerable list of "diseases," including sterility, impotence, menstrual irregularities, neuralgic or rheumatic pains, and the evil eye. But its most effective employment was against hydrophobia, for which malady it was administered in wine with cantharides (*Mylabris*). This practice depended upon the Chinese theory as to the nature of the disease. The bite of a mad dog was believed to produce conception and the resulting growth, in the body of the victim, of an embryo dog. Treatment consisted in driving out the foetus by way of the urinary passage and by means of excessive doses of the above mixture, inducing violent diuretic effects and considerable bleeding, and resulting not infrequently in the death of the patient.

The chemical and pharmaceutical researches of the French workers listed above are contradictory. Fumouze, unable to detect any substance akin to cantharidin, and failing to obtain vesicating effects with any of the extracts tested, denied any medicinal properties; yet he admitted that the peculiar odour of the material was strong enough to irritate the eyes (1888c). The substance responsible for the odour was isolated, and some five other bodies,

including a greasy compound, some waxy, and some oily matters and the two pigments mentioned in Chapter IV.

Béguin, however, obtained slight vesication with a plaster of the powdered insect, and remarks that this cicada is the only known insect outside certain groups of Coleoptera, in which this property as distinct from urtication exists.

Smith (1871a) likewise obtained vesication, and so also Arnaud and Brogniart (1888a) who attributed it to "*une huile épaisse, verdâtre*" which they compare with crotonol, an oily material of similar properties obtained from *Croton tiglium*.

Schumacher (1915a, p. 82) remarks that the scent-organ in *Huechys* is still unknown. He thinks the odour perhaps streams out of slit-like openings which lie between coxae and pleura; especially at the first pair of legs. This is a point for field-observers.

### INJURIOUS

The verdict of Anacreon—"Thou doest ill to none"—has been in large measure confirmed even under the conditions of modern agriculture. Taken as a whole the family Cicadidae is economically almost negligible and contains no major pests of plants. Only certain species, periodically abundant, may by excess of numbers cause sufficient damage to be ranked as injurious insects. Dismissing as almost entirely fanciful or mistaken, the reports of "stinging" on the part of *Magiccada septendecim* (Marlatt, pp. 86-88), we can distinguish three directions in which Cicadidae may become injurious. Firstly, the sap-sucking of the adults and nymphs may constitute such a drain on the vitality of the host-plant as to check its growth; secondly, the mere mechanical effects of oviposition may, in exceptional cases, involve serious injury; and thirdly, the insect may be concerned in the transmission of plant-disease—an activity in which the Hemiptera are becoming rapidly and increasingly notorious. We shall consider these three possibilities in turn.

#### DAMAGE TO PLANTS BY SUCKING THE SAP

There are apparently no records of injury consequent on adult feeding-habits save those of *Melampsalta incepta* (Walk.). Froggatt in Australia found this species during one season doing serious damage to peach and other fruit trees. The feeding punctures were sometimes 45 to the square inch; piercing completely the bark and entering the sapwood. The result was severe gummosis. Somewhat similar effects were seen on eucalypts. Quaintance (1902) observed considerable exudation of sap when *Magiccada septendecim* fed. Jack (1916) mentions cicadas as occasional feeders on citrus trees in Rhodesia, but does not attribute much damage to them. Pead (1917) estimates that cicadas and their relatives destroy about

one-sixth of the crops every year in Rhodesia; but little of this damage is inflicted by the cicadas. Kuhlitz (1905) records the nymphs of *Ueana dahlia* as feeding on the roots of cotton, but not confined thereto, in the Bismarck Archipelago. He does not, however, mention any appreciable damage—merely, "*die Pflanzer halten sie für schädlich*." Leprieur (1877) received cicada nymphs from Teheran, Persia, where they were said to be living on the vine roots in such numbers as to destroy them. Marlatt (1907, p. 126) discusses the possible damage occasioned by the nymphs of *Magiccada septendecim* and decides that the time required for development is so excessive that the effect of feeding on the plant is probably negligible. He regards the extensive injury described by Miss Morris (1846, 1847) as susceptible of some other explanation. She was firmly convinced that the unhealthy condition of some fruit trees was due to the feeding of *Magiccada septendecim* nymphs, of which she found as many as 500 on the roots of one tree.

*Carineta fasciculata* Germ. and *Fidicina pullata* Berg are serious pests of coffee in the São Paulo state of Brazil. These are forest species, which, on the clearing of the forests, have become adapted to live on coffee and other cultivated plants. As many as 400 nymphs of *Fidicina* have been found on the roots of one coffee plant (Hempel, Moreira, da Costa Lima). According to d'Utra the trees are often killed.

Morrill (1914) states that nymphs of *Tibicen cinctifera* (Uhl.) attack roots of citrus, alfalfa, olive, peach, and other plants in Arizona.

Banks (1904) records an undetermined species of cicada as a serious pest of cacao trees in the Philippine Islands.

#### INJURY TO PLANTS THROUGH OVIPOSITION

By far the most destructive activity of the adult cicadas is oviposition. It is this which at times constitutes *Septendecim* a serious pest. But as Marlatt (1907, p. 140) justly remarks:

"In discussing this subject it is well to be again reminded that the fears aroused by the presence of this insect when in great numbers are unquestionably out of all proportion to the real damage likely to be done. While they are most abundant in old and undisturbed forest tracts and confine their work for the most part to forest trees, it is true also that in parks and lawns, especially such as contain trees of the original forest growth or their natural and immediate successors, the cicadas sometimes appear in scarcely diminished numbers. This is true also of orchards located on cleared lands or in the vicinity of standing forests, and under such circumstances instances of serious or fatal results to cherished plants or fruit trees are not uncommon."

"The weakening of the twigs by the punctures causes many of



them to be partly broken off by the winds, and the brown withered leaves are conspicuous for the remainder of the summer" (p. 106).

Orchard trees are sometimes completely denuded of their fruit-bearing branches. Hopkins (1898, 1900) has shown that the open wounds serve as favourite points of attack for woolly aphis (*Eriosoma lanigerum*) and for wood-boring beetles. The same author has given the most detailed account of the healing-process in the oviposition tissue.

Marlatt includes most references to the work of *Septendecim* published up to 1907. The most important which have appeared since are by Felt (1912, 1913, 1916, 1918), Haseman (1915), Troop (1919), Edmundson (1916), Gossard (1914, 1916, 1919), Rumsey (1914, 1918), Marlatt (1911).

Busck (1902) found *Tibicen biconica* (Walk.) (listed surely by a slip as *Cicada bicosta* Walk., a Central American species) ovipositing in leaves of coconut in Cuba, but the damage was insignificant.

Costa (1877) under the name of *Macroptopus oleae* n.g. et sp.; Del Guercio (1911); and Silvestri (1921) have described the injury "*assai notevoli*" occasionally inflicted upon fruit trees in Italy by *Cicada orni* L.

Morrill (1912, 1914, 1915, 1917, 1919) and Glick (1923) report serious damage in Arizona by *Tibicen cinctifera* (Uhl.) to a number of cultivated plants, especially olive, citrus, and cotton.

Wilmon Newell (1906) found during one season that an irruption of *Tibicen erratica* (Osb.) had inflicted serious injury on cotton over a considerable area in Louisiana. On one plantation he estimated that 20 per cent of the young cotton plants had been killed by the oviposition of this cicada. More recently it has inflicted even greater damage on the same crops.

Maskew (1906, 1917-1919) intercepted considerable numbers of cicada eggs "on" persimmon and wistaria imported into California from Japan; but as he records some also from Hawaii where cicadas do not occur it is doubtful whether his determination is correct.

Middleton (1912) states that much damage was done by the oviposition of a "cicada" or "salmon fly" in new shoots of young trees along the Columbia River in Western Canada.

Townsend (1892) notes *Tibicen* sp. ("*Cicada ochreoptera*," which is a *nomen nudum*) damaging fruit trees in New Mexico.

Schugorow (1906a) lists *Tibicen plebeia*, *Cicada orni*, *Tibicina haematodes*, and *Cicadatra atra* as widespread and injurious in vineyards in Russia; but Gadd (1908b, p. 142) believes most of these cicadas frequent vineyards less than is generally supposed.

Scott (1919) describing the irruption of an unknown species in Baluchistan (Quetta) mentions that "some of the smaller trees were so damaged by their attacks that they lost their leaves."

Maki (1916) in a paper in Japanese, records *Tibicen ochracea* (Walk.) and *Mogannia hebes* (Walk.) as minor pests of mulberry in Formosa, while Schumacher (1915a) records the latter as injurious to sugar-cane.

Allen (1912) describes oviposition in peach branches in Australia, and attributes the work to *Macrotristria angularis* (Germ.) and *Cyclochila australasiae* Don.

Jarvis (1922) records in Queensland a single instance of a *Melampsalta* sp. ovipositing in vine.

Vosseler (1905) considers cicadas as agricultural pests in former German East Africa.

The true cause of the damage is often curiously mistaken. Thus Hay, writing of a swarm of Cicadas in Afghanistan, remarks:

"Their clinging propensities had, however, entirely deprived some branches of their shoots."

Cicadas as pests have been recorded by Anon. (1926), Brittain (1914), and O'Dell (1927) in North America; by Stellwaag in Europe, by Pierrot and by Wurth as injuring coffee.

#### POSSIBLE TRANSMISSION OF DISEASE

The Cicadidae have not yet been implicated in the transmission of plant diseases; but in view of the accumulating evidence indicting members of other families of Hemiptera—groups as varied as Mirids, Cicadellids, Flatids, Aphides, and Coccids, the possibility may one day need consideration. We envisage especially the "filterable virus" diseases.

Craighead (1916) states that chestnut blight spores have many times been found in wounds caused by cicadas and treehoppers. He suggests the possibility that these insects carry the spores and directly inoculate the wound, but thinks it improbable. Such a case, if existent, would bridge the gap between true disease-transmission and phoresy.

An example of the latter is given by Wolff (1921), who found the blister mite, *Eriophyes tiliae liosoma* Nal., carried on the abdomens of "Zikaden." The *Review of Applied Entomology* has listed these as "cicadas," but they are almost certainly Cicadellids, and probably Typhlocybines.

#### CONTROL

The measures adopted against the periodical cicada are well-summarized by Marlatt (1907, p. 141) and by Gossard (1919). This species is unique among injurious insects in that its visitations can be predicted with astronomical accuracy.

Following Marlatt we may distinguish between (1) methods for killing the adults and nymphs above ground, (2) preventives of or

deterrents to oviposition, (3) general precautions, and (4) measures to destroy the nymphs in the soil.

Under (1) may be grouped hand-picking, especially in the early morning, when the insects are sluggish; pyrethrum-dusting, which kills freshly-emerged adults and many mature ones; and kerosene-emulsion spraying, which is effective only against nymphs.

Bordeaux-mixture or lime-sulphur with excess of lime, or even lime-wash alone, are said to supply a repellent surface owing chiefly to their whiteness. Evil-smelling repellents, such as fish-oil sprays, are considered useless.

Winter and spring pruning should be entirely omitted prior to the season when the brood is expected, and the planting out of young fruit trees should be deferred until the danger is past. Gossard advises wrapping of trunks and branches of young orchard trees with paper, or where practicable, netting them wholesale. Ditmars (1920) recommends guarding against bush fires the season before, and planting young forest trees for the cicada to oviposit in.

Under (4) Marlatt recommends especially either the incorporation of tobacco dust in the soil or the injection of carbon bisulphide. Moreira (1921, p. 126) found the latter effective against the nymphs of the coffee cicadas, *Carineta fasciculata* and *Fidicina pullata*. Satisfactory results were obtained also by the use of kainite and of saltpetre.

Miller (1925) using granular calcium cyanide in the soil against the pear-leaf midge larvae (*Perrisia pyri*) in New Zealand, found that this treatment, although successful in its object, had no effect on the nymphs of *Melampsalta cingulata*, for these issued through the poisoned soil and underwent their final ecdysis without injury.