CHAPTER 8

CONTROL THROUGH HUMAN USE

Human Consumption The human consumption of land snails has been practiced since the very earliest times, and even during the height of the Roman Empire it was of such common practice that special utensils were devised so that the soft parts of the snail might be more easily extracted and eaten (Taylor 1900). The demand for the edible helicine snails has been so great that "heliculture" or snail farming, especially in parts of Europe, is today a very sizable industry. Not only have snails been raised in almost unbelievable quantities for shipment alive to domestic and foreign urban areas, but with the modern facilities for refrigeration and quick shipment, snails are prepared with butter and spices ahead of time at the snail farms so that all the consumer has to do is to warm the "instant snails" for a few minutes in the oven before eating them. Their very high nutritive value has been expounded upon by Léger (1925) and Moretti (1934). Simon (1940) has pointed out that they are neither fish nor flesh and their consumption is permitted on meatless days. As might be expected, there has been much written, in several languages, on every conceivable phase of raising, preparing, and marketing edible snails. Among the most notable contributions are those of Locard (1890), Rust (1915), Boisseau and Lanorville (1931), Arnould (1933), Kaibo (1935), Ri (1935), Maubert (1943), Pardo (1943), Metteo (1946), Benthem Jutting (1952*a*), and especially Cadart (1955). Rust urged the American people during the trying periods of World War I to become more adventurous in their eating and,

as a substitute for meat, partake of the edible helicine snails already introduced into parts of this country. Even the canning of pickled snails was encouraged (Anon. 1914).

In France, Remlinger (1916) made a more practical suggestion by recommending that snails be used instead of precious beef in preparing bacteriological culture plates. The Second World War brought a return of the suggestion that they be used for human consumption (Aguayo 1944*b*). The fact that native gastropods were already being eaten by people in this country was pointed out by Allen (1916) in this reference to the consumption of the giant slug *Ariolimax* in parts of Oregon and Washington and *Triodopsis albolabris* in Massachusetts. Earlier, de Stefani (1913) reported that great quantities of *Helix pisana* (*Theba*) were being sent from Sicily to the United States. (It is significant that this species later became a serious pest in California.) Some idea of the amount of helicine snails consumed in this country is indicated in figures released by the U.S. Bureau of Entomology and Plant Quarantine wherein 721 cases and 24,969 baskets of living snails were imported into New York City alone between May, 1947, and April, 1948 (Mead 1951*b*). It has been stated that for a number of years almost exactly 1,000,000 pounds of snails has been imported annually into this country just from Morocco (Helfer 1949). With approximately fifty snails to the pound, the total number of snails would figure close to 50,000,000; or, in linear measurement, close to a thousand miles of snails. Who would have guessed that such an appetite for snails existed in this country! In France, however, the amount of snails consumed is understandably about fifteen times as great (Cadart 1955).

In British West Africa, various species of *Achatina* and *Archachatina* are eaten to a very great extent. In Ghana, these snails actually form the largest single item of animal protein in the diet of the common people. It was in that country that the author saw the natives eating giant snails which had been put in boiling water or on hot coals, removed from the shell, freed of the soft visceral mass, chopped, and combined with some starchy dish, such as cassava or cocoyam, and palm oil or peanut oil to form their standard meal of "fufu." Lang (1919) similarly describes the methods used by the natives in the former Belgian Congo and adds further that the snails are occasionally served at the tables of Europeans. He did not indicate, however, how well they were received in the latter case. During the dry season, the snails tend to go into estivation and they become very difficult to find. They are therefore collected in great quantities during the rainy season. To assure a supply throughout much of

the year, a large portion of the catch is dehydrated. The shells are broken to remove the animals, which are eviscerated, washed in water but a single time, drained, impaled on split bamboo sticks, smoked and partially dried for six hours over a slow fire of wood embers, and, finally, completely dried in the sun before they are stored (Martinson 1929, cf. Dartevelle 1953). For many years now, such inroads have been made on the native achatinas of West Africa that their collections have had to be regulated by the colonial forest conservation laws, through the co-operation of the local native chiefs. To maintain jurisdiction over the collecting areas is a sovereign right of the chiefs; they set the collecting dates and determine what percentage of the catch is to be given to them as tribute. The increasing scarcity of achatinas has forced a greater and greater limitation of the collecting period. This in turn has put a high premium upon making use of every available moment during the short collecting period. The seriousness with which the natives regard this matter is reflected in the words of G. Saunders of Kintampo, Ghana, who writes (*in litt.* Feb. 6, 1952) that "the date of a baby-show had to be postponed because it coincided with the opening of the snail-collecting season, and all the mothers go snail hunting!" Conolly (1939) stated that *A. fulica* in its native heath of East Africa is regarded as a "culinary delicacy." In the region of Kenya and Zanzibar, however, Williams (1951) was unable to confirm this in the inquiries he made. This may help explain why Williams, Abbott, and Krauss found the native species of *Achatina* considerably more abundant than Bequaert and the author found in certain comparable regions of central West Africa.

Torres (1950) has indicated that the native South American giant land snail, *Strophocheilus oblongus,* known as "Aruá," is consumed by the aborigines in that region. Ernest G. Holt, of the U.S. Soil Conservation Service, stated to the author that years ago he actually saw indisputable evidence of the fact that the natives eat this snail. As far as its use for human food is concerned, it quite likely is comparable in many ways to the giant African snail. Monte (1944) and Anon. (1945) report on other snails used in South America as food and medicine.

It was known before World War II that the Malays and Chinese would eat *A. fulica* (Jarrett 1923, 1931). This knowledge, coupled with the very rapid spread of the snail during the Japanese occupation and the persistent rumor that the Japanese ate the snails, apparently was responsible for the appearance in the literature of the assumption that the Japanese people considered the giant African

snail a "great delicacy," for example, Abbott (1948), Anon. (1948*b*, 1949*f*, *g*), Herklots (1948), Rees (1951), Somanader (1951), and Zuk (1949). As doubt about this increased, efforts were made to soften it with the suggestion that the Japanese ate them, but with wry faces (Anon. 1949*j*). Rumors from other quarters carried the story that the Japanese people actually disliked the snails and would not touch them at all. This was elaborated with the suggestion that the Japanese soldiers introduced the snails into the islands for sheer spite. It was perfectly obvious at the time that the problem of the giant African snail was surveyed in Micronesia that this whole question had to be elucidated with as much supporting evidence as possible. The information which was gathered was almost entirely hearsay; but the story from the most reliable and probably least biased sources was always the same, viz., that the Japanese very definitely did consume the giant snail.

It was in Chichi Jima that the bulk of the information was obtained. Moses Savory of that island stated that he had not only seen the Japanese soldiers eat the snails, but he himself had eaten them. He described how the achatinas were roasted in their shells, removed, washed in two changes of water to clear them of most of the slime, eviscerated, and eaten with soya sauce; that is, essentially only the muscular foot was eaten. He said that they were something like limpets and were "not bad," though his lack of enthusiasm in relating the details and the expression on his face seemed to tell a somewhat different story. His brother Hendrick added that it was his belief that the Japanese soldiers "liked" the achatinas, that they were especially fond of soup for breakfast and that they would often prepare "snail soup" for that first meal of the day. Wilson Savory and Mrs. Oste Webb, also of that island, concurred with details of their own observations.

The native skipper of a boat that took the author from Moen to Dublon, in the Truk Islands, stated through an interpreter that the Japanese people had eaten the giant snails on Dublon. According to him, they were heated in the shell, removed, cooked again, eviscerated, and eaten with soya sauce. The people of Moen gave a similar story. In Guam, Mr. Joaquin Guerrero of the Naval Government Agricultural Experiment Station turned over to the author a copy of a letter which he had addressed to the head of the Commerce and Industry Department in Guam on December 26, 1945. The following quotation from the letter, made with Mr. Guerrero's kind permission, presents earlier convincing evidence: "Mr. Jose L. Shimizu further stated that while he was imprisoned at the stockade, Island

Command, he overheard statements made by the Japanese prisoners to the effect that while they were hiding in the woods, they sometimes ate these snails."

While in Koror, Palau Islands, Kondo (1950*c*) obtained the following information on this subject: "The African snail . . . was introduced by an enterprising Japanese just prior to the war to be raised for canning. A small factory or 'koba' was constructed and Okinawans were employed to gather and to process the snails. The informant stated that the canned product was excellent eating but he himself would not take the trouble of gathering the living snails to prepare them for the table. With the advent of the war the . . . factory closed down. It is not known whether the canned snails were exported to Japan but presumably they were since the objective of most of these enterprises was to send the finished product back to the mother country. It is also not known how the snails were prepared for canning but because most of the shellfish were cooked in soy-sugar sauce the same method was probably applied in this instance."

Additional information from Saipan is reported by Jones (1949). He states, "Japanese soldiers consumed them in quantity when normal meat supplies were short. It is reported by reliable native sources that these snails were dried and shipped in large quantities to the Japanese homeland during the war. The price was equivalent to five United States cents per pound."

As one seeks deeper into the reasons behind the importation and consumption of the giant African snails by the Japanese, one frequently finds that the presumed great medicinal properties of the snails have provided the motivation. But this is not something invented by the Japanese. Taylor (1900:428) not only discusses the possible curative powers of snails in ridding the body of tuberculosis but recommends a method of puncturing the snail shell "to enable the patient to suck the oozing liquor." Clapp (1902) similarly refers to slugs in coconut milk as a cure for asthma. The use of helicine snails in medicine has been traced by Cadart (1955) from the earliest times right up to the present where it has been reported that the mucus of *Helix pomatia* favors the action of penicillin. Hooper (1910) and Read (1931) have given rather exhaustive and certainly most interesting treatments of the use, by the Orientals, of snails and other animals in materia medica. An article in the April 19, 1936, issue of the Osaka Mainichi Shinbun, translated by R. Urata and E. I. Naito (Anon. 1936), discusses at length, with testimonials, the special curative powers with which snails are supposed to be endowed. The curative substance extracted from the snails is stated to be "Ishimoto

Negligin" which proves to be orthocalcium phosphate. This is perhaps the "medicinal substance" which the Institute of Medicine in Japan was reportedly extracting from the giant snails (Pangga 1949:342). This chemical is claimed to cure kidney disease, tuberculosis, anemia, diabetes, asthma, urticaria, circulatory disorders; to improve constipation and hemorrhoids; to prevent influenza; to restore virility and vitality; to perpetuate beauty and clear the skin; and to be recommended especially for those who sing a lot and those in need of hormonal injections! The keynote for the entire article is struck in the first paragraph with this sentence: "Buying meat and fish for your table is unnecessary, there will be no sickly person in the house, doctors are kept away and it brings smiles to the home." Tazawa (1934 *et seq.*), especially, urged the cultivation of *A. fulica* and made numerous recommendations for increasing production and simplifying the task for raising the snails. Ri (1935), Kagiya (1936), and Takamura (1936) made further suggestions in a whole series of articles appearing in Nogyo Sekai ("Agricultural World"). The series (in which the giant snail was variously referred to as the "edible snail," "land ear-snail," and "Shirafuji snail") was obviously designed to promote the development of a "new industry" and covered everything from a strictly zoological treatment (Taki 1935) to an attempt to establish a convincing parallel with the edible helicines of France (Kaibo 1935, Sato 1935).

With propaganda of this sort being turned out in agricultural journals, newspapers, magazines, and the pamphlets of those promoting snail sales, it is little wonder that within a few years *A. fulica* became established in a number of new localities. The infestation in the island of Maui in the Hawaiian Islands is unquestionably a result of this advertising campaign. The Japanese importer there had not only introduced *A. fulica* for "food or medicine," and had advertised them in the papers in that manner, but had proved to be his own best customer by consuming 425 of them himself (Pemberton 1938). (Since he had reportedly sold only six other specimens since he had obtained the original stock over a year previous to that time, it is possible that he was eating them out of sheer necessity!) The infestation in Chichi Jima is another case in point. It was determined from the older residents that sometime in 1937–38 a store owner in Chichi Jima, by the name of Katsu Nishimura, brought back from Japan some of these snails in the hopes that their broth would clear up the tuberculosis he and one or both of his two children had contracted. It might be recalled at this point that it was for precisely this same reason that they were introduced into the island of Mauritius (Bosc

1803). Mr. Nishimura jealously guarded these snails and fed them only the most choice food items. Only his closest friends received some of the first batch of eggs. As expected, the containers were often inadequate and there were early escapes. All too soon the population build-up of the escapees took on the familiar pattern, and the people on Chichi Jima found themselves plagued with a new pest. Charles Washington, the oldest resident on that island, said that Nishimura died of tuberculosis before the war and his two children were evacuated to Japan. The story of the Pagan infestation runs essentially in this same vein (Kondo 1950*a*, *c*).

In a strange sort of way, the giant snail, at first the apparent precious bearer of a medical panacea and then a cursed plague of the vegetable and flower garden, turned out to be a salvation to the besieged Japanese soldiers. Fishing could not be indulged in because of a constant state of alert. Supplies were cut off, although often enough there were sufficient stores of rice to last for a considerable period of time. The only source of animal protein on the islands was the giant snails, which in the meantime had become abundant. These then provided that critical food item. In fact, it was stated that the commanding officer of the Japanese contingent on Chichi Jima insisted that his men spend their rest period collecting these snails so that they might be added to their store of food. There was found much evidence in support of the assumption that these men "seeded" the giant snails near their hundreds of small fortifications so that they would have an easily obtainable protein item in the event of siege (cf. Benthem Jutting 1952*b*:395).

It seems perfectly clear from the foregoing that there should exist no reasonable doubt about the facts that the Japanese people actually have eaten the giant African snails, that the original purpose in many cases for eating them was their supposed curative powers, that the snails were introduced into uninfested areas with the intent that they were to be eaten, and that not infrequently the exigencies of the war made eating them a necessity. There still is uncertainty regarding the extent to which the Japanese would under normal conditions voluntarily select the giant snail as a food item of choice. In spite of the praises sung in their "flavor," there is a great deal of evidence to the effect that such claims were only to promote additional sales; that is, they were apparently raised to sell and not raised to eat. Buyers in turn sold them to still others. According to Esaki and Takahashi (1942), some of these who got in early on the rapidly expanding market, amassed a net profit of 2,000 yen in six months. These authors have very beautifully summed up their opinions in this whole

matter in the following (translated): "It will first be necessary to erase the name 'edible snail' to correct people's misbelief . . . it is not so tasteful, as can be ascertained if one tastes it. Even though it be tasteful and rich in nourishment, Japanese are not used to eat snails, demand will be very scarce, and it has no commercial value as food material or canned food. . . . If difficulties in cooking and taste problem are ignored, it is certain that the snail will not be popularized among Japanese, judging from the actual affairs in various places. . . . Canning and other commercial enterprises are totally out of the question." It is more than probable that today these statements reflect accurately a consensus among the Japanese people. It is significant that Esaki had been asked to visit Koror Island and offer suggestions for the control of the giant snail; he therefore was familiar with the attempts to can the snails on that island.

The question immediately comes up as to whether or not other peoples react in the same way. It has already been mentioned that the Chinese in Singapore have been observed eating *A. fulica.* M. W. F. Tweedie, director of the Raffles Museum and Library in Singapore, corroborated this with the following statement (*in litt.* Dec. 19, 1949): "In the Japanese Internment Camp in Singapore the protein-starved internees used them for food; they are said to be palatable, suitably spiced, but rather tough. The trouble was that there were not enough snails to go around." A. F. Caldwell of the University of Malaya adds the following firsthand information (*in litt.* April 23, 1953): "During the Japanese occupation these snails were eaten by the civilian internees after allowing the snails to empty the digestive tract for a day or two. They taste somewhat like a piece of tough kidney but the flavor is not so pronounced." H. A. A. M. Wirtz stated to the author that while he was a prisoner of war in Singapore, he had eaten many achatinas. He prepared them by breaking the shell, removing the viscera, and cooking them for seven to ten minutes. Cooking them longer made them tougher. If fat of any sort was available, it was added to them. He claimed that he did not object to eating them, although it was apparent that they were not relished. Garnadi (1951) reports that because of the slime in the freshly prepared snails, he found them less appetizing than dishes containing the dried snails. According to him, Franssen (1936) considered the snails "very tasty." Thomas (1949), in an apparently somewhat facetious vein, makes the following comment, "Your photographs of the giant Achatina snail made my mouth water, for here, undoubtedly, was my 1944 Christmas dinner in Singapore, looking every bit as succulent as one of those specially fattened snails. . . . Three friends and I con-

sumed 40. . . ." From the Hong Kong area, Herklots (1948) makes a similar report: "During the occupation these snails were certainly eaten by the hungry Chinese and even after the war large specimens could be seen for sale in the market. They are made into soup which is said to be sweet and nutritious. A recipe worth trying is this one: Remove snails from shells, stew in water, rub hard with ashes to remove the slime, wash and boil with lean pork. One of my gardeners who has been suffering from a chronic cough swears that he has been permanently cured by eating these snails regularly." Additional firsthand information on eating the giant snails in concentration camps is offered by Kalshoven (1950). A letter from R. E. Dean of Hong Kong (Dec. 15, 1949), however, reports that the Chinese in that area are no longer collecting the giant snail for consumption. According to Vosburgh (1950), the Chinese in the coastal regions of Formosa similarly do not eat these snails, although the aborigines in the interior eat them regularly with evident relish. These latter people are the only ones other than the native West Africans known to eat the achatinas from choice. It would be interesting to know whether developing an appetite for these snails is producing any appreciable effect upon the snail population in that region. The people of the Philippine Islands were also forced during the war years to collect and eat the giant snails (Allan 1949) and they are reported as being offered for sale in the Manila markets (Pangga 1950). There is no evidence that this practice is being continued now although Talavera and Faustino (1933) indicate that the freshwater snails *Pila luzonica* Reeve and *Vivipara burroughiana* Lea are regularly consumed by the poorer class of people in Manila. It is therefore possible that the same class of people has more recently turned to eating *A. fulica.* The Indonesians are known to eat aquatic snails; but they are prejudiced against eating the giant snail, apparently because of its known coprophagous habits (Garnadi 1951). The natives of New Guinea have not so far shown "any great enthusiasm for the snail as a supplement to other diet" (Harrison 1951, Allan 1949).

But the Micronesians seem to have gone one step further. It was not a matter of lack of enthusiasm. It was downright antipathy which often approached abhorrence, in every sense of the word. By far the majority of the Micronesians, when asked if they had eaten or would eat the giant snails, were most emphatic in their denial; in fact, it seemed many times that the question had offended them, for they displayed an obvious resentment. One instance in particular stands out in the mind of this investigator. The native skipper in the Truk Islands was asked through an interpreter if he ate the giant snails. He

registered shock and surprise and then indulged in gesticulations and denunciations which sounded like a mouth-filling Trukees oath. Translation was not necessary. The question however was pressed further with a "Why not?" To this, no verbal answer was given. Instead, he indulged in a loud, protracted, agonizing demonstration of intense reverse peristalsis that left the interrogator weak, convinced, and without appetite. Even though his feelings were very negative and very intense, his reactions probably reflect the general type of response that most Micronesians, and incidentally most other peoples of the world, would give to such an inquiry. An investigation into the reasons for this almost automatic and seemingly inherent aversion brought to light the following: (1) there is a natural abundance of fish; (2) the Micronesians consider anything coming from the ocean as being basically "clean" and conversely that land invertebrates (worms, slugs, snails, insects, etc.) are basically "dirty"; (3) the giant snails are extremely slimy and the slime is very tenacious and repulsive; (4) the snails have been observed to feed on many unappetizing things, such as rotting vegetation, human feces, feces of livestock, animal carcasses, including those of their own kind, etc.; (5) when the snails are cooked, the so-called liver mass gives off an acrid, offensive odor; (6) the natives are uncertain as to how to prepare them even if they should become curious about eating them; (7) and, finally, some have eaten them under semistarvation conditions and have subsequently become sick—they reason from this that the snails are probably poisonous.

Reputed Poisonous Properties There has been much talk but little written on the presumed toxic nature of the giant snails as a food item. It has been pointed out above that the death of Guaminian dogs and cats has been blamed on the giant snails. Kondo (1950*c*) writes that he heard in Guam, Saipan, and Pagan reports of deaths following a snail dinner. His informant from Pagan offered the suggestion that death of the Japanese soldiers was caused by insufficient cooking of the snails. He said that they merely threw the snails upon hot coals to broil and ate them without further preparation when they seemed to be done. It was suggested that the copious slime was the toxic factor and that they should have removed this through frequent washings before they attempted to eat them. This conclusion does not appear to be a safe one. Both van Weel (1948) and the author have sampled the slime with no untoward effects, although the former did report that "one feels in the throat an itching, but no more." This same sensation was experienced by the author only when the raw "liver" mass was eaten, probably because of the power-

ful digestive juices it contains. It is likely that van Weel had some contamination from that organ. Possibilities of an urticarial property of the slime seem to have been dispelled by van Weel.

G. H. Haldén of Millbrae, California, writes (*in litt.* Nov. 1, 1949) that during his internment in the Philippine Islands, he and his wife cooked and attempted to eat some of the giant African snails but a physician companion warned against it. It was said that some of the internees had eaten them and had become sick. The evidence that the snails are poisonous is of course entirely circumstantial. Nausea and regurgitation can be stimulated purely through auto-suggestion; and with a natural repugnance for such things as snails, this would not seem to be difficult, especially with plenty of time afterward to contemplate what had been done in a fit of hunger. In times of stress, the food that is eaten may be contaminated, partially spoiled, of poor quality, or of insufficient and irregular quantity—any one of which can precipitate a digestive upset. In attempting to find a reason for such an upset, it is altogether easy to blame it on the most novel and unusual thing that has been consumed. If snails had been eaten, they would be elected on the spot. But there is another factor involved. It is a well-known fact that rich food taken in any quantity, especially after prolonged deprivation, may cause illness; and, as indicated below, snail meat is rich indeed. Haldén himself pointed toward an explanation of this sort when he related that after a great many months in a prison camp, he became ill upon drinking his first glass of milk. Herklots (1948) supplies a bit of information which by comparison is considerably more mild in its censure of the giant snail. He writes, ". . . a friend who was interned in Borneo tells me that those prisoners who ate these snails did not improve their physique in comparison with those that left this free food alone." It might be facetiously added that worry over dire consequences could explain the difference.

Quite aside from all these comments, however, there remains the indisputable fact that other species of *Achatina* are eaten by choice in great quantity and with impunity in West Africa. But again, these people know how to prepare them. An insufficiently cooked snail which had recently fed on contaminated or infectious material could obviously provide a real threat. It has been suggested that cases of helicine snail poisoning have resulted when the noxious contents of the intestinal tract had not been allowed to pass before the snails were prepared for consumption (Cadart 1955).

Experiments in Eating the Giant Snail While in Chichi Jima, it was decided by Kondo and the author that the gustatory qualities

of *A. fulica* should be determined through firsthand experience. The shells of a dozen large achatinas were cracked with a hammer and the soft parts were removed. The snails produced very little slime with this treatment and seemed to remain surprisingly placid. The visceral mass was cut off, leaving the muscular foot and mantle. These latter were dropped in salt water as they were prepared. They were washed in several changes of fresh water (at least eight) and a half gallon was used each time. Even the water used in the last washing soon became as viscous as thin egg white; there seemed to be no end to the slime. Finally, the foot of each was bisected and they were placed, slime and all, in a pan of water seasoned with salt and chopped onions. After boiling one and a half hours, they were still tough and rubbery—like pickled limpets or clams. Another forty-five minutes saw some improvement, for they could be cut with the edge of a spoon with difficulty. The black pigment of the foot had boiled out sufficiently to produce an unappetizing black broth. The aroma issuing from the pan was reminiscent of a chicken freshly scalded for plucking and it was not in the least associated with anything for consumption. The gingerly initial taste of the broth convincingly demonstrated the fact that one cannot determine by sniffing how a thing will taste. Instead of hot feathers, it tasted more like a handful of rich forest humus had been added to it. The snails had the consistency of "tough mushrooms," if that can be imagined, and the earthy flavor seemed to help this illusion. Mastication did not crush and render soft the pieces of snail flesh, instead it merely split them into smaller and smaller discreet, firm particles. The obvious "flatness" in flavor seemed to be due to the lack of fats or oils, the addition of which might have helped considerably, as would other seasonings, which unfortunately were not available for this experiment. A number of recipes, originally designed for the Mediterranean helicines, have recently been recommended by those who feel that the giant snail will prove to be good eating (e.g., Garnadi 1951). They all seem to have two things in common, viz., a pound of butter and half the spice cupboard. Almost *anything* would be acceptable with its own flavor so effectively disguised. It might be of interest to note here that the Savorys' omnivorous dog, Patty, dashed to her dish in great anticipation when the rest of the achatina stew was put there; with her right paw cautiously curled under her, she took one sniff, backed up, and retreated to the far corner to sulk.

Subsequent experimentation has shown that boiling the snails in the shell for approximately five minutes and then dressing them produces a much less contracted and more tender morsel. The disadvan-

tage in this type of preparation, however, rests in the fact that the hot hepatopancreas or "liver" imparts a pungent, acrid odor which to the novice might prove more than discouraging. As will be shown below, the hepatopancreas is the most nutritious part of the snail. To solve the problem of an excessive amount of slime in the freshly prepared snails, van Weel (1948) suggests soaking them for one to two hours in a weak solution of vinegar, lemon juice, or grapefruit juice. This he says "renders the snail hard at the same time, thus making it more palatable." He does not recommend cooking them in brine. The copious slime, on the other hand, was ingeniously and successfully utilized by H. A. A. M. Wirtz as a "binder" in the process of making bread out of ground soybeans in a Japanese internment camp in Singapore. One correspondent in all seriousness volunteered the suggestion that the snails might be cleaned in a washing machine!

As an experiment in Saipan, Allie Jones pickled the African snails in brine. Like the cooked snails, they proved edible but, by most standards, not palatable. It should be mentioned at this point that Jones was sent to Saipan, under the sponsorship of the Pacific Science Board in 1949, to investigate the possibilities of making use of the giant snail for human and poultry consumption. Before his experiments were hardly more than under way, he sustained severe burns in a most unfortunate accident. It is hoped that the projected research will ultimately be completed. Apparently extensive experiments of this sort were carried on in Japan by Shingo Tazawa; and according to Esaki and Takahashi (1942), he "insisted that the snail is rich in nourishment, good as a tonic, will give excellent dishes in vinegar mixture, sesame bean-mash, bean-mash mixture, broiled with soy, coquille or stew" and that "these dishes gained high praise at experimental tasting eating parties." However, since Tazawa was doing everything possible to promote the sales of the giant snails, his reports were doubtless biased. As an interesting contrast, but without qualifying evidence, Mahony (1955) states, "The snail is edible, but when cooked and eaten it has a highly offensive odor and taste."

If commercial use of the giant African snail is to be made in the future, it would seem at least at this time that it is as impractical as it is unrealistic to presume there will be any extensive use of them as an item of food for humans. The Micronesians will not eat them. And it is sheer folly to assume that they can be "educated to eat them." The same probably obtains for the other peoples of the world who do not already customarily eat snails. Those who do eat snails will not find the giant snails as acceptable as the edible helicines unless some wholly new method of preparation can be devised.

Although there is need for exploring the possibilities of their use *directly* in human consumption, it is not at all likely that anything practicable will be discovered. Their use in curries or in the chow mein type of dish is the most promising suggestion made so far. The Japanese of course did eat them, but the reasons for it have been shown to be temporary. The Chinese have eaten them and it is conceivable that because of their naturally greater versatility in eating and because meat of any sort is perennially a particularly scarce item in China, there may be in the future some possibility of marketing processed achatinas in that country. This needs and warrants exploration. It would seem, then, that any use to which the snails can be put must be found in something other than human consumption.

Food for Poultry The fact that chickens and ducks will consume achatinas has already been mentioned. This suggests in the light of the present discussion that perhaps the giant snails can be used for poultry feed. Van Weel (1948), Jones (1949), Pangga (1949), and others urge this consideration. The possibility was explored to a small extent by the author in Chichi Jima and inquiries were made elsewhere. Small living snails were given to chickens with no success. They occasionally would unenthusiastically pick at them but would give up almost as soon as they started. Other observers in Micronesia reported the same results. According to Garnadi (1951), Djaenoedin (1942) had no better results even when the snail flesh was mixed with coarse corn. On the other hand, van Weel (1948) found that chickens would not reject well-crushed snails but that they would not take to them as avidly as ducks invariably do. In Guam, Duane H. Kipp (*in litt.* Aug. 4, 1956) reported that his chickens ate the giant snail "raw, boiled, and roasted" but "seemed to prefer them crushed and boiled." Steven Haweis (*in litt.* Oct. 26, 1949) has recommended the method used in the Dominican Republic; viz., the freshly killed endemic snails are pounded with corn meal before they are fed to the chickens. The Formosan Chinese crush the large achatinas before feeding them to their ducks (Vosburgh 1950). South (1926*b*), however, indicates that in Singapore the Chinese cooked the snails before using them as duck feed.

It was decided to cook some of the snails before feeding them to the chickens. The freshly boiled specimens were quite slimy and the chickens were observed to be very slow to peck at them. The heavy slime often discouraged them after an initial examining peck. As the snails became somewhat dried out, the chickens would peck at them more frequently though never enthusiastically. After many hours, the cooked snails would be consumed. Kondo (1950*c*) observed

chickens in Guam feeding on the burned carcasses of large specimens of *A. fulica.* Next, it was decided that boiled and dehydrated snails should be tried. The brown, sun-dried pieces of snail did not elicit even the slightest interest from the chickens, even at feeding time. Nor did remoistening to form a soft, rich meal make any improvement in its attractiveness. In the Seychelles Islands, the dehydrated achatinas are reportedly used for poultry food; but there is no indication as to how well they are received (Rees 1950). It is possible, however, that a reasonably fine meal is made of the dehydrated snails and that this is incorporated into the regular feed. Since chickens apparently do not readily eat the giant snails, a method of this sort would seem to be the only way in which they could be fed to chickens. A portion of the achatina shell could also be ground up and combined with the snail meal as an added source of calcium carbonate. In the proper proportion, it would obviate the necessity of using oyster shell or other calcareous substitutes (e.g., cf. Scholes 1945). But using snail meal in chicken feed brings up some questions. Will it taint the eggs or the flesh of the chickens? What does it contain in the way of essential nutrients? In what way will the chickens react to it? How does it compare with other supplemental feeds? How dependable is the source of supply?

As to the possibility of a snail diet imparting an off taste to eggs, van Weel (1948) offers a negative answer with this statement: "No ill flavour was observed in eggs of fowls, fed with *Achatina.*" He has not elaborated, however, on the extent of his experiments. It seems reasonable that further experimentation will prove verifying on this point. As an intresting sidelight, Taylor (1900:430) presents the belief that the flavor of the flesh of sheep is improved when great numbers of snails are consumed in grazing. In contrast, some Chamorros on Guam believe that when pigs are fed on a diet of giant snails, the flesh acquires "a different and undesirable taste" (Kondo 1952).

Chemical Assay of Snail Meal Determining the essential nutrients is going to be a more difficult problem. A start in this direction has been made with the reports of chemical analyses of van Weel (1948), Mead (1950*b*) and Garnadi (1951). There is shown in Table 1 a comparison of the percentages that were found. Because the tests were not equally extensive, the constituent chemicals compare in only four instances. It seems clear from the figures that approximately three-fourths of the weight of the snail, exclusive of its shell, consists of water (cf. Pelseneer 1935:15; Fischer 1941). The variation in the amount of ash is not serious. But as gastropods are notoriously lacking in fats, as such, it is not understood how van Weel and Gar-

nadi arrived at such comparatively high figures. The presence of small amounts of fats in marine forms has been demonstrated by Albrecht (1921 *et seq.*) and Struve and Kairies (1930). Biedermann and Moritz (1899) actually showed that ingested fats were deposited in the digestive gland. The "ether solutes" listed by Mead, however, amount to scarcely more than a trace, as was earlier predicted. In fact, it is this paucity of fats which makes it even more practical to consider making use of snail meal; for it should not be necessary to run the meal through a fat-removing process in order to insure against its

TABLE 1

CHEMICAL ANALYSES OF DEHYDRATED *Achatina fulica*, EXCLUSIVE OF SHELL, WITH PERCENTAGES BASED ON DRY WEIGHT

	Mead (1905*b*)*	Lot A†	van Weel (1948)	Garnadi (1951)
Parts assayed	Foot and mantle	Visceral mass	All soft parts	All soft parts
Per cent H_2O before dehydration	76.51	76.51	80.2	*ca.* 72
Ash	11.13	10.72	17.7	10.0
Calcium	0.257	0.265	.....	.....
Ether solutes ("fats")	0.75	1.19	8.0	6.5
Glycogen	.....	.....	6.0	.....
Nitrogen	9.835	9.848	.....	.....
"Nitrogen-free rest"	.....	.....	.....	30.5
Phosphate (P_2O_5)	11.78	35.34	.....	.....
Phosphorus	3.67	10.7	.....	.....
Potassium	2.75	3.35	.....	.....
Protein	60.95	60.99	55.6	53.0

* Analyses made by Edwart L. Breazeale of the University of Arizona Agricultural Experiment Station, Tucson, Arizona.

† Collected by Mr. and Mrs. Peter J. R. Hill, Koror, Palau Islands, and dehydrated there in a plant drier at about 160° F. for 26 hrs.

becoming rancid in storage. The percentages of protein are all very close, and together they vouch for the great value of snail meal as a source of animal protein. The extremely low percentage of calcium suggests that this important constituent is not accumulated to any great extent in the mantle or elsewhere in the body, but is speedily deposited in the shell. The whole problem of calcium metabolism in *Helix pomatia* and *H. aspersa* is considerably elucidated by the detailed work of Dexheimer (1951) and Wagge (1952), respectively. W. Fernando (1946) first discovered galactogen in the albumen gland and glycogen in the albumen gland and reproductive cells of *A. fulica*. Van Weel found a significant amount of glycogen in his analysis of the soft parts of this species. This carbohydrate has been demonstrated in other gastropods (Creighton 1899, Levy 1890, Erhard 1912,

Léger 1924). The very high percentage of phosphate (and therefore phosphorus), especially in the visceral mass, which consists largely of the hepatopancreas or "liver," greatly increases the value of the snail flesh as both a feed and a fertilizer. This finding lends support to Léger's statement that the visceral mass of *H. pomatia* is its most nutritious part and that therefore the snail should be eaten *"in toto"* (cf. Table 3 and Moretti 1934). In no other constituent in *A. fulica* is there any significant difference between the values found for the visceral mass and the muscular mass.

TABLE 2

COMPARATIVE CHEMICAL ANALYSES OF DEHYDRATED *Achatina fulica* FROM VOLCANIC AND CORALLINE ISLANDS WITH PERCENTAGES BASED ON DRY WEIGHT*

	Lot		
	B	C	D
Origin (island)	Koror	Ngarmalk	Koror
Type of soil	Volcanic	Coralline	Volcanic
Date collected	3 Apr. 1950	25 Apr. 1950	27 Apr. 1950
No. of specimens	29	12	14
Ash			
Calcium	0.26	0.25	.33
Ether solutes	0.75	Trace	Trace
Nitrogen	9.8	9.2	9.7
Phosphate (P_2O_5)	12.0	13.50	12.32
Phosphorus	4.0	5.36	5.38
Potassium	2.75	2.18	2.93
Protein	61.0	57.5	60.6
Shell:			
$CaCO_3$	98.7	99.0	98.9
SiO_2	1.2	1.0	1.1

* Collectors and analyses as for Lot A, Table 1, except dehydration was for 72 hrs.

In subsequent analyses, efforts were made to determine whether major environmental differences produce any appreciable corresponding differences in the values of the basic chemical constituents. Specimens collected in areas of volcanic soil were compared with those collected in areas of coralline soil. An examination of Table 2 will show that unless many other tests are run with essentially the same results, the slight differences shown cannot be considered significant. It is probable that at least a portion of the SiO_2 in the pulverized shell analyses came from contamination with soil. But, on the subject of variations, Brand (1932) made interesting discoveries in checking the chemical composition of *H. pomatia* at various seasons of the year. The variability which he found may help explain

why there is not closer agreement in the analyses of different investigators. Table 3 has been drawn up to emphasize this point. Snails often consume a fair amount of soil. Since the digestive tract is left intact, and since the soil which it may contain will vary from place to place in its chemical makeup, it is more than apparent that still another variable enters the picture in this way.

Further contributions along this line have been made by Boycott (1921), Vincent and Jullien (1941), and Janda (1951), who report on

TABLE 3

CHEMICAL ANALYSES OF *Achatina fulica* AND *Helix pomatia* WITH PERCENTAGES BASED ON LIVE WEIGHT

	Balland (1898)	Brand (1932)	Léger (1932)		Garnadi (1951)†	Mead (1950b)*		van Weel (1948)
Species	*H. pomatia*	*H. pomatia*	*H. pomatia*		*A. fulica*	*A. fulica*		*A. fulica*
Parts assayed	All soft parts	All soft parts	Foot	"Liver"	All soft parts	Foot	Visc. mass	All soft parts
Ash	1.55	2–3.4	1.64	2.29	1.52	2.61	2.52	3.51
Calcium	.....	.....	.....	.....	.....	.060	.062	.....
Ether solutes ("fats")	1.08	0.5	0.42	1.78	0.988	0.176	0.279	1.58
"Extractives"	1.97	.....	1.91	5.98	.....	.....	.....	.....
Nitrogen	.....	1.5–2.0	.....	.....	.....	2.31	2.31	.....
"Nitrogen-free rest"	.....	.....	.....	.....	4.63	.....	.....	.....
Glycogen	.....	.....		0.842†		.....	.....	1.19
Phosphate (P_2O_5)	.....	.....				2.77	8.30	.....
Phosphorus	.....	.....				0.862	2.51	.....
Polysaccharides	.....	1.5–2.8				.....	.....	.....
Potassium	.....	.....				0.646	0.787	.....
Protein	16.10	.....	15.87	17.31	8.06	14.32	14.32	11
Water	79.30	80–84	80.16	72.64	84.7	76.51	76.51	80.2

* Computed on basis of dry weight percentages.

† As a part of "extractives."

the presence of manganese in land mollusks (cf. André 1923), and Fischer (1941), who states that under varying conditions the water content of aquatic snails will go from 66 per cent, after prolonged exposure to air, to an apparent optimum of 86–93 per cent. Chemical studies of marine forms have been made by Albrecht (1921 *et seq.*) and McCance and Shipp (1933), B. Bergeret of Yaounde, French Cameroun, has announced (*in litt.* Dec. 25, 1953) that he has established the nutritional value of *Archachatina marginata* and *Archachatina* sp.

Dr. Y. W. Hes very kindly turned over to the author an unpublished manuscript, dated August, 1951, containing a chemical analysis of the "big shells" (>15 mm.), "small shells" (<15 mm.), and

"operculae" (i.e., epiphragms) of eastern Javanese specimens of *A. fulica.* This analysis is probably the only one extant for the giant snail; and it is for this reason that it has been reproduced, with permission, in Table 4. A somewhat comparable analysis was made by Turek (1933) on the shells of *Cepaea nemoralis* in which there were found the following values: water 0.48 per cent, N 0.201 per cent, SiO_2 0.217 per cent, Fe 0.0014 per cent, Ca 38.88 per cent, Mg 0.0025 per cent, organic matter 1.36 per cent (of which 14.8 per cent was N), P 0.0040 per cent, and conchiolin 1.21 per cent. In discussing the shell of *A. fulica,* Garnadi (1951) states merely that it is made up largely of $CaCO_3$ with small amounts of CaP_2O_5 and $MgCO_3$. Other analyses of gastropod shells were reported upon by Clarke and

TABLE 4

CHEMICAL ANALYSIS OF SHELLS AND EPIPHRAGMS OF *Achatina fulica* (EX MS W. HES)

	Large Shells	Small Shells	Epiphragms
Water (dried at 105° C.)	0.2	0.3	1.4
CO_2	39.6	39.8	36.7
N	....	.....	0.4
SiO_2	0.1	0.1	0.3
$Fe_2O_3+Al_2O_3$	Traces	0.1	0.2
CaO	54.6	53.7	50.1
MgO	0.3	0.2	0.8
Organic matter	5.0	4.9	9.7

Wheeler (1917, 1922), Döring (1872), Steel (1922), and Struve and Kairies (1930). Stolkowski's more recent work (1951) especially should be mentioned because of its detailed treatment and exhaustive bibliography.

Vitamin Assay of Snail Meal Even though vitamin A is quite susceptible to oxidation, especially in dehydration, a preliminary assay for this vitamin was conducted in the nutrition laboratory of the Univeristy of Arizona. The tests run by Mitchell G. Vavich of that laboratory on the dehydrated material sent from Koror revealed the presence of vitamin A in the dehydrated visceral mass to the extent of 5.4 μg/g. For comparison, beef liver has 300–400 μg/g. The pro-vitamin carotene, not heat-labile at moderately high temperatures, appeared in 10.3 μg/g. These figures are low for animal tissue. Analyses run on the dehydrated foot and mantle tissue brought still lower values. These tests establish the fact that snail meal does not provide a good source of vitamin A or carotene; and if it is to be used as a food supplement, other sources must be depended upon for

these essential factors. It is of at least academic interest, however, to report the presence of these factors even in small quantity. Projected tests will determine the relative amounts in the live and freshly killed snails. Vitamin B_1 (thiamine) was found in only small amounts by Koller (1941) who discovered it in the liver and whole animal of active *Helix pomatia* in 0.3 μg/g and 0.9 μg/g, respectively. In the dormant animal, the assays were negative. In contrast, vitamin B_2 (riboflavin), in this species and in *H. aspersa,* was not only found in considerably higher amounts, but the values actually increased during hibernation. The amounts, expressed in terms of micrograms per gram of the fresh tissue, are: hepatopancreas 16.3, kidney 7.0, muscle 1.4, and genital system 2.3 (Raffy and Ricart 1943). Hoar and Barberie (1945) have shown that marine mollusk tissue is higher in vitamin B_2 than mammalian muscle and fish; and that drying, canning, or salting the tissue may produce great losses of this vitamin, whereas freezing and smoking do not. Destruction of "vitamin B" was earlier demonstrated by Jones and Murphy (1926) in the dehydration of oysters at temperatures as low as 40° C. In contrast, preliminary chick feeding tests at the University of Arizona indicate that there is no vitamin B deficiency when dehydrated giant African snail meal is the only possible source of this vitamin complex (Mead 1959*b*).

The presence of vitamin C (ascorbic acid) in *H. pomatia,* in considerably less quantity than in beef, was reported by Wenig and Halačka (1948). Earlier, Marchi (1928*a, b,* 1929) and Randoin and Portier (1923) found that this vitamin was present in a number of marine mollusks; but Nešpor and Wenig (1939), after finding it in *H. pomatia,* concluded that it did not figure importantly in invertebrate metabolism. According to Meenakshi (1951), vitamin C in *A. fulica,* as in other gastropods examined, is strangely concentrated intracellularly toward the distal ends of the hepatopancreatic cells. These several reports, plus such more comprehensive works as that of Waisman and Elvehjem (1941), should stimulate in the near future fairly exhaustive vitamin assays of *A. fulica.*

Amino Acid Assay of Snail Meal The discovery of a very high protein content in the snail meal in turn has introduced the question of the amino acid makeup of this protein. Preliminary amino acid assays revealed the very significant fact that the essential amino acid lysine was present in the dehydrated, pulverized snails to the extent of $1\frac{1}{3}$ times that of whole chicken egg (Mead and Kemmerer 1953; Anon. 1953*d*). The consistent deficiency of lysine in the common sources of plant protein used as food supplements, such as cotton seed meal, makes this discovery all the more important. In these

same preliminary tests, arginine was shown to be 2⅓ times the relative amount found in whole egg; this amino acid, however, has not been established as essential in normal nutrition. Other amino acids were sufficiently high in concentration, as compared with whole egg, to increase considerably the estimates of the value of snail meal as a poultry and livestock supplemental feed. The variation in the assays of snails collected in different environments suggests that a series of experiments should be set up to determine, among other things, what environmental conditions predispose the maximum production of lysine. Sekiné (1926) has not only demonstrated the presence of lysine in the marine bivalve *Meretrix meretrix* but has determined that it is almost 1¼ times the amount in meal made of the salmon, *Oncorhynchus masou*.

It is not enough to demonstrate that certain amino acids are present in desirable amounts. There still remains the question as to whether or not growing animals will actually respond properly to a diet in which the protein item consists largely or entirely of snail meal. This properly implies that other growth-promoting factors, not yet determined, would be allowed to come into effect under such conditions. Just such investigations as these are currently in progress at the University of Arizona, with day-old chicks as the experimental animals. Attempts will be made to determine the most effective way in which to incorporate the meal into chicken feed and to detect any possible idiosyncrasy that the chickens might have to the snail meal. In the chick feeding tests, a comparison will be made between snail meal and other sources of animal protein, such as blood meal and fish meal. A. F. Caldwell of the University of Malaya gives some interesting information (*in. litt.* April 23, 1953) regarding the response of ducks to a diet of snails. He states, "I did notice that the addition of snails to the diet had a bearing on egg production; in dry weather when the snails retreated to hide outs egg production fell, but increased again as soon as they were given snails." H. A. A. M. Wirtz of Java independently offered essentially identical information. Along this same line, Fronda (1919) and Frigillana (1923) in the Philippine Islands reported that when their experimental chickens were fed ground and boiled snails (probably the freshwater snails *Vivipara* and *Pila* according to Talavera and Faustino 1933), there was a marked increase in the number and size of the eggs and the weight of the chickens as compared to chickens on substitute diets of copra meal, "palay" (unhulled rice), or cowpeas. Geseco (1921) obtained similar results with ducks. Because the snails were periodically difficult to obtain, Cruz (1932) attempted to find a sub-

stitute. On the basis of cost, shrimp meal was recommended. But now that the people in the Philippines have a *free* source of *A. fulica,* it is quite likely that giant African snail meal is currently being used.

Food for Livestock According to Kalshoven (1950), Djaenoedin (1942) has recommended that the giant snails be incorporated into the daily rations of pigs. The value of fortifying their diet with snail meal can be predicted on the basis of the present experiments with chicks. The same goes for other livestock and pet feeds.

Wilson Savory of Chichi Jima stated that his pigs would take to the live snails quite as readily as they would to the boiled and chopped ones. In contrast, Frank L. Brown of Rota failed to persuade his pigs to eat the live snails, even after considerable fasting, although they would eat them if they were cooked. Father H. F. Costigan of Kolonia, Ponape, regularly fed his pigs on small cooked achatinas left in the shell and mixed with other food. In Tinian, a farmer was seen to feed his pigs boiled achatinas which had been removed from the shells (Chamberlin 1952*a*). In no case were the snails eaten avidly nor were the larger specimens consumed unless they were crushed or removed from the shells.

Garnadi (1951) states that the surgeon of the Veterinary Institute of Bogor determined that pigs put on a diet entirely of giant snails lost weight but showed no signs of sickness.

Fish Bait Using the giant snails as salt-water fish bait in preliminary experiments in Saipan did not prove encouraging (Jones 1949). Living edible European snails, however, are being used as freshwater fish bait in the United States (Ingram 1952). If the numbers sold for this purpose are any criterion, they must be good. The raw flesh of the Philippine pond snail *Pila luzonica* Reeve is reportedly used as a bait for line fishing (Talavera and Faustino 1933).

Fertilizer In spite of the fact that primitive peoples all over the world have made use of disintegrating animal flesh to replenish the plant-growth-promoting constituents in depleted soils, the survey of the giant African snail problem in Micronesia failed to reveal any extensive use of *A. fulica* for this purpose. The people of Chichi Jima were the only ones observed at that time to be making direct use of the giant snail in this manner. There they collected mostly the small, thin-shelled snails in metal oil drums. These were allowed to stand in the hot sun until the snails died and had reached a high degree of putrefaction. These rotting, maggot-infested snails were then scooped out, the shells were crushed, and the putrid, slimy, odoriferous mess was added as a fertilizer to young vegetable plants. The reason for the generally better quality of the crops in Chichi

Jima, as compared with other areas, rests at least in part in the use of snail fertilizer. Its use in this case, however, introduced two pronounced disadvantages. The inadequately covered oil drums permitted escape of the fly maggots as a threat to public health, and the addition of the crushed shells to the soil moved the soil pH even more strongly in a basic direction. More recently, the latter disadvantage has been eliminated in the similar use of snail fertilizer in Guam in that only the "liquor" is drawn off and diluted with ten parts of water before being added to the soil (Peterson 1957*b*).

In areas where the soil is excessively acid, as is the case in humus soils of forests, the alkalizing effect of adding crushed shells would of course be desirable as far as most crops are concerned. But conversely, coralline soils are already excessively basic and should not have more calcareous material added to them. This suggests immediately that if there is ever commercial use of the giant snails in fertilizers, two different kinds should be made available—one with, and one without shell fragments. One thing is certain, the thin, quickly leached soils of tropical areas need enriching of some sort if they are to be used for much more than two or three years. Where this is not possible, the natives abandon the plot, burn off another portion of the forested area and use that until the soil nutrients in turn are depleted. All too often the abandoned land is soon taken over by sword grass (*Miscanthus*) or some other noxious plant with little chance, for a long time, of the land being recovered again for crops.

Production of Snail Meal The practicability of producing fertilizer from the giant African snail is in most respects on a par with that of producing the supplemental feeds. In both cases, it would be desirable to dehydrate the snails and reduce them to a powder or meal. In this form it could be stored and used when needed either as a fertilizer or a feed supplement. The big question at this point is not whether the snail meal has value in either of the categories. The relatively high percentages of phosphate and lysine quickly answer that question. The real question is: "How dependable is the source of supply?" An examination of the reports in the literature and an examination of an invading population would tend to convince one that the snails are present in inexhaustible numbers. This is misleading. In any given area, irrespective of the abundance of the snails, an intensive collecting campaign will remove in a relatively short time so many snails that no further specimens can be found even with diligent hunting. Experience has demonstrated over and over again, however, that eradication is not thereby effected. In a year or two the residual snail population builds up in appreciable numbers once

again (unless the phenomenon of population decline comes into the picture, *vide infra*). This almost automatically suggests that perhaps a system of "harvesting" the snails could be set up wherein the collecting could be rotated from one area to another on a long enough program so that population recovery could take place before reharvesting.

Let us assume that the island, or region of the mainland, and the snail population are large enough for such a system of harvesting. There still remains the problem of labor. Native help could be enlisted. With the coconut tree actually or virtually wiped out on a number of the Micronesian islands, and with no chance of reviving trade in the Japanese-introduced sugar cane, the Micronesians in many cases are hard put to find some means of providing for their needs. In such areas, collecting and selling the ubiquitous giant African snail could be a welcome source of native income. In some other areas, however, attempting to enlist the help of the native people would not be altogether easy, for the pay might not be sufficiently high to arouse their interest. But in past times in a number of areas where only a very modest bounty could be offered for the snails during their initial build-up, considerable native help was obtained. The "emergency" nature of the situation at that time and possible elements of conscription may help explain the co-operation that was obtained. In a regular program of harvesting the snails, however, these persuasive factors would not be present. Nonetheless, since the native people will be collecting the snails in their garden plots as the most effective and most inexpensive means of controlling them, for a modest fee they could be persuaded to bring them into a common collecting place instead of trying to destroy them at an often even greater expenditure of energy.

Let us suppose further that, through the means indicated, sufficient snails are brought into a centrally located processing plant to keep it in indefinite operation. There still must be worked out an economically feasible processing program in which at least some of the snails would be removed from their shells before they are dehydrated. Developing an economical method of dehydration, avoiding chemical decomposition with excessively high temperatures, avoiding maceration with insufficiently high temperatures, and maintaining dehydration in storage, are only a few of the problems which would have to be met. And even with these out of the way, there still remains the problem of marketing the snail meal on a commercial basis. This problem is sufficiently great in the minds of some investigators to cause them to reject summarily the whole idea of

attempting to make use of the snail meal. They state: "With shipping rates as high as they are, how can you ever hope to market snail meal in this country at a price which will permit it to compete successfully with other animal protein sources?" But it is not in this country that the greatest critical shortage of animal protein food supplements exists. Ironically enough, it is right in the areas where the snails abound that there is the greatest need! As a case in point, in Guam in 1949 eggs sold for $2.50 per dozen and chickens sold for $3.00–4.00. The high cost and scarcity of imported chicken feeds were given as two of the major reasons for these exorbitant prices. Yet right on that island there are tons of giant snails, living, dying, and going to waste. Marketing should be no problem there or in any comparable area. The possibility of marketing the meal on a large scale commercially not only seems remote, but the present need for it is questionable. Local demand alone should take care of the supply. In regions where lime is in demand, the achatina shells could be reduced in lime kilns as a by-product in the preparation of the snail meal. The shells of *Melania* and *Corbicula* are apparently being used in this manner in Malaysia (Benthem Jutting 1948:137).

It is a paradox indeed that these snails are forming from unwanted rotting and decaying materials a very rich source of protein for which there is a continually growing need both as a poultry feed supplement and a fertilizer, and yet next to no direct use is being made of them. More than that, current methods of control call for their destruction with no apparent thought given to their utilization. There has been a definite hesitancy, on the part of many who are concerned with the control of the giant snail, to prescribe any measure which would in any way make, or even suggest, a use for the snails. The reason for this undoubtedly rests in the fears reflected in the words of the first major survey report coming out of the Pacific after World War II, viz., ". . . if any persons found the snail a benefit, others would be tempted to introduce it elsewhere, regardless of the common good. It might, therefore, be unwise to try to develop uses for it." (Townes 1946; cf. Rees 1950:586). It cannot be denied that the warning is a sound one; but it has had an inordinate effect upon subsequent control programs. There is considerable doubt in the minds of some that any really appreciable spread of *A. fulica* would result from finding a use for it. On the contrary, finding a use for it could be responsible for reducing the population to the point where the snails would practically cease to be a problem. It is the great multiplicity factor which largely causes them to be branded as a pest. But, whether or not any use is found for them, the snails *will* con-

tinue to spread into new areas, in spite of all efforts to the contrary. If they are going to spread, why not enlist the interest of man to help keep their numbers down to the point where they are not a serious problem? Man always has been at the head of the list of known enemies of the giant snail. It is almost completely impossible to try to teach man, in the recently invaded areas, to eat the snails; but at least he can be taught to make indirect use of them toward his own benefit. In this manner, the snail could be a blessing rather than a curse (Mead 1953*b*, 1955*b*). Apropos of this, much attention is currently being given to various invertebrates as possible natural sources of highly complex organic compounds, a development which holds great promise for the fields of medicine and organic chemistry.