CHAPTER 6

CONTROL THROUGH MECHANICAL DEVICES

Various mechanical methods have been devised to control *Achatina fulica,* and other pestiferous snails, especially in the absence of suitable chemicals. Some of these provide under a great variety of conditions the only, and sometimes the best, means whereby snail pests can be held in check. At the very least, however, they serve as valuable adjuncts to other types of control.

Barriers Fences made of closely placed bamboo sticks are used in many places to create a mechanical barrier against the giant snails. But even where the fence is six to eight feet high, the barrier effect is only temporary; for the larger snails scale the fence and the smaller ones manage to work their way through the gaps. Nonetheless, erecting a fence in conjunction with hand picking and destroying, is probably the most common method of control that is used, other than just hand picking alone. G. S. Dun (*in litt.* Dec. 17, 1953) found that painting a board fence with crude creosote increased considerably its effectiveness as a barrier.

Effective barrier fences have been constructed of other materials. Large experimental vegetable plots at the Agricultural Development Station in Ponape are surrounded by a very high fence of closely placed strips of wood. Torres (1950) similarly suggests erecting a wooden fence to protect coffee plants from the attacks of the giant South American snail, *Strophocheilus oblongus.* The people in Chichi Jima strapped together large sheets of corrugated iron around their garden plots to keep out the giant snail. The fact that these become excessively hot in the bright sunlight should not suggest added protection, as the heat quickly dissipates before the crepuscular and nocturnal snails come in contact with them. Actually, the corrugated iron sheets can be more easily and more quickly scaled than wooden or bamboo fences. Because of vast surplus stores of these sheets in Guam, it was recommended by high government officials in 1949 that they be used for snail barriers. Sheet zinc is recommended by Hall (1932) as being an absolute deterrent to snails and slugs; but of course their use as a mechanical barrier is quite out of the question from the standpoint of cost in anything but the most small-scale control measures.

As early as 1933, Corbett suggested without elaboration that flower beds could be protected from the giant African snail by surrounding them with an 18 inch high, ¼ inch mesh wire netting. Bryan (1949) repeats the suggestion. Independently of these recommendations, Peter J. R. Hill of the War Memorial Laboratory in Koror (Palau Islands) erected around his 65 by 45 foot vegetable garden a 6–8 inch high, 18-mesh copper wire screen barrier. The screen was buried in the ground at a 45° angle so that the top of the screen leaned away from the garden. The horizontal wires were removed from the upper inch of the screen, the last one of which was removed at an oblique angle so that the vertical wires were alternatingly vertical and almost horizontal. This produced a double row of inch-long sharp projections along the top of the wire fence. This type of barrier is very effective because of the following advantages: the screen helps to break the suction of the foot and the snail's own weight tends to pull it off; the angle of the fence increases the effectiveness of the pull on the foot and causes the snail to fall away from the fence; the sharp vertical wires force the snail to loop way out in an attempt to circumvent it, leaving such a small portion of the foot in contact with the screen that purchase is invariably lost; and in the areas where a double barrier of this sort was set up, the snails which did manage to get over the first fence were imprisoned between two fences and died because of exposure to the hot sun the following day. But these advantages were found to be offset by disadvantages. With the fence only 6–8 inches high, the snails were found to pile up along the fence in certain areas to such an extent that others could crawl upon them and drop over the other side. Even though the fence is relatively inexpensive, it still is considerably beyond the means of most native people. And since the necessity of removing the snails, as they accumulate along the fence, is still not obviated, the native people find it more economical not to erect the fence and simply resort to frequent hand collecting. A possible improvement of this fence might be effected if it were constructed along this same design but built to stand one foot high. The upper four inches of this could then be bent away from the garden plot at a 90° angle. This would force the snail to crawl *upside down* for a way even before it got to the barrier of the double row of vertical wires. The drop-off should be 100 per cent. But, again, this would significantly increase the cost.

Kondo (1952) announced that his description and figures of the "Peter Hill snail fence" were mimeographed in 1949 by naval personnel and distributed in the Trust Territory. As an apparent outcome of this, Manuel Mendiola of Rota used the fence to protect his extensive bell pepper plantings. Kondo gives a vivid and detailed account of the effectiveness of this approximately 1,400 foot fence, reemphasizing the advantages and the inherent difficulties in the use of this type of barrier (see Fig. 11).

It has been suggested by Lange (1947) that brush taken from clearings be piled up around the periphery as a mechanical barrier to the giant snail. Such accumulations of decaying plant material are particularly attractive to these snails because of the almost ideal conditions of food, moisture, and protection from the sun. It would seem then that such a practice might invite the build-up of dangerously high peripheral populations. On the other hand, this method coupled with other control measures, such as the use of molluscicides, might be very effective.

Rattan or coir fiber tied to the trunks of trees susceptible to the attacks of the giant snails has proved effective (Feij 1940, Bertrand 1941). Even coir fiber rope was considered by South (1926*b*) to be of value in setting up a mechanical barrier around gardens. But experimental plantings of thorny mimosa plants did not produce any barrier effect at all (Feij 1940). Trenches filled with sawdust have also been recommended (South 1924*b*). In the Pallekelle estate in central Ceylon, freshly planted cacao seeds and young seedlings were protected from the ravages of the giant snail by specially constructed wire cages; but this practice soon became economically prohibitive.

Technically, repellents are chemical barriers and should be considered here; however, they have already been treated above in the discussion of chemical control.

Burning-Over This practice has been resorted to by native peoples in many parts of the world primarily because it is the easiest and quickest means of clearing land before planting. It is very effective in killing a high percentage of snails present in spite of the fact that this benefit is only incidental. Burning-over is most often done during the dry season and at this time a great share of *A. fulica* are in estivation. Estivation often takes place right on the surface of the ground under vegetation or other superficial types of protection. To a great degree, snails under such conditions will be killed in the burning-over process. Other specimens, however, will go down into the ground as much as four or five inches before estivating. These will survive and re-establish the population with the return of normal conditions. Other species of the giant snail were shown by Lang (1919) to survive in the same manner the annual grass fires in the former Belgian Congo. No matter how thoroughly it is done, burning-over is not eradicative by any means. But besides this, snails from contiguous high-pressure population areas will quickly invade the burned-over area and speed up repopulation just that much more. Tsetkov (1940) emphasizes this point. Early unsuccessful attempts to "burn out" *A. fulica* in Agaña, Guam, gave further convincing proof.

The systematic use of the flame thrower, after clearing the land of vegetation, proved much more effective than simple burning-over in controlling *T. pisana* in California (Basinger 1923*a*, Gammon 1943). But even this method, in efforts to control *H. aperta* in southern California, was disappointing because this species has a greater propensity for estivating at comfortable distances below the ground. In contrast, but with similar results, Henderson (1936) found *Polygyra uvulifera* survived grass fires where other species did not, simply because it habitually retreated to large, thick protective leaves. Joubert and Walters (1951) found that burning-over fields heavily infested with *T. pisana* was very effective in South Africa.

Clean Culture As early as 1926, it was suggested by Pereira that the responsibility for a renewed outbreak of *A. fulica* in Ceylon rested in the fact that the people had failed to destroy weeds and to clean up accumulated refuse. Leefmans (1933*c*), Corbett (1933), Feij (1940), Lange (1947), Anon. (1947*a*), van Weel (1949), Rees (1951), and Peterson (1957) have further emphasized the importance of reducing the numbers of the giant African snail through clearing and weeding. There is no question about it; rubbish, debris, wild plant growth, and the like do afford a sanctuary for these snails. A premium therefore is put on their removal. Lovett and Black (1920) produced "remarkable results" in reducing slug and snail damage through the simple expedient of cleaning away all possible refuge in areas adjacent to crops. Although keeping the ground free from plant debris may be conducive to good snail control, it is contrary to the long established agricultural practice of allowing the trimmings especially of green manure plants (e.g., *Gliricidia* and *Erythrina*) and the leaves of crop plants (e.g., cacao) to accumulate as a natural mulch. Through this practice, weed growth is kept down, moisture is retained, nutrients are added to the soil, and, unfortunately, insect and snail pests are increased.

The nocturnal and crepuscular habits of *A. fulica* normally permit it to escape the killing effect of the sun. It has been observed over and over again in the field that snails which were unable to find protection from the sun, after a night's foraging, were quickly immobilized and soon killed. In fact, in many places, by far the majority of deaths in the snails can be attributed to overexposure to the sun. The drying effect and the excessive heating of both the snail and the ground are probably the causes of death; but the work of Carmichael (1928, 1931) suggests that it may be the ultraviolet rays which produce the lethal effect. At any rate, advantage can be taken of this knowledge by removing as much as practicable of anything which affords protection from the sun. This was tried on a large scale on an experimental farm in Tinian by Nelson Young. A large field was plowed over, leaving exposed to the sun both snails and their eggs. This essentially neutralized area was then planted and by harvest time, the snails in the adjacent uncultivated areas had been able to move only a short way into the big field. Damage was limited to the peripheral areas. Of course, similar peripheral damage in a smaller plot would exact a much higher percentage of loss. In fact, the usual, very small native garden plot is so small that the snails can often reach its center in a few hours' time during a single night. This does emphasize, however, the importance of clearing around the plot as large a buffer area as practicable. The daily removal of snails from this buffer area, especially in the early morning, would greatly increase its effectiveness. Clearing through the use of weed killers has been tried in only a few instances (e.g., in Guam in 1949), and it is possible that with the introduction of more effective weed killers we will see them more frequently used for this purpose. But as far as large-scale farming is concerned, little help of a practical nature can be expected. The necessity for mechanized farm equipment, for one thing, would put it completely out of the question for the majority of native peoples. Whether the clearing is done on a large or a small scale, it introduces still another difficulty, viz., soil divested of its normal plant cover not only quickly loses its nutrients through leaching, but it is subject to rapid erosion. In the coralline islands especially, where the soil is often exceedingly thin, this would be a real tragedy. Where the cover of vegetation is thick, as in the case of grass, not removing it entirely, but cutting it down to a stubble is a compromise measure put to effective use at the Agricultural Experiment Station in Peradeniya, Ceylon.

Drowning Anyone who has attempted to drown a snail or slug in order to preserve it in an extended condition, knows full well how difficult it is to produce a kill by this method (cf. Frömming 1929, Courtois and Duval 1927). Even when the dissolved oxygen had been driven off by boiling the water, Rees (1951) was able to demonstrate that it took 48 hours for young *A. fulica hamillei* to die after complete submersion. Earlier, van Weel (1948) stated that it took 20–24 hours for the giant snail to drown (cf. Meer Mohr 1949*b*:5); but the water was probably maintained at a higher temperature. He introduced evidence to show how this capacity has permitted the giant snail to survive apparent drownings and spread more rapidly to adjacent uninfested areas (c.f. van der Goot 1939). He stated that snails dumped into the Mahakam River at Tenggarong, East Borneo, were apparently able to withstand a long trip in the water; for just a year later a healthy infestation was found in Djambajan, over eleven miles downstream. Scarcely one-tenth this distance was covered upstream via other means of transportation. Meer Mohr (1950) observed this snail apparently "deliberately" entering pools of water during the rain and drowning; on the other hand, Davis (1958*a*) observed a small specimen successfully negotiate a trip across standing water.

Submerging snails in sea water has not seemed to produce appreciably better results. One of the classical experiments was that of M. Aucapitaine of Corsica in which he plunged specimens of several species of land pulmonates in the ocean for fourteen hours (Caziot 1928). He obtained 87 per cent survival! Dartevelle's observations (1952*b*) were less dramatic but just as significant. *A. fulica* has similarly demonstrated its capacity to withstand such treatment, Somanader's remarks (1951) to the contrary notwithstanding. In 1923, Jarrett reported that specimens of this species were being destroyed in Malaya by dumping them in the ocean. Later (1931), however, he indicated that such specimens were found to wash ashore in a viable condition. Of course, a number of factors, such as temperature of the water, salinity, oxygen tension, and onshore wind, would undoubtedly seriously affect survival rates; but even when such factors are far from favorable, there is great enough survival to warrant the use of caution when resorting to this method. Crushing the snails before dumping them in the water would seem to eliminate all danger of this sort. Under any circumstances, the possibility of fouling the water must be taken into consideration.

Floods provide only a temporary setback in the snail population as witnessed by South (1925, 1927) in northern Malaya. A tidal wave in 1946 in Chichi Jima similarly caused a delay of less than two years in the expanding snail population on that island (Mead 1950*b*).

Hand Collecting and Destroying Without question, no single control method has gained a broader general acceptance than the simple expedient of collecting the snails and eggs by hand and destroying them. An examination of the literature shows over and over again that this, almost without exception, is the method resorted to in the very earliest phases of an invasion by *A. fulica*. Frequently, in fact, participation is stimulated by offering bounties for both the snails and eggs. Invariably, the bounties are discontinued after a relatively short time because the rapid increase in the snail population, in spite of the collections, soon exhausts even the most generous funds that have been set up for this purpose. Such has been the experience of many, many areas, including quite recently Hawaii (Wong 1951). For the same reason, people despair of the seemingly endless and ineffective collecting, discontinue their efforts, and let the snails "take over" (*vide*, e.g., Bertrand 1928). One thing is certain, no matter how assiduously this collecting is done, it is never eradicative; that is, if countless unsuccessful attempts in the past are any criterion. Nor can it ever be eradicative except on the very smallest scale, despite some of the optimistic statements in the literature to the contrary (e.g., Peterson 1957). But this does not justify dismissing summarily this method as an impractical one. Actually, when the giant snail population is vigorously building up, as in the early stages of invasion, this method is least effective. On the other hand, after the snail population has reached stability or a "climax," collecting and destroying the snails, especially on an extensive and intensive scale, has been shown in a number of recent instances to reduce the population to a point where it never again completely recovers. Factors of population senility and "decline" doubtless enter into the picture at this phase. These points are discussed below.

But quite aside from whether or not the population is increasing or decreasing, hand collecting and destroying on the largest practicable scale is still the only inexpensive, effective method to which the poor native peoples can turn. For this very reason, it is currently being used on a far greater scale than any other method, especially in and around flower and vegetable gardens—where the greatest damage is done. Because the eggs and young are easily overlooked and because of the tremendous reproductive potential of these snails, the task of collecting resolves itself into an indefinite, daily harvesting. This is usually done in the early morning when the snails are still quite active, although occasionally it is done at night with the aid of a light. Rough terrain or dense vegetation makes this method impossible or impracticable (Corbett 1937). Unfortunately such conditions are common in areas where *A. fulica* abounds.

It is of interest and perhaps significance at this point to note the effect of hand collecting in the control of other terrestrial gastropods. Both Basinger (1923*a*, 1927) and Gammon (1943) strongly indorse this method; in fact, Gammon goes so far as to say that it "in many instances has constituted the difference between success and failure" in the control of *T. pisana* in California. Lewis and LaFollette (1941), on the other hand, report that it is of some value in controlling *H. aspersa* in California citrus groves but, in general, is "not satisfactory." Barnes (1949*b*) removed between 10,000 and 17,000 slugs per year for four successive years in a garden in Harpenden and "in spite of removing these numbers no reduction in population was observable."

The real problem in this method, however, is not the mechanics of collecting the snails but what to do with them after they are collected. At first thought, this problem would not seem to be a big one; but one reconsiders when one learns that large-scale collections will bring in tons of snails almost indefinitely. What then? South (1926*b*) was the first to make a number of suggestions in an attempt to answer this question. These and other suggestions should be considered here for what they are worth.

Usually, the snails are dumped into pits, crushed, and covered with soil. In Java during the early phases of the invasion by the giant African snail, 2,105,743 snails and 491,350 eggs were collected in a few weeks' time and disposed of in this manner (Leefmans 1933*c*). In some cases, they had not even been crushed; but a two-foot layer of superincumbent, well-packed soil insured a complete kill. Plunging the snails into boiling water; dusting them with CaO; letting them soak in solutions of $CuSO_4$ (4 per cent) or NaCl before burying them—all have proved successful. Such methods, however, add needless expense and man-hours of labor. Further, the addition of these chemicals to the soil in any great quantity can produce unfortunate changes in the soil and therefore the plant cover it can support. And, as pointed out above, even the addition of $CaCO_3$ in the form of snail shells will change the soil pH in a basic direction. In strongly acid soils, this might have an advantage; but in cases where the crops, such as tea, demand an acid soil, a change of this sort could reduce crop yields. Such actually has been the case, for example, in some parts of Ceylon.

Dumping the live snails into the ocean or rivers has already been shown to be inadvisable. Crushing them before dumping them in the ocean would seem in many respects to be the best way to dispose of them. Unfortunately, collections of snails made even a reasonably short way inland manifestly could not practicably be disposed of by this means, to say nothing about the danger of starting new foci of the infestation along the route. Burning the snails in incinerators or on piled brush has been frequently resorted to and, although this method has merits, the offensive smell and its effect upon health have to be taken into consideration.

Obviously, the best method of "disposing" of the collected snails involves making *use* of them for the benefit of man. This whole subject is discussed in detail in chapter eight.

Shifting Cultivation In many areas, for example in the colony of North Borneo, the natives practice shifting cultivation to insure continued high yields in their crops. They clear off an area and put in their crops. The giant snails gradually invade the preferred cultivated plots from adjacent second growth areas. Hand collecting by the natives simply and effectively impedes this invasion. By the time the snail population has built up sufficiently to cause concern, the few harvests and the tropical rains will have removed the greater share of the soil nutrients, and it will be time to move on anyway to another area which has not recently been cultivated and which naturally supports only a small snail population—or perhaps none at all.

In contrast, some native people will travel long distances to plant crops in achatina-free areas. A case in point was found in Rota in 1949. According to Frank L. Brown of that island, the inhabitants travel almost ten miles on foot to the opposite side of the island to plant their watermelons, of which the giant snails are inordinately fond. In that achatina-free area, examined by Kondo and the author, the watermelons grow to full maturity with practically no care. Such was almost impossible in the snail-infested areas.

Traps So far as can be determined, no elaborate trap has been devised to control *A. fulica.* In fact, trapping as such has been quite incidental to other control measures even in intensive programs. Typical of trapping methods in general, the little trapping that has been done has been designed to take advantage of a particular proclivity or appetite. The snail's manifest fondness for decaying vegetation has encouraged some people to pile plant debris peripherally around an area to be protected and then periodically either collect and destroy the snails that this debris has attracted or burn the debris to kill the snails. Fortifying the debris with a molluscicide is an obvious alternative and although this would increase the cost, it would reduce the labor of maintenance. In fact, to neglect unfortified peripheral piles of plant debris "traps" would seem only to invite greater snail damage.

Appealing to the snail's propensity for crushed individuals of its own kind has also been used in setting up traps. A group of snails is piled in a protected place and crushed, and when these have attracted other snails, they in turn are crushed only to increase the amount of "bait." A system of periodic visits to a series of such traps to kill any live snails in the vicinity has been reported as being very effective. An ever increasing accumulation of rapidly putrifying flesh and the flies it would attract are only two of several obvious drawbacks to a control measure of this sort.

Any device which would cause the snails in quantity to become stranded in the hot sun would be effective, as, for example, setting up temporary shelters in clearings and then removing them in midmorning. Again, however, the problem of the rapid accumulation of dead snails introduces great difficulties. An interesting though unintentional modification of this method was observed on Agiguan Island. Giant snails had sought refuge under large pieces of corrugated iron, only to be cooked to a turn the following day as the sun's rays heated the iron like a stove.

Chamberlin's work in Tinian (1952*a*, *b*) strongly suggests that the positive anemotaxis in *A. fulica* should be taken advantage of in setting out baits and traps by placing them upwind of the snail concentrations.