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ABSTRACT: None of the so-called developing countries has an adequate rodent control program at present. In only a few of these countries is any rodent control research occurring despite the fact that rodent problems are actually quite serious in many regions and potentially so in others. Expertise, techniques and materials from the developed countries are of limited usefulness because of major differences in rodent species involved, standards for food handling and sanitation, and in the cultural contexts in which rodent control must occur. Trained personnel, both for control work and the basic research needed, are in very short supply. In addition, rodent control is frequently a low priority item in the generally meager budgets of developing countries. To date international agencies, foreign aid programs and foundations have had very limited success in altering this situation, although at present there is an upsurge of interest in rodent control problems.

The problems of rodent control are much the same in both the developing and the developed countries. The major difference is that these problems are far more serious, widespread and difficult to solve in the developing countries. Thus, it is more a question of degree than of kind. Even the problems arising from reluctance to kill rats because of religious beliefs in Asia have somewhat of a counterpart in laws preventing cruelty to animals in North America and Europe. This does not mean, however, that knowledge and techniques available in the developed countries are easily applicable in developing countries. Such a view ignores the profound technical, cultural and political differences not only between the two groups of nations but also among the developing countries themselves.

Among the technical problems the most serious is that the rodents themselves are very poorly known. Basic life history studies are badly needed throughout Asia, Africa and the Americas. In some regions, India and Pakistan, for example, much has already been published but it is largely anecdotal and fails to include work on population dynamics. There has, of course, been some research on the taxonomy of rodents in developing countries. But, even here, the murid rodents, which include a major share of pest species are a taxonomically difficult group and more work is needed.

One of the few major research efforts on the population dynamics of a pest rodent is the study on the Lesser Bandicoot Rat (*Bandicota bengalensis*) in Calcutta warehouses by Spillett (1968). He was able to demonstrate in this species one of the highest population densities and reproductive performances yet reported under natural conditions. His estimates on food losses, based on known intake and population density, are of considerable value in assessing the impact of this species on man.

This problem of assessing damage is an important one throughout the developing countries. In India estimates of rodent damage to foodstuffs range from 2.4 million to 26 million tons annually (Pingale et al., 1967). When such estimates can range over an entire order of magnitude, there is clearly room for improvement. The chief difficulty lies in the extrapolation of very local and limited studies to very large regions, which magnifies any errors. The truth is, no one knows what food and goods losses from rodents are in the developing countries, or, for that matter, anywhere else. Fortunately, there is presently a U.S. AID rodent research team in the Philippines working on rat damage to rice. Equivalent work on other food crops is not under way.

Rat problems are aggravated by the fact that most of the species involved are native to the developing countries and are abundant and well-adapted to these areas. For example, the skin collections in East African universities contain a bewildering variety of rat and mouse species, many of them already serious pests and many more of them potential pests to developing agricultural regions. In India and Pakistan over 14 species are serious pests (Bentley, 1968; Pingale et al., *op. cit.*).

Particularly in Asia, agriculture is very ancient and rodents have had a long time to adapt to human-dominated environments. This raises the question of the occasional calls for rodent "eradication." It is very doubtful that we could successfully eliminate all the pest rodents from regions as complex as those in the tropics and subtropics. Even if this were possible, our current lack of understanding of the other roles played by rodents in their ecosystems rules out such drastic measures. Rodents may consume insects, weed seeds and a variety of other items which are important to man's agriculture and public health.

Even where specific control measures have been instituted and show some success, we are hampered by a lack of field testing of alternative methods on a comparative basis. In India, for example, one control program was based on the use of traps and the acute poison zinc phosphide (Deoras 1968). In another location, rat control is done with the slow, cumulative anticoagulants (Krishnamurthy et al., 1968). Practitioners of these two approaches, both operating at the village level, disagree on their relative effectiveness. What appear to be needed are well-designed, large-scale field tests comparing the methods. To the best of my knowledge, this has yet to be done.

A complicating factor in developing countries is the danger of using acute poisons among populations with a high level of illiteracy and low nutritional levels. In these populations which contain large numbers of children, there is an ever-present danger of accidental poisoning; hungry children the world over, will eat almost anything. Yet the acute rodenticides, especially zinc phosphide, are the most widely used, and the relatively safe anticoagulants are quite limited in application. A major reason for this is the time and attention required for effective application of the anticoagulants. Where poverty is widespread and population density is high, most of the labor force is busy from dawn to dusk eking out a living, they have little time or inclination to tend bait stations. This situation is changing, however, as the level of sophistication in farming practices rises.

The widespread use of acute poisons under these circumstances generally requires that the technical personnel employed be specifically trained for rodent control work. This introduces additional complications. A major problem in developing countries is the shortage of technically trained workers. Since other programs (e.g., industrialization, agricultural production) are generally of a higher priority, few rodent control workers are trained.

It is a characteristic of human behavior in all fields of activity to institutionalize and bureaucratize. The field of rodent control is no exception. In developing countries this may reach particularly vexing proportions, partly because of the large educational gap between the control technicians and those they serve. Thus, it is typical that most rodent control is done by periodic rat-killing campaigns which are organized and imposed from outside the villages involved. While these campaigns frequently produce spectacular kills, follow-up work is seldom attempted and instead the control crews move on to other villages. Since there is little direct involvement of the beneficiaries, there is essentially no residual impact and after the campaign things return quickly to "normal" problem levels. It would, of course, be desirable for follow-up work to be done by agricultural extension workers, but these too are in very short supply.

Poor communication is at the root of yet another problem. Extensive outbreaks of rodents may occur without the knowledge of responsible government agencies. Travel to the hinterlands in developing countries tends to be difficult at best, especially during rainy seasons. By the time reports of rodent damage or, for that matter, rodent-borne disease, reach the population centers, major damage or illness has already occurred. It is not unusual to get two entirely different accounts of rodent problems, one from officials, and the other from farmers and slum-dwellers. Of course, the developing countries have no corner on this particular problem, as recent events in the U.S. Congress will testify!

Where human beings have been living with large numbers of rodents for a very long time, they develop a pretty high tolerance for the rodents. It is thus necessary to educate such people to the actual impact rodent pests have on their lives. Rodent damage to crops may be simultaneously widespread and difficult to detect. This paradox exists in part because rodents may spread their depredations widely through fields of small-grains such as rice, wheat and barley, where the vegetative growth is dense. Usually the damage to these crops can be detected only by a laborious, time-consuming search for cut tillers, unless the affected areas are relatively small. Rodent depredation is more easily detected in crops such as maize, because any plant attacked is likely to be extensively damaged: rodents climb the stalk and do conspicuous damage to all or most of the ears.

The difficulty of detecting rodent crop damage also stems from the fact that very poor accounting methods typify agricultural production in developing countries. Grain grown for home use is not weighed or measured, and the farmers have only a sketchy knowledge of actual production. This makes detection of stored grain losses difficult. Home storage of grain for family use accounts for up to 70% of production in the countries of Asia. Most of this grain is stored in bins, jute bags, or in rooms that are neither insect nor rodent proof. Losses are widespread and rarely does one examine such storage without finding rodent damage. The house mouse (*Mus* sp.) is an especially serious pest of grain stored under such conditions, and its habit of widespread nibbling adds to the difficulties in detecting losses.

Thus, another major rodent control problem is providing rodent-proof storage containers. A variety of such bins has been devised, generally from sheet metal, and some are unquestionably affective. The major difficulty is cost. Where subsistence farming is the rule, the cash outlay for such bins is generally prohibitive without extensive subsidies. At present, such funds are in generally short supply and the outlook for the immediate future is not good. There is a real need for research on effective alternatives to current storage facilities, especially on the adaptation of indigenous materials and techniques familiar to farmers.

The rapid expansion of population and increased demands for additional food have resulted in an extension of agriculture into previously unfarmed areas. These "new lands" programs have on several occasions been accompanied by a dramatic increase in rodent damage. An enormous outbreak of rodents, which reached a peak in 1953, occurred in the Philippines on the island of Mindanao (Clark, 1958). This outbreak coincided with extensive new agricultural development and was so severe that relief supplies had to be brought in to the beleaguered farmers to prevent starvation. There are scattered reports, generally undocumented, of such "new lands phenomena" throughout the developing countries. The most recent one I am aware of was reported in Ethiopia, where losses in barley planted on new lands exceeded 50%. Unfortunately, we suffer from the same problem as do epidemiologists. By the time news of such out-breaks reaches us, the critical time to study and understand how such events developed has passed. Consequently, much of what we can say about these rodent outbreaks is conjectural.

The increases in agricultural production involve not only opening new lands, which are in short supply, but most especially the use of better seeds and improved farming practices on land already in production. This increases the concentration of available food/acre not only for man but also for his pests. Rodent damage to higher yielding varieties of grain may be very severe and such situations support high rodent concentrations. Also, cropping is being extended into traditionally "off" seasons when water has been in short supply. This results from using drought-resistant grains and improving irrigation. Rodent damage to these off-season crops may be especially severe, particularly if the fields are surrounded by uncultivated areas. One can also imagine that such increases in food during seasons normally difficult for rodents will increase the carrying capacity and larger populations will be present at the beginning of the usual cropping season.

I think it is clear from the foregoing that there is no shortage of rodent problems in the developing countries. Despite this, the contribution of the developed countries to solving these problems has been slight. The reasons for this are complex. Technologically and scientifically North America and Europe (including the USSR) are best equipped to develop rodent control programs, and most of the theoretical background research on rodent populations has been done in these regions. With the possible exception of the USSR, however, rodent pests are not the serious agricultural problem in temperate regions that they are in the tropics and subtropics, notably in South Asia and the Pacific Basin. There has been some good research on agricultural rodent pests in each of the "developed" regions, but the demand for such work is not great.

The most important rodent pests in North America and Europe are the commensal rodents closely associated with human habitation. Our primary attention has been focused on town and city rodent populations living in relatively simple environmental circumstances. Certainly, from a theoretical viewpoint these rodents, most of them introduced from elsewhere, are easy to control by manipulating their environment. There is ample evidence that good sanitation, harborage removal and rodent-proofing of buildings will greatly reduce or eliminate these pests. The chief problem lies in changing human behavior to achieve these results. From a practical viewpoint this is extremely difficult to achieve, so much so that many biologists and rodent control specialists have considered it beyond the realm of their professional capabilities. This has resulted in a serious stalemate in urban rodent control and reliance on such short-term and relatively simple procedures as rat killing campaigns and spot treatments in answer to complaints. Efforts are currently being made in some of the major cities of the U.S. to break this stalemate, but the sociological and public affairs orientation of these programs is of limited applicability to cities in other human cultures or to the problems of agricultural areas. This is also true of the "rat-free" towns program in Germany where intensive poisoning and superior sanitation give good results (Jackson, 1968). While the general level of sanitation in German towns may be a model to emulate in the villages of South Asia, it is extremely unrealistic to believe that this can be accomplished in the near future, it is a tribute to Teutonic determination that the Federal Republic of Germany is trying to adapt this approach at present to the barrios of the Philippines.

A large number of professionals concerned with pest control in the developing nations were trained in the U.S. and Canada. Since these regions do not have an agricultural rodent

pest problem of serious dimensions, the education given there does not often consider these pests. Certainly we do not have much familiarity with the problems as they are encountered in the fields and villages of the developing nations.

It is extremely important to realize just how much rodent problems are, in reality, cultural problems. The way a farmer tends his fields and handles his grain is strongly influenced by tradition. Levels of tolerance for rodents are a product of the culture itself and are interwoven with accepted standards for such things as sanitation, food contamination and dwelling construction. In India the reverence for life extends to rats and in many villages rat-killing is impossible. At Dethnoke in the Rajasthan desert is a beautiful temple dedicated to the rat where a population of thousands of *Rattus rattus* are fed and protected. Ganesh, a very important Hindu god, reputedly rode on the back of the rat, and this god typically had a rat portrayed at its feet. It seems clear that cultural and social considerations are generally of overriding importance in rodent control. The usual level of understanding of other cultures by specialists from developed countries is inadequate, and we must accept the fact that control of rodents in developing countries will only begin to be effective when directed by those who understand these cultural implications. Only then can our rodent control technology be translated into effective local programs.

Finally, although we have indeed made great strides toward understanding the complex interactions governing population size, much remains to be learned, especially about the applicability of our models to reality. It is difficult to justify the expenditure of large amounts of time and money on some of the more sophisticated and long term rodent control proposals until we can more accurately predict the outcome. And meanwhile, the problems won't wait! Thus we are forced to do what we can in the name of expedience to satisfy the need and demand for rodent control. This, coupled with the usual shortages in funds and manpower, results in programs designed for immediate, visible results of a predictable sort.

The result of all these difficulties is that rodent control in the developing countries is in a rudimentary stage at present. There is a big gap between what is being done, in the form of rat campaigns, and what is possible through application of the ecological principles underlying effective long-term control. Fortunately, a number of international agencies, national governments and foundations have shown renewed interest in these problems. If the entire complex of technical, cultural and political factors are taken into account by these agents, we can hope for some signs of improvement in what is presently a fairly bleak situation.

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