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III. The Predaceous Enemies of Ants

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American Museum of Natural History

Hymenoptera - Formicoidea
" Sphecidae - Crabronina
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By J. Bequaert

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Three common driver-ant birds of the Ituri Forest: *Alethe castanea woosnami* Grant (Fig. 1), *Neocossyphus rufus gabunensis* Neumann (Fig. 2), and *Bleda eximia ugandæ* van Someren (Fig. 3), following a column of *Dorylus* (*Anomma*) *wilverthi* Emery.

III.—THE PREDACEOUS ENEMIES OF ANTS

By J. Bequaert

The various means by which Nature prevents an excessive increase of the species not only forms in itself an interesting chapter of ecology, but its study is also of great importance in an understanding of the true meaning of Natural Selection. In the case of ants it has been contended that they are better defended than other insects against the attacks of predatory animals. Poulton[1] evidently takes this for granted when he considers that ants, together with wasps, are among the favorite models for "mimicking" insects and other arthropods. These ant-like arthropods, having acquired by Natural Selection their resemblance "to the aggressive, abundant, and well-defended ants," would according to this theory escape many of the attacks of their deceived and disgusted predaceous enemies. Though the evidence presented in the following pages is still very fragmentary, I trust the reader may easily conclude for himself to what extent such resemblances, which, in some cases at least, can hardly be doubted, have a real protective value. There is certainly little or no evidence to show that, as the theory is often expressed, ants are unpalatable to most insectivorous animals and are merely eaten accidentally or "during the time in which young birds or other animals are learning what to eat with impunity and what to reject."[2]

Another consideration of interest is the relative efficacy of parasitism and predatism in acting as a check on the reproductive power of the species. This point has been profusely discussed, and the argument has frequently been made that parasitism is in this respect of foremost importance. It must, however, be kept in mind, that, while we have been very completely and steadily informed of the activities of parasites, predatism has been much less investigated. It is not my intention to go further into this question; but I think a rather conservative view will be to consider that ecto- and endoparasites, while working all the time, though affecting only a small number of individuals at once, constitute a more regular check to the increase of the species. On the other hand, predatory enemies as a rule destroy large numbers of individuals at a

[1]Poulton, E. B., 1908, 'Essays on evolution,' (Oxford), pp. 252–261. See also Jacobi, A., 1913, Mimikry und verwandte Erscheinungen,' (Braunschweig), pp. 95–114; Marshall, G. A. K., 1902, 'Five years' observations and experiments (1896–1901) on the bionomics of South African insects, chiefly directed to the investigation of mimicry and warning colors,' Trans. Ent. Soc. London, pp. 287–584, Pls. IX–XXIII; McAtee, W. L., 1912, 'The experimental method of testing the efficiency of warning and cryptic coloration in protecting animals from their enemies,' Proc. Acad. Nat. Sci. Philadelphia, pp. 281–364; Pocock, E. I., 1911, 'On the palatability of some British insects, with notes on the significance of mimetic resemblances,' Proc. Zool. Soc. London, II, pp. 809–868.

[2]H. C. McCook (1890, 'American spiders and their spinningwork,' II, pp. 357–365) has fully discussed the possibility of ant-mimicking spiders having arisen by means of Natural Selection, either to enable them to more readily obtain their food or to protect them from natural enemies.

time, but only at intervals. They are also apt to make their influence more felt when their prey for some reason or other suddenly multiplies on an exceptional scale. Professor Forel's aphorismic statement that "the most dangerous enemies of ants are always other ants, just as the worst enemies of man are other men," may be true in a general way for temperate regions, where ants are not superabundant and lead a rather inconspicuous life, but it can hardly be applied to the tropics. Ants, it is true, attract comparatively few of the predaceous arthropods, against which they are very effectively armed. They form, however, a considerable portion of the diet of many reptiles, amphibians, birds, and certain insect-eating mammals, some of these vertebrates being almost exclusively myrmecophagous. It may be further mentioned that many of these predaceous animals by no means confine their attacks to the smaller, more timid species of ants, but rather prefer the large-sized, powerfully defended members of the ponerine and doryline groups.

The information contained in the following pages is based to a considerable extent upon examination of stomachs and pellets of predaceous animals in the wild state. I fully agree with Swynnerton that these sources of information are most valuable with regard to the general preferences of a predaceous animal, the insects it usually feeds upon and on which it for the most part "fills up." But I also believe with the same author that a knowledge of its detailed preferences must come in the main from continuous observation of individual wild animals and from special experiments both in nature and in captivity. The experimental method has been used with much skill and care by Swynnerton[1] to test the palatability of butterflies and its bearing on the efficiency of cryptic form and coloration. Miss A. H. Pritchett[2] has also published the results of a number of experiments with lizards and various insects, including ants, that possess protective, mimetic, and warning colors or that have some disagreeable characteristics which in a measure are supposed to prevent their being devoured by insect-eating animals. Such investigations with ants and their natural enemies should be extended and could not fail to add considerably to a better understanding of predatory habits.

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[1]Swynnerton, C. F. M., 1919, 'Experiments and observations bearing on the explanation of form and colouring, 1908–1913,' Journ. Linn. Soc. London, Zool., XXXIII, No. 224, pp. 203–385. See also Poulton, E. B., 'The experimental proof of the protective value of colour and markings in insects in reference to their vertebrate enemies,' Proc. Zool. Soc. London, 1887, pp. 191–274; Dahl, F., 1913, 'Vergleichende Physiologie und Morphologie der Spinnentiere unter besonderer Berücksichtigung der Lebensweise,' (Iena), I, vi+113 pp.; Heikertinger, F., 1919, 'Die metöke Myrmekoidie. Tatsachenmaterial zur Lösung des Mimikryproblems,' Biol. Zentrabll., XXXIX, pp. 65–102; Dahl, F., 1921, 'Täuschende Aehnlichkeit mit Bienen, Wespen und Ameisen,' Naturw. Wochenschr., N. F., XX, pp. 70–75.

[2]Pritchett, A. H., 1903, 'Some experiments in feeding lizards with protectively colored insects,' Biol. Bull., V, pp. 271–287.

Arthropods

In the following account I shall consider only the arthropods which prey on ants without entering their nests; the nidal synechthrans, or carnivorous inmates of ant nests, are better studied in connection with true ant guests, though they may in some cases have been derived from outside marauders. Neither have the predaceous activities of ants towards other ants of the same or of different species been considered here.

Ants are comparatively immune from the attacks of predaceous arthropods, being themselves usually well provided against such enemies with offensive, defensive, or repulsive weapons. They nourish, however, a host of parasites and commensals belonging to almost every group of arachnids and insects, but these fall outside the scope of the present account. It must be admitted that, with the exception of certain of the most striking cases, such as ant-lions, but little attention has been paid to ant-hunting arthropods.

Arachnida

Ants do not often fall a prey to spiders and their relatives, except in the winged phases during the short period of the nuptial flight when large numbers of them perish in spider webs. The cautious ways of most worker ants make them a difficult game for terrestrial arachnids and in the larger forms the sting is an effective weapon against the attack of the soft-bodied spider. At one of the meetings of the Entomological Society of London, Poulton exhibited a spider and its prey taken at Itigi (former German East Africa) by Carpenter, the specimens being accompanied by the note: "Spider seen coming out of a nest of *Megaponera* bearing one feebly struggling, upside down in its fangs. Caught in a box the spider settled down to feed on the ant."[1] Poulton comments upon the remarkably small size of the spider as compared with its victim, which is one of the largest of African ponerine ants.

Certain terrestrial spiders of the Old World genus *Zodarion* Walckenær (=*Enyo* Audouin) are true ant hunters. "The *Zodarion*," says E. Simon,[2] "which I have observed in southern Europe, live at the expense of the ants and settle in their vicinity. They make neither snare nor web to stop their prey, but during their hunting hours they roam about the formicaries and mix with the long rows of ants, going from one

[1]1918, Trans. Ent. Soc. London, (1917), Proc. p. lx.

[2]1893, 'Histoire naturelle des araignées', (Paris), I, pt. 2, pp. 434–435. See also Simon, E., 1874, 'Les Arachnides de France,' (Paris), I, p. 242; van Hasselt, A., 1891, Tijdschr. v. Ent., XXXIV, pp. xxxiv-xxxvi; Krausse, A., 1913, 'Eine Spinne (*Zodarium nigriceps* Sim.) an den Abfallplätzen der Ernteameisen auf Sardinien,' Arch. f. Naturg., LXXIX, A, Heft 9, pp. 66–67.

to another and unexpectedly seizing feeble individuals, or such as are hurt or hampered by too heavy a burden. When the spider has caught its prey, it drags it aside, near its own abode; this is always surrounded by remains which leave no doubt as to the nature of its diet. These observations relate to *Z. elegans* and *nigriceps* E. Simon which, in southern France, Sardinia, and Corsica, live at the expense of the ants of the genus *Atta*" (=*Messor* Forel).

Many other terrestrial spiders are probably to some extent myrmecophags. Such is the case, for instance, with *Cœlotes atropos* Walckenær, which was observed in the act of capturing ants by Wasmann[1] in southern Germany. According to H. Lebert,[2] *Dysdera erythrina* Latreille, in Switzerland, constructs its tubular silk tent near ant hills, or sometimes even in the middle of ant nests, and plays great havoc with these insects.

E. Wasmann[3] and H. Schmitz[4] describe the skill with which the "gallows-spider" (*Theridion triste* Hahn) of western Europe preys upon the blood-red ant (*Formica sanguinea* Latreille) and related species. This spider spins no web, but lies in wait on a low plant for foraging worker ants: suddenly it drops from its lurking place on to an unsuspecting victim passing below. Then, quickly rendering the ant helpless by a few threads entwined around the body, the spider hoists its prey up to the plant as to a gallows and fastens it there. The sucked bodies of the ants are left hanging from the plant, either singly or in groups of two or three. Here again, there is a strange disproportion between the large and fierce worker ant and the small, soft-bodied, feebly armed spider.

Another European species, *Theridion riparium* (Blackwall), was observed by Henking[5] feeding chiefly on the workers of *Myrmica lævinodis* Nylander. This spider spins an irregular web between leaves and branches a short distance from the ground; in the middle of the web is woven a conical tent of silk, closed above, open below, and densely covered on the outside with bits of earth and remains of insects. A number of oblique or vertical sticky threads connect the whole structure with the ground and serve to entrap the ants. If a worker *Myrmica* happens to touch one of these snares with the antennæ or legs, its frantic efforts to get loose attract the attention of the spider hidden in her tent;

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[1]Quoted by van Hasselt, A., 1892, Tijdschr. v. Ent., XXXV, p. xxii. In the same periodical (1890, XXXIII, pp. 212–214), van Hasselt gives an account of European spiders associated with ants, including those that have been found inside formicaries.

[2]1877, Neue Denkschr. Schweiz. Naturf. Ges., XXVII, Abth. 2, p. 33.

[3]1898, 'Ameisenfang von *Theridium triste* Hahn,' Zool. Anzeiger, XXI, pp. 230–232.

[4]1916, 'De Nederlandsche mieren en haar gasten,' Jaarb. 1915 Natuurh. Genootsch. Limburg, Maastricht, pp. 110–111 (of separate).

[5]Henking, H., 1886, 'Nahrungserwerb und Nestbau von *Theridium riparium* (Blackw.) Thor.,' Kosmos, XVIII, pp. 1–11.

she at once rushes to the thread pulled by the ant and tries to drag her intended victim into the air; if the ant succeeds in holding fast to the soil, the spider runs down the thread, throws some additional silk on her prey, which sooner or later loses its grip and is then quickly dragged up and entangled in the irregular maze above.

In his account of the agricultural ant of Texas, H. C. McCook[1] writes:

> The only other natural enemies of [*Pogonomyrmex*] *barbatus*, so far as observation has yet determined, are the spiders. There is a large theridioid (*Theridion lineamentum* McCook = *T. lineatum* Hentz) who is especially destructive of these ants. I found her nest established upon the grass-grown disks in the followingmanner: several stalks of the *Aristida* were bent over near the top, or midway of the spire, and firmly bound together by silken cords. Within this tent and just below the apex, the strong snare of right lines (retitelarian) was fixed, in the midst of which the spider hung in the usual inverted position. The ants are constantly climbing the grass-stalks for purposes which I could not divine. . . . They thus become entangled in the snare and fall victims to the watchful aranean. It is not impossible that the spider, whose snare sometimes hung quite near the ground, swings down and seizes the ants as they pass through the tent. Their dry shells might be seen clinging to the threads, or the yet warm bodies trussed up and swathed for food. Under one of these tents I picked up a small ball of six or eight ant skeletons rolled up and tied together just as they had been cast out of the snare.

Coleoptera

One might expect that certain of the predaceous members of this order, both larval and adult, occasionally capture ants, though this kind of prey is often carefully avoided. Adult tiger-beetles (Cicindelidæ) have been seen catching ants. Wasmann[2] mentions the fact that in the vicinity of Pará, Brazil, the columns of the leaf-cutting saúba-ant (*Atta sexdens*) are often attacked by *Megacephala* (*Tetracha*) *rutilans* J. Thomson. Chitty, in England, observed *Cicindela campestris* holding a *Myrmica rubra* in its jaws:

> I thought the ant was struggling, for it was alternately right inside the mouth of the beetle and then nearly out, but I think this was really the mode adopted by the beetle in devouring its food. Finally the mesothorax and spiny metathorax were ejected from the mouth and also the shell of the abdomen, which had been sucked empty. The rest of the ant was apparently consumed, but possibly it was only the contents of the abdomen that were really eaten.

The larvæ of the tiger-beetles are very voracious and fierce. They live in deep, tube-like holes which they burrow more or less vertically

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[1] 1879, 'The natural history of the agricultural ant of Texas,' (Philadelphia), p. 203.
[2] Quoted by Horn, W., 1908, 'Genera Insectorum, Fam. Carabidæ, Subfamily Cicindelinæ,' p. 10.
[3] Chitty, A. J., 1904, '*Cicindela campestris* feeding on *Myrmica rubra*,' Ent. Record, XVI, p. 206.

into the ground; the hole is blocked, a short distance below the entrance, by the strongly chitinized, horizontal upper surface of the enlarged head and prothorax. If a spider or insect drops into the burrow and comes in contact with this plate, with a reflex motion the larva's head automatically jerks back, throwing the prospective prey against the walls of the tube. Thus stunned the victim is easily seized by the larva's long, sharp jaws, dragged to the bottom of the burrow and sucked out. From published data it would seem that the exact nature of the food of these larvæ has been but little investigated. In his interesting account of the life-histories and larval habits of *Cicindela*, V. E. Shelford[1] writes: "The food of the larvæ consists of land crustacea, centipedes, spiders, dragonflies, butterflies, flies, beetles, and larvæ of all sorts, in fact any small animal that comes within reach." Because of their inquisitiveness, terrestrial ants must frequently enter the burrows of cicindelid larvæ. In a recent publication, Stäger[2] concludes from his feeding experiments with *Cicindela* larvæ kept in glass tubes, that ants which drop into the burrows are merely stunned, killed and hurled out without being sucked dry, so that they can not be regarded as part of the diet of these larvæ but rather as their most dangerous enemies.

Neuroptera

Perhaps the best known ant enemies among insects are the ant-lions or certain members of the genus *Myrmeleon*. The larvæ of these Neuroptera secure their prey by means of funnel-shaped pitfalls which they excavate in sheltered places in dry, loose soil. The size of these funnels varies with that of the larvæ and the nature of the soil, and may be a few millimeters to 10 or 12 cm. across, the depth being about half the diameter.

The interesting habits of the common European species, *Myrmeleon formicaleo* (Linnæus) (=*formicarius* Linnæus) were first accurately described by Réaumur and have since been frequently studied. The larva buries itself at the bottom of the pit, only the upper part of the head and the elongate, widely extended jaws projecting out of the dust. Thus ambuscaded, it remains motionless, sometimes for hours, until a wandering insect runs over the edge of the funnel and either tumbles down at once into the jaws of the waiting ant-lion or slides only a short way and then attempts to crawl up and out of the pit. In the latter case, however, the soft, loose soil on the slope readily yields beneath the legs

[1]1908, Journ. Linn. Soc. London, Zool., XXX, No. 197, p. 178.
[2]Stäger, R., 1918, 'Biologische Beobachtungen an der Cicindelen-Larve,' Mitt. Naturf. Ges. Bern, (1917), pp. 22–44.

of the struggling insect and rolls down on the ant-lion larva, which at once forcefully throws dust with its head. At one time it was believed that these particles were aimed at the victim, but as a matter of fact they are flung out of the pit. In this way the ant-lion merely deepens its funnel, the steep walls then crumbling down under their own weight, carrying the unfortunate insect with them into the jaws of the larva. The mandibles and maxillæ of the latter act together as sucking jaws; their tips are thrust into the body of the captive and do not loosen their grip until it has been emptied of its liquid contents, when the corpse is hurled out of the hole. Any insect that happens to drop into the pitfalls is taken by the ant-lions, but ants are most likely to do so and many sucked-out bodies of these insects are usually found near the pits.[1]

The other genera of the family Myrmeleonidæ also have predaceous larvæ, but, so far as known, they do not dig pits and apparently hunt in the open, their prey consisting chiefly of plant-lice and other soft-bodied insects.

Diptera

It is most interesting that, in the dipterous family Leptidæ, the larvæ of certain genera have acquired the behavior and some of the structural peculiarities of the ant-lions. These belong to the genera *Vermileo* and *Lampromyia*, while the other members of the family possess free-living predaceous larvæ. The best studied case is that of *Vermileo vermileo* (De Geer) (= *V. degeeri* Macquart), of southern Europe, the "ver-lion" of Réaumur, very completely described and figured by both this naturalist and De Geer, about the middle of the eighteenth century.[2] The larva of this fly hides at the bottom of a funnel-shaped pitfall after the manner of the ant-lion; it is a vermicular maggot, which buries and fixes itself in the loose sand by means of four digitate processes, armed with stiff, hooked bristles, at the end of its anal segment; and by means of supplementary stiff bristles on some of the posterior rings. The four anterior segments are slender and fimbriate on the sides; they can be curved against a ventral projection of the fifth segment so as to form a loop, with which the larva throws out the dust while burrowing its pitfall. When a small insect, usually an ant, drops into the pit it is seized and

[1]Réaumur, 1742, 'Mémoires pour servir à l'histoire des Insectes,' VI, pp. 333–386, Pls. XXXII–XXXIV. See also Doflein, F., 1916, 'Die Ameisenlöwe,' (Jena), 138 pp., 10 Pls.; Navás, L., 'Algunas costumbres de las hormigas y hormigaleones,' Actas Soc. Españ. Hist. Nat., 1900, pp. 218–222: Meissner, O., 1911, 'Ameisen und Ameisenlöwen. Ein Beitrag zur Ameisenpsychologie,' Societas Entomologica, XXVI, pp. 59–60.

[2]De Geer, 1752, Act. Ac. Sci. Suec., p. 180, Pl. v; 1776, 'Histoire des Insectes,' VI, p. 168, Pl. x. Réaumur, 'Histoire du Ver-Lion,' Mém. Ac. Sci. Paris, 1753, pp. 402–419, Pl. XVII. Brauer (1883, Denkschr. Ak. Wiss. Wien, math. naturw. Kl., XLVII, Abt. 1, pp. 43–44, Pl. IV, figs. 84 and 85) gives an accurate description and drawing of this larva. The earliest reference to the habits of *Vermileo* is by an anonymous writer in Histoire Ac. Sci. Paris (1706), 1731, pp. 7–8, where it is called *Formica-vulpes*.

firmly held by the loop around the thorax or behind the head, the loop thus taking the place of the ant-lion's jaws. Many years ago a similar funnel-burrowing fly larva was discovered by Prof. J. H. Comstock in the Sierra Nevada, California, but could not be reared to the adult stage. Prof. W. M. Wheeler has recently been more successful in obtaining the flies of these larvæ, thus adding a second, North American species to the genus *Vermileo*.[1] He states that the larva is in behavior and structure very similar to that of *V. vermileo*, and that it also traps in its pitfalls small insects, especially ants.

The adults of the allied genus *Lampromyia* are very distinct in their greatly lengthened, slender, stiff proboscis, but the larvæ differ only in minor details from those of *Vermileo*. P. Marchal[2] has written an interesting paper on the habits of *Lampromyia pallida* Macquart (=*L. miki* Marchal), of which he discovered the funnel-burrowing larvæ near Tunis. Three other species have been described in this genus: *L. cylindrica* (Fabricius) from Northern Africa and Spain, *L. canariensis* Macquart from the Canary Islands, and *L. sericea* Westwood from Damaraland. During my stay at Algiers in June 1910, I had the good fortune to observe rather closely the larvæ of a species of this genus, probably *L. pallida*. They were found in numbers on the outskirts of Mustapha Supérieur, along the highway to Blidah, in the suburb of Colonne Voirol. Wherever the soft sandstones of the road banks happened to be excavated or weathered into miniature caves, one was sure to find the dry, powdery dust beneath the shelter of the overhanging rock fairly dotted with the funneled pits of *Lampromyia*. At that season adult flies were frequently seen resting on the rocky ceilings of the excavations. I found that the most common victims of these larvæ were workers of the little *Tapinoma erraticum* (Latreille).

Robber-flies (Asilidæ) are occasionally observed sucking the juices of winged ants, but I am not aware that they ever attack the workers.

Certain tropical muscid flies of the genus *Bengalia* have developed predaceous habits quite unique among the calyptrate Muscoidea; they are frequently found on roads and in clearings hunting for soft-bodied insects after the well-known manner of robber-flies. Attention was first called to these peculiar habits by Nangle[3] in India and E. E. Green[4] in Ceylon; in both cases the flies, *Bengalia obscurepennis* (Bigot), were

[1]Wheeler, W. M., 1918, '*Vermileo comstocki*, new species, an interesting leptid fly from California,' Proc. New England Zool. Club, VI, pp. 83–84.

[2]Marchal, P., 1897, 'Notes d'entomologie biologique sur une excursion en Algérie et en Tunisie. *Lampromyia Miki*, nov. species; Cécidies,' Mém. Soc. Zool. France, X, pp. 5–25, Pl. 1.

[3]1905, Journ. Bombay Nat. Hist. Soc., XVI, No. 4, p. 747.

[4]1906, Spolia Zeylanica, III, p. 220; 1907, ibid., IV, pp. 183–184 (the fly is here called *Ochromyia jejuna* F.). Poulton, Trans. Ent. Soc. London, 1906, p. 394.

hunting winged termites flying at night. J. W. Yerbury saw the same species "trying to take her burden from a large ant (*Lobopelta* species)." F. W. Thomson made the following observation with regard to the Indian *B. jejuna* (Fabricius): "I always noticed specimens of this species on the ground, or on a stone or leaf near an ant's nest. On watching, I saw them swoop down on any ant carrying an 'egg' or larva, take it from the ant, carry it away a short distance and proceed to suck it."[1] *Bengalia latro* de Meijere, in Java, lurks in the neighborhood of the columns of *Pheidologeton diversus* (Jerdon); when a worker ant comes along carrying its prey, the fly dashes into the moving ant column, quickly steals the prey from the carrier, and returns to its perch where it devours its catch at leisure.[2] Lastly, G. R. Dutt, in his entertaining 'Life Histories of Indian Insects,'[3] writes of *Monomorium indicum* Forel as follows: "One morning I observed the inmates of a nest marching out with young ones. Close to the nest was sitting a muscid fly (*Ochromyia* species) which attacked from time to time the larvæ and pupæ that were being carried by the workers. The fly never snatched the victim from the grasp of the ant, but simply 'licked' it from its place with the proboscis, which when withdrawn left the larva or pupa quite shrivelled up."

The African *Bengaliæ* evidently have much the same habits as their Indian congeners. According to W. A. Lamborn,[4] *Bengalia depressa* (Walker), in Southern Nigeria, regularly follows the marauding armies of *Dorylus nigricans*, to rob them of their prey. On one occasion the whole performance was closely watched and described as follows:

> I soon saw three or four of the muscids flying about the moving column and occasionally settling near it, sometimes on the ground quite close to the ants, sometimes on a blade of grass, stone or other raised object. Such as settled on the ground were extremely alert, and being able to run rapidly, never allowed any ants to approach any nearer to them than about a quarter of an inch. When, as frequently happened, any ant made a little circuit away from the main body, a fly would generally pursue it at a distance of about half an inch, but backing away directly the ant turned towards it. Other flies, having rested motionless a few minutes, flew up and poised themselves on the wing over the ants, but, immediately the drivers realized their presence and stretched out towards them with widely opened mandibles, flew again to a place of rest. Eventually I saw a muscid stalking a minor ant which had strayed from the main body carrying a pupa in its jaws. Suddenly the fly rushed forward, and it must have driven its proboscis, which seems to me armed with strong bristles, into the pupa, for the ant was brought to a standstill with a sharp jerk. Then ensued

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[1]Observations recorded by Poulton, 1914, Trans. Ent. Soc. London, (1913), Proc., pp. cxxviii–cxxix.
[2]Jacobson, E., 1910, '*Pheidologeton diversus* Jerdon und eine myrmecophile Fliegenart,' Tijdschr. v. Ent., LIII, pp. 328–335. Meijere, J. C. H. de, 1910, 'Ueber drei von Jacobson auf Java bei *Pheidologeton diversus* Jerdon beobachtete Fliegen,' ibid., LIII, pp. 336–340.
[3]1912, Mem. Dept. Agric. India, Ent. Ser., IV, No. 4, p. 251.
[4]1914, Trans. Ent. Soc. London, (1913), Proc., pp. cxxv–cxxviii.

a tug-of-war between ant and fly fastened on at opposite ends of the pupa, but neither had the advantage till, as it seemed to me, the ant must have got annoyed and loosening its hold rushed towards the fly, which of course instantly flew off with the pupa, and this it proceeded to suck on the ground about a foot away from the ants. It allowed me to get quite close before taking to the wing with its prey, and it settled again two or three feet further off and became so preoccupied with its meal that it fell an easy victim to my net. I then carefully watched a fly hovering over the ant column. It suddenly swooped down and rose instantly with an ant pupa, with the driver that had been carrying it still hanging on, fixed to its proboscis. The fly carried this burden for about a foot, then dropped it and alighted on the ground near by. The ant started to run away with the pupa, but the fly pursued it, again impaled the pupa and started a tug-of-war with the ant. Neither side had any advantage, and then the fly rose again about three feet into the air with the pupa and ant and after a flight of about eighteen inches let them fall. The ant being discomposed by this procedure let go of the pupa, and no sooner had it done so than the fly seized it and, flying off with it triumphantly, settled near by and proceeded as in the previous case to suck the prey. This one again fell easily to my net, so that the flies are evidently keenly alert only when in the immediate vicinity of the ants. I subsequently noticed that the Diptera seemed to have certain preferences in regard to their prey, for I repeatedly noticed one poised over the ant column make an unsuccessful swoop and then fly, keeping level with the ant carrying the particular object which it had missed, making occasional rushes in an endeavor to secure it. Those I took had obtained ant pupæ, but I am sure they take other things from the drivers, probably portions of dead insects.

Further observations by Lamborn[1] in East Africa have shown that the Dorylinæ are by no means the only species of ants favored by the attentions of the African *Bengaliæ*. At Lindi, former German East Africa, a female *B. peuhi* Brauer and v. Bergenstamm was observed alighting near a column of *Crematogaster castanea* Smith which was passing up and down a baobab tree; the fly made various attempts to rob some of the ants of their food, tiny fragments of beetles; it was very alert, retiring immediately when any stray ant happened to come its way. *Bengalia gaillardi* Surcouf was seen in the same locality stealing food carried to the nest by workers of *Pheidole liengmei* Forel, *Camponotus* species, *Leptogenys stuhlmanni* Mayr, *Prenolepis longicornis* (Latreille), etc.; at Daressalaam this fly was watching for similar purposes the home-coming *Plagiolepis custodiens* (F. Smith).

The genus *Bengalia* is restricted to the Old World tropics and belongs in the Calliphorinæ. It differs conspicuously from the other members of this group in the structure of the proboscis, which is rigid, chitinized, strongly toothed at the apex, directed forward, and evidently

[1] 1920, Trans. Ent. Soc. London, (1919), Proc., pp. lii-lviii.

adapted to its predaceous habits.[1] *Bengalia gaillardi* Surcouf was observed by Gaillard at Koulouba, French Sudan, preying upon termites in a rotten tree stump which had been freshly dug up.[2] G. D. Carpenter[3] saw *Bengalia depressa* Walker sucking the juices from a winged termite, at Kilindini, British East Africa.

Several species of *Bengalia* are commonly found in the Belgian Congo, along paths and roadsides, hunting for various insects. On June 4, 1915, I caught a number of *B. spurca* Brauer and v. Bergenstamm and *B. floccosa* van der Wulp[4] near a column of driver ants in a forest gallery at Thysville; the female flies would hover over the moving army close to the ants and seize the prey or pupæ carried by the workers, as described above by Lamborn.[5]

Some other Diptera also follow the columns of driver ants, but apparently for purposes very different from those of *Bengalia*. In his account of the foraging *Eciton* of the Amazon, H. W. Bates has this interesting passage.[6]

> The armies of all *Ecitons* are accompanied by small swarms of a kind of two-winged fly, the females of which have a very long ovipositor, and which belongs to the genus *Stylogaster* (family Conopsidæ). These swarms hover with rapidly vibrating wings, at a height of a foot or less from the soil, and occasionally one of the flies darts with great quickness towards the ground. I found they were not occupied in transfixing ants, although they have a long needle-shaped proboscis, which suggests that conclusion, but most probably in depositing their eggs in the soft bodies of insects, which the ants were driving away from their hiding-places. These eggs would hatch after the ants had placed their booty in their hive as food for their young. If this supposition be correct, the *Stylogaster* would offer a case of parasitism of quite a novel kind.

Similar observations were made some years later by C. H. T. Townsend in the State of Vera Cruz, Mexico. Under the heading *Stylogaster*, this author writes:[7]

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[1]See Green, E. E., Trans. Ent. Soc. London, 1908, Proc., pp. xxvi–xxvii. Bezzi, M. 1913, 'Einige Bemerkungen über die Dipterengattungen *Auchmeromyia* und *Bengalia*,' Ent. Mitt. Deutsch. Ent. Mus. Berlin, II, pp. 70–78. Cragg, F. W., 1918, 'The mouth-parts of *Ochromyia jejuna*, a predaceous muscid,' Indian Journ. Med. Res., V, pp. 516–522, Pl. XLVIII. Roubaud, E., 1914, 'Études faune parasitaire Afrique Occ. Française,' I, p. 33, fig. 7B.

[2]Surcouf, J., Bull. Mus. Hist. Nat. Paris, 1912, p. 427.

[3]1920, Trans. Ent. Soc. London, (1919), Proc., p. lviii.

[4]Identified by Dr. J. Villeneuve.

[5]It may be noted that the first stages of *Bengalia* are unknown. A subcutaneous maggot which bores into the skin of man and various animals in South and Central Africa [*Cordylobia anthropophaga* (Grünberg)], has been wrongly identified as belonging to *Bengalia depressa* (Walker) and this error has been repeatedly copied. As stated by Austen (Trans. Ent. Soc. London, 1907, Proc., pp. xliii–xlvii), there is no evidence whatever to show that the larva of the true *B. depressa* is a subcutaneous parasite.

[6]1863, 'The naturalist on the River Amazon,' II, pp. 365–366. Bates' observations on this fly have been strangely misunderstood by later authors. Brauer apparently first makes the statement that, according to Bates, *Stylogaster* "verfolgt mit ihrer Legeröhre Termiten" (1883, Denkschr. Ak. Wiss. Wien, math. naturw. Kl., XLVII, p. 84). This erroneous conception is unfortunately repeated by Williston (1885, Trans. Connecticut Ac. Arts Sci., VI, p. 389), by de Meijere (1904, Tijdschr., v. Ent., XLVI (1903), p. 151), and again by Krober (1919, Arch. f. Naturg., LXXXIII, (1917), Abt. A, Heft 8, p. 11). There is not the slightest evidence at hand to show that *Stylogaster* is associated with termites.

[7]1897, Ann. Mag. Nat. Hist., (6) XIX, p. 23.

Fifty-one specimens of this interesting genus were taken hovering over the front ranks of a moving army of ants, in a *cafetal* at Paso de Telayo, during the last hour or two of daylight on March 29. In company with them were numerous specimens of *Hyalomyia* and some other small tachinids. The ants have been determined by Mr. Theo. Pergande as *Eciton foreli*, Mayr. . .[1] The column of ants was about 15 feet wide and 25 feet long, and moved slowly but surely in a straight line through the *cafetal*, swarming rapidly over the thick covering of dead leaves, branches, and other obstructions that strewed the ground under the coffee-trees. The specimens of *Stylogaster* hovered continually over the ants, now and again darting at them, without doubt for the purpose of ovipositing in their bodies. During the whole three months of my collecting in this locality, I saw not a single specimen of *Stylogaster* at any other time, but on this occasion, during the short time that I had before dark overtook me, I succeeded in capturing fifty-one specimens, by sweeping closely with the net over the front ranks of the ants.

From the accounts quoted above it is evident that both Bates and Townsend base their conclusions on mere surmises, since neither of them has succeeded in finding the eggs. Their observations merely show that *Stylogaster* is in some way associated with the columns of driver ants, though it is by no means certain that this is true for all the members of the genus. Some of the North American species are found as far north as Illinois and New York, in regions where foraging ants are altogether absent. Yet it is possible that the African species of *Stylogaster* are associated with the columns of the Dorylinæ.[2] G. D. H. Carpenter, in Uganda, in his description of the frantic efforts made by cockroaches to escape from the columns of *Dorylus*, remarks: "I twice saw, hovering over these cockroaches, and occasionally suddenly pouncing down (apparently for the purpose of ovipositing) several of a small long-bodied insect—it might have been a dipteron or an ichneumon, but the hovering and darting flight suggested rather a syrphid. It was so extraordinarily active that I failed to catch it."[3]

In a recent account of his observations on army ants in British Guiana, Wheeler[4] observes that although he saw *Stylogaster* on several occasions accompanying the advancing armies of *Eciton burchellii* and darting at the ants or even at open spaces on the ground, there was nothing to convince him that these flies were ovipositing. Once he came upon a swarm of both sexes of *Stylogaster* hovering above a spot where

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[1]According to Wheeler, a synonym of *Eciton burchellii* Westwood.

[2]Dr. H. Brauns, of Willowmore, wrote me recently as follows: "*Stylogaster* habe ich seiner Zeit einige Male in Westafrika (Cameroon, Gaboon) beobachtet. Die Thiere fielen mir dadurch auf, dass sie wie Falken über *Anomma* Zügen schwebten. In welchen Zusammenhang sie mit den Doryliden stehen, weiss ich nicht. Dass sie ihre Eier auf dem Raube von Doryliden, den diese mit sich schleppen, ablegen sollten ist kaum anzunehmen, da dieser alsbald verzehrt oder verfüttert wird." (Letter of June 5, 1920). I have collected one of the North American species (*Stylogaster neglecta* Williston) on flowers of *Clethra alnifolia*, *Monarda clinopodia*, *Helianthus strumosus* and *Eupatorium purpureum*.

[3]1915, Trans. Ent. Soc. London, (1914), Proc., pp. cviii–cix.

[4]1921, Proc. American Ac. Arts Sci., Boston, LVI, p. 296.

there were no *Ecitons*, although a few workers of *Gigantiops destructor* and *Ectatomma ruidum* were running about in the vicinity. "This observation," he says, "and the fact that some species of *Stylogaster* occur in North America north of the range of *Eciton*, make it seem doubtful whether these flies are as intimately attached to the ants as some authors have supposed. They are, perhaps, attracted by the rank odor of the *Ecitons*."

Hymenoptera

The following four species of Sphegoidea are the only ones known to provision their nests with ants. It is somewhat surprising that so few predaceous wasps have developed a liking for this kind of prey.

1.—*Tracheloides quinquenotatus* (Jurine) (=*Crossocerus luteicollis* Lepeletier and Brullé; *Fertonius formicarius* Ferton). This remarkable little wasp is apparently distributed over the entire Mediterranean subregion. Its curious habits were first observed by Ferton[1] in Algeria. It preys there on the workers of *Tapinoma erraticum* (Latreille), storing forty to fifty paralyzed ants in each cell; the nest is placed in crevices in walls or burrowed to a slight depth in sandy soil. I have frequently observed its hunting behavior in the vicinity of Algiers (June 1910) in the same locality in which I found the pitfalls of *Lampromyia* described above. The females were hovering over the foraging files of *Tapinoma erraticum* and would suddenly pounce on one of the ants, seldom missing their aim.

Similar habits were described for this species by Ferton[2] in Corsica, where also it preys on *Tapinoma erraticum*. Bignell[3] likewise found *quinquenotatus* there, taking small ants which were travelling in a continuous stream across the road.

2.—*Tracheloides curvitarsis* (Herrich-Schæffer) is only known from southern Germany, Italy and Austria. Emery[4] observed this wasp near Portici and Bologna, Italy, storing about forty partly paralyzed workers of *Liometopum microcephalum* (Panzer) in each of its cells which were located in abandoned beetle borings in a tree.

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[1]Under the designation *Fertonius luteicollis:* Ferton, C., 1890, 'Un Hyménoptère ravisseur de fourmis,' Actes Soc. Linn. Bordeaux, XLIV, pp. 341–346.

[2]Under the designation *Fertonius formicarius:* Ferton, C., 1895, 'Nouveaux Hyménoptères fouisseurs et observations sur l'instinct de quelques espèces,' Actes Soc. Linn. Bordeaux, XLVIII, pp. 261–272. Under that of *Brachymerus quinquenotatus:* Ferton, C., 1901, 'Notes détachées sur l' instinct des Hyménoptères mellifères et ravisseurs (1ère série),' Ann. Soc. Ent. France, LXX, pp. 83–148, Pls. I–III.

[3]Bignell, G. C., 1900, '*Crabro 5-signatus*, Jurine, carrying off ants in Corsica,'Ent. Monthly Mag., XXXVI, p. 264.

[4]Emery, C., 1891, 'Zur Biologie der Ameisen,' Biol. Centralbl., XI, pp. 165–180; 1893, 'Sur un Crabronide chasseur de fourmis,' Ann. Soc. Ent. France, LXII, Bull., pp. lxiii–lxiv.

Tracheloides Aug. Morawitz (of which *Brachymerus* Dahlbom and *Fertonius* Pérez are synonyms) is regarded by Kohl in his able Monograph of the Palearctic Crabroninæ[1] as a species-group or subgenus of *Crabro* Fabricius. Only the two species mentioned above are known; they possess a large, much thickened head, with the face strikingly broad below, a peculiarity evidently adapted to their ant-hunting habits, since it makes the jaws with which they seize the ants much more powerful than is usual among species of *Crabro*. Indeed, most other members of this extensive genus prey on rather soft-bodied and harmless insects, chiefly Diptera.

3.—*Aphilanthops taurulus* Cockerell. Ainslie[2] found this philanthid wasp preying on the workers of *Pogonomyrmex barbatus* subspecies *rugosus* Emery in New Mexico.

4.—*Aphilanthops frigidus* (F. Smith). This interesting species of eastern North America has been very completely investigated by Wheeler[3] near Boston. Curiously enough, it selects only fertile females, or queens, of ants to provision its nests and seems to restrict its attacks to various species of the genus *Formica* (*Formica fusca* Linnæus and its variety *subsericea* Say; *F. pallidefulva* Latreille subspecies *nitidiventris* Emery; and *F. neogagates* Emery). It forms colonies of from thirty to sixty nests, located in open patches, roads or clearings in woods. The burrow descends with a very steep slope to a depth of six to eight inches, where it terminates in a small cell, there being two or three other cells on the sides. The *Formica* queens are captured during the short time of their nuptial flight, before they have lost their wings, and are merely stung and paralyzed. The wasp does not mutilate or malaxate her victims, which still move their palpi, legs, and antennæ either spontaneously or when touched, for several hours or even for a few days after they have been captured and placed in the nest. The wasp carries the ant under her body, supporting it by means of her middle and hind legs and holding its antennæ in her mandibles. Having dragged the ant a few inches into the burrow, she proceeds to cut off its wings, usually very neatly, although the stubs she leaves attached to the body are a little longer than in queen ants that have deälated themselves; more rarely the wasp simply gnaws off the tips or apical halves of the wings. Wheeler believes that each female *Aphilanthops* secures several queen ants, usually five to seven, often belonging to more than one species, and

[1]Kohl, F. F., 1915, 'Die Crabronen der paläarktischen Region,' Ann. Naturh. Hofmus. Wien, XXIX, pp. 1–453, Pls. I–XIV.

[2]Ainslie, C. N., 1909, 'A note on the habits of *Aphilanthops*,' Canadian Ent., XLI, pp. 99–100.

[3]Wheeler, W. M., 1913, 'A solitary wasp (*Aphilanthops frigidus* F. Smith) that provisions its nest with queen ants,' Journ. Animal Behavior, III, pp. 374–487.

stores them in two or three cells, from which they are taken as needed to feed a single larva. "The egg is evidently laid on an isolated ant which the mother wasp cuts in two in order that the larva may gain access to the nutritious contents of the thorax and gaster. Then the other ants are taken from storage and brought to the larva one by one as they are required, till all are consumed and the larva is ready to pupate."

Aphilanthops Patton is a strictly Nearctic genus of fossorial wasps, of which eleven species have been described, mostly of the western United States. It is highly probable that all will prove to be ant hunters, and an interesting field of study is here open to the myrmecologist [1]

The prey of *Polybia scutellaris* (White), a social wasp of southern Brazil, consists mainly of winged termites, which are stored whole in the nest, often by the hundreds; but occasionally this wasp collects winged male ants too. In one case about a hundred males of *Dorymyrmex pyramicus* (Roger) and a few other male ants were found in its nest.[2]

Amphibians[3]

The diet of many amphibians consists almost exclusively of various arthropods. Only living and moving prey is devoured; dead or motionless food has little or no attraction for them. In the frogs and toads the tongue, attached in front and free behind, is often the chief organ used in seizing the food, being thrown out with lightning-like rapidity; it is soft, extensile, coated with a glutinous secretion, and adheres firmly to the prey, which is swallowed whole. The teeth, when present, are used only for catching and holding the prey; they are absent in many genera. Digestion is very rapid. The American toad, *Bufo americanus* Holbrook, for instance, feeds continuously throughout the night, except when food is unusually plentiful; in twenty-four hours it consumes a quantity of insects equal to about four times its stomach capacity. In other words, the toad's stomach is practically filled and emptied four times in each twenty-four hours.[4]

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[1]The species of the genus *Microbembex* store dead insects in their nests, a very unusual procedure among predaceous wasps; they can occasionally be seen collecting dead ants that have been thrown out at the entrance of ant nests. See Parker, J. B., 1917, Proc. U. S. Nat. Mus., LII, pp. 134–141.

[2]Wasmann, E., 1897. 'Beutethiere von *Polybia scutellaris* (White) Sauss.,' Zool. Anzeiger, XX, pp. 276–279.

[3]I am under great obligation to Mr. C. L. Camp for valuable suggestions on the subject of ants as food of batrachians and reptiles.

[4]Kirkland, A. H., 1904, 'Usefulness of the American toad,' U. S. Dept. Agric. Farmers' Bull. No. 196, p. 6; reprinted with changes from Bull. 46, Hatch Exp. Stat. Amherst, Mass., 1897, pp. 1–30, Pl. II. See also Ritchie, A. S., 1869, 'The toad as an entomologist,' Canadian Naturalist, N. S., IV, pp. 174–178; Garman H., 1901, 'The food of the toad,' Kentucky Agric. Exp. Stat. Bull. 91; Hodge, C. F., 1898, 'The common toad,' (Worcester, Mass.); Storer, T. I., 1914, 'The California toad. An economic asset,' Univ. California Journ. Agric., II, pp. 89–91; Munz, P. A., 1920, 'A Study of the food habits of the Ithacan species of Anura during transformation,' Pomona Journ. Ent. Zool., XII, pp. 33-56.

Toads and frogs being more often seen while in search of good, the stomach contents of specimens in collections are frequently little or not at all digested and can then be easily identified; many insects with hidden habits may thus be obtained. Amphibians are in this respect of very great help to the collector of ants.

Numerical data relating to the food of these animals has not often been published, even for the species of temperate regions. Perhaps the most complete records of the kind are those in H. A. Surface's 'Report on the economic features of the amphibians of Pennsylvania.'[1] From this paper it may be seen that, while almost all salamanders, toads, tree-frogs, and frogs occasionally eat ants, these insects constitute an important item in the diet of certain species.

Food of Certain Amphibians in Pennsylvania (Surface)

	Number of Stomachs with Recognizable Food	Number of Specimens Eaten	Number of Ants	Percentage of Ants
Plethodon cinereus (Green)	260	583	182	30
" *glutinosus* (Green)	125	367	63	17
Desmognathus fusca (Rafinesque)	235	378	33	8
Bufo americanus Holbrook	52	150	20	13

Kirkland's paper referred to above contains the result of an examination of 149 stomachs of toads (*Bufo americanus* Holbrook) in Massachusetts; in this case 19 per cent of the total contents were ants; the percentage was higher in May, when ants formed 23 per cent of the food and were present in 70 per cent of the stomachs.

The Texan robber frog, *Eleutherodactylus latrans* (Cope), a land animal of secretive and nocturnal habits, probably feeds extensively on ants. J. K. Strecker[2] mentions that "the stomach of one example contained the elytra of a ground beetle and the remains of many spiders and ants."

True frogs of the genus *Rana* take very few or no ants, at least in North America, though, as may be seen below, the stomachs of certain of the African species contain a fair proportion of these insects, mostly in the winged phases. Surface, in Pennsylvania, found few or no ants in *Rana*, and this result is confirmed by C. J. Drake's very extensive study

[1] 1913, Zool. Bull. Div. Zool. Pennsylvania Dept. Agric., III, Nos. 3 and 4, pp. 134–147.
[2] 1910, Trans. Ac. Sci. St. Louis, XIX, No. 5, p. 82.

of the food of the leopard frog (*Rana pipiens* Schreber) in Ohio;[1] of 209 stomachs examined only 19 contained one or two specimens of ants (about 2.5 per cent of the total animal food). J. C. Needham obtained similar results with the bullfrog (*Rana catesbiana* Shaw) in New York State; in the stomachs were found only a few remains of the winged males and females of *Camponotus pennsylvanicus*, which evidently had dropped on the surface of the water, where they were taken by the frogs.[2]

In his paper on Nicaraguan amphibians, G. K. Noble[3] mentions ants among the stomach contents of the following species.

Dendrobates tinctorius (Schneider). The stomachs of two specimens "contained mostly ants, although a few beetles and other insects were present. There were about fifty ants in each stomach. Dr. Wheeler has identified most of these as *Wasmannia auropunctata* Roger. Seven other genera were represented, but each by only a few workers: *Strumigenys*, 2 species; *Rhopalothrix*, new species; *Leptogenys* (*Lobopelta*), species; *Trachymyrmex*, species; *Ponera*, species; *Pheidole*, 2 species; and *Solenopsis*, species." (*op. cit.*, p. 322).

Dendrobates typographus Keferstein. The stomachs examined contained "mostly small red ants." (*op. cit.*, p. 323).

Eleutherodactylus polyptychus (Cope). The stomachs "contained only insects and mostly large ants." (*op. cit.*, p. 329).

Eleutherodactylus rugosus (Peters). "One medium-sized individual contained in its stomach two beetles and a large ant, *Neoponera obscuricornis* (Emery)." (*op. cit.*, p. 331).

Bufo hæmatiticus Cope. "It had been feasting on ants. Its stomach contained a great many large red and black ones. The following species were represented in the contents of this single stomach: *Pachycondyla harpax* F. (4), *Ectatomma ruidum* Rog. (1), *Eciton hamatum* F. (3), *Atta cephalotes* (4), *Apterostigma* species (1)." (*op. cit.*, p. 333).

Bufo coniferus Cope. "A few ants contained in one stomach belonged to *Paraponera clavata* F., *Neoponera obscuricornis* Em., *Apterostigma* species and *Hylomyrma* species." (*op. cit.*, p. 334).

Hyla quinquevittata Cope. "The largest specimen contained in its stomach over a dozen termites and one ant (*Tetramorium guineense* Fabr.)" (*op. cit.*, p. 341).

It is evident that many more observations are needed before we can fully realize the part amphibians play as predaceous enemies of ants.

[1]Drake, C. J., 1914, 'The food of *Rana pipiens* Schreber,' The Ohio Naturalist, XIV, pp. 257–269.
[2]Needham, J. C., 1905, 'The summer food of the bullfrog (*Rana catesbiana* Shaw) at Saranac Inn,' New York State Mus., Bull. 86, pp. 9–15.
[3]1918, 'The amphibians collected by the American Museum Expedition to Nicaragua in 1916,' Bull. American Mus. Nat. Hist., XXXVIII, pp. 311–347, Pls. XIV–XIX.

Enough is known, however, to make it certain that these animals are of prime importance in this respect.

While studying the amphibians of the Lang and Chapin collection, Mr. G. K. Noble, Assistant Curator of Herpetology at the American Museum, dissected the stomachs of a large number of specimens and has turned their contents over to me for identification. The results of these examinations will be published in detail in Mr. Noble's report. From the point of view of the myrmecologist they were of great interest, yielding a large number of remarkable forms; eighty different species, subspecies, and varieties were obtained in this way and, of these, forty were not otherwise represented in the collection upon which Prof. Wheeler's report is based; seventeen of these forms were new to science. Many of the ants found in the stomachs of amphibians are in an excellent state of preservation; others are considerably improved by a thorough cleansing with caustic potash. Future collectors in tropical countries are urged never to neglect this novel manner of increasing their material.

In the table below, I have condensed the results of the examination of 308 stomachs of the eleven species of Congo frogs and toads which apparently show a decided preference for ants; for five of these species ants constitute about 50 per cent or more of the total stomach contents. In addition, several species of Congo frogs had eaten isolated specimens of ants, which may, in some cases, have been swallowed accidentally together with mud, dead leaves, or vegetable matter, an abundance of

Stomach Contents of Congo Amphibians

	Number of Stomachs with Recognizable Food	Total Number of Insects Eaten	Number of Ants	Per Cent of Ants
Bufo polycercus Werner	53	759	406	66.66
" *tuberosus* Günther	5	160	38	23.73
" *funereus* Bocage	55	1292	705	54.56
" *regularis* Reuss	31	963	484	50.25
" *superciliaris* Boulenger	50	746	182	24.39
Rana occipitalis Günther	25	55	14	25.45
" *ornatissima* Bocage	14	30	6	20.
" *albolabris* Hallowell	19	42	25	59.28
" *mascareniensis* Duméril and Bibron	24	40	11	27.50
Hemisus marmoratum (Peters)	22	1006	96	9.54
Phrynobatrachus natalensis(A.Smith)	10	47	20	42.55

which is often found in the stomach. For other species, however, the number of stomachs examined was too small to furnish reliable data; when more completely investigated, some of these may prove to be true ant-feeders.

A number of amphibians collected by the American Museum Congo Expedition and the forms of ants which could be identified by Prof. Wheeler among their stomach contents are listed below. Such records give an insight into the great variety of ants eaten by some of these animals and also, to a certain extent, into the preferences shown by individual species. I must, however, point out that much of the ant débris found in the stomachs was too poorly preserved to permit correct identification, at least with our present knowledge of African myrmecology. These lists could, therefore, be considerably lengthened. Nevertheless, in the case of the toads a sufficient number of specimens have been examined to show that ants are a very important article in their diet; a total of 1815 ants was found in 194 stomachs of the five species of Congo toads; these ants belong to 72 forms, six (or 8 per cent) of which are Dorylinæ, thirty (or 42 per cent) Ponerinæ and Cerapachyinæ, sixteen (or 22 per cent) Myrmicinæ, and nineteen (or 27 per cent) Formicinæ. Terrestrial ants seem to be taken almost exclusively and this fact undoubtedly accounts for the high proportion of the Ponerinæ represented.

Xenopus mülleri (Peters)

A common frog of the Sudanese and East African savannahs. Of ten stomachs examined, only one contained a single ant:

Polyrhachis aërope Wheeler.

Xenopus tropicalis (Gray)

A frog confined to the Rain Forest. Of eleven stomachs examined, two together contained five ants:

Camponotus pompeius subsp. *marius* Emery.

Bufo regularis Reuss

This widely distributed African toad occurs in the forest and in the savannah as well. Of thirty-eight stomachs examined, thirty-one showed recognizable food and nineteen of these contained ants:

Dorylus nigricans subsp. *burmeisteri* (Shuckard).
" " subsp. *sjæstedti* Emery.
Platythyrea gracillima Wheeler.
Megaponera fœtens (Fabricius).
Bothroponera soror (Emery).

Anochetus bequaerti Forel.
Pheidole kohli Mayr, var.
" *megacephala* subsp. *melancholica* (Santschi).
Myrmicaria eumenoides subsp. *opaciventris* (Emery).
" " " " var. *crucheti* (Santschi).
Crematogaster excisa (Mayr).
Monomorium bicolor Emery.
" *afrum* var. *fultor* Forel.
Tetramorium guineense subsp. *medje* Wheeler.
Plagiolepis tenella Santschi.
Camponotus maculatus (Fabricius).
" " subsp. *congolensis* Emery.
" " subsp. *solon* Forel.
" " subsp. *brutus* (Forel).
" *acvapimensis* Mayr.
" *rufoglaucus* subsp. *cinctellus* var. *rufigenis* Forel.
" *chapini* Wheeler.
" *polyrhachioides* Emery.
Polyrhachis militaris (Fabricius).

Bufo funereus Bocage

This toad is commonly found in the Rain Forest and the outlying forest galleries. Of sixty-three stomachs examined, fifty-five contained recognizable food and forty-three of these ants:

Dorylus emeryi subsp. *opacus* Forel.
" *kohli* Wasmann.
" *nigricans* subsp. *arcens* (Westwood).
" *wilverthi* Emery.
Cerapachys cribrinodis Emery.
Paltothyreus tarsatus (Fabricius).
Megaponera fœtens (Fabricius).
Bothroponera talpa Ern. André.
" *pachyderma* (Emery).
" *soror* (Emery).
Phrynoponera gabonensis (Ern. André).
" " var. *esta* Wheeler.
" " var. *fecunda* Wheeler.
" " var. *striatidens* (Santschi).
Euponera ingesta Wheeler.
" *sennaarensis* (Mayr).
Plectroctena cristata Emery.
Psalidomyrmex procerus Emery.
Leptogenys stuhlmanni subsp. *camerunensis* var. *opalescens* Wheeler.
Anochetus estus Wheeler.
" *opaciventris* Wheeler.
Odontomachus assiniensis Emery.
" " var. *furvior* Wheeler.
" *hæmatoda* (Linnæus).

Pheidole batrachorum Wheeler.
Myrmicaria eumenoides subsp. *opaciventris* (Emery).
" " " var. *crucheti* (Santschi).
Meranoplus nanus subsp. *soriculus* Wheeler.
Triglyphothrix gabonensis Ern. André.
" *mucidus* Forel.
Cataulacus guineensis F. Smith.
Engramma wolfi Forel.
Plagiolepis tenella Santschi.
Pseudolasius weissi var. *sordidus* Santschi.
Camponotus maculatus subsp. *solon* Forel.
" " subsp. *brutus* (Forel).
" *acvapimensis* Mayr.
" *pompeius* subsp. *marius* Emery.
" *wellmani* var. *rufipartis* Forel.
" *rufoglaucus* subsp. *cinctellus* var. *rufigenis* Forel.
" *vividus* subsp. *cato* (Forel).
Polyrhachis militaris (Fabricius).
" *concava* Ern. André.

Bufo tuberosus Günther

A forest toad, much less common than the other species. Only five stomachs could be examined and each contained a number of worker ants:

Paltothyreus tarsatus (Fabricius).
Bothroponera soror (Emery).
" *pachyderma* (Emery).
Phrynoponera gabonensis var. *esta* Wheeler.
" " var. *fecunda* Wheeler.
" " var. *striatidens* (Santschi).
Euponera subiridescens Wheeler.
Odontomachus assiniensis Emery.
Triglyphothrix gabonensis Ern. André.
Cataulacus guineensis F. Smith.
Polyrhachis viscosa F. Smith (?).

Bufo polycercus Werner

One of the three common forest toads of the Congo. Of the fifty-four stomachs dissected, fifty-three contained recognizable remains and thirty-one of these ants:

Dorylus wilverthi Emery.
Paltothyreus tarsatus (Fabricius).
Megaponera fœtens (Fabricius).
Bothroponera pachyderma (Emery).
" " var. *funerea* Wheeler.
" *talpa* Ern. André.
" *soror* (Emery).

Phrynoponera gabonensis (Ern. André).
" " var. *esta* Wheeler.
" " var. *fecunda* Wheeler.
" " var. *umbrosa* Wheeler.
" " var. *striatidens* (Santschi).
Euponera ingesta Wheeler.
" *subiridescens* Wheeler.
Plectroctena cristata Emery.
" *minor* Emery.
Psalidomyrmex procerus Emery.
" *reichenspergeri* Santschi.
Leptogenys stuhlmanni subsp. *camerunensis* var. *opalescens* Wheeler.
" *ergatogyna* Wheeler.
Anochetus opaciventris Wheeler.
Odontomachus assiniensis Emery.
" " var. *furvior* Wheeler.
Pheidole batrachorum Wheeler.
" *megacephala* (Fabricius).
Crematogaster concava Emery.
Triglyphothrix gabonensis Ern. André.
Cataulacus guineensis F. Smith.
Engramma wolfi Forel.
Plagiolepis tenella Santschi.
Pseudolasius weissi var. *sordidus* Santschi.
" *bufonum* Wheeler.
Camponotus maculatus subsp. *solon* Forel.
" " subsp. *brutus* (Forel).
" *pompeius* subsp. *marius* Emery.
" *vividus* subsp. *cato* (Forel).
Polyrhachis militaris subsp. *cupreopubescens* var. *nkomoënsis* Forel.
" *nigrita* Mayr.

Bufo superciliaris Boulenger

A common toad of the Rain Forest in Cameroon, Gaboon and the Congo. Of fifty-six specimens examined in this respect, fifty showed recognizable remains of food in the stomach and thirty-five of these contained ants:

Dorylus nigricans subsp. *sjœstedti* Emery.
Paltothyreus tarsatus (Fabricius).
Megaponera fœtens (Fabricius).
Bothroponera talpa Ern. André.
" *pachyderma* (Emery).
" *soror* (Emery).
Phrynoponera gabonensis var. *esta* Wheeler.
" " var. *fecunda* Wheeler.
" *bequaerti* Wheeler.
Euponera subiridescens Wheeler.

Plectroctena cristata Emery.
Psalidomyrmex procerus Emery.
" *obesus* Wheeler.
Odontomachus assiniensis Emery.
" " var. *furvior* Wheeler.
Myrmicaria eumenoides subsp. *opaciventris* Emery.
Tetramorium guineense (Fabricius).
Engramma wolfi Forel.
Pseudolasius bufonum Wheeler.
Camponotus pompeius subsp. *marius* Emery.
" *wellmani* var. *rufipartis* Forel.

Phrynobatrachus perpalmatus Boulenger

A water frog of the forest region. Only eight of the stomachs examined contained recognizable remains of food and ants were found in one of these:

Polyrhachis alluaudi var. *anteplana* Forel.

Parts of many more ants were seen in the stomachs of the related savannah species *Phrynobatrachus natalensis* (A. Smith), but too poorly preserved for correct identification.

Arthroleptis variabilis Matschie

This is one of the typical frogs of the Cameroon, Gaboon and Congo Rain Forest. Seventeen of the stomachs examined contained recognizable food and two of these included ants:

Pheidole batrachorum Wheeler.
Aëromyrma sp.

Rana occipitalis Günther

A large-sized frog, common in the vicinity of streams, ponds, and swamps throughout the forest and savannah, from Senegambia to Angola, Uganda and East Africa. All of the twenty-five stomachs examined, contained recognizable food and ants were present in ten cases:

Dorylus nigricans subsp. *sjœstedti* Emery.
Paltothyreus tarsatus (Fabricius).
Megaponera fœtens (Fabricius).
Bothroponera soror (Emery).
Odontomachus hæmatoda (Linnæus).
Myrmicaria eumenoides subsp. *opaciventris* (Emery).
Camponotus maculatus subsp. *congolensis* Emery.
" *acvapimensis* Mayr.
" *cæsar* Forel.
" *wellmani* var. *rufipartis* Forel.
" *chapini* Wheeler.

Rana albolabris Hallowell

A characteristic frog of the Rain Forest, extending a little beyond the limits of the forest in swamps and along forest galleries. The

stomachs of twenty-three individuals were dissected and nineteen of these showed recognizable remains of food; ants were present in three cases only:

Bothroponera pachyderma (Emery).
Odontomachus assiniensis var. *aterrimus* Wheeler.
Camponotus maculatus subsp. *solon* Forel.

Rana mascareniensis Duméril and Bibron

Perhaps the most common frog throughout the larger part of the African continent. Of the thirty-nine stomachs examined, twenty-four contained recognizable remains, and a small number of ants, all of the winged phases, were found in five of them:

Pheidole megacephala (Fabricius).
Camponotus vividus subsp. *cato* (Forel).

Rana ornatissima Bocage

This frog is much rarer than the three preceding species; it is known from the savannahs south of the Rain Forest, from Angola to Southern Rhodesia and also from the northeastern Uele, where Lang and Chapin collected a number of specimens at Garamba. Of these, fifteen were examined for their food contents and fourteen contained recognizable remains; a few ants were found in a single stomach:

Pheidole kohli Mayr, var.
" *megacephala* subsp. *melancholica* (Santschi).
" *speculifera* Emery.

In addition, twenty stomachs of two other common Congo frogs (*Rana oxyrhynchus* A. Smith and *R. christyi* Boulenger) were dissected, but only a single winged ant was found. The pronounced aquatic habits of all species of *Rana*, which keep them in or near the water, evidently prevent them from feeding to any large extent on ants, except on individuals that accidentally drop into the water, as for instance, during their nuptial flights.

Kassina senegalensis (Duméril and Bibron)

A small frog occurring throughout the savannah country of Africa, with rather terrestrial habits and also said occasionally to ascend trees. A few ants were found in two of the nineteen stomachs dissected. The occurrence in one stomach of a number of workers of the hypogæic ant *Dorylus kohli* is interesting in connection with the burrowing habits of this frog.

Dorylus kohli Wasmann.
Pheidole megacephala subsp. *melancholica* (Santschi).

Hemisus marmoratum (Peters)

This little burrowing frog, of pronounced terrestrial habits, is found in the savannah country of a large part of Africa, north, south, and east of the Rain Forest. It lives mostly underground, and, according to Mr. Lang's observations, comes out of its burrows only after heavy rains. It is the most typical "ant-eater" of all Congo amphibians; twenty-two stomachs examined contained no other food than termites and worker ants, though termites were by far more abundant. True ants were found in four stomachs only:

Dorylus kohli Wasmann.
" *conradti* Emery.
Tetramorium pusillum var. *hemisi* Wheeler.

REPTILES

Lizards often chew or lacerate their food to such an extent that the examination of their stomach contents gives but very general indications with regard to their diet. There can hardly be any doubt, however, that Formicidæ are part of the bill of fare of many of these reptiles. In Miss A. H. Pritchett's careful experiments,[1] ants, *Pogonomyrmex barbatus* subspecies *molefaciens* (Buckley) and *Pachycondyla harpax* (Fabricius), were eaten readily by *Sceloporus spinosus floridanus* (Baird), a common lizard of Texas. Another species, *Gerrhonotus infernalis* Baird, refused to eat *Camponotus maculatus* subspecies *sansabeanus* (Buckley) and *C. fumidus* variety *festinatus* (Buckley), but the author suggests that these ants were possibly too small to be noticed, as insects below a certain size are apparently not perceived by the large species of lizards. Concerning *Phrynosoma cornutum* (Harlan), Miss Pritchett writes: "The 'horned toads' were kept in cages with other lizards and also separately and were never seen to eat anything but ants. They are especially fond of the large agricultural ant, *Pogonomyrmex barbatus* Smith variety *molefaciens* Buckley" (p. 284).

In his paper on 'The horned lizards of California and Nevada of the genera *Phrynosoma* and *Anota*,' H. C. Bryant[2] says that ants, flies, and other insects constitute the principal diet of these genera and remarks: "Why the animal is never bothered by being stung internally by the ants it eats, seems hard to explain. Certainly the lining of the mouth and stomach must be particularly adapted to withstand the poisonous sting of insects, for when stung externally, the lizard shows no little discomfiture" (p. 17). Unlike most other reptiles, the horned toad catches

[1] 1903, Biol. Bull., V, pp. 271–287.
[2] 1911, Univ. of California Publ. Zool., IX, No. 1, pp. 1–84, Pls. I–IX.

the insects on the end of its viscid tongue and swallows them alive, its feeding habits being indeed very similar to those of true toads. C. L. Camp[1] has published more detailed observations on the food of many California lizards. He found remains of ants in the stomach contents of the following species: *Uma notata* Baird, *Callisaurus ventralis ventralis* (Hallowell), *Uta stansburiana elegans* (Yarrow), *Sceloporus magister* Hallowell, *Phrynosoma platyrhinos* Girard, and *Cnemidophorus tigris tigris* Baird and Girard. In the case of one of the horned toads (*Phrynosoma*) examined, the contents of the stomach were: "fifteen parasitic nematodes, six Coleoptera, one orthopter, 145 red-headed ants, all apparently of the same species and swallowed whole, and one pebble" (p. 528). These ants belonged in all probability to one of the seed-storing species of *Pogonomyrmex*, for Mitchell and Pierce[2] also note that in Texas remains of *P. barbatus* (F. Smith) subspecies *molefaciens* (Buckley) were found several times in the excrement of the horned toad, *Phrynosoma cornutum* (Harlan), and "one colony was absolutely exterminated before the enemy left it."

The Australian horned dragon or moloch (*Moloch horridus*) is said by Saville Kent to feed exclusively on ants of the minutest size.

> The small black evil-odored species [of ant], common in both South and Western Australia, was always a prime favorite with the specimens kept by the author, and wherever these ants abounded, in conjunction with a sufficiently warm temperature, no difficulty was experienced in maintaining these lizards in perfect health. . . . . They would soon settle down to feeding in a row, and the number of ants an individual lizard would assimilate was something astonishing On several occasions experimental reckoning elicited the fact that no less than from one thousand to fifteen hundred ants were taken in successive order at a single meal, each ant being separately picked up by a flashlike protrusion of the slender adhesive tongue.[3]

On examination of the stomachs of the lizards and chameleons collected by the American Museum Congo Expedition, Mr. K. P. Schmidt[4] found remains of ants, usually in a condition preventing any further identification, in the following species: *Lygodactylus picturatus gutturalis* (Bocage), *Agama colonorum* Daudin, *Bedriagaia tropidopholis* Boulenger, *Algiroides africanus* Boulenger, *Holaspis guentheri* Gray, *Ger-*

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[1]1916, 'Notes on the local distribution and habits of the amphibians and reptiles of Southeastern California in the vicinity of the Turtle Mountains,' Univ. of California Publ. Zool., XII, No. 17, pp. 503–544, Pls. XIX–XXII. Through the courtesy of Mr. Camp I have been able to examine the stomach contents of a number of reptiles collected by him near the Turtle Mountains, Riverside Co., California. In the case of *Uma notata* the stomachs were almost entirely filled with heads and parts of the body of *Pogonomyrmex*, while in those of *Phrynosoma platyrhinos* there were heads of ants and also pieces of beetles.

[2]1912, Proc. Ent. Soc. Washington, XIV, p. 72.

[3]Saville Kent, W., 1897, 'The naturalist in Australia,' (London), pp. 85–86.

[4]1919, 'Contributions to the herpetology of the Belgian Congo based on the collection of the American Museum Congo Expedition, 1909–1915. Part I. Turtles, Crocodiles, Lizards, and Chameleons,' Bull. American Mus. Nat. Hist., XXXIX, pp. 385–624.

rhosaurus flavigularis nigrolineatus (Hallowell), *Mabuya polytropis* Boulenger, *Chamæleon gracilis* (Hallowell), and *C. ituriensis* K. Schmidt.

The African skinks of the genus *Mabuya* feed on a great variety of insects, but certain of the forest species often follow the columns of the driver ants (Dorylinæ). Sjöstedt has observed this in Cameroon with *Mabuya raddoni* (Gray). He says:

> This lizard is one of the most diligent persecutors of driver ants, and wherever one of their columns was seen on the move in or at the margin of the forest, especially after the ants had scattered in search of food, one could be sure to find one or more of these graceful animals preparing for an excellent catch. It was a delight to observe how adroitly the agile lizards would plunge into the crawling swarm, fill their mouth with ants and then retire to a place of safety to devour their booty. Busily engaged in their hunt, they would fearlessly run about the motionless observer and not even hesitate to climb his legs, always twinkling their lively little eyes, on the lookout for possible danger.[1]

Birds

Comparatively few birds of temperate regions have acquired a fondness for ants; for instance, of fifty species in Tyrol whose stomach contents were examined by Dalla Torre,[2] only the following five contained remains of ants to any extent: *Cypselus melba* (Linnæus), *Anthus arboreus* Bechstein, *Tetrao medius* Meyer, *Colymbus cristatus* Linnæus, and *Picus viridis* Linnæus. In the case of the green woodpecker, the stomach was crammed full of *Formica rufa* and *Lasius niger*. Newstead[3] found that the European song-thrush, *Turdus musicus* Linnæus, and the blackbird, *Merula merula* (Linnæus), occasionally eat worker ants. Many insectivorous and omnivorous birds undoubtedly have similar habits.[4]

A great fund of accurate information concerning the food of Hungarian birds is contained in a series of articles by E. Csiki.[5] The identification of the insects found in each bird stomach examined is given and also the number of specimens of each species. I have been able to consult only the first eight papers of the series (1904–1912), in which fifty-six species of birds are studied in this respect. All of them, however, are insectivorous or at least carnivorous, with the exception of the common

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[1] 1897, Bihang Svenska Vet. Ak. Handl., XXIII, pt. 4, No. 2, pp. 14–15.

[2] Dalla Torre, K. W. v., 1889, 'Untersuchungen über den Mageninhalt verschiedener Vögel,' Biol. Centralbl., VIII, pp. 473–480.

[3] Newstead, R., 1901, 'The food of some birds inhabiting an orchard,' Gardeners' Chronicle, (3) XXX, pp. 197 and 217–218.

[4] H. C. McCook (1890, 'American spiders and their spinningwork,' II, pp. 361–363) gives some additional evidence of birds feeding on ants. See also Cockerell, T. D. A., 1890, 'What are the uses of bright colors in Hymenoptera?' Ent. News, I, pp. 65–68.

[5] Csiki, E. 'Positive Daten über die Nahrung unserer Vögel,' Aquila, Budapest, 1904, XI, pp. 270–317; 1905, XII, pp. 312–330; 1906, XIII, pp. 148–161; 1907, XIV, pp. 188–202; 1908, XV, pp. 183–206; 1909, XVI, pp. 139–144; 1910, XVII, pp. 205–218; 1913, XX, pp. 375–396; 1914, XXI, pp. 210–229. 'Die Insektennahrung des Rebhuhns (*Perdix perdix* L.),' ibid., 1912, XIX, pp. 202–209.

gray partridge, *Perdix perdix* (Linnæus), which is chiefly a grain-feeder. Of the fifty-six birds, forty-nine showed ants in their stomach contents, but in the majority of cases these insects were present in isolated specimens only. The following eight birds, alone, evidently exhibited a true myrmecophagous propensity:

Dryobates major (Linnæus). The greater spotted woodpecker is a typical ant-feeder; of twenty-three stomachs examined, fifteen contained ants, often in large numbers, belonging to the following six species: *Lasius flavus, L. niger, L. fuliginosus, Camponotus ligniperdus, Formica rufa,* and *Dolichoderus 4-punctatus.*

Dryobates medius (Linnæus). The middle spotted woodpecker feeds also largely on ants; of nine stomachs, six contained such insects, also often in abundance. The following species were recognized: *Lasius fuliginosus, L. alienus, Formica rufibarbis, F. rufa,* and *Myrmica lævinodis.*

Dryobates minor (Linnæus). Ants are also readily eaten by the lesser spotted woodpecker; five of the eight stomachs examined contained specimens, often in great numbers, of the following species: *Lasius alienus, L. fuliginosus, Camponotus sylvaticus,* and *Dolichoderus 4-punctatus.*

Picus viridis Linnæus. The main food of the green woodpecker consists of ants, which were present in all of the twenty stomachs analyzed, often the only contents and in considerable quantities (as many as 500 or 600 specimens in a single stomach). Ten species of ants were recognized: *Lasius alienus, L. flavus, L. fuliginosus, L. niger, Formica pratensis, F. rufa, F. rufibarbis, Camponotus vagus, Myrmica lævinodis,* and *Aphænogaster structor.*

Picus canus Gmelin. Only ants were found in the stomachs of the three specimens of the gray-headed green woodpecker examined; they belonged to five species: *Lasius alienus, L. flavus, Formica rufa, F. rufibarbis,* and *Camponotus vagus.*

Dryocopus martius (Linnæus). There were ants in five of the six stomachs examined of the great black woodpecker; often in abundance and of three species: *Lasius alienus, Camponotus ligniperdus,* and *C. vagus.*

Jynx torquilla (Linnæus). The wryneck subsists chiefly on ants; all the eighteen stomachs examined contained these insects, often in large numbers, six species being represented: *Lasius niger, L. alienus, Formica rufa, Camponotus sylvaticus, Myrmica lævinodis,* and *Tetramorium cæspitum.*

Perdix perdix (Linnæus). The common gray partridge feeds mainly on seeds and other vegetable substances, but it frequently picks up animals of various kinds. Of the 285 stomachs examined by Csiki, 177 (or 61.1%) also contained insects. The bulk of this insect food seems to have consisted of ants, which were found in 134 stomachs (or 47%), often in great quantities. *Lasius alienus* was present in 72 cases; *L. niger* in 57 cases; *Formica rufa* in 11 cases; *F. pratensis* in 2 cases.

All European observers agree that the green woodpecker, *Picus viridis* Linnæus, is one of the foremost ant-feeders. According to Wasmann's[1] observations in the Netherlands, this bird does not merely limit its myrmecophagous appetite to wood-boring ants (*Camponotus*), but frequently burrows into the nests of certain terrestrial species. In the spring and fall the excrement contains remains of many kinds, such as *Myrmica rubra, M. scabrinodis, Lasius niger, L. flavus, L. fuliginosus, Formica pratensis, F. rufa, F. rufibarbis*, and *F. sanguinea*, while in severe winters this woodpecker seems to feed almost exclusively on *Formica rufa* and *F. pratensis*, inserting its bill into their mound-shaped nests. W. C. Angus[2] also found that the stomach of one of these woodpeckers, shot in January in North Wales, contained *Myrmica scabrinodis*, "a common ant which nests on ground-hillocks, but never in trees."[3]

The very complete inventory of the food of the woodpeckers and their allies (Picidæ) in the United States published by Beal has led to the interesting results contained in the table below, in which the species are arranged in the order of their importance as ant-eaters. It may be seen that, for these birds, "ants constitute the largest item of animal food—28.41 per cent, considering the whole 16 species collectively—and are actually the largest item in the stomachs of 8 species. The Williamson sapsucker, the red-cockaded woodpecker, and the two flickers take the highest rank in this respect. Beetles stand next in importance, and amount to 20.42 per cent. These two items together form nearly half the food. The remainder of the animal food is composed of insects, with a few spiders, millepeds, and sowbugs, and occasionally a salamander, tree frog, lizard, or snail."[4]

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[1]Wasmann, E., 1905, 'Zur Myrmecophagie des Gruenspechts,' Tijdschr. v. Ent., XLVIII, pp. 214–220. Wasmann likewise observed the chaffinch, *Fringilla cœlebs* Linnæus, boring into a small nest of *Lasius niger* of which it picked up cocoons and workers as well.

[2]1885, Proc. Nat. Hist. Soc. Glasgow, N. S., I, p. xviii.

[3]See also Leisewitz, W., 1905, 'Ueber die wirtschaftliche Bedeutung unserer Spechte,' Verh. Ornithol. Ges. Bayern, V, (1904), pp. 64–76.

[4]Beal, F. E. L., 1911, 'Food of the woodpeckers of the United States,' U. S. Dept. of Agric. Biol. Surv., Bull. 37, p. 10. See also C. V. Riley's account of 'Insects that woodpeckers eat' in Warren, B. H., 1890, 'Report on the birds of Pennsylvania,' 2d. Ed., (Harrisburg), pp. 176–178.

Food of North American Picidæ

Name of Species	Number of Stomachs Examined	Per cent of Animal Food	Per cent of Ants
Williamson sapsucker, *Sphyrapicus thyroideus* (Cassin)	17	86.67	85.94
Red-cockaded woodpecker, *Dryobates borealis* (Vieillot)	76	81.06	56.75
Red-shafted flicker, *Colaptes cafer* (Gmelin)	183	67.74	53.82
Flicker, *Colaptes auratus* (Linnæus)	684	60.92	49.75
Red-breasted sapsucker, *Sphyrapicus ruber* (Gmelin)	34	68.92	42.49
Pileated woodpecker, *Phlœotomus pileatus* (Linnæus)	80	72.88	39.91
Yellow-bellied sapsucker, *Sphyrapicus varius* (Linnæus)	313	49.31	34.31
Downy woodpecker, *Dryobates pubescens* (Linnæus)	723	76.05	21.36
Hairy woodpecker, *Dryobates villosus* (Linnæus)	382	77.67	17.10
Lewis woodpecker, *Asyndesmus lewisi* Riley	59	37.48	11.87
Three-toed woodpecker, *Picoides americanus* Brehm	23	94.06	8.29
Nuttall woodpecker, *Dryobates nuttallii* (Gambel)	53	79.41	8.19
California woodpecker, *Melanerpes formicivorus bairdi* Ridgway	84	22.59	8.09
Red-bellied woodpecker, *Centurus carolinus* (Linnæus)	271	30.94	6.45
Arctic three-toed woodpecker, *Picoides arcticus* (Swainson)	28	88.69	6.35
Red-headed woodpecker, *Melanerpes erythrocephalus* (Linnæus)	443	33.83	5.17
Total	3453		
Average		64.26	28.49

It would be worth while to consider in more detail the choice of food made by these ant-eating woodpeckers. Unfortunately, I have not found the needed information for some of the species included in the above list, such as, for example, the Williamson sapsucker; many of the other woodpeckers, especially those of the genera *Dryobates*, *Phlœotomus*, and *Melanerpes*, merely eat ants which they find in wood or underneath bark (*Camponotus* and *Crematogaster*). The flickers (*Colaptes*), however, are the ant-eaters *par excellence* among North American birds, for they have made ants their favorite food; they are also more terrestrial in

habits than the other woodpeckers and this explains how their ant diet includes not only wood- and bark-boring species, but also many others that nest in the ground (*Formica, Lasius, Myrmica, Aphænogaster, Solenopsis, Prenolepis,* etc.).

In one case a stomach and crop [of *Colaptes auratus*] were both filled with very small ants (*Crematogaster* species). The whole mass was divided with care into 16 parts as nearly equal as possible, and in one part 315 ants were counted, giving 5,040 in one meal of one flicker. In addition there were at least 100 pupæ. Two other stomachs and crops examined in the same way each gave a little over 3,000 ants. Probably each of the 100 stomachs in the collection contained nearly as much ant food as these, but the number of ants was less because they were of larger species. A large proportion of the ants eaten are of species that live in the earth, and these appear to be the principal food the flicker obtains on the ground. In every case where the stomach held a quantity of these small ants, a lot of fine sand revealed their source.[1]

In his study on 'The tongues of woodpeckers,' F. A. Lucas has the following interesting remarks which may be quoted in connection with our subject.

Considering the tongues in relation to food, we find that those of the various species of flickers (*Colaptes*) have the fewest terminal barbs and the longest dorsal tract of fine points; they are also among the longest. The members of the genus are particularly fond of ants, and the tongue seems especially adapted for probing ant hills. The function of the fine points on the upper part of the tongue seems to be to form a rough surface to which the sticky saliva will readily adhere and to which in turn the ants will be stuck. In this genus the submaxillary salivary glands reach the maximum size in the group.[2]

In North America the western meadowlark, *Sturnella magna neglecta* (Audubon), and the roadrunner, *Geococcyx californianus* (Lesson), may be taken as typical illustrations of occasional ant-feeders. The food of these birds has been investigated in California by H. C. Bryant.[3] About 2000 stomachs of the western meadowlark were examined, and 16.7 per cent of these contained remains of ants, which amounted to 3 per cent (volume) of the total food of all the specimens studied. Ants appear to be taken by this bird irrespective of size or kind. Of species identified, I may mention *Tapinoma sessile, Messor andrei, Pogonomyrmex californicus,* and species of *Camponotus* and *Formica*. In the case of the roadrunner, of which 84 stomachs were examined, a little over 4 per cent of the total food was made up of ants, bees, and wasps; one of these stomachs contained over 250 red ants (*Pogonomyrmex californicus*), along with a quantity of caterpillars, crickets, beetles, and grasshoppers;

[1]Beal, F. E., *op. cit.*, p. 54.
[2]1895, U. S. Dept. of Agric. Biol. Surv., Bull. 7, p. 38.
[3]1914, 'A determination of the economic status of the western meadowlark (*Sturnella neglecta*) in California,' Univ. of California Publ. Zool., XI, No. 14, pp. 21–24; 1916, 'Habits and food of the roadrunner in California,' *op. cit.*, XVII, No. 5, pp. 21–58, Pls. I–IV.

another bird had eaten ten carpenter ants (*Camponotus* species). According to records in the United States Biological Survey, published by W. D. Hunter,[1] the following Texas birds are known to prey upon the agricultural ant, *Pogonomyrmex barbatus* subspecies *molefaciens* (Buckley): great-tailed grackle, *Megaquiscalus major macrourus* (Swainson); upland plover, *Bartramia longicauda* (Bechstein); burrowing owl, *Speotyto cunicularia hypogæa* (Bonaparte); Texas nighthawk, *Chordeiles acutipennis texensis* Lawrence; scissor-tailed flycatcher, *Muscivora forficata* (Gmelin); kingbird, *Tyrannus tyrannus* (Linnæus); redbird, *Cardinalis cardinalis* (Linnæus); and mockingbird, *Mimus polyglottos* (Linnæus).

Cleland's recent account of the food of Australian birds,[2] makes it clear that the rich ant fauna of that continent is preyed upon by a great many birds of different families. Of a total of 224 species examined with regard to their stomach contents, 73 were found to contain ants, though as a rule these insects were present in small quantities only. The following list contains such species as seem to show a preference for ants.

Black-breasted plover.—*Zonifer tricolor* (Vieillot).
Lesser golden plover.—*Charadrius dominicus* (P. Müller).
Brown flycatcher.—*Micræca fascinans* (Latham).
Flame-breasted robin.—*Petræca phœnicea* Gould.
Scrub robin.—*Drymaœdus brunneopygius* Gould.
Coach-whip bird.—*Psophodes crepitans* (Latham).
Blue wren.—*Malurus cyanochlamys* Sharpe.
Grey shrike-thrush.—*Collyriocichla harmonica* (Latham).
Black-backed magpie.—*Gymnorhina tibicen* (Latham).
White-backed magpie.—*Gymnorhina leuconota* Gray.
White-throated thickhead.—*Pachycephala pectoralis* (Gould).
Yellow-breasted shrike-robin.—*Eopsaltria australis* (White).
White-throated tree-creeper.—*Climacteris picumna* (Temminck).
Brown tree-creeper.—*Climacteris scandens* Temminck.
Noisy minah.—*Myzantha garrula* (Latham).
Yellow-throated minah.—*Myzantha flavigula* Gould.

Most of the ants found in these stomachs were not identified. In the case of the *Micræca* and the species of *Myzantha*, remains of *Camponotus nigriceps* (Smith) and of a *Polyrhachis* were recognized. Two of the stomachs of *Psophodes crepitans* contained a large quantity of the heads and legs of ants, chiefly the "green-head ant" [*Rhytidoponera metallica* (F. Smith)]; some of the *Malurus cyanochlamys*, *Gymnorhina tibicen*, *Eopsaltria australis*, *Climacteris picumna*, and *C. scandens* had also fed on this or allied Ponerinæ. Bulldog ants (*Myrmecia* species)

[1] 1912, U. S. Dept. Agric. Bur. Ent. Circ. No. 148, p. 6.
[2] Cleland, J. B., 1918, 'The food of Australian birds. An investigation into the character of the stomach and crop contents,' Science Bull. No. 15, Dept. of Agric. New South Wales, 112 pp.

were found in large numbers in the stomachs of *Collyriocichla harmonica*, *Gymnorhina tibicen*, *G. leuconota*, *Pachycephala pectoralis*, *Eopsaltria australis* [in this case the ant being identified as *Myrmecia gulosa* (Fabricius)], and *Myzantha garrula*. I am informed by Prof. Wheeler that the two ponerine genera *Myrmecia* and *Rhytidoponera* contain some of the largest and most conspicuous members of the Australian ant-fauna, and all of them sting or both sting and bite severely.

The myrmecophagous habit is perhaps most highly developed among birds of tropical regions, many of which are entirely or almost restricted to this kind of diet. Thus, F. Dahl concludes that, in the Bismarck Archipelago, insectivorous birds are the most dangerous enemies of ants. Of about ninety species of terrestrial birds examined by Dahl in that region, twenty-eight were found to be more or less ant-eating; some fifteen of these had captured the winged sexual phases only, at the time of the nuptial flights; twelve others had also fed on worker ants picked up outside their nests, the list of these including flycatchers (*Pœcilodryas*, *Monarcha*, *Rhipidura*), thickheads (*Pachycephala*), drongos (*Dicrurus*), honeyeaters (*Myzomela*), timeliids (*Ortygocichla*), and warblers (*Cisticola*). The stomach of one of the warblers, *Megalurus macrurus* (Salvadori), was filled with the workers and sexual phases of a species of *Polyrhachis* (near *schenki*),[1] of which it apparently destroys the nests, though it feeds on many other insects too.[2]

In their discussion of the food-habits of Indian birds, Mason and Maxwell-Lefroy[3] summarize the evidence concerning the Formicidæ as follows:

> The ants, like the grasshoppers, are exceedingly abundant insects and form a very large proportion of the insect food of birds in India. They are perhaps the favorite food of the woodpeckers, wrynecks, rollers, and some of the pheasants. Most birds that eat insects of any kind will almost certainly be found to take ants of one species or another. The following species occur in this paper as taken by birds: *Acantholepis frauenfeldi* variety *bipartita*, *Camponotus compressus*, *Cataulacus taprobanæ*, *Crematogaster subnuda*, *Dorylus* species, *Meranoplus bicolor*, *Myrmecocystus setipes*, *Œcophylla smaragdina*, *Pheidole malinsi*, and *Polyrhachis simplex*.

Of 109 species of birds examined by these authors in the plains of northeastern India, near Pusa, forty-eight showed remains of ants in their stomach. In most cases these insects were present in small

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[1]Forel remarks in this connection: "I have long suspected that the spines of the species of *Polyrhachis* may have the purpose of disgusting birds and other predaceous animals from using them as food. But this is a mere supposition. At any rate the findings of Prof. Dahl show that they are eaten by birds, which seems natural considering that they so frequently nest among leaves."

[2]Dahl, F. 1901, 'Das Leben der Ameisen im Bismarck-Archipel,' Mitt. Zool. Mus. Berlin, II, 1, pp. 43–44. It must be noted that the stomach of only one *Megalurus macrurus* was examined.

[3]Mason, C. W. and Maxwell-Lefroy, H., 1912, 'The food of birds in India,' Mem. Dept. Agric. India, Ent. Ser., III, pp. 1–371.

numbers only. Certain Indian birds, however, feed entirely on ants and foremost among these are, again, the woodpeckers. Three stomachs of the northern rufous woodpecker, *Micropternus phæoceps* Blyth, contained exclusively ants: 1459 *Crematogaster subnuda* in the first; 2600 of the same ant in the second; 725 of this *Crematogaster*, 304 *Pheidole malinsi*, and 27 pupæ and larvæ of *Œcophylla smaragdina* in the third. Of 3921 insects taken by 16 specimens of another woodpecker, *Brachypternus aurantius* (Linnæus), 1738, or 44 per cent, were ants (*Camponotus compressus*, *Œcophylla smaragdina*, *Meranoplus bicolor*, *Myrmecocystus setipes*, and *Crematogaster subnuda*), and in several instances the bird's stomach contained nothing else. An interesting result was obtained with the wryneck, *Jynx torquilla* (Linnæus): seven stomachs contained 1540 insects, all but eight of which were ants, mostly of the species *Pheidole malinsi*. Another prominent ant-feeder in India is the brown shrike, *Lanius cristatus* Linnæus; of 111 insects taken by seven birds, 41, or 36 per cent, were ants (*Œcophylla smaragdina* and *Crematogaster subnuda*).

Similar observations on South and Central American birds would be extremely valuable, for it is surprising how few accurate data have been published, as yet, with regard to the food habits of most tropical birds. For this reason, I include a list of the Nicaraguan birds in the stomach of which Mr. W. De Witt Miller has found remains of ants.[1]

Geococcyx velox (A. Wagner). One stomach contained a mass of insects, including three fairly large ants; several other birds of this species showed no ants.

Chloronerpes rubiginosus yucatanensis (Cabot). Fragmentary remains of many ants were found in one stomach. The proventriculus and stomach of another individual were filled with ants, some of these being mostly yellowish and 10 mm. long; there was also one beetle. In a third case the stomach contained a large number of ants of at least two kinds, by far the majority belonging to a small yellowish species; also at least one small beetle. Many ants were present in the stomach of a fourth bird.

Ceophlœus lineatus similis (Lesson). Two stomachs examined contained numerous ants and bits of other insects.

Centurus hoffmanni Cabanis. In one case the stomach showed no other food than many ants of various kinds, while that of another bird was filled with fruit of a *Cecropia*.

[1]I am greatly indebted to Mr. W. DeWitt Miller, Associate Curator of Ornithology in The American Museum of Natural History, for permission to use this information, and also for many valuable suggestions and criticisms on my account of birds as predaceous enemies of ants.

Xiphocolaptes emigrans emigrans Sclater. Insects, including many ants, in one stomach; three other stomachs contained no ants.

Saltator magnoides medianus Ridgway. One stomach contained, among other things, a number of myrmecine ants.

Amblycercus holosericeus (Lichtenstein). One stomach was filled with insects, including at least one small black ant.

Thamnophilus doliatus (Linnæus). One stomach contained two small black ants among other insects; that of another individual was filled with fair-sized ants of at least two kinds, some black, some yellow; no ants were found in three other stomachs of this species.

Pachysylvia decurtata (Bonaparte). Two stomachs contained in one case one, and in the other four ants, among other insects.

Pachyrhamphus cinnamomeus Lawrence. One stomach was completely filled with insects, including two ants.

Synallaxis pudica nigrifumosa (Lawrence). One ant among many other insects, in one stomach.

Hylocichla ustulata swainsoni (Cabanis). Insects, including one ant head, were found in one stomach.

Euthlypis lachrymosa (Cabanis). The contents of one stomach consisted of insects, including ants.

Cyclarhis flaviventris Lafresnaye. Insects, including a few ants, were found in one stomach. Another bird contained no ants.

Myiopagis placens accola Bangs. One stomach showed a few insects, including one ant head.

Salpinctes fasciatus Salvin and Godman. In two stomachs examined a number of ants were found, together with other insects.

As Mr. Miller points out, it would seem that, except in the case of certain woodpeckers (*Chloronerpes, Ceophlœus,* and *Centurus*), ants are an exception in the food of the insectivorous birds of Central America. Perhaps the most pronounced ant-feeders of all Neotropical birds are the curious woodpeckers of the genus *Celeus*. G. F. Gaumer describes the habits of the common species, *Celeus castaneus* (Wagler), in Yucatan, as follows: "This bird has a very strong and peculiar odour, derived from its food, which consists exclusively of a small hymenopterous insect called the *Uss*. It is solitary, and lives in the deepest part of the forest. The specimens obtained were very tame and were watched for some hours before being shot; they jump nimbly about the trees, and are constantly catching the small insects which seem to be attracted to them by their odour."[1] I am informed by Mr. Miller that, according to Mr.

[1]Quoted by A. Boucard, Proc. Zool. Soc. London, 1883, pp. 452–453.

G. K. Cherrie's observations made in Central America, the "hymenopterous insects" in question are ants.[1]

Phœnicothraupis rubicoides (Lafresnaye), one of the tanagers, is often credited with following swarms of ants in search of its food, as, for instance, by G. F. Gaumer[2] from observations made in Yucatan and by C. C. Nutting[3] in Nicaragua. The latter remarks: "Curiously enough, although a tanager, this bird is usually seen clinging to the tree-trunks, like the Dendrocolaptidæ, and hops about the ground like the Formicariidæ. Indeed it seemed to be living almost entirely upon ants. There were many places where the ground was actually swarming with these insects, and there *P. rubicoides* would congregate in large numbers, either picking up the ants from the ground, or climbing about the trunks of trees in pursuit of the same insect."

Eucometis spodocephala (Bonaparte), another tanager, and *Dendrocincla sancti-thomæ* (Lafresnaye), one of the Dendrocolaptidæ, were also seen by C. C. Nutting in Nicaragua, feeding largely upon ants (*op. cit.*, pp. 382 and 385).[4]

It is especially the Neotropical ant-thrushes, or Formicariidæ, that have been credited with habitually following the columns of the foraging ants (Ecitonini) in much the same manner as will later be described for the African ant-thrushes and doryline ants. R. Schomburgk[5] mentions that, in British Guiana, the moving armies of *Eciton* are always accompanied by large numbers of several species of birds, the most common of these being *Formicarius colma* (Boddaert) and *Pithys albifrons* (Linnæus). This traveller evidently believed that the birds were feeding on the ants themselves. H. W. Bates, speaking of his experiences with the foraging ants in Brazil, also writes that "when the pedestrian falls in with a train of these ants, the first signal given him is a twittering and restless movement of small flocks of plain-colored birds (ant-thrushes) in the jungle."[6] Belt's observations in Nicaragua are somewhat similar: "The numerous birds that accompany the army ants (*Eciton prædator*) are ever on the lookout for any insect that may fly up, and the heavy flying locusts, grasshoppers, and cockroaches have no chance of escape. Several species of ant-thrushes always accompany the army ants in the forest. They do

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[1]Lüderwaldt (1909, Zeitschr. Wiss. Insektenbiol., V, p. 312) tells that the Campos woodpecker [*Colaptes? campestris* (Vieillot)] ransacks the ground nests of *Camponotus rufipes* (Fabricius) in southern Brazil.

[2]Quoted by A. Boucard, Proc. Zool. Soc. London, 1883, p. 443.

[3]1883, Proc. U. S. Nat. Mus., VI, No. 24, p. 382.

[4]None of the few stomachs of *Phœnicothraupis* and *Dendrocincla* from Nicaragua examined by Mr. Miller contained ants.

[5]Schomburgk, R., 1848, 'Reisen in Britisch-Guiana,' (Leipzig), II, pp. 287–288 and 421.

[6]1863, 'The naturalist on the River Amazon,' (London), II, p. 357.

not, however, feed on the ants, but on the insects they disturb. Besides the ant-thrushes, trogons, creepers, and a variety of other birds, are often seen on the branches of trees above where an ant army is foraging below, pursuing and catching the insects that fly up."[1] It does not appear, however, that the food of the Formicariidæ has often been determined from actual examination of the stomach contents of these birds.

During his sojourn in Africa with the American Museum Congo Expedition, my friend Mr. J. P. Chapin made accurate investigations as to the food of birds, examining the stomach and crop contents of most of the specimens collected by him. He has kindly allowed me to use his observations, and some of his field notes are quoted in full below. Of about 6000 Congo birds examined by him in this respect, some 200, belonging to about 85 or 90 species, had included ants in their diet.

In the following account I have grouped the African ant-eating birds according to the interest they show in this kind of food and the manner in which they procure it. Data heretofore published bearing on the subject have been referred to, in so far as I have been able to ascertain in the extensive literature on African ornithology; in this, too, I have been very effectively aided by Mr. Chapin.

1.—In a first group may be placed birds that feed occasionally or accidentally on ants, without, however, showing much preference for this kind of diet. A great number, if not all, of the African insectivorous and omnivorous species should perhaps be included here; for most of them available records merely give "insects" in general as food. The following are the only species for which ants have been expressly mentioned as part of the diet.

Glareola fusca (Linnæus), according to v. Heuglin,[2] in Nubia pursues swarms of winged ants in the evening, as do other species of *Glareola*.

Sarciophorus superciliosus (Reichenow). Zech, in Togo, found ants in the stomachs.[3]

Œdicnemus œdicnemus (Linnæus), according to v. Heuglin,[4] feeds partly on ants in Nubia.

Abdimia abdimi (Lichtenstein) eats even ants, according to Hartmann,[5] and G. K. Marshall[6] in Rhodesia found, in the stomach of this

[1]1874, 'The naturalist in Nicaragua,' (London), p. 20.
[2]Heuglin, T. v., 1873, 'Ornithologie Nordost-Afrika's,' (Cassel), II, p. 982.
[3]Quoted by Reichenow, A., 1901, 'Die Vögel Afrikas,' (Neudamm), I, p. 191.
[4]Heuglin, T. v., 1873, *op. cit.*, II, p. 988.
[5]Quoted by Heuglin, T. v., 1873, *op. cit.*, II, p. 1104.
[6]1902, Trans. Ent. Soc. London, p. 350.

stork, beetles and "ants of the genus *Carebara*" (probably of the winged, sexual phases.)

Melierax canorus (Rislach). The stomachs examined by Oates, in Transvaal, contained large ants, rats and lizards.[1]

Falco concolor Temminck. Antinori observed in Eritrea flocks of this bird hunting winged ants (perhaps termites?).[2]

Pogoniulus pusillus uropygialis (Heuglin). v. Heuglin[3] found some ants among the stomach contents of this bird in Nubia.

Irrisor senegalensis (Vieillot), according to v. Heuglin,[4] eats ants among other insects in Nubia.

Batis orientalis (Heuglin). G. W. Bury noted, for a specimen collected in Northern Somaliland, that "the stomach was found to contain a large number of ants."[5]

Batis molitor (Hahn and Küster). Insects of various kinds, also ants, in the stomachs of Gazaland specimens.[6]

Laniarius erythrogaster (Cretzschmar), according to v. Heuglin,[7] eats ants among other insects in Nubia.

Ploceus aureoflavus A. Smith. Fischer[8] found in the stomach of this weaver-bird, in British East Africa, seeds and sometimes also ants and caterpillars.

Nectarinia arturi Sclater. The crops examined by Swynnerton,[9] in Gazaland, contained flying ants, small flies and several large gnats.

Chalcomitra kirki (Shelley). The crop of one bird examined in Gazaland by Swynnerton[10] contained beetles and ants.

Tarsiger stellatus (Vieillot). The crops of two specimens examined in Gazaland by Swynnerton[11] contained berries, various insects and ants.

Muscicapa cœrulescens (Hartlaub). Large black ants and beetles were found in the stomach of a specimen taken in Gazaland by Swynnerton.[11]

At Salisbury, Rhodesia, G. K. Marshall[12] found remains of ants in the stomachs of the following birds:

Bradornis mariquensis (A. Smith).
Pratincola torquata (Linnæus).

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[1]Oates, F., 1881, 'Matabele Land and the Victoria Falls,' (London), p. 298.
[2]Antinori, O. and Salvadori, T., 1873, Ann. Mus. Civ. Genova, IV, p. 389.
[3]Heuglin, T. v., 1871, *op. cit.*, I, p. 762.
[4]1869, *op. cit.*, I, p. 216.
[5]Bannerman, 1910, Ibis, (9) IV, p. 312.
[6]Swynnerton, 1907, Ibis, (9) I, p. 70.
[7]Heuglin, T. v., 1871, *op. cit.*, I, p. 464.
[8]Quoted by Reichenow, A., 1904, 'Die Vögel Afrikas,' (Neudamm), III, p. 92.
[9]1907, Ibis, (9) I, p. 42.
[10]*Op. cit.*, p. 43.
[11]*Op. cit.*, p. 67.
[12]1902, Trans. Ent. Soc. London, p. 351.

Monticola angolensis niassæ Reichenow.
Saxicola pileata (Gmelin).
Dicrurus adsimilis divaricatus (Lichtenstein).
Thamnolæa cinnamomeiventris (Lafresnaye).
Crateropus jardinei kirkii Sharpe.
Lophoceros leucomelas (Lichtenstein).
Campothera bennetti (A. Smith).
Crecopsis egregia (Peters).

From Mr. Chapin's observations it appears that in the Belgian Congo swallows [*Riparia riparia* (Linnæus) and *Psalidoprocne nitens centralis* Neumann],[1] *Coracina pectoralis* (Jard. Selby), shrikes [*Nilaus afer* (Latham), *Corvinella corvina* (Shaw)], and certain kingfishers (*Halcyon pallidiventris* Cabanis) are very fond of catching sexual winged ants together with other flying insects, while francolins (*Francolinus lathami* Hartlaub, *F. squamatus* Cassin, *F. icterorhynchus* Heuglin) and Guinea fowl (*Guttera plumifera schubotzi* Reichenow, *G. pallasi* Stone, *Phasidus niger* Cassin, *Numida ptilorhyncha* Lesson) often indiscriminately pick up worker ants from the ground with snails, beetles, seeds, and even pebbles. With regard to the two species of forest Guinea fowl, Mr. Chapin remarks that their flesh "is rather dry eating and has, in addition, a peculiar strong taste, due probably to something they eat, possibly the ants usually found in their crop." At Ngayu the crop and stomach of a black forest Guinea fowl, *Phasidus niger*, were filled with thick green leaves and driver ants. In the case of the savannah Guinea fowl, *Numida ptilorhyncha major* Hartlaub, ants were frequently found in the crop; usually, as in a specimen examined at Faradje in September 1911, these ants belonged to the large, black, termite-hunting species, *Megaponera fœtens* (Fabricius).

The following list contains the birds from the Belgian Congo which showed remains of ants in their stomachs. In most cases these insects were present only in small numbers, or the individuals taken belonged to the winged phases. In some of the pipits (*Anthus*) and thrushes (*Thamnolæa* and *Monticola*), however, worker ants and even their larvæ were sometimes present in large quantities; it is possible that these birds, and perhaps others in the list, may prove on further observation to be rather regular ant-feeders.

Glareola melanoptera Nordmann.
Galachrysia nuchalis emini (Shelley).
Neotis denhami (Children).
Himantornis hæmatopus whitesidei Sharpe.
Ciconia ciconia (Linnæus).
Coturnix coturnix (Linnæus).

[1] In a specimen of *Hirundo nigrita* G. R. Gray, from Gamangui, Mr. Chapin found that "the right metatarsus had been bitten by a driver ant, whose head still adhered to it, and all the lower part of the foot had died and dried up, without falling off."

Coturnix delegorguei Delegorgue.
Milvus ægyptius parasitus (Daudin).
Centropus grillii Hartlaub.
Cuculus solitarius Stephens.
Cuculus jacksoni Sharpe.
Lybius guifsobalito Hermann.
Coracias abyssinicus Hermann.
Eurystomus afer (Latham).
Eurystomus gularis Vieillot.
Bucorvus abyssinicus (Boddaert).
Ceratogymna atrata (Temminck).
Bycanistes sharpei (Elliot).
Horizoceros granti (Hartlaub).
Irrisor erythrorynchos (Latham).
Scoptelus adolfi-friederici Reichenow.
Caprimulgus inornatus Heuglin.
Caprimulgus batesi Sharpe.
Macrodipteryx longipennis (Shaw).
Cosmetornis vexillarius (J. Gould).
Muscicapa striata (Pallas).
Stizorhina vulpina Reichenow.
Oriolus larvatus lætior Sharpe.
Onychognathus hartlaubi Hartlaub.
Hyphantornis cucullata feminina Grant.
Malimbus nitens microrhynchus Reichenow.
Pyromelana crassirostris Grant.
Estrilda atricapilla Verreaux.
Melanopteryx nigerrimus (Vieillot).
Parmoptila jamesoni (Shelley).
Anthus leucophrys gouldi Fraser.
Pycnonotus tricolor (Hartlaub).
Cinnyris superbus (Shaw).
Cinnyris splendidus Shaw.
Hedydipna platura (Vieillot).
Eremomela badiceps (Fraser).
Monticola saxatilis (Linnæus).
Thamnolæa nigra (Vieillot).

In the case of the weaver-birds included in the above list, it is evident that some of the species (*Parmoptila*, *Malimbus*, *Estrilda*, etc.) have a marked predilection for ants, since the crop and stomach very often contained their larvæ, pupæ, and workers. Mr. Chapin's note concerning a *Melanopteryx nigerrimus* obtained at Avakubi is worthy of quotation: "its stomach contained many of the large light brown ants[1] that bind together the leaves of mango, as well as those of other trees, with silky fibers produced by their larvæ."

2.—Birds that feed chiefly or to a very large extent on ants are of more interest to the myrmecologist, and some of them have developed peculiar habits in connection with this kind of diet.

a.—Swifts and bee-eaters seem to show, in tropical Africa, a marked preference for ants in the winged phases, which they catch in flight. The stomach of one of the most common swifts, *Micropus apus* (Linnæus), was frequently found by Mr. Chapin to be filled with brownish-black winged ants; many other species, such as *Micropus streubeli* (Hartlaub), *M. affinis* (Gray and Hardwicke), *Tachornis parvus* (Lichtenstein), *Chætura cassini* Sclater, *C. ussheri sharpei* Neumann, *C. sabini* Gray, and *C. melanopygia* Chapin, have similar habits. Mr. Chapin observes that swifts feed mainly on winged ants, while swallows catch them only occasionally. The red-breasted bee-eater, *Merops*

[1] *Œcophylla longinoda* (Latreille). [J. B.]

malimbicus Shaw,[1] also shows a great predilection for winged ants; in the eight specimens shot near Monsembe, on the Congo River, from a flock of 175 to 200 which was resting in the top of a dead tree, the gizzard was well filled with such insects. Similar observations were made on related species at Avakubi (*Merops albicollis* Vieillot) and Bafwabaka [*Melittophagus mülleri* (Cassin)].

b.—A rather small group of insectivorous birds attack the nests of ants and feed on the workers as well as on the brood. This is a very common habit with many species of woodpeckers. Sjöstedt[2] relates that some of the Cameroon species seem to live chiefly on ants, which were the only insects he found in the stomach of *Campethera permista* (Reichenow). Kersting[3] found ants in the stomach of *Campethera nivosa* (Swainson) and v. Heuglin[4] in that of *Mesopicus schoensis* (Rüppell) and *Dendropicos obsoletus* (Wagler), brood as well as worker ants being present. Similar observations were made by Mr. Chapin on the following Congo species: *Campethera caroli* (Malherbe), *C. permista* (Reichenow), *C. balia* Heuglin, *C. abingoni chrysura* (Swainson), and *C. nivosa* (Swainson). His following note relates to a specimen of the last-named species from Avakubi: "the stomach contained larvæ and pupæ of a very small black ant that builds large brown nests in the trees.[5] From this it would seem that this woodpecker had been pecking holes in a nest."

A specimen of *Campethera abingoni* (A. Smith) obtained by Swynnerton[6] in Gazaland had its stomach filled with hundreds of a small black tree-ant in all stages of development.

c.—Some birds of the African forests have developed the curious habit of following the columns of doryline driver ants, much as do the South American Formicariidæ I have previously mentioned. The earliest observations of the kind were made by Du Chaillu[7] in the Gaboon: "Hunting in the rear of the village (of Obindji) on the 15th [of April 1858], I shot a curious bird, the *Alethe castanea*—a new species. . . They fly in a small flock, and follow industriously the bashikoway ants [driver ants] in their marches about the country. The bird is insectivorous; and when the bashikoway army routs before it the frightened grasshoppers and beetles, the bird, like a regular camp-follower, pounces on the prey and carries it off. I think it does not eat the bashikoway."

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[1]Hartert found winged ants, together with other insects, in the stomach of *Merops malimbicus* examined by him in Nigeria (1886, Journ. f. Ornithol., XXXIV, p. 593).
[2]1895, Kongl. Svenska Vetensk. Ak. Handl., N. S., XXVII, No. 1, pp. 54 and 56.
[3]Quoted by Reichenow, A., 1903, 'Die Vögel Afrikas,' (Neudamm), II, p. 170.
[4]Heuglin, T. v., 1871, 'Ornithologie Nordost-Afrikas,' (Cassel), I, p. 804 and 810.
[5]Evidently a species of *Crematogaster*. [J. B.]
[6]1907, Ibis, (9) I, p. 290.
[7]Du Chaillu, P. B., 1861, 'Explorations and adventures in equatorial Africa,' (New York), p. 319.

Reichenow[1] made similar observations on the same species of bird in Cameroon, but he found the stomachs of specimens examined by him filled with driver ants. He also claims that *Turdinus fulvescens* (Cassin) has similar habits.[2] According to Sjöstedt,[3] the following birds are found near the moving columns of *Dorylus* (*Anomma*) *nigricans* subspecies *arcens* in Cameroon: *Bleda notata* (Cassin), *B. syndactyla* (Swainson), *Alethe castanea* Cassin, *Criniger calurus* (Cassin), and *Neocossyphus poensis* (Strickland). This observer notes that *Bleda notata* on such occasions does not remain on the ground, but rather on the lower branches of trees and shrubs, whence it jumps down to the ants and returns at once to its perch. The stomach of *Neocossyphus poensis* was found to contain ants only, while that of *Bleda notata* contained ants and beetles. At Efulen, Cameroon, G. L. Bates[4] also saw *Alethe castanea* "in thickets where an army of driver ants covers the ground and bushes, as they are very fond of feeding on these ants, though they do not come into open places to do so." In another paper, Bates[5] writes: "Whenever you see a number of birds of different kinds flitting about near the ground in one place and twittering excitedly, you may be pretty sure there is an army of 'driver ants' at hand. Many different kinds of birds join in the chase of driver ants. I have even seen the small white-crested hornbill (*Lophoceros hartlaubi*) engaged in it." Another hornbill, *Orthologhus cassini* Finsch, was once seen by Bates[6] to join with smaller birds in pecking at a swarm of driver ants on the ground.

On Mount Ruwenzori, between 6500 and 9000 feet, R. B. Woosnam found *Alethe poliophrys* Sharpe "frequenting the forest zone and the lower edge of the bamboo. It appeared to be particularly fond of the soldier ants and might often be seen attacking a column of these insects as they crossed a path or open spot. Whether it really ate the ants or merely snatched away the eggs they were carrying, was a point we could never decide; probably the eggs were the attraction, for it seems difficult to imagine anything more unsatisfactory than a meal of angry soldier ants."[7]

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[1]1875, Journ. f. Ornithol., XXIII, p. 29.

[2]Mr. Chapin did not find this to be the case with *T. fulvescens* in the Upper Congo.

[3]Sjöstedt, Y., 1895, 'Zur Ornithologie Kameruns,' Kongl. Svenska Vetensk. Ak. Handl., N. S., XXVII, No. 1, pp. 1–120, Pls. I–X. In a later paper Sjöstedt further mentions certain woodpeckers of the genus *Campethera* and *Stiphrornis gabonensis* Sharpe as occasionally following the columns of the dorylines in Cameroon, though not so regularly as the *Criniger* and *Alethe* ('Exped. Kilimandjaro, Meru, etc.,' II, 8, 1908, p. 111).

[4]Quoted by R. B. Sharpe, 1908, Ibis, (9) II, p. 128.

[5]Quoted by R. B. Sharpe, 1904, Ibis, (8) IV, p. 92.

[6]1905, Ibis, (8) V, p. 89. Under the name *Orthologhus albocristatus* (Cassin).

[7]Woosnam, quoted by O. Grant, 1910, Trans. Zool. Soc. London, XIX, p. 374

In his account of the columns of *Dorylus* in Gazaland, South East Rhodesia, Swynnerton[1] has the following remarks: "I have also on a few occasions watched birds attending *Dorylus*, to rob stragglers of their prey, and for the sake of the flying and hopping insects flushed by the ants. Some of the birds on occasion eat the ants themselves. In my experiments on many species of insectivorous birds, I found that some ate ants generally, including *Dorylus*, far more readily than others. Of these others some showed a strong repugnance to them, and it is doubtless in relation to this latter class of enemy, that ant-mimicry finds its main use. Yet even the birds that prey on ants show caution in attacking *Dorylus* in column, merely (in my observations) dropping down to stragglers and hastily returning to their perch." It would be interesting to know which species of birds in South Africa have acquired these habits, since most of the true ant-thrushes are more at home in the West African forest region.

In the forest of the Belgian Congo, Mr. Chapin found the following birds associated with the armies of Dorylinæ: *Alethe castanea woosnami* Grant, *A. poliocephala carruthersi* Grant, *Bleda eximia ugandæ* van Someren, *B. syndactyla woosnami* Grant, *Neocossyphus rufus gabunensis* Neumann, *N. poensis præpectoralis* Jackson.[2] Several of these species occur together, as indicated in the following field-note written at Avakubi, April 16, 1914: "We came to a spot in the forest this morning where a great number of driver ants were crossing the road in several columns; and, noticing that there were also birds on hand, we stopped for some time to watch the proceedings. Besides a half-dozen small brown thrushes (*Alethe*, mostly *A. c. woosnami*, but also one or two *A. p. carruthersi*), there were two rufous thrushes (*Neocossyphus rufus gabunensis*), at least one with white patches in the tail (*Neocossyphus p. præpectoralis*) and one *Bleda s. woosnami*. It was quite evident that all these birds were attracted by the ants, and they seemed especially interested in a spot where these irritable insects had spread out widely over the path. The *Alethe* were, of course, most in evidence, fluttering back and forth across the road, occasionally darting down right among the ants, and perching in the bushes bordering the way. *Alethe c. woosnami* has a habit of fluttering its wings slightly, like a bluebird, while perching. From time to time one of the larger rufous thrushes would fly out of the undergrowth, sometimes even alighting on the ground amid the ants, but, as usual,

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[1]1916, Trans. Ent. Soc. London, (1915), p. 318.

[2]It may be remarked that these African "ant-thrushes" are not all related forms, for, while *Alethe* and *Neocossyphus* belong to the Turdidæ, *Bleda* is placed among the Pycnonotidæ.

these birds were very shy and it was only after long waiting that I could shoot one.

"Now, what are the birds after? It is not, as a rule, the adult ants, for these are generally only eaten, if at all, in very small numbers. Nor is it their young, for they frequently do not carry any, and this circumstance has no relation to the presence or absence of birds. Is it the victims—other insects and the like—being carried by the ants? Surely there ought to be easier ways than this to procure the same food. Yet the three ant heads in the stomach of one of the *Neocossyphus rufus* might have come there in that way. Seizing some coveted morsel, the bird found, perhaps, that several ants had buried their jaws in it, but plucked off their bodies at, any rate, before eating it."[1] On another occasion, at Bafwabaka, the stomach of an immature *Neocossyphus p. præpectoralis* was found filled with driver ants; but in most of the other "ant-thrushes" examined for this purpose the food consisted mostly of small insects, with occasionally a driver ant. A number of stomachs of *Alethe* also contained the bones of small frogs.

Plate I (frontispiece) represents a typical association of three driver ant birds commonly found in the Ituri Forest following the columns of the dorylines: *Alethe c. woosnami* Grant, *Neocossyphus rufus gabunensis* Neumann, and *Bleda eximia ugandæ* van Someren.

Mammals

That many insectivorous and omnivorous mammals, such as moles, shrews, monkeys, and the like, will at times feed on ants can be expected after what we have learned above of the feeding habits of insectivorous birds; we know, however, but little about this from actual observation. We have the authority of John Muir that certain North American black bears are very fond of carpenter ants (*Camponotus*); they "tear and gnaw their home logs to pieces, and roughly devour the eggs, larvæ, parent ants, and the rotten or sound wood of the cells, all in one spicy acid hash."[2] Mr. C. L. Camp has kindly informed me that he once saw in the Yosemite National Park, California, bear-droppings containing masses of the chitinous remains of ants. Moles, too, must devour large numbers of worker ants and their pupæ, though I have found no

[1] Mr. Chapin also notes that, at Faradje, he once watched a chicken eating army ants.

[2] Muir, J., 1916, 'My first summer in the Sierra,' (Boston and New York), p. 46. C. H. Merriam (1884, 'The mammals of the Adirondack Region,' New York, p. 95) writes that the American black bear (*Ursus americanus* Pallas) "is *par excellence* an omnivorous beast, and his larder consists not only of mice and other small mammals, turtles, frogs, and fish; but also, and largely, of ants and their eggs, bees and their honey, cherries, blackberries, raspberries, blueberries and various other fruits, vegetables, and roots. . . . He delights in tearing open old stumps and logs in search of the ants that make their homes in such situations."

definite records thereof, except in the case of the American mole, *Scalopus aquaticus* (Linnæus). Scheffer[1] has examined one hundred stomachs of this animal in Kansas and found remains of ants in nineteen of them, these insects being then, as a rule, present in large numbers; one of the stomachs, for instance, contained 205 ants and 44 other insects; another, 250 ant puparia and 6 other arthropods.

So-called "ant-eaters" are found in practically all tropical regions, but the confusion so commonly made by casual observers between the true ants (Formicidæ) and the "white ants," or termites, in many cases makes it hard to decide from published accounts which of these mammals are truly myrmecophagous and to what extent. Moreover, but little information based on actual study has been published concerning their feeding habits and stomach contents. White ants, or termites, constitute, of course, an attractive food for almost every insectivorous animal, while true ants, as Beebe remarks, "are all flavored more or less strongly with formic acid, and must be an acquired taste."[2] Further interesting questions which cannot be answered at this time are whether the various ant-eaters prefer ants to other insects and whether they can make a selection between different species of ants. These points would be of importance in considering the possible use of these animals to combat the leaf-cutting ants of tropical America, as suggested by certain observers.

The echidnas, or spiny ant-eaters (*Echidna aculeata* Shaw and allies), of New Guinea, Tasmania, and Australia belong to the order Monotremata and are among the most primitive and odd-looking of present-day mammals. The Australian species, at least, is said by most observers to feed on "ants," though from the descriptions of G. Bennett[3] and Saville Kent it would appear that by this termites are meant as well as Formicidæ. Saville Kent, for instance, writes that when the echidnas are placed in contiguity to a teeming ant track, they take no notice of it, "appreciating the insects only under the conditions obtaining in the nests or hillocks. These edifices they would soon tear open with their powerful claws, exposing to view the white succulent nymphs, larvæ, and pupæ, or so-called eggs, upon which alone they concentrated their attention."[4]

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[1]Scheffer, T. H., 1910, 'The common mole,' Bull. 168 Kansas State Agric. Coll. Exper. Stat., pp. 1–36; 1914, 'The common mole of the Eastern United States', U. S. Dept. Agric. Farmers Bull. 583, pp. 1–10. See also West, J. A., 1910, 'A Study of the food of moles in Illinois,' Bull. Illinois St. Lab. Nat. Hist., IX, 2, pp. 14–22.

[2]1918, Bull. Zool. Soc. New York, XXI, No. 1, p. 1561.

[3]Bennett, G., 1860, 'Gatherings of a naturalist in Australasia,' (London), pp. 147–150.

[4]1897, 'The naturalist in Australia,' (London), p. 19.

The echidna is chiefly nocturnal and shows many remarkable adaptations to its habit of feeding on subterranean insects. The face is drawn out into a long, tapering, cylindrical snout, terminating in a very small mouth. The tongue is elongated, very slender, and capable of being protruded for a considerable distance. The jaws are slender and entirely destitute of any kind of teeth, of which, moreover, no trace has been found in the young. The palate, however, and the back of the tongue are rough with small spines, presumably to hold the living prey. "For ants and their eggs form the staple food, and these the *Echidna* obtains by digging up the ant or termites' nests with its powerful limbs. Then the tongue covered with a sticky saliva is protruded; it becomes covered with ants, and is then quickly drawn back into the mouth."[1]

More circumstantial evidence concerning the food of the echidnas in Queensland is to be found in a short note by Bennett's son:

> They are particularly partial to the white ants, which erect small mounds of clay about 18 inches in height. These they attack in a most systematic way, by working round the nest, by clearing away the earth and forming a trench where the nest joins the earth, and devouring all before them; and then they make a hole in the center and clear out the whole nest, leaving none behind to tell the tale of their visit. The soldier ant (a large stinging ant) they do not touch; their nests were close to the white ant mounds, but were untouched. The larger sugar ants, which raise mounds of sand about 16 inches high and 4 feet in diameter, they attack first, by lying on the mound with their tongue out and drawing in the ants that cross it; there they remain sometimes for hours. This, I have no doubt, is the time that they get the sand found in their stomach. They then make a hole from one side to the other, and devour the most delicate morsels coming in their way. In the daytime they do not move about much, beginning their search about a couple of hours before sundown.[2]

K. Dahl[3] also states that the Australian *Echidna aculeata* depends upon termites for its food.

Among the extensive order of marsupials, many of the insectivorous species must occasionally eat ants. One of them, the banded Australian ant-eater, *Myrmecobius fasciatus* Waterhouse, is often considered as belonging to a peculiar subfamily, the Myrmecobiinæ, and is said to feed on "ants" and perhaps also on other insects. This interesting animal offers, among the marsupials, all the adaptive characters of the South American ant-eaters: the elongate and pointed muzzle, the slender and extensive tongue, the stout fore limbs, and the long, curved, digging

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[1]Lucas, A. H. S. and Le Souef, W. H. D., 1909, 'The animals of Australia,' (Melbourne), p. 148.
[2]Bennett, G. J., 'Observations on the habits of the *Echidna hystrix* of Australia,' Proc. Zool. Soc. London, 1881, pp. 737–739.
[3]1897, Zoologist, (4) I, p. 200. See also König, C., 1911, 'Der Ameisenegel,' Aus der Natur, V II pp. 621–633.

claws. In Western Australia, the stomach of one example proved upon dissection to be full of white ants, most of which had evidently been swallowed whole.[1]

There are several mammals formerly included in the heterogeneous "order" Edentata which are said to feed chiefly on "ants." In the case of the exclusively African aardvarks (*Orycteropus*; Pl. XXIV, fig. 1), I am assured by Mr. H. Lang, from his examination of stomach contents, that the regular food consists of termites, while true ants are only taken when they happen to occur in the termite mounds, as is frequently the case, and are then unintentionally swallowed together with the white ants. How far this is true also of the South American ant-eaters (Myrmecophagidæ, with the genera *Myrmecophaga*, *Tamandua*, and *Cyclopes*) remains uncertain; the available information does not go beyond the general statement that they feed on ants, termites, and their larvæ.

Concerning the great ant-eater or ant-bear, *Myrmecophaga tridactyla* Linnæus, Flower and Lydekker[2] say: "Its food consists mainly of termites, to obtain which it opens their nests with its powerful anterior claws, and as the insects swarm to the damaged part of their dwelling, it draws them into its mouth by means of its long, flexible, rapidly-moving tongue covered with glutinous saliva." That *Myrmecophaga* feeds on termites, and not on true ants, would also appear from the accounts given by H. W. Bates[3] and others. On the other hand, Hensel[4] maintains that the tamandua (*Tamandua tetradactyla* Linnæus) does not feed on termites, but that in all the specimens of that species examined by him the stomach was filled with true ants, even in localities where termite mounds were very common. His statements are, however, contradicted by A. Zietz[5] who fed the tamandua in captivity with termites, while ants were obstinately refused. The little, or two-toed, ant-eater (*Cyclopes didactylus* Linnæus) is an arboreal species which seems to feed chiefly on true ants. At least, Miss Snethlage[6] was unable to feed it in captivity with termites; she says that not all ants are to its taste; the pupæ of a species which lives in dry imbauba trunks are eaten with predilection, also the pupæ and workers of another small, black ant with triangular abdomen, found chiefly in inga trees.

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[1]G. C. Shortridge, quoted by O. Thomas, Proc. Zool. Soc. London, 1905, II, p. 772.
[2]Flower, W. H. and Lydekker, R., 1891, 'An introduction to the study of mammals living and extinct,' (London), p. 191.
[3]1863, 'The naturalist on the River Amazon,' II, pp. 178–179. Nill (1907, Zoolog. Beobachter, XLVIII, pp. 145–151) fed *Myrmecophaga jubata* in captivity on red ants (*Formica rufa*), which the animal would take through the neck of a bottle.
[4]Der Zoolog. Garten, Frankfurt a.M., 1872, p. 177.
[5]Der Zoolog. Garten, Frankfurt a.M., 1872, pp. 301–304.
[6]Quoted by Strassen in Brehm's 'Tierleben,' 4th Ed., 'Säugetiere,' I, 1912, p. 544.

The armadillos (Dasypodidæ), which range in many species over the tropical and temperate parts of South America, one of them even reaching Texas, are said to be omnivorous, feeding on roots, insects, worms, reptiles, and carrion; in how far this diet may include true ants is by no means easy to gather from the very scanty descriptions of the habits of these animals; in many cases termites are in all probability the chief food.[1] The snout of the armadillos is moderately elongate, and the tongue is long, pointed, extensile, though less so than in the Myrmecophagidæ.

It would thus appear that the pangolins or scaly ant-eaters (Manidæ; Pl. XXIV, fig. 2; Pl. XXV, figs. 1 and 2) of the Old World tropics are the only edentates whose myrmecophagous propensities are beyond doubt. These animals are at once recognizable by the large overlapping scales which cover the whole of the upper surface of the head, the upper surface and sides of the body, the whole of the tail; and the outer sides of the limbs; the legs are short and end in curved claws, those of the fore limbs being especially powerful. The snout is pointed and conical; teeth are entirely absent; the long, vermiform, protractile tongue is flattened toward the tip and kept sticky with saliva abundantly produced by enormous submaxillary glands. The structure of the stomach shows further curious adaptations to their ant diet; in *Manis javanica*, for instance, most of the mucous membrane is transformed into a pavement epithelium of horny texture, raised into folds in the cardiac region near the œsophagus, while it forms horny teeth in the pyloric part, at the end of the great curve; opposite these pyloric teeth, at the end of the small curve, the middle line is swollen into an organ of trituration, covered with numerous horny teeth and moved by powerful underlying muscles. The gastric glands are united into a few voluminous glandular bodies which pour their abundant secretion into the stomach by way of wide glandular ducts. The insects are swallowed whole and reach the stomach together with saliva, sand, and small pebbles often as large as a pea; this mixture is then ground up by the peristaltic movements of the stomach, whose inner walls are effectively protected by the horny pavement epithelium; gastric juice is profusely poured over the stomach contents, which undergo a final grinding by the organ of trituration in the pyloric region.[2]

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[1]Lüderwaldt (1909, Zeitschr. Wiss. Insektenbiol., V, p. 312) mentions incidentally that the armadillos in Brazil prefer to grub about in the earthen mounds of the stinging *Solenopsis geminata*.

[2]See Weber, M., 1904, 'Die Säugetiere,' (Jena), pp. 426–427.

Seven species are now generally recognized in this family and are all included in the genus *Manis:* four of these occur on the African continent, while the remaining three are found in the Oriental Region (Ceylon, India, Burma, southern China as far as Kianghsi, Formosa, and Sunda Islands). The ant-eating habit is common to all, though it has been investigated in only a very general way. I have been able to find but one record of the complete analysis of the stomach contents of one of these animals. It was made from a specimen of *Manis* (said to have been *temmincki*, but probably *gigantea* Illiger), the stomach of which was sent by Solon from the Lower Congo to Forel, who extracted from it the following ants,[1] several of which were at that time new to science.

Dorylus (*Anomma*) *emeryi* subsp. *opacus* Forel. Numerous workers.
Pheidole punctulata Mayr. Several workers and two soldiers.
Crematogaster impressa Emery. Very numerous workers and several males.
Macromischoides aculeata (Mayr). A few workers.
Myrmicaria eumenoides var. *congolensis* Forel. Very numerous workers.
Rhoptromyrmex opacus var. *estus* Forel. Very numerous workers, a number of males and a few females.
Plagiolepis tenella Santschi. Female.
Œcophylla longinoda (Latreille). Workers.
Polyrhachys concava André. A small number of workers.
Camponotus manidis Forel. A small number of workers.
Camponotus foraminosus subsp. *delagoensis* var. *sorptus* Forel. A very large number of workers, a goodly number of females and several males.

Büttikofer,[2] in Liberia, fed the smaller, arboreal species, *Manis longicaudata*, with larvæ taken from mushroom-shaped termite nests. Of the large, terrestrial *Manis gigantea*, he says that the anterior portion of the stomach of a specimen contained about six liters of termites, while the posterior portion was filled with an equal amount of driver ants. Vosseler[3] found that the excrement of a *Manis temmincki* Smuts which he observed alive at Amani in Usambara consisted entirely of the chitinous remains of driver ants.

The habits of the oriental species of the genus should not materially differ from those of their African relatives. Kreyenberg,[4] who observed *Manis javanica* in China, states that all stomachs examined by him contained large numbers of ants and their larvæ exclusively. And speaking of the same species in Borneo, Beebe[5] writes: "Ants, both stinging and harmless, form the entire food, although we must extend this general

[1]1909, Ann. Soc. Ent. Belgique, LIII, pp. 58–63.
[2]Büttikofer, J., 1890, 'Reisebilder aus Liberia,' (Leiden), II, pp. 393–395.
[3]1907, Zoolog. Beobachter, XLVIII, p. 197.
[4]1907, Zoolog. Beobachter, XLVIII, p. 184.
[5]Beebe, C. W., 1914, 'The pangolin or scaly-anteater,' Zool. Soc. Bull. New York, XVII, pp. 1141–1145.

term to include the neuropterous white ants or termites. I have counted five hundred fire ants in the gizzard of a pangolin, their bites and stings powerless against the sticky, merciless tongue which played and played again among them, each time sweeping away scores. Lacking teeth, the creature swallows tiny pebbles which, as in a chicken, aid in crushing the hard bodies of the ants."

The following notes on ant-eating mammals in the Belgian Congo have been contributed by Mr. Herbert Lang.

"The scaly ant-eaters (Manidæ), or pangolins, are distributed over southern Asia, part of the Malay Archipelago, and Africa. Those of the Ethiopian Region frequent chiefly the wooded portions where hiding is rendered easy and in the Savannah Province their distribution coincides with the forest galleries. During the day they rest, slightly rolled-up and concealed in any suitable shelter, thus escaping observation. The terrestrial forms usually dig their own retreat. The signs of their fossorial practice are as often a cause of their discovery as is the strong odor they emit, and dogs of native hunters never fail to challenge their presence. Various highly valued talismans, which their captors obtain from the claws, scales, hairs, and other parts of some of the scaly ant-eaters, suffice to make them an always welcome prize and their meat is an additional incentive for their destruction.

"The giants among living Manidæ are found only in Africa and are represented by two closely related forms. Of these, *M. temmincki* Smuts is apparently restricted to the southern and eastern portions of the Ethiopian Region and *M. gigantea* Illiger (Pl. XXIV, fig. 2; Pl. XXV, fig. 2) to the western parts. The two other, much smaller, species occur only in the West African Forest Province, though the rarer, long-tailed *M. tetradactyla* Linnæus (Pl. XXV, fig. 1) alone is truly arboreal. The most common and smallest of these ant-eaters, *M. tricuspis* Rafinesque, is also an excellent climber, but more frequently remains near the ground. It reaches a length of about three feet, less of two-thirds of which are taken by the tail. In *M. tetradactyla,* the tail is proportionally longer.

"The African scaly ant-eaters generally appear so sluggish as to detract much from the interest they otherwise might arouse. Being timid, they readily make use of their natural safeguard and, when even slightly annoyed, roll up in a ball cinched by the grip of the strong, muscular tail. *M. tricuspis* and *M. tetradactyla* often hook the tip over the reclined dorsal scales, thus closing up very tightly and sometimes so fast that one has to be careful not to have a finger caught between the

scales. When forcibly unrolled, they may succeed in driving off their tormentors by well directed jets of an ill-smelling, acrid liquid from the anal region; native dogs suffer for a considerable time from the effect of this substance, which greatly irritates their mucous membranes. The sharp claws, however, are not used at all for defense, though in a struggle they may inflict severe wounds.

"In spite of their timid ways, these animals are not really shy, for, if unmolested and placed near their favored prey, they uncoil readily and, not minding the presence of man, surprise by their agility even more than by their cleverness. One soon realizes how thoroughly they are specialized as ant-eaters, for their methods of attack and disposal of ants are as effective as their ways of guarding themselves against the defensive means of their prey. In the regions we visited, the pangolins preferred true ants, as stomach contents clearly showed, though many of our captives would plunder termitaria with great eagerness. After opening the galleries of ants' nests they watched for a moment the infuriated masses swarming outside to defend their home, adjusted their position, and commenced feeding.

"The feeding process is assisted by many interesting adaptations. The strong, muscular fore limbs readily break into and tear apart the structures built by the tiny insects. Most of the ants that attempt to attack the pangolins are readily shaken off by a shivering movement of the scales. Other protective features are the moist snout; the easily closed, narrow nostrils; the thick, swollen-looking eyelids, acting like heavy pads over the small, globular eyes; and the practical absence of external ears, represented merely by muscular folds which shut the ear-opening at will. The mouth, even when fully opened, is but a narrow tube. The slender, slimy tongue shoots out and, well loaded, slips quickly back into its furrow. The food adhering to it is thus automatically pushed off and slides down into the stomach. Immediately the tongue, newly charged with slime, is thrown forward again and the performance continues with great rapidity. A huge gland, providing a steady supply of viscous matter, lies on either side of the throat and in *M. gigantea* attains the size of a goose egg. The furrow which accommodates the tongue and is so essential in removing the food and renewing its viscosity reaches far back into the thoracic cavity and carries with it the hyoid muscles. Their increased and altered function gives great importance to the sternoglossal muscles fastened upon the xiphisternal cartilage, which varies in extension in the different species. In the African and especially in the smaller arboreal forms it is more highly

specialized. In *M. gigantea* it has the form of a loop, consisting of two, broad, band-like projections distally united and reaching back half the distance from sternum to pelvis. In *M. tricuspis* and *M. tetradactyla*, however, two rod-like, cartilaginous projections extend outside the peritoneum much farther back and, turning upward to the right, are loosely fastened to the last ribs. The prehensile tongue also acts as an organ of touch and, due to its shape, can follow the intricate turns and windings of the galleries in ant and termite structures. This explains why the inmates and their larvæ are cleaned out as by enchantment. An adult male *M. tricuspis* pushed its tongue into the galleries of a sectioned ant nest for a distance of four inches, moving it just as easily sideways as up or down. After making room to insert its tiny snout, it sniffed into the tunnel, thereby still more inciting the inhabitants that, hurrying to the place of disturbance, were then lapped up so rapidly that it was difficult to see how well loaded the tongue was as it shot back and forth.

"The prey is disposed of so instantaneously that neither the ejection of formic acid, the powerful, pinching mandibles, the armature of spines, nor even the stings of the ants are of much avail. The giant anteaters, with their broader, more ribbon-like tongue, are more deliberate than the smaller species in feeding, but their methods are equally efficient. From the behavior of various forms observed it appears that they are not affected by the defensive weapons of any of the ants they feed upon. Probably these insects have little chance to make effective use of them before they are enveloped in slime, and later the gastric juices and the triturating action of the stomach render any further efforts impossible.

"The variety of ants taken by these pangolins proves that taste alone does not guide them in their choice, and I have already mentioned that our captives fed on termites with the same eagerness. Furthermore, the food, covered with slime, passes through the completely toothless mouth and throat so quickly that flavor is perhaps of little or no importance. In fact, the passage from mouth to stomach might be compared to a chute, and a process replacing mastication begins only after the food reaches the stomach.

"In spite of this apparent immunity of the scaly ant-eaters, we found that certain kinds of ants are evidently not preyed upon by at least some of the pangolins. Near one of our camps at Avakubi there was a nest of robber ants (*Megaponera fœtens*). When we inserted a grass-stalk into its entrance, the owners hurried out to attack the intruder. In a very few moments a *Manis tricuspis* lying rolled-up nearby was overrun by the

ants, which belabored it with their mandibles as well as with their painful stings. The pangolin became restless, unrolled by fits and starts, got to its feet, erected its scales, and hurried off to some distance. Then, again and again hooking its fore limbs into the ground, it dragged itself from spot to spot, at every pull exercising considerable pressure against the grass, thus endeavoring to free itself of the tormentors. Rolling up and unrolling and scratching with its claws exhausted its means of defense.

"Experiments with other captives of this species showed considerable variation in individual behavior. One taken near a column of army ants (*Dorylus*) merely made good its escape, another quickly broke up the well-ordered line. Sitting on its hind limbs and with its tail steadying its movements, the fore part of the body was swung about freely. The claws of the fore limbs were kept busy removing those of the fierce assailants that, in spite of the oft repeated shivering movements of the scaly armor, succeeded in gaining a hold. Lashing its sticky tongue through the confused crowds, the ant-eater lost no time in moving back and forth along the ant column as quickly as the dense clusters vanished into its mouth. Its hunger satisfied, it at once retreated, freeing itself of the few army ants that had managed to dig their mandibles into the soft parts of its hide. *M. tricuspis* fed freely on many other kinds of ants. Those we had alive at Avakubi, Medje, and Niapu were particularly fond of ants of the genus *Myrmicaria*. Brought within reach of such colonies, the pangolins always turned their attention to the deeper, open tunnels these ants construct across cleared spaces and trails. Here the steady stream of tiny travelers made their meals doubly easy. Curious was the habit of the ant-eaters, especially when sitting partly erect, of turning the outer edge of the tail down and suddenly sweeping into a heap all the fragments of ant or termite structures they had scattered about. This gave them a new chance of disposing of their victims that emerged again in numbers from the débris. Though undoubtedly nocturnal in habits, our captives had no objection to feeding during the day and only the direct rays of the sun interfered with the chances thus offered.

"While African pangolins have helped to enrich the stores of witchcraft both helpful and injurious, those of some parts of Japan, China, and Malaysia have furnished the folklore with a curious tale, slightly differing in details in the various regions, on their supposed feeding habits. According to the legend, the pangolin, after tearing open an ants' nest, erects its body scales and waits until as many ants as possible have

crawled beneath them. Suddenly the scales are pressed down hard, crushing the tiny prey to death; the ant-eater then goes into the water, erects its scales, and proceeds to enjoy a meal of dead ants floating on the surface.

"However great their reputation for slowness, under certain conditions the African species seen could proceed in a shuffling manner for a short distance at the rate of eighty yards a minute, the giant species being slightly faster. All four limbs and the tail take an active part, but walking on hind limbs or leaping was not observed. They can sit erect, steadied by their strong tail and pillar-like hind limbs, thus enabling them to carry out any movement with the fore part of the body and greatly increasing their ability to dig and feed. In walking, *M. tricuspis* and *M. tetradactyla* held their claws in a normal position, the tip of the claws striking the ground. The giant pangolins, however, walk on the "knuckles" of the fore limbs, so to speak, the claws being folded beneath and slightly turned inward so that only the longer, outer curve of the claw touches the ground.

"The strong, prehensile tail of the smaller pangolins, *M. tetradactyla* and *M. tricuspis*, is provided on the lower surface of the tip with a rough skin pad of great tactile sensibility. By means of this the long tail can rapidly explore the neighborhood for possible means of progress. It can grasp firmly even the slightest projection, thus enabling these ant-eaters hanging upside down to plunder ants' nests even more easily than when sitting on a branch, for at any moment they can pull themselves out of reach of the attacking ants. By forcing the head up over the breast and belly they can hook the claws into their tail as into any nearby branch. These pangolins readily carry out a three-quarter twist with the forward part of the body, or turn back at a right angle to the surface on which they are climbing, and descend any slender tree or branch head downward by quickly shifting the grip of the prehensile tail.

"The smaller species, when suddenly frightened while climbing, may let themselves drop from any height, landing uninjured in a rolled-up condition, the flexible scales, backed by the resilient, strong panniculus carnosus, evidently absorb the shock. In the arboreal *M. tetradactyla*, the long tail, with its sharp-ridged and pointed scales on the under side, is dexterously used in getting about and often serves as stabilizer. As soon as the claws of the hind feet have gained firm hold in the bark the security of the position is greatly increased thereby. The body can then be bent even backward and the free fore limbs are put into action to widen the breach in the ant galleries as fast as the sticky tongue can empty them.

"The two giant species are terrestrial and fossorial in habits but are rather scarce. They alone have succeeded in holding their own over most of the Ethiopian Region. The Vaal-Orange River in the south and Abyssinia in the north are probably the limits of distribution for *M. temmincki*, and *M. gigantea* is known from the West African Rain Forest and the adjoining wooded galleries. The latter is the only large species we met in the Belgian Congo; specimens were taken at Bafuka, Niangara, Poko, and Niapu, the largest attaining five feet in length, the tail being less than half of this.

"Near the last-named place various burrows from which Pygmies had secured giant pangolins, both dead and alive, showed that the tunnels attain a length of fifteen feet and reach about five feet below the surface. In these forests the ant-eaters seemed to prefer the higher-lying, sloping sites for their permanent homes, evidently a safeguard against being drowned in a country with such a heavy rainfall. The heap of excavated soil near the open entrance seldom offers a clue to the real size of the irregular, winding burrow, as the weather rapidly effaces the traces of diggings carried on from time to time. Pygmy boys, with one end of a strand of rattan fastened to the waist and the other held by friends waiting outside, entered the burrows without hesitation and stated that there is a more spacious resting place at the very end of the tunnel shared often by an adult pair and their young. These boys, armed with only a knife, merely fastened the rattan around the live pangolin, which they prodded from behind while their companions pulled it slowly out of the hole. These otherwise harmless beasts, when touched while rolled up, suddenly switch their tail sidewise with such force that, if one's hand is caught between the rough body scales and the tail, it is seriously mutilated by the shearing action. Natives of the Ituri and Uele districts claim that the giant pangolins stay for weeks at a time in their burrows, but it is certain that at times they leave them several nights in succession to feed. One trailed to its underground home after a heavy rain was caught in nooses eighteen days later when trying to escape.

"One might think that animals so large and muscular would need great quantities of food, but this is only relatively true, for their sluggish habits considerably reduce the demands for nourishment. An adult male from Niapu measured 1530 mm. from snout to tip of tail, the latter accounting for 690 mm. The capacity of their stomach is relatively small, hardly more than two quarts (about two liters). In an adult female the stomach measured antero-posteriorly only 170 mm. and dorso-ventrally 70 mm. Büttikofer's remark, cited by Dr. Bequaert (p. 319), about a

stomach of *M. gigantea* containing six liters of ants is evidently due to a slip of the pen. Ants and other food arrive intact in the stomach of the pangolin, but soon afterwards appear well disintegrated.

"In general outline and arrangement, the stomach of these giant anteaters is similar to that of *M. javanica* which is so well described by Weber (cited p. 318), though without the horny, tooth-like structures in the pyloric part. Nor does the large gland situated near the middle of the great curvature terminate in a common orifice but it presents an even surface, the individual follicles of the oval patch secreting directly into the stomach. In the absence of teeth, the stomach, with its highly specialized grinding mechanism, has become an organ replacing mastication. Half a handful of pebbles, the largest not exceeding five millimeters, usually found in the cardiac section, and the wall-muscles assist the trituration of food. These, and especially the more heavily muscled and distinct pyloric section, remind one of the gizzard of gallinaceous birds. The larger of the little stones are probably selected for this very purpose and are not incidentally introduced with the food as may happen with fine grit and other débris.

"The stomach is divided into two distinct parts, a larger cardiac and a smaller pyloric section. Both have somewhat the function of a gizzard. The cardiac section is lined with pavement epithelium and irregularly folded except for the large, well-defined gland patch. Here the processes of assimilation are greatly advanced. The food, mixed with the excretion of the glands, is easily ground to pieces between the pebbles and fine grit; usually only the hard, chitinous covering of the head and the strong mandibles of the ants escape being crushed in this section. The milling process is carried much further between the powerful muscles of the pyloric section, which is well set off from the other. This portion is lined with an epithelium similar to that in the cardiac section. Near and along the pyloric orifice there is, however, a well-defined smooth glandular area. The semicircular muscular mass, opposed on either side by, or rather fitted between, two other strong muscular pads is important. With the assistance of fine grit, this arrangement works much like a mill and the food before reaching the pylorus is transformed into a finely ground mass from which nourishment can easily be assimilated. The intestine is without cæcum and rather long, measuring in an adult female 10.8 meters. A large amount of the blackish, hard excrement consists of the glossy particles of chitin of ants.

"The stomachs of *M. tetradactyla* and *M. tricuspis*, as shown long ago for the latter by Klinckowström,[1] are also divided into two parts. The cardiac section is lined with horny pavement epithelium, the mucous membrane showing folds with numerous, wavy crossbars. The pyloric section, with its soft, gland-bearing mucous membrane, is sharply set apart. Though the distribution of various glands differs in the two species, the muscular portion of the pyloric section in both is much like that of *M. gigantea*. A mass of fine grit also helps pulverize the ants during the extended milling process.

"The numerous forms of the aardvark, *Orycteropus afer* (Pallas) (Pl. XXIV, fig. 1), are distributed over most of the Ethiopian Region and are equally common in the Savannah and Western Forest Provinces. Their food consists of white ants (termites), and true ants are only incidentally taken, as they often inhabit termitaria. In external characteristics the aardvark resembles a pig, about six and one-half feet in total length, with a slender head, long ears, and a heavy, tapering tail about two and one-third feet long. Its very muscular limbs with their enormous claws denote fossorial abilities. The mouth is small, the snout slightly protruding and rather easily moved. The nostrils can be opened and shut at will and the edges are set with a dense border of short, stiff bristles turned outward in such fashion as to prevent insects from entering the nose. The long, extensile tongue is of relatively normal shape and the rather flat-crowned, peculiar cheek-teeth are capable of crushing food. The stomach lacks the highly specialized triturating organs of the Manidæ, though strong, muscular walls are present in the pyloric section. The absence of stone and grit also indicates that the gastric juices play the most important rôle in the disintegration and digestion of food and are sufficient to assimilate the soft-bodied termites but not the well-chitinized ants. Numerous parasitic worms are thus enabled to live in the stomach.

"Of the many aardvark burrows seen near Faradje, those with one entrance were scarcer than those with two, but three and even as many as eight openings to a single retreat were recorded. In one case the three entrances to a burrow were as much as fifty feet apart. Many of the tunnels, which reached about five feet below the surface, were deserted; those inhabited seemed to indicate that the aardvarks occupy them at intervals and occasionally dig holes merely for shelter. At times these inoffensive animals are driven out of their lodgings by warthogs and py-

[1] 1895, Zool. Jahrb. Abt. Anat. Ontog., VIII, p. 495.

thons, the latter being known to feed upon their young and to estivate in their burrows as well as in the cavities of termite hills.

"The extensive tunnels of the burrows are large enough to admit a small man, who, among the Logo at Faradje, is armed with a short spear but trusts far more to his talismans for protection. The beast usually tries to save itself by digging, throwing the excavated earth into the face of its pursuer. Should the aardvark succeed in walling itself off, the undertaking is generally given up. If, however, the native is able to kill it, he indicates his position to an eagerly listening friend by tapping against the upper wall of the burrow. As rapidly as possible a shaft is sunk in his direction and the valiant hunter and the aardvark are lifted out. The meat is highly prized and in many regions the body has to be presented to the chief before any of the parts containing powerful medicines are removed.

"One of the African mongooses, *Bdeogale nigripes* Pucheran (Pl. XXV, fig. 3), not only satisfies its regular carnivorous instincts but, as stomach contents proved, feeds also on ants and termites. This mongoose attains the size of an otter, which it resembles in general appearance. It has large, dagger-like canines and an otherwise strong dentition; the palate is relatively wide and, especially in the young, has the general shape of that of the termite-feeding *Proteles cristatus* Sparrman.

"Of nine specimens collected, the stomach of one contained termites and those of three, driver ants which filled two of them to capacity; their possible incidental introduction with other food need, therefore, not be considered. The ants in the stomach were only slightly chewed and some of them were completely intact. This carnivore seems to have no adaptations that would allow it to devour with impunity an insect so dreaded by most other animals. It may be that these driver ants are swallowed dead, since they are often killed in masses when their droves are unexpectedly exposed to the deadly effect of the direct rays of the sun, as it may happen after a shower, when they are still on the march or feeding in great numbers on carrion.

"Among other mammals, some of the insectivores, especially certain Macroscelididæ (*Rhynchocyon*, *Elephantulus*, and *Macroscelides*), are credited with occasionally feeding on ants, probably those emerging from the ground in masses during their nuptial flights and which are easily taken.

"Chimpanzees (*Pan schweinfurthii* Giglioli) are well known to be omnivorous and, in addition to their regular vegetarian diet, feed on many insects and their larvæ. Nevertheless, I was surprised to see to

what trouble they would go merely to relish half a handful of cocoons that a nest of robber ants (*Megaponera fœtens*) might contain, leaving untouched all the dead ants they might kill in the process. These primates are evidently not deterred in their raids by the painful sting and strong, pinching mandibles of the ants. They seldom pass one of the rather inconspicuous, temporary ant nests, which are marked only by a small heap of excavated particles of earth near the open entrance, without digging it out. After uprooting the plants they sometimes scoop out a hole one or two feet deep. In the Rain Forest near Niapu, I saw about seven nests of these robber ants destroyed in this manner.

"Colonies of certain large *Camponotus* are also looted by the chimpanzees, which, in this case, are fond of the ants themselves. Hollow or decayed trees are torn apart and the galleries searched for these ants, which, when attacked, do not swarm out but retreat speedily into the deeper recesses they excavate. In the forest about Niapu and on the road to Medje there were several such instances. In one case a troop of five or six of these anthropomorphs must have spent considerable time in trying to tear open a hollow portion of a log."

Man

Certain species of ants constitute an important article of food with many uncivilized peoples, especially of the warmer parts of the globe.[1] In tropical Africa the large, winged queens of *Carebara vidua* F. Smith, which at certain seasons emerge in great numbers from termite mounds, are often highly prized as delicacies; they are eagerly gathered for their swollen gaster, which is eaten raw or roasted.[2] In Kanara and other parts of India, and throughout Burma and Siam, a paste of the green weaver ant, *Œcophylla smaragdina* (Fabricius), is eaten as a condiment with curry.[3] Beccari[4] also records that the Dyaks of Borneo "eat this ant,

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[1]Provancher (1882, Natural. Canadien, XIII, pp. 30–31) mentions that the Canadian lumberjacks sometimes eat carpenter ants (*Camponotus pennsylvanicus*). See also Riley, C. V., 1893, 'The edible quality of ants,' Insect Life, V, p. 268.

[2]Bequaert, J., 1913, Rev. Zool. Afr., II, pt. 3, p. 429. Mr. Lang, who observed the nuptial flight of *Carebara vidua* at Stanleyville in March 1915, also notes that these ants are comestible; "only the abdomen is eaten by the natives, sometimes raw, sometimes fried, also crushed."

[3]Bingham, C. T., 1903, 'Fauna of British India. Hymenoptera,' (London), II, p. 311.

"The Murries of Bastar—the southernmost Native State in the Central Provinces—use the red ants (*Œcophylla smaragdina*) as a regular article of diet. Throughout the year, but more especially during the dry season, the Purjas—a sub-class of the Murries—collect nests of the red ants, and after tearing them open, shake out the contents into a cloth, and beat the insects—mature and immature—into a pulpy mass with a stone, and when all are dead, enclose them in a packet, about the size of a goose's egg made of sal leaves. In this condition the article is taken to the bazaar and sold, about 16 being sold for a pice, or 4 cowries each. To prepare the squashed ants for food, they are mixed with salt, turmeric and chillies, and ground down between stones, and are then eaten raw with boiled rice. They are sometimes cooked up with rice flour, salt, chillies, etc., into a thick paste, and in this condition the food is said to give the eater of it great power of resistance against fatigue and the sun's heat" (Long, A. M., 1901, 'Red ants as an article of food.' Journ. Bombay Nat. Hist. Soc., XIII, No. 3, p. 536).

[4]Beccari, O., 1904, 'Wanderings in the great forests of Borneo,' (London), p. 161. (1902, 'Nelle foreste di Borneo,' (Florence), p. 237).

or rather they mix it with their rice as a condiment; it has a pungent acetic taste and smell which they evidently like." The same ant is used by the natives of North Queensland mashed up in water, like lemon squash, and forms the basis of a pleasant acid drink appreciated even by many European palates.[1]

Moreover, it is generally known that certain American Indians eat ants, as well as other insects, freely. This is especially true of the tribes that are but little inclined toward agriculture, periods of famine with them being rather frequent, due to the absence of permanent vegetable staples.[2] In his delightful book, 'My first summer in the Sierra,' John Muir[3] tells how the Digger Indians of California are fond of the larvæ and even of the adults of the large jet-black, wood-boring ants (*Camponotus*), of which "they bite off and reject the head, and eat the tickly acid body with keen relish." In his account of the honey ants of North America, McCook[4] remarks that the uses to which the Mexicans and the Indians of the southwestern United States put the replete of *Myrmecocystus* are various. "That they eat it freely, and regard it as a delicate morsel is beyond doubt. Prof. Cope, when in New Mexico, had the ants offered to him upon a dish as a dainty relish. The Mexicans (Lœw) press the insects, and use the gathered honey at their meals. They also are said to prepare from it by fermentation an alcoholic liquor. Again they are said (Edwards) to apply the honey to bruised and swollen limbs, ascribing to it great healing properties."

One finds in the narratives of Barrère,[5] de Azara,[6] Humboldt,[7] Rengger,[8] Richard Schomburgk,[9] and other travelers[10] frequent allusions to the fondness of many South American tribes for the large males and

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[1]Saville Kent, W., 1897. 'The naturalist in Australia,' (London), p. 253.

[2]See Skinner, A., 1910. 'The use of insects and other invertebrates as food by the North American Indians.' Journ. New York Ent. Soc., XVIII, pp. 264–267.

[3]Muir, J., 1916, 'My first summer in the Sierra,' (Boston and New York), p. 46.

[4]McCook, H. C., 1882. 'The honey ants of the Garden of the Gods and the Occident ants of the American plains.' (Philadelphia), p. 32.

[5]Barrère, P., 1741, 'Essai sur l'histoire naturelle de la France Équinoxiale,' (Paris), p. 198. Speaking of an ant of British Guiana which he calls *Formica major, volans, edulis*, this traveller writes: "Cette fourmi est passagère et paraît en grand nombre au commencement des pluies. Les nègres et les créoles mangent le derrière de cet insecte, qui est une sorte de petit sac, de la grosseur à peu près d'un pois chiche, rempli d'une liqueur blanchâtre, miellée, qui ne paraît être autre chose que les œufs qu'il dépose dans ce temps-là."

[6]de Azara, F., 1809, 'Voyages dans l'Amérique Méridionale,' (Paris), p. 199: "Les habitants de la ville de Santa Fé, qui est de ces côtés-là, vont à la chasse de ces fourmis ailées: on en prend la partie postérieure, qui est fort grasse, on la fait frire, et on la mange en omelette; ou bien après les avoir fait frire, on les passe au sirop et on les mange comme des dragées." After quoting this passage, Gallardo (1916, An. Mus. Nac. Buenos Aires, XXVIII, p. 344) adds that the gaster of the females of *Atta sexdens* (Linnæus), called *tanajúra*, is still eaten by the Brazilians.

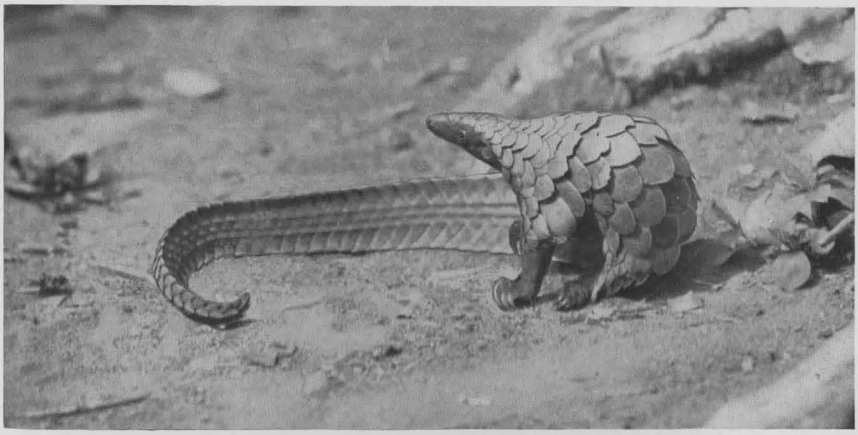
[7]Humboldt, Al. de, 1822, 'Voyage aux régions équinoxiales du Nouveau Continent, fait par A. de Humboldt et A. Bonpland,' (Paris), VII, pp. 443–444.

[8]Rengger, A., 1835, 'Reise nach Paraguay in den Jahren 1818 bis 1826 von Dr. J. R. Rengger,' (Aarau), p. 253.

[9]Schomburgk, Rich., 1848, 'Reisen in British Guiana,' (Leipzig), II, p. 112.

[10]See Orton, J., 1876, 'The Andes and the Amazon,' 3d Ed., (New York), p. 301; Spruce, Rich., 1908, 'Notes of a botanist on the Amazon and Andes,' (London), I, p. 484.

queens of the common leaf-cutters, *Atta cephalotes* (Linnæus) and *A. sexdens* (Linnæus). Schomburgk vividly describes how these ants are collected by the Indians of British Guiana, when, with the first rain-storms, large numbers of the winged, sexual forms leave their mound-shaped nests. Their heads are pulled off as soon as they are caught, and the swollen gaster, filled with fatty tissue, is roasted or otherwise cooked; "thus prepared, these insects are considered even daintier than the larva of *Calandra palmarum*."



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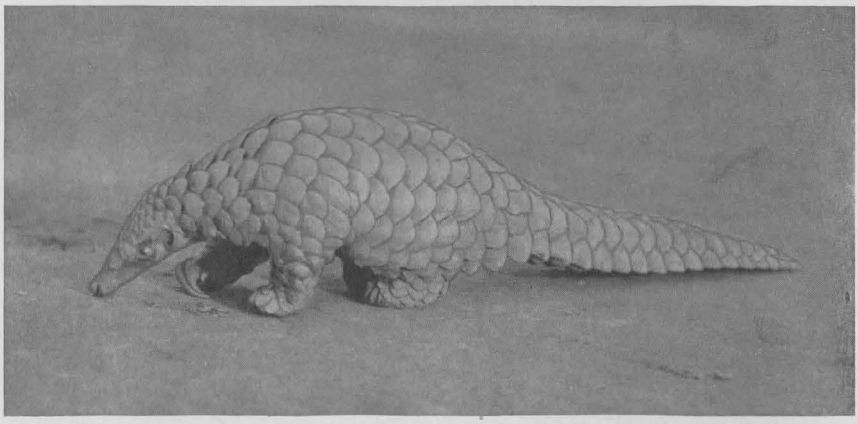

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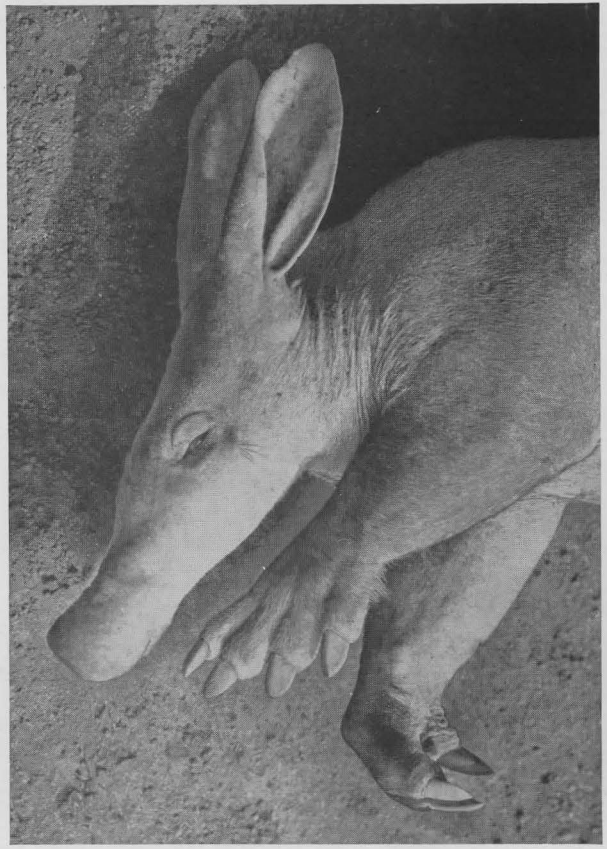
PLATE XXIV

Fig. 1. *Orycteropus afer* (Pallas). Freshly killed female, at Faradje, March 6, 1911. Anterior portion of the body, showing the elongated snout and the heavily built fore limbs with their powerful digging claws.

Fig. 2. *Manis gigantea* Illiger. Freshly killed female, at Niangara, April 26, 1913. Anterior view, showing the elongate snout and lengthened, heavy claws of the fore limbs.



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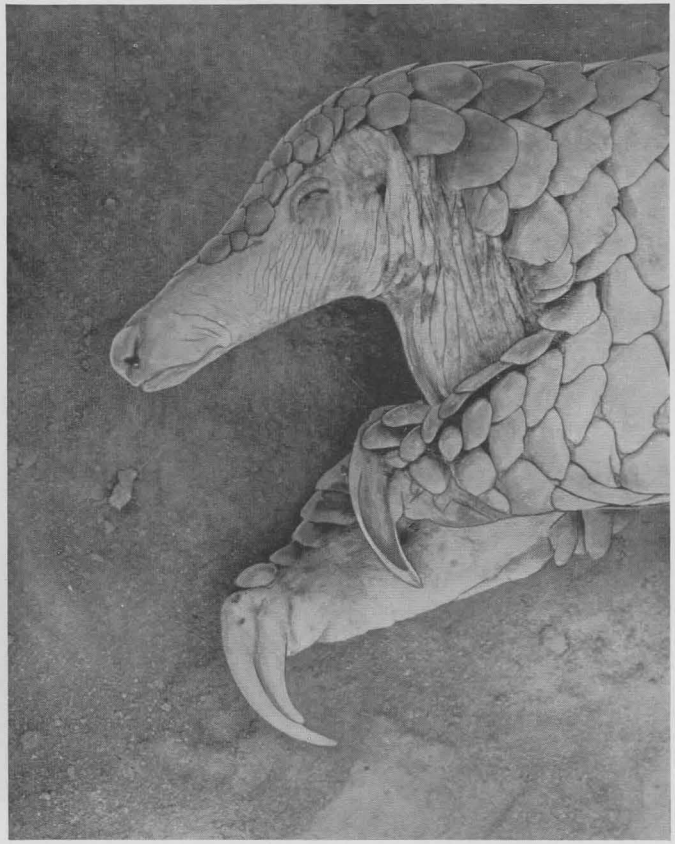

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PLATE XXV

Fig. 1. *Manis tetradactyla* Linnæus. Living male, at Niapu, December 16, 1913. An arboreal species.

Fig. 2. *Manis gigantea* Illiger. Live young female, at Poko, August, 1913. Typical pose of the animal while in search of its food.

Fig. 3. *Bdeogale nigripes* Pucheran. Freshly killed male, at Akenge, October 8, 1913.

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