Life History and Feeding Habits of the Giant African Snail on Saipan[1]

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THE GIANT AFRICAN SNAIL, *Achatina fulica* Férussac, has recently received considerable attention as an economic threat to the people occupying certain islands included in the Trust Territory of the Pacific Islands because of its catholic taste for fruits and vegetation. In addition, its introduction (but not its establishment, to date) into California on heavy equipment returned from Pacific islands has brought to our attention its status as a potential threat to agriculture in the continental United States.

Achatina is very abundant on Saipan, where it causes extensive damage to many types of fruit and vegetable crops. The present study was an attempt to secure additional information concerning its habits, life history, feeding preferences, natural enemies, and seasonal activity. This information may prove of value not only in relation to the possible introduction of natural enemies, but also in determining the economic potentialities of this snail should it ever become established on the mainland of the United States. During this study an opportunity was available to make limited observations of this snail in the Philippines (Luzon), Siam, Malaya, and Java. A survey was made of the other terrestrial and fresh-water snails of Saipan inasmuch as a knowledge of these species is an important adjunct to a biological or chemical control program.

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DISTRIBUTION

This is a species which is native to the east coast of Africa, from Natal and Mozambique in the south to Kenya and Italian Somaliland in the north[3] (Mead, 1949:38); from there

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[3]Bequaert (personal communication, February 14, 1950) reports that the known distribution is only from northern Mozambique (17° S.) in the south to southern Abyssinia and the southern half of Italian Somaliland in the north (7° 30′ N.). Inland it extends 150 to 500 miles from the coast, going farthest inland in the northern section of the range.

it has spread through many tropical and subtropical areas. It was introduced to Mauritius (1803, or before), later to Seychelles, and about 1847 was introduced to Calcutta, India (Jutting, 1934:43). Several authors report its spread from India (Jarrett, 1931:263; Jutting, 1934:43; and Mead, 1949:38–39). In 1900 it appeared at Ceylon, and in 1911 was present at Singapore and later in other Malayan localities. In Borneo (Sarawak) it appeared in 1928 and in 1933 its presence was noted in Java and Sumatra. It appeared at Amoy, China, in 1931 and was recorded at Hong Kong in 1937.

The Japanese apparently hastened the spread of the African snail during their Pacific campaign because they carried snails as a supplementary diet from one island to another. The snail was undoubtedly present on certain of the islands before the war, but on others had not been introduced. As a result, the snail became more widely distributed in the Dutch East Indies, particularly in New Guinea, New Britain, and New Ireland. It appeared in the Philippines and is known from the Bonin Islands.

In Micronesia, Townes (1946:15–16) reported *Achatina fulica* from Saipan, Tinian, Rota, and Guam in the Marianas and from Koror, Ponape (near Colonia), southern Babelthuap, Peleliu, and part of Truk (Dublon) in the Carolines. T. R. Gardner (personal communication) supplied more detailed information regarding its distribution in the Palau Islands as follows: Angaur, Malakal, Koror, Arakabesan, and the south half of Babelthuap. Mead (1949:39) reported it at Pagan in the Marianas. Reliable natives on Saipan report that the snail has been present on the island for about 10 years. It had also been reported from Pagan prior to the Pacific conflict.

In the Philippines this snail was very common on October 22, 1947, at Los Banos, Luzon, feeding upon papaya fruits. It was found by the writer in southern Siam, north of Haadjai, on December 8, 1947. In Malaya it was a common, but non-destructive, mollusk in the Port Swettenham region near Klang.

DESCRIPTION

The degree of variation in shell size and markings and the internal anatomy of *Achatina fulica* are described by Tryon and Pilsbry (1904–05:55–58).

On Saipan typical shells are dull whitish, yellowish, or gray-tan, with characteristic transverse dark brown to purplish-brown streaks. Transverse dark markings are more prevalent in juvenile specimens. In older individuals the first whorls become white to gray and the body whorl often becomes a uniform tan devoid of transverse markings.

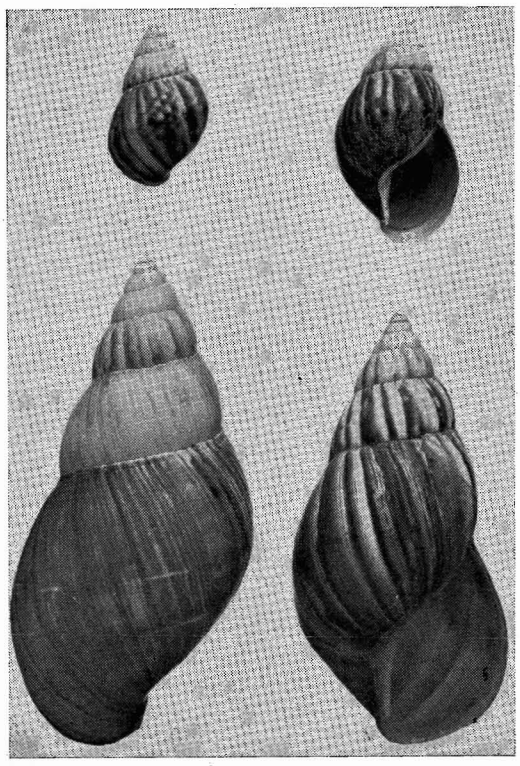

FIG. 1. Shells of *Achatina fulica:* above, juvenile specimens, Saipan, November 3, 1947; below, left, specimen from Rota, March 16, 1948, showing reduction of dark bands; right, typical Saipan specimen, November 3, 1947.

Average specimens are smaller than on Guam, ranging from 2.5 inches to 3.75 inches long. Differences in markings are shown in Figure 1. The shell whorls have transverse striations and microscopic, spiral striae. The animal is gray-tan to black.

Shells often show whitening and, in some individuals, complete loss of color. This condition was quite prevalent on parts of Rota. Many shells show scratching of the surfaces as if caused by burrowing in the soil or by crawling under objects on the surface of the soil. On Saipan an abnormal condition of many shells was observed, namely, the presence of a thin, paper-like shell, easily broken by handling. Shells of normal thickness are found in the same area, but there are areas, such as Marpi Point on the north end of the island, where normal shells are more commonly found. This condition could be a genetic one concerned with carbonate metabolism, or could be a result of the availability of carbonates in particular areas.

LIFE HISTORY AND DEVELOPMENT

Inasmuch as the life history and development of the snail on Saipan deviates to some extent from other published reports, a few salient records will be cited. Jarrett (1931: 263) reported that in China the African snail laid 100 eggs the first year, 200 to 300 eggs the end of the second year, and produced 1,000 eggs during a 3-year period. He stated that in Malaya egg laying occurred during March, April, and May. The same writer stated that in Borneo eggs were laid in October, and probably throughout the year.

Green (1911:43) concluded that *Achatina fulica* reached full growth in 2 years, but were sexually mature in 1 year, at which time they were about half grown. He did not record a maximum number of eggs, but stated that each snail deposited at least 100 eggs the first year and 500 the second year.

Pilsbry (1919:60–61) described the Achatinae as oviparous, laying as many as 196 eggs in loose soil just beneath the surface.

The fact that *Archachatina marginata* lays eggs in trees is mentioned by Tryon and Pilsbry (1904:205).

D. B. Langford (personal communication) recorded the time interval from egg to sexual maturity as 147 days on Guam. Measurements of Langford's reared specimens on deposit at the Hawaiian Sugar Planters' Association Experiment Station, Honolulu, are tabulated here:

AGE *weeks*	NUMBER OF WHORLS	LENGTH *mm.*
1	3	5
2	3.5	8
3	4	12
4	5.5	26
5	6.5	34
6	6.5	40
7	7.5	63

Mead (1949:40) recorded male sexual maturity before the snail is a year old; development of female organs and egg deposition takes a few months longer. The same author also reported retention of the eggs inside the uterus so that eggs hatched within a few hours, but this phenomenon was not observed during the present observations.

On Saipan the eggs are nearly globular, approximately 4 mm. by 5 mm. in size, white when first laid but later turning yellowish. When first laid they are covered with a clear mucus which gives them a glistening appearance. In a few hours the mucus dries and the eggs become a dull white. Eggs are shown in Figure 2.

This snail is hermaphroditic, although reciprocal mating occurs and both individuals lay eggs. Snails mate chiefly at night, but on Saipan mating was continued during the day, particularly if the weather was rainy or overcast. Snails mating under the protection of dense jungle cover or creeping vines often continued to mate during the day. Snails often started to mate in the late afternoon,

FIG. 2. *Achatina fulica* and eggs, Saipan, October 29, 1947.

and it was noted that individuals crawling about in trees during the day occasionally extruded the genital organs.

In mating one snail usually climbs above another, the organs are interchanged, and both snails fall to one side, remaining together for a period varying from less than 1 hour to 24 hours or more. The manner of mating is shown in Figure 3. Snails collected during coition were held in the laboratory in gallon cans which had been filled with 4 inches of moist soil. After mating, eggs were deposited in from 8 to 20 days, with an average interval of 10 to 12 days. On Saipan a preferred site for egg deposition was under loose soil at the bases of breadfruit trees as shown in Figure 4. Eggs were also laid under rocks, boards, or other objects, or in the soil wherever there was a cover of vines, shrubs, or trees. Eggs were often merely scattered about on the surface of the soil or barely covered, and rains often exposed many of these. Usually a snail made a depression about 2 inches wide by 1.5 inches deep in loose soil in the ground, deposited its eggs, and covered them with soil.

Egg masses were found in the field from October 16, 1947, to November 11, 1948. The presence of young snails on October 16, 1947, indicated that eggs had been laid prior to this time. The number of eggs laid in the field varied from 93 to 184, with an average of 139 eggs. In the laboratory, egg deposition was observed from October 30, 1947, to November 19, 1947; the eggs were laid in gallon cans filled with 4 inches of soil. The number of eggs laid by individual snails in the laboratory varied from 62 to 243, with an average of 129 eggs.

In captivity most of the snails laid their eggs during one night, but occasionally an

individual would lay a few eggs at a time over a period of several nights.

The length of the egg period in the laboratory on Saipan varied from 6 to 12 days with a mean average period of 8.8 days. In the field the egg period was approximately 11 days. It was noted that under field conditions there was a high incidence of infertility which was not true under laboratory conditions. For this reason failure to hatch under field conditions was attributed to desiccation or other adverse exposure to environmental factors.

After hatching, the young snails began to devour the egg shells and ordinarily remained together in a group feeding on the shells during a 3- to 4-day interval. After this time they scattered, seeking other food. On the day of hatching snails were placed in cans approximately 4 inches wide by 6 inches deep and growth was observed in the laboratory. They were fed upon pieces of potato or breadfruit, and 1 gram of powdered calcium carbonate was placed in each can to assist in shell formation. Distilled water was used, inasmuch as the ordinary chlorinated drinking water was found to affect young snails adversely. During these observations, which extended over a 5-month period, snails increased in size from 2.5 whorls at hatching to 6.5 whorls. Of 20 individuals observed from October 31, 1947, until April 4, 1948, only eight were successfully reared. The following tabulation gives a summary of the information obtained.

TIME EXAMINED	AVERAGE WEIGHT	AVERAGE WHORLS
	grams	*number*
At hatching	0.04	2.5
25 days	0.22	4.0
60 days	2.14	5.0
121 days	6.37	5.5–6.0
156 days	8.96	5.5–6.5

These rearings are not considered indicative of the rate of growth under field conditions inasmuch as snails were fed irregularly

FIG. 3. *Achatina fulica* mating on ground in jungle area near Klang, Malaya, January 2, 1948.

FIG. 4. *Achatina* clustered about the base of a breadfruit tree—a favorite site for egg deposition. Saipan, October 19, 1947.

during a 2-month period when I was in the field. The average weight increase was from 0.04 gram at hatching to 14.7 grams at the end of 156 days. This was an increase in weight of from 63 to 368 times above the initial weight, depending upon the particular snail involved. These rearings suggest that individuals vary greatly in their rate of growth, that weight can be lost when food or water is withheld, and that whorls are added regardless of the presence of adequate food. Mature, pregnant snails were found in the field which were 2.25 to 3.5 inches long, having 7 to 7.5 whorls.

It was noted that under field conditions there was a definite correlation between egg laying and wet and dry periods. Egg laying occurred during the wet season. During the dry season no eggs were laid and many snails secreted brown to whitish epiphragms and became inactive. On October 28, 1947, eight of the 50 snails examined in an area under breadfruit trees were pregnant. On November 11, 1947, observations made in the same area showed that of several hundred examined only three were pregnant. Of hundreds of snails examined during the period from February 6, 1948, to April 4, 1948, no pregnant snails were found on Saipan. The location of observations apparently influenced the relative percentages of pregnant snails, because, of several hundred snails examined on November 3, 1947, at Marpi Point, Saipan, feeding on *Operculina turpethum* along a roadway, not a single pregnant snail was found. Snails seeking sites for oviposition were found more frequently in more protected areas.

Ordinarily there is a wet and a dry season on Saipan, although this may not be marked inasmuch as rain can fall during any month. There is also considerable variation, depending upon where the observations are made. The wet season is from July to November

FIG. 5. *Operculina turpethum,* a preferred food plant of *Achatina;* Saipan, March 18, 1948.

and the dry season from January to May. The mean average temperature at Tanapag during 1947 varied from 79.7° F. in January to 82.7° F. in August. This small difference would not materially influence activities of the snails. The relative humidity is high all year around, averaging 82 per cent. Records kept at Tanapag during 1947 gave an average of 80 per cent relative humidity during an 8-month period.

Rainfall apparently influences activities of the snails more than any other single factor. The record of the total monthly precipitation at Tanapag during 1947 and part of 1948 is as follows:

MONTH	RAINFALL *inches*	
	1947	1948
January	2.45	4.47
February	1.12	1.48
March	1.40	3.68
April	1.26	4.52
May	1.90	2.53
June	1.21	3.22
July	7.80	
August	4.93	
September	5.49	
October	15.20	
November	4.00	
December	1.42	

From January to June, 1947, there was a drought in Saipan, and the rainy season extended from July through November. Limited observations made on snail activity indicated that egg-laying periods were definitely correlated with periods of extensive rainfall, although feeding was possible at any time when moisture was present. This was also substantiated by an examination of the internal genital structures. Specimens collected during October and November had a full development of the female organs, whereas in specimens collected from February to April these structures were atrophied.

FEEDING HABITS

On Saipan the snail is omnivorous in its feeding habits, but is primarily a scavenger, preferring human and animal excreta, garbage, decaying leaves, rotting fruits, crushed snails of its own kind, and soil. At night the crackling sound caused by the feeding of countless thousands of snails upon decaying leaves can be heard for considerable distances. In one instance 215 snails were counted feeding upon a single decaying breadfruit. Plane runways and roads where snails were crushed by traffic were favorite feeding sites for thousands of snails.

Of the fruits selected by *Achatina,* bananas (also the leaves and new shoots of banana trees), papayas, breadfruit, and ripe passion fruits were preferred. The snail caused severe damage to certain vegetables such as okra, Chinese cabbage, lettuce, melons, and yams. It also fed upon beans, carrots, corn, cucumbers, eggplant, pepper, pumpkins, radishes, squash, and watermelons.

An attempt was made to study the feeding preferences of the snail in relation to other types of vegetation. In general, snails preferred weeds and succulent plants to plants with thick, leathery leaves. In view of these findings the plants listed below will be separated into those preferred and readily eaten and those not readily eaten.

The preferred food plants of the snail on Saipan, together with the Chamorro name (if known) and the family, are listed below:

NAME	CHAMORRO NAME	FAMILY NAME
Annona muricata		Annonaceae
Amarantus spinosus	kilitis	Amaranthaceae
Albizzia lebbeck		Leguminosae
Asplenium nidus	galag	Polypodiaceae
Blechum pyramidatum	yerbas babui	Acanthaceae
Canavalia gladiata	gaye	Leguminosae
Cassia occidentalis		Leguminosae
Colubrina asiatica		Rhamnaceae
Grewia mariannens's		Tiliaceae
Ipomoea alba	fofgo	Convolvulaceae
Ipomoea pes-caprae	halai hai	Convolvulaceae

Melanolepis multiglandulosa	alom	Euphorbiaceae
Morinda citrifolia	lada	Rubiaceae
Operculina turpethum	alag-alag	Convolvulaceae
Passiflora foetida	dulce	Passifloraceae
Physalis peruviana	tomates chaca	Solanaceae
Pipturus argenteus	atmahayan	Urticaceae
Portulaca oleracea	bordolagus	Portulaceae
Tectaria sp.		Polypodiaceae
Thespesia populnea	pago	Malvaceae
Vigna marina		Leguminosae

Of the above plants certain ones are greatly preferred by the snails. These include *Passiflora foetida* (fruit and leaves); certain weeds such as *Blechum pyramidiatum* and *Physalis peruviana;* creeping vines such as *Ipomoea alba* and *Operculina turpethum* (see Fig. 5); and *Melanolepis multiglandulosa* (which is also a preferred host plant of *Partula gibba*).

Certain plants which are fed upon only occasionally are:

NAME	CHAMORRO NAME	FAMILY NAME
Bikkia mariannensis		Rubiaceae
Callicarpa cana		Verbenaceae
Capparis cordifolia		Capparidaceae
Cerbera manghas	hunig	Apocynaceae
Clerodendron inerme		Verbenaceae
Colocasia esculenta		Araceae
Ficus tinctoria	hodda	Moraceae
Hernandia ovigera		Hernandiaceae
Muntingia calabura		Tiliaceae
Ochrosia mariannensis		Apocynaceae
Ochrosia oppositifolia		Apocynaceae
Pandanus spp.		Pandanaceae
Psychotria mariana		Rubiaceae
Pemphis acidula		Lythraceae
Trema orientalis var. *argentea*		Ulmaceae

Economic damage to vegetable crops varied from slight damage to complete losses depending upon the kind of crop and its location in relation to adequate diurnal resting places for the snails. Ripe fruits were preferred to green fruits.

HABITS

During the latter part of October, 1947, snails were quite active, and the presence of small snails indicated that a major egg-laying period had already been passed. Snails were more active at night although they continued to feed diurnally during overcast or rainy periods. Daytime refuges included trees,

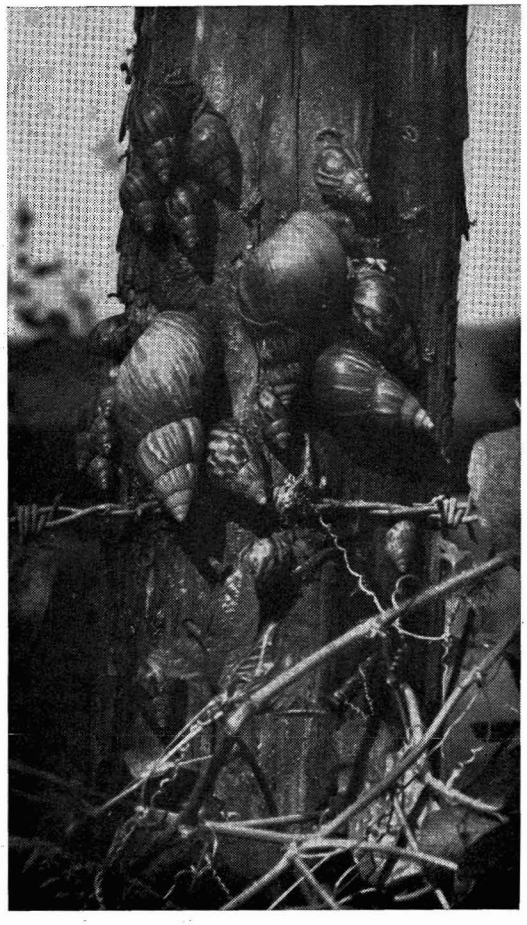

FIG. 6. *Achatina* resting on fence post, Saipan, October 19, 1947. The vine is *Passiflora foetida*, a preferred food plant.

fence posts (see Fig. 6), sides of buildings, rock piles (see Fig. 7), the under surfaces of leaves, boards, and other objects, or dense jungle growth. During favorable conditions snails crawled forth from these protected places to feed. Because of the uneven distribution of refuges, the distribution of snail populations varied and was often concentrated in certain areas. Snails often climbed up into trees to positions 10 to 25 feet above the ground and remained there during the day.

In certain areas on Saipan, Rota, and Tinian, such as plane runways, it was observed that snails often became gregarious and congregated in rather compact masses, as shown in Figure 8. It was thought that this was a method of securing protection and a mechanism of moisture conservation.

It was observed that snails were able to endure lengthy periods without feeding. One snail placed in a cardboard mailing tube lived 5 months without food, except for some of the cardboard lining. The snail died within

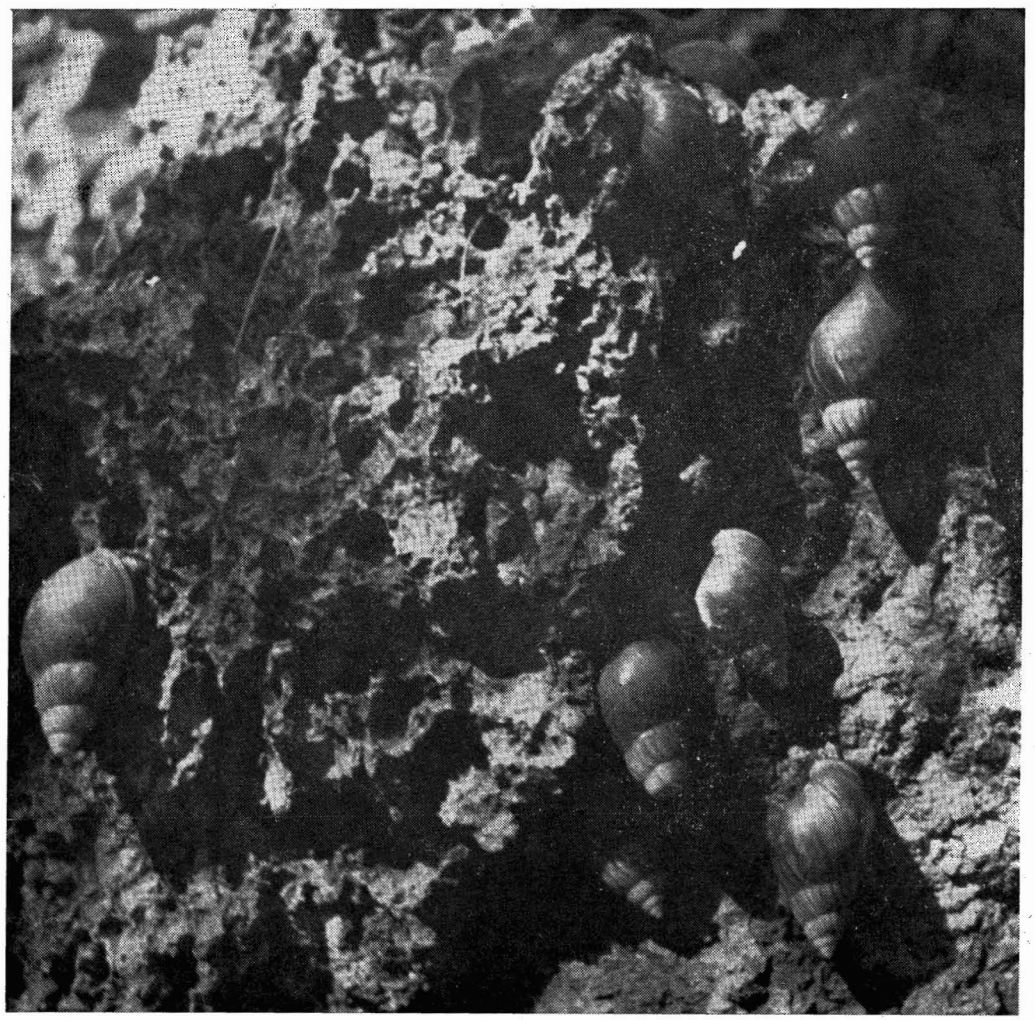

FIG. 7. *Achatina* attached to rocks during the day, Mt. Tapachou, Saipan, March 16, 1948. Note loss of apical whorls in one specimen.

a few days after it was dropped and the epiphragm broken. Another snail lived for 5½ months in an outdoor cage without food.

During unfavorable conditions snails were observed to secrete a brown calcareous epiphragm over the aperture. In the field it was noted that certain snails with epiphragms remained in an inactive condition regardless of adequate moisture. In this case it was thought that inactivity was not correlated with wet and dry conditions at the time, but with the physiological condition of the snails or status of development of the female structures.

NATURAL ENEMIES

A few natural enemies of *Achatina fulica* are reported in the literature. Green (1911: 43) lists enemies in Ceylon as the common pond tortoise, *Nicoria trijuga* var. *thermalis;* an ant *(Pheidologeton affinis),* which attacks the eggs; insectivorous birds; and carnivorous beetles.

Bequaert (1925:201; also in Pilsbry, 1919:61–63) records minute, ectoparasitic mites on a living *Achatina* in the Belgian Congo and mentions the wingless flies of the genus *Wandolleckia* (family Phoridae), which live in the adult stage upon the slime of *Achatina.*

Jarrett (1931:263–264) records the Indian firefly, *Lamprophorus tenebrosus* Wlk., as an important parasite of young *Achatina fulica.*

In the Marianas no effective natural enemies of the giant snail were observed, and the toad *Bufo marinus,* supposedly introduced to feed upon snails, took no appreciable toll. On March 13, 1948, a few snails on Saipan and Tinian were found in a moribund condition although the cause of sickness was not determined. The bodies of the snails became

FIG. 8. Aggregation of *Achatina* on Tinian airstrip, March 13, 1948. Several hundred snails were found in an area of approximately 54 square inches.

lighter, receded into the shells, then became black, and finally a watery, dark-colored liquid exuded from the apertures. From dying and dead snails two species of sarcophagids were reared, namely, *Sarcophaga gressitti* Hall and Bohart and *S. dux* Thomsen (determined by C. W. Sabrosky). These flies were apparently saprophagous, being attracted to dying snails. Hall and Bohart (1948:132) report *Sarcophaga gressitti* from Saipan, Tinian, and Rota, where it was associated chiefly with filth, dead fish, dead land crabs, and snails.

During these observations there was no evidence of an epizootic among snails; rather it appeared that dying snails were stranded on roads and runways and partially desiccated before they could obtain adequate cover. This does not, however, preclude the possibility of a pathological condition among snails in other areas or under other conditions.

The presence of thin and consequently fragile shells among snails on Saipan, Tinian, and Rota did not seem associated with a pathological condition. The possibility of genetic factors is indicated in certain Saipan localities where normal thick-shelled individuals occurred in association with thin-shelled snails. In certain cases, as on Rota (Fig. 9), the bleached shells of dead snails were found in large numbers. The reason for the death of these snails could not be determined.

CONTROL

The control of the giant African snail on Saipan has been approached in three ways: by chemical control, cultural control, and biological control. In certain cases it was possible to protect crops by the frequent use of pelleted baits containing metaldehyde and calcium arsenate. In areas separated from dense growth the use of a peripheral weekly treatment with pellets was found to give sat-

FIG. 9. Bleached shells of dead *Achatina* on Rota airstrip, March 16, 1948.

isfactory protection. Extensive chemical control methods in rocky or dense terrain would probably be of only temporary value unless new and more specific chemicals could be developed. The developments in new chemicals would probably have to be a divergence from related aldehydes, as was shown by the work of Lange (1941:321) in which chemicals related to metaldehyde were found to have no attraction for slugs and the European brown snail.

Cultural methods had definite value. Clearing dense underbrush near gardens or field plantings was found to be of value, as was the elimination of piles of refuse or other places where snails could hide during the day.

The work of Dr. F. X. Williams in Africa, reported by Mead (1949:41), revealed two predatory snails (*Gonaxis* sp. and *Edentulina* sp.) which may prove of value, but they require special investigation before they can be liberated. Most terrestrial predatory snails, unless they have a reproductive potential greater than *Achatina* or a decided specificity for *Achatina,* probably would not be entirely satisfactory in reducing large populations of the giant snail. This conclusion would also apply to the large predacious carabid beetle, *Tefflus* sp., found by Dr. Williams in Africa.

OTHER TERRESTRIAL SNAILS

In a control program it is necessary to recognize other terrestrial or fresh-water mollusks present in an area, and to know their distribution and ecological relationships. A complete survey was not made, but the following list shows present knowledge concerning these other species found in the Marianas Islands:

LOCALITY AND DATE COLLECTED	SPECIES	DETERMINER
Magicienne Bay, March 18, 1948	*Lymnaea (Fossaria) ollula*	Abbott
Loa Loa, March 11–12, 1948	*Lamprocystis* sp.	Lange
	Omphalotropis cookei	Lange
	Omphalotropis erosa	Kondo
	Omphalotropis submaritima	Kondo
	Pythia intermedia ?	Kondo
	Subulina octona	Kondo
	Succinea sp.	Kondo
	Truncatella querini	Kondo
Mt. Nafutan, March 12, 1948	*Gastrocopta lyonsiana*	Abbott and Kondo
	Lamellaxis gracilis	Abbott
	Lamprocystis misella	Kondo
	Omphalotropis conica	Kondo
	Omphalotropis cookei (type locality, Abbott, 1949:263–66)	Abbott
	Omphalotropis erosa	Kondo
	Pythia sp.	Kondo
	Succinea piratorum ?	Kondo
	Succinea sp.	Kondo
	Synopeas javanicum ?	Kondo
	Truncatella querini	Kondo
Marpi Point, March 4, 1948	*Diplommatina taeneolata*	Abbott and Kondo
	Georissa biangulata	Abbott
	Lamprocystis sp.	Abbott
	Nesopupa quadrasi	Kondo
	Omphalotropis erosa	Kondo
	Omphalotropis submaritima	Abbott
	Paludinella conica	Abbott
	Partula gibba	Abbott and Kondo
	Succinea sp.	Abbott
Marpi Point, March 18, 1948	*Lamellaxis* sp.	Lange
	Omphalotropis cookei	Lange
	Omphalotropis sp.	Lange

Mt. Tapachou, April 2, 1948	*Bradybaena (Eulota) similaris*	Kondo
	Lamprocystis fastigata	Kondo
	Partula gibba	Abbott
N.E. Saipan, April 2, 1948 (fresh-water spring)	*Lymnaea (Fossaria) ollula*	Abbott

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