

**WORLD HEALTH
ORGANIZATION**



**Regional Office
for the Eastern Mediterranean**

**ORGANISATION MONDIALE
DE LA SANTÉ**

**Bureau régional
pour la Méditerranée orientale**

SEMINAR ON PUBLIC HEALTH AND ECONOMIC
ASPECTS OF RODENT CONTROL

Alexandria, 2-8 December 1974

EM/SEM.PH.EC.ASP.ROD.CTL./12

21 October 1974

ENGLISH ONLY

PRINCIPLES OF RODENT CONTROL

by

Dr. W.E. Howard*
WHO Temporary Adviser

* Professor of Wildlife Biology and
Vertebrate Ecologist, California, USA

TABLE OF CONTENTS

	<u>Page</u>
I. Preliminary Survey, Collection of Basic Data, Assessment of the Needs.	1-7
A. Preliminary survey	1-2
(1) <u>Biopolitics</u>	1
(2) <u>Define the problem</u>	1
(3) <u>Examples</u>	1-2
(4) <u>Ecological factors</u>	2
B. The Collection of Basic Data	3-6
(1) <u>Species identification</u>	3
(2) <u>Determining population density</u>	3-5
(3) <u>Review previous control efforts</u>	5
(4) <u>Establish communications</u>	5-6
C. Assessment of the needs	6-7
(1) <u>Political support</u>	6
(2) <u>Leadership</u>	6
(3) <u>Back-up research</u>	7
(4) <u>Funds and equipment</u>	7
II Strategy and Plans of Control Programmes	8-15
A. Planning	8
B. Why rat control programmes frequently fail	8-9
C. Miscellaneous principles of control	9-12
D. Annual rodent control campaigns	12-13
E. Outline for rodent control programmes	13-15
(1) <u>Write out detailed plans</u>	13
(2) <u>Make a survey</u>	13
(3) <u>Laws and regulations</u>	13
(4) <u>Government structuring and available co-operation</u>	13
(5) <u>Budget, equipment and supplies</u>	14
(6) <u>Communication and education</u>	14
(7) <u>Sanitation, sewers and drainage</u>	14

	<u>Page</u>
(8) <u>Buildings and street repair</u>	15
(9) <u>Exclusion (rat proofing)</u>	15
(10) <u>Control methodology</u>	15
III. Biological and Ecological Aspects	15-19
A. Principal categories	15-16
(1) <u>Habitat requirement</u>	15
(2) <u>Reproductive capabilities</u>	15
(3) <u>Food habits</u>	15
(4) <u>Life history</u>	16
(5) <u>Social behaviour</u>	16
(6) <u>General behaviour</u>	16
(7) <u>Senses (vision, smell, taste, hearing, touch)</u>	16
(8) <u>Movements</u>	16
(9) <u>Physical abilities (climbing, jumping, digging, gnawing, and swimming)</u>	16
(10) <u>Dynamics of structure of populations</u>	16
B. Population dynamics	16-18
C. Balance of nature	18-19
IV. Rodenticides (Characteristics)	19-25
A. Ideal rodenticide	19
B. Acute rodenticides	20-23
(1) <u>General comments</u>	20-21
(2) <u>Zinc phosphide (Zn_3P_2)</u>	21
(3) <u>Sodium fluoroacetate (1080) and fluoroacetamide (1081)</u>	22
(4) <u>Red squill or scilliroside</u>	22
(5) <u>ΔNTU or alpha-naphthylthiourea</u>	22
(6) <u>Norbormide</u>	22
(7) <u>Strychnine</u>	22
(8) <u>Thallium sulfate</u>	22
(9) <u>Other acute rodenticides</u>	22
(10) <u>Experimental compounds</u>	23

	<u>Page</u>
C. Chronic rodenticides	23-24
D. Reasons for failures with anticoagulants	24-25
(1) <u>When baits are well accepted</u>	25
(2) <u>When baits are poorly accepted</u>	25
E. Safety precautions with rodenticides	25
V. Rat Resistance to Anticoagulant Rodenticides	26
VI. Principal Methods of Rodent Control	26-30
A. Rodenticides	27
B. Baits and baiting	27-30
(1) <u>Formulating baits</u>	27-28
(2) <u>Bait preference tests</u>	28
(3) <u>Trebaiting</u>	28-29
(4) <u>Bait placement</u>	29
(5) <u>Bait stations (bait boxes)</u>	29-30
(6) <u>Water baits</u>	30
(7) <u>Paraffin bait blocks</u>	30
VII. Trapping, Tracking Powder and Fumigants	30-31
A. Traps	30-31
B. Tracking Powder	31
C. Fumigants	31
VIII. Community Sanitation and Rat Proofing Premises	31-32
IX. Various Other Control Techniques	32-33
A. Chemosterilants	32
B. Repellents	32
C. Diseases	32
D. Predators	33
E. Bounties	33

- I. Preliminary Survey, Collection of Basic Data, Assessment of the Needs
- A. Preliminary survey -- A rodent problem has been reported. You are requested to investigate. What should your preliminary survey include ?
 - (1) Biopolitics. Become familiar with what branches of various government levels are involved with the rodent problems. Rodent control is very much a people problem. As must be said over and over again, killing rodents is not difficult; the problem is to develop a safe and economical programme that will work effectively with the biopolitical situation which exists.
 - (2) Define the problem. Make sure that you have clearly defined what the rodent problem consists of, and that you have been able to express it in writing. Unless the problem has been described in written words, it probably has not been adequately thought through. Is the problem important because of its significance to public health, agriculture, stored foods or field crops ? Is it a general nuisance or an unusual problem situation, a perennial or temporary problem ?
 - (3) Examples. What specific examples can be found to define the problem ? What specific damage has occurred ? How extensive are the losses thought to be ?

Rodent control, especially of rats and mice, is complementary to other procedures for maintaining a cleaner and more sanitary community, since effective rat control is benefited by frequent garbage collection, a good sewage disposal

and storm drainage system, and general cleanliness in the municipality. Rats do not recognize municipal, county, or other governmental boundaries any more than they recognize individual property lines.

It is worth noting that the presence of a high rat population is often a symptom of some other greater social and community problem. Rats exist in a community today only because: 1) of man's indifference; 2) his lack of recognition of both the dangerous health hazards and the magnitude of the economic losses caused by rats; or 3) he either does not have the necessary materials or knowledge as to how to control the rats.

- (4) Ecological factors. Are there significant environmental factors that have created the rodent problem? Higher yielding varieties of rice and other cereals are often the ones most seriously attacked by rodents. If the habitat has been altered, is there an ecological solution to the problem? Note the population of non-target species such as domestic animals that will have to be considered prior to the use of toxic rodenticides. Are crop storage facilities adequate and rodent proof? Animal control is not the killing of a few objectionable animals, but is applied ecology. Usually it is the regulation of population densities of species that have become troublesome because of their increased density, often as a result of man's agriculture or other modification of the environment. All control measures should be based on a proper translation of ecological factors into effective ~~management~~ policy.

B. The Collection of Basic Data

- (1) Species identification. The number of kinds (species or subspecies) of rodents present varies greatly in different parts of the world, and their proper identification is often difficult, even to the species level. This is true with both the field rodents and the commensal rodents. Even the different kinds of rats of the genus Rattus present in some localities are difficult to identify. But it is usually quite important that rodent pests be properly identified at least to the species level, because the kinds of rodenticides used and the methods of control can vary depending upon the species. For example, sometimes placing all of the anticoagulant bait stations at ground level does not control all of the roof rats (R.rattus).
- (2) Determining population density. It is extremely difficult to census a rodent population, and it is usually necessary to use relative densities, that is the sign or the number of animals trapped is more or less than at some other location or over a period of time. Using the most practical criteria, the success of a control operation may be based on the relative difference between the pre-and post-census. On what bases are criteria to be selected ?
 - a. Sign. These include sounds of rats in buildings (gnawing, clawing, running and climbing, various squeaks, and fighting noises); the size, number, and freshness of droppings; urine stains on stored foods identified with ultraviolet light; smudge marks on pipes and beams made from the oil and dirt on the fur of rats; runways on the ground or well-polished trails next to walls or between stored goods; footprints or tail marks in dust, sand, or muddy places; presence of

gnawed wood chips or other material, which sometimes reveal sign of tooth marks to help distinguish between rats and mice; visual sighting of rats in daytime generally indicates a high population; night observations with a powerful flashlight are often helpful; nests and food caches; behaviour of cats, dogs or other pets may indicate presence of rodents; and sometimes rat or mouse odours will indicate their presence.

- b. Trapping. Some rodents are easily trapped by live traps or kill traps, but, in general, rats are quite difficult to trap. This method is generally too difficult and time-consuming to be practical in the collection of basic data. With many field rodents, fairly useful estimates of the relative number of individuals present can be determined by setting a fixed number of snap traps for one to three nights before a control operation and then follow with the same number of trap-nights (number of traps times the number of nights traps were set) after the control.
- c. Amount of food eaten. Some estimate of the minimum number of rodents present can be obtained by placing measured amounts of non-toxic bait in various locations for a week or so and recording the maximum amount consumed during any one night. With rats, this amount can be divided by 10 grams to obtain a rough estimate of the minimum number of animals that were feeding on the bait. This method is seldom practical with rats, however, because it may take them too long to start feeding on the bait, it is too difficult to keep other animals from eating it, the rats may have too much other food available to spend much time feeding on the bait, or, even if it is a ground food, an occasional rat may cache far more than it eats.

- d. Tracking patches. Talc or flour can be spread along walls or wherever rodents would be expected to travel, and then examined for several days to determine whether rodent tracks appear on them. Even though some animals may at first shy from these tracking dusts, it is still one of the most practical ways of determining whether or not rodents are in a building. It is so sensitive that it is hard to use for determining relative densities. In Korea it was found that wheat flour worked better than talc and that patches put out only one night gave reliable results. Also, it is possible to distinguish between mouse and rat tracks.
- e. Bait spots. A food item, such as a single kernel of ear corn, a sunflower seed, or some other food item can be placed at a strategic location where rats or other rodents are likely to visit. The number of these individual baits that are taken overnight are an indication of the relative number of commensal or field rodents present. They can be dyed with a food dye or some other non-repellent dye to make them easier to locate and identify.
- (3) Review previous control efforts. It is very worthwhile often to analyze carefully why previous attempts to correct a rodent problem may have failed before starting another programme. Too often the same mistakes are repeated because programmes which have failed are seldom well documented. Good points of previous programmes should also be considered in new control efforts.
- (4) Establish communications. It is generally worthwhile to make many inquiries before launching a control programme. Visit as many officials and individuals related to the problem as is possible, and it will be surprising how much you will learn about the history of the rodent problem you are concerned

about and previous mistakes that were made in attempting to cope with the same problem. Most people find it difficult to ask questions. They fail to realize that to ask someone a question is a form of flattery to that person, and your gesture of humility will usually be appreciated.

C. Assessment of the Needs

- (1) Political support. There is little chance of obtaining support for a rodent control programme from individual property owners if local and national governments fail to support the programme. With rat control how can individuals be expected to do their part if government fails to control the rats in areas under their jurisdiction like public waste dumps, sewers, parks, etc ? How can homeowners be expected to rat proof their houses and practice good sanitation if government does not set an example ?
- (2) Leadership. To kill some rats is quite simple, but to effectively control a rat population requires trained personnel. This will be discussed further in another section of the Seminar.

Before rodent control campaigns can be effective, the administrative organization must be properly structured. A first premise to any area-wide or community-wide rodent control programme is to establish the correct administrative responsibility. Without precise designation of the various channels of authority, it is impossible to co-ordinate the other aspects of a successful control programme such as public health, sanitation, garbage collection, sewage disposal, street repair, building construction codes, and other activities related to rodent infestations.

- (3) Back-up research. No permanent rodent control programme will be any better than the back-up basic and applied research unit studying the problem. Rodent control, unfortunately, is highly unsophisticated and much more research is needed throughout the world.
- (4) Funds and equipment. The basic reason nearly every cereal crop in some parts of the world is damaged by rodents at one stage or another, either in the field or storage, is because so little resources have been available for coping with these problems. This field of science is still quite unsophisticated, even in the developed countries. No rodent control programme will be successful if it is inadequately funded and the necessary equipment is not available.

For a control operation to be successful, the bait materials must be of good quality. Many a programme has failed because there was an attempt to save money by using inferior bait materials or toxicants. Blenders and mixers are essential for formulating good baits. Proper safety devices and equipment must be available for the safety of the formulator or the applicator.

There is a good deal of technical information available in the world about the more common rodents, although this knowledge is scanty and based on limited research compared to what is known about the economically significant kinds of insects, plant and animal diseases, weeds, crops and livestock. The methodology of rodent control in the United States of America, and throughout the world, is not very sophisticated, and the solutions to many rodent and other vertebrate pest problems often cannot be found in other countries but will have to be researched, in part, in each country.

II. Strategy and Plans of Control Programmes

- A. Planning -- It hardly needs mentioning, since it is so obvious, that no rodent control programme should be initiated until it has been very carefully planned and outlined in writing to the minutest detail.
- B. Why rat control programmes frequently fail -- How to control rats is not complicated. There are a variety of effective rodent control tools available. Methodology for rat control - including dry and liquid poison baits, tracking powders, traps, rat proofing, and environmental sanitation - is well known. Then why are many rodent control programmes failures?

Effective rat control is not just a matter of using the best biological control procedures, but more importantly it requires a thorough knowledge of the various human relationships that are involved. The most complicated part of a successful rat control programme is to analyze properly and completely all of the economic, social, and political aspects of the programme. No control programme will be successful unless all of the scheduled steps involved are completely acceptable to government and also the people who will be affected by the control operation.

No rat control programme will succeed unless it is designed so that the people concerned will give it their enthusiastic support. An ideal rat control programme, as far as methodology is concerned, may ultimately fail because for some, often obscure, reason it proved unworkable with the cultural, philosophical, or political aspects of the people the programme was designed to serve. Usually it either costs too much or expects too much voluntary support from the people before the programme could possibly succeed.

Even the best researched rodent control programme may fail if there is inadequate publicity. The most difficult part of any control operation is to create truly enthusiastic support from those who are to benefit by the reduction in rodents. One common reason for lack of support is that the people may lack confidence in the programme because previous attempts have failed, or, more likely, they do not understand the merits of the programme sufficiently to share the pest control operator's optimism.

The most important hurdle to surmount is adequate communication between the control operators and the people. This does not mean merely explaining what is to be done, but rather the much more subtle aspects of a close communication which produces deep appreciation and understanding of each other's thoughts and opinions. This is the type of communication that is extremely difficult to obtain between people of different cultural, economic, social, or political backgrounds, yet it is essential. It is far more complicated than designing the control procedures to be followed. And this mutual understanding should receive the highest priority, for only after it has been achieved can good decisions be made regarding how rats should be controlled and kept under control.

- C. Miscellaneous principles of control -- Improperly conducted rat control programmes are inexcusable and they may create much criticism, producing widespread emotional bias against the control operation that will be difficult to rectify in the future. However, control operations must be both realistic and practical. They need to be simple, inexpensive, effective under adverse weather conditions, adaptable to various types of habitats, and the methodology must not require too frequent attention. Immediate action is often needed due to political pressures. Even so, the operation must be based on practical

needs, intelligent appraisal, and thorough planning. One important aspect to consider is that if additional research and improved communications are also undertaken at the same time, it will mean that the same operation will be conducted more effectively the next time.

When field rodents are damaging an agricultural crop, it usually is necessary to control them with poison bait. Some biologists suggest that instead of using poisons it would be better to find a means of altering the habitat or to develop a procedure for harvesting or managing the crop so as not to provide a suitable habitat. This is a good principle, but usually highly impractical since it is the agricultural crop that makes the habitat suitable for these species of rodents, and to stop planting the crop is not a satisfactory solution. However, most rodent pests first invade a crop by immigrating from some other habitat. Quite often habitat modification, such as weed or vegetation control around the periphery of the planted crop, will effectively prevent adjacent populations of potential rodent pests from developing which later can disperse into the field containing the agricultural crop. But it may destroy desirable nesting cover for birds that require this vegetation.

If a dense infestation of rats exists, it is highly advantageous both economically and from the point of view of control effectiveness to first use one application of an acute rodenticide. If possible, of course, precede this poisoning operation with several days of pre-baiting, using the same bait material but without the toxic rodenticide. Following the application of the acute rodenticide, a permanent or maintenance control programme with an anticoagulant (a chronic rodenticide) should commence. It is desirable to use different kinds of bait material with the two poisons. The anticoagulant baits will remove any survivors of the acute

poison and prevent any immigrating rats from becoming established in the treated area.

One of the main reasons rat infestations are not eliminated, is because effective area-wide control efforts are not accomplished. All rat populations should be controlled simultaneously. Usually it is not possible to eradicate rats completely from large areas because they quickly immigrate into controlled areas from sewers, drains or other locations where some were able to survive the control efforts. Rat-free conditions can be achieved only if the rats are controlled in all parts of a region or city at the same time, and if there is also an inspection team or reporting mechanism available to detect promptly the establishment of any new colonies. Another factor responsible for the general lack of rat-free conditions, even though control has been carried out, is the common belief that it is impossible to eradicate rats from any sizeable area, so no genuine attempt to do so is tried. Furthermore, too often the people doing the control do not have sufficient knowledge about the behaviour, ecology and control of rats. For example, after rats have been controlled in a sizeable area, most new immigrants that move into the area usually do so by following rivers, streams, ditches, or other embankments as along roads or railways.

Another important reason why many control operations fail is because bait acceptance tests were not done prior to the poisoning programme. There is always a strong incentive to economize with the bait material used, since this is often the major expense to a control operation. When one type of bait material only costs half as much as another one, there will be strong pressures to use the cheaper material. The person in charge is always tempted to assure himself that acceptance of the cheaper bait will probably be adequate.

even though no careful field bait acceptance tests have been conducted to ensure that acceptance will be adequate. It takes but a small proportion of a population of rats to refuse a bait to cause the difference between a failure and effective control. Most successful control operations would have been a failure if very few additional rats had survived, because it takes very few rats to provide the breeding potential necessary for the population soon to build up again.

- D. Annual Rodent Control Campaigns -- The reason most annual rat control campaigns have not solved the pest problem is because the necessary follow-up work is not done. Any animal as prolific as rats and some other small rodents cannot be effectively controlled by an annual campaign, unless there are practically no surviving rodents. If very many individuals survive, the population will soon recover due to their high reproductive potential and the high survival of the young following a control operation.

With annual campaigns it is impossible to obtain area-wide coverage, and for one reason or another many populations of rodents will be missed. Furthermore, it is not possible to obtain effective control when so many untrained people are trying to use an acute rodenticide. Killing large numbers of rodents may only provide temporary relief. The objective should be permanent control aimed at achieving as near a permanent rodent-free situation as is possible.

The only value of most annual rodent control campaigns is that they keep the subject before the people, and public awareness is one requirement of any successful programme. Where year-around control is being practised with anti-coagulants, an annual campaign might be used to locate any rat infestation that has been overlooked or, due to resistance or some other reason, has survived previous control efforts. But once an urban rat control programme becomes successful,

there will be little public interest in annual campaigns, so they should be discontinued.

- E. Outline for Rodent Control Programme -- It is far more complicated to carry out a successful rodent control programme in a city than it is with agriculture, because of the many more socio-political problems associated with an urban environment. The following list covers most of the principles concerned with the strategy and plans to consider when developing a control programme for an urban or field situation.
- (1) Write out detailed plans
 - (2) Make a survey. Determine the extent and severity of the problem and correctly identify the species involved.
 - (3) Laws and regulations. One must become very familiar with the various laws and regulations that pertain to all aspects of rodent control. Often the insistence that certain existing laws be enforced will expedite a control operation, especially those laws that require better sanitation practices. Those experienced in rodent control should be willing to recommend any new laws or regulations that may be needed to ensure an effective control programme.
 - (4) Government structuring and available co-operation. Complete familiarity with the many branches of government responsible for various aspects of a rodent control programme is essential. Too often those responsible for a rodent control programme have not established good communications with the various branches of government and the other agencies and organizations that could help with the control operation.

- (5) Budget, equipment, and supplies. Make certain the operation will be adequately financed and that the necessary equipment and supplies are procured well in advance of their need. Do not attempt a control operation that exceeds the available finance and equipment. The plan of operation will vary considerably depending upon resources available.
- (6) Communication and education. Good communications must be established between all who are related to the problem. The public must be fully informed of urban rat control programmes, for everyone's co-operation or assistance will be needed. The mass media (newspapers, etc.) should be used. Education about the need for rodent control at all levels in schools is wise, for children will then take the information home to their parents. Films and slide-tape programmes make excellent visual aids. The films should indicate the various things homeowners and shopkeepers can do to control rodents. Examples are rodent proofing, proper storage of foodstuffs, how to deprive rats of water, how to seal holes and cracks in foundations, the proper way to use anticoagulant rodenticides, how to set snap traps, and all aspects of sanitation and general cleanliness and tidiness.
- (7) Sanitation, sewers and drainage. Refuse storage and collection practices generally need to be improved. Poor sanitation with open sewers and drainage systems providing rats with drinking water and good harbourages make urban rat control extremely difficult. Open garbage and other waste foods and refuse can lead to rodent infestations on farms and in cities. Also, improper storage of foodstuffs and other materials often provide suitable food and cover for rodents.

- (8) Buildings and street repair. Many dilapidated buildings should be destroyed and holes in streets, sidewalks, walls and buildings, which provide access for rodents to food or shelter, should be sealed.
- (9) Exclusion (rat proofing). The most effective and permanent form of rodent control is permanently to exclude them by building them out, that is, make it impossible for the rodents to find any access into houses, apartments, hotels, warehouses, sewer or drainage systems, septic tanks, etc. All places where food is stored, processed, prepared, or served should be rodent proof, all openings where water pipes, electric wires, telephone wires, sewer pipes, drain spouts, and vents enter a building should be tightly sealed to prevent rodent access. Doors, windows, screens, and roofs must be tight-fitting. Rodents even enter buildings through chimneys that are not covered with a wire mesh screen. Do not use gnawable material when rodent proofing.
- 10) Control methodology. This involves the type of materials that will be needed and the procedures to follow.

III. Biological and Ecological Aspects

- A. Principal Categories -- Any attempt to control rodents should be done in an ecological context. This means that if one is to plan a control programme properly so the operation will be truly effective, he must thoroughly understand the following characteristics of the rodent species that is to be controlled. It would require too much space to write comments here about each of these categories, so they will only be listed here, but will be discussed at the Seminar.

- (1) Habitat requirements
- (2) Reproductive capabilities
- (3) Food habits

- (4) Life history
- (5) Social behaviour
- (6) General behaviour
- (7) Senses (vision, smell, taste, hearing, touch)
- (8) Movements
- (9) Physical abilities (climbing, jumping, digging, gnawing, and swimming)
- (10) Dynamics of structure of populations

B. Population Dynamics -- As density of a rat population increases, the reproductive success, that is the number of young that are successfully reared to weaning age per adult female and by the entire population, will eventually decline to more or less that needed to replace the adults that die. On the other hand, after a rat population has been reduced 70 or 80 per cent by a control operation, the reproductive success of the survivors will be greatly increased since all offspring will then have a much better chance of surviving. For example, the main reason the human population has increased so much during the past century, even though the number of babies produced per family has declined, is because such a high percentage of the children that are born now live long enough to produce children of their own. For most of the time man has been on this earth, infant mortality was very high.

One of the major concepts that must be understood, if a rodent control campaign is to be effective permanently, concerns the population dynamics of the species to be controlled. This is the term that includes reproduction (number, size, and frequency of litters produced), mortality rates, and various movements (home range, immigration, migration and emigration)

made by individuals. These factors are all related to the density of the population, weather conditions, the suitability of habitat (food, water, cover, and breeding places), presence of other competing species and predators.

The mortality rate is another important aspect of the population dynamics of rodents, for that is what prevents birth rates from getting completely out of hand. As the population increases in density the mortality rate soon increases rapidly due to self-limitation (a self-regulating mechanism) of rodents. The rodents then become their own worst enemy; thus preventing any further increases, after a certain maximum carrying capacity density is reached. Among the various ways this population self-limitation is achieved there does seem to be a pituitary-adrenal mechanism that acts as a negative feedback, with some species, by reducing the birth rate and increasing the mortality rate after the population begins to reach a high density. Unless control operations are highly successful or permanently maintained by using anticoagulants, everything seems to favour a rapid recovery in the density of any population that predators or rodent control operations have reduced below the carrying capacity of the species in that particular set of environmental conditions. This homeostatic mechanism is what causes population densities to change up or down toward the carrying capacity at any particular season. The suitability of the environment, that is the habitat conditions that exist, are also important factors affecting the population dynamics of the species. Where sanitary conditions are poor and much food and cover are available to rats, for example, the capacity of the environment to support a rat population is generally much greater than in a clean and tidy environment.

It is important to understand the various biological and ecological factors which regulate the productivity and stability of rodent communities. The minimum population density where a population of rodents can still maintain itself (the threshold density) is quite low with rats and most species of small rodents that produce more than one litter each year. But once an essentially rat-free condition is attained, most new invaders will come one at a time and not have a good chance of surviving. Permanent anti-coagulant bait stations are a security that helps prevent any new arrivals from becoming established.

- C. Balance of nature -- It is important to note that free-living populations of rodents will not continue to increase indefinitely beyond certain upper limits, even if more food and shelter are provided, due to the self-limiting mechanisms which have evolved in all species. These maximum levels of density are not easily definable for any specific habitat.

When man alters the environment and introduces exotic vegetation (agricultural crops) or non-native animals, many of the native species will then suffer. Some native species may find the environmental changes so favourable that their population density increases far beyond that which was possible under natural conditions. Pest rodents ~~are~~ those species which find these environmental changes by man desirable and are also so well adapted that they are difficult to control, hence, have remained a pest.

In natural environments the balance of nature is not very sensitive. That is, if the population density of one species was somehow drastically altered, it would have little immediate effect on other native species until this loss of individuals

produced a modification in the environment. If by some magic means all deer in North America were suddenly removed, it would be very difficult to detect this effect on any other species of vertebrates until vegetational changes occurred due to the lack of grazing and browsing by deer. The balance of nature becomes upset primarily when man introduces exotic plants and animals for which no balance has evolved, or when he drastically modifies the environment with fire, axe, or plough.

IV. Rodenticides (Characteristics)

- A. Ideal rodenticide -- What is required of an ideal rodenticide ? Even though no perfect rodenticide exists, what are the desirable factors we would like to have present in a rodenticide ? For humane reasons, it should produce a painless death. It should be highly selective for just the target species and safe to man, pets, livestock, and other non-target species. The compound should be readily degraded, so as not to poison other animals that might eat the poisoned individuals, or to contaminate water, soil, or vegetation. If not odourless and tasteless, it must be well accepted by all ages and both sexes of the target species and require that only a small amount of bait be consumed. It should be easily counteracted with an antidote. It should be slow acting so individuals will die away from the bait, or at least it should not create bait shyness when sub-lethal amounts are consumed. They should not cause resistance or immunity to develop. Re-acceptance of the rodenticide should be good. Baits made with the rodenticide should have a long shelf-life so they can be stored until needed. Also, such an ideal rodenticide should be inexpensive and easy to formulate into various types of dry and liquid baits.

B. Acute Rodenticides

- (1) General comments. Rodenticides are conveniently divided into acute and chronic rodenticides. An acute rodenticide is effective following one feeding, hence it is also called a single-dose rodenticide in contrast to chronic poisons that require multiple doses or feedings for more than one day. Both types of rodenticide are needed.

All of the currently marketed acute rodenticides that have proven to be fairly well accepted by rats and also effective are, unfortunately, also toxic, in various degrees, to a broad spectrum of mammals, birds and other wildlife. This means there is a great risk of poisoning man, pets, livestock or other non-target species when an acute rodenticide is used by anyone other than a highly trained pest control operator. And accidental poisoning of non-target species creates unfavourable public relations that then make it difficult to create or maintain enthusiastic public support for a new rodent control programme.

There are situations, however, where it is desirable to use acute rodenticides, if put out by trained people. With field rodents, it is usually necessary to use an acute poison because of the expense and labour of attempting to control field rodents with chronic poisons. One good example of an exception to this is the control of deer mice (Peromyscus), a forest rodent, with but a single broadcasting of either of two anticoagulants, diphacinone or chlorophacinone.

It is often necessary to use quick-acting acute rodenticides in the case of outbreaks of diseases like plague. Whenever there is a high population of rats, if trained pest control operators are available, it is often cheaper and more satisfactory to knock the population down first with an acute poison, and then follow-up with permanent anticoagulant bait stations.

Acute rodenticides will be needed whenever anticoagulant resistance is suspected or if for some other reason the anticoagulant baiting is not satisfactory. It often is not practical to use anything but acute rodenticides at garbage dumps, in sewers and drains, around slaughterhouses, and in some warehouses where it is difficult to get the rats to feed on anticoagulant bait for several days in succession.

Because of the potential of creating bait shyness, the same kind of acute rodenticide should not be used in the same locality more than twice a year, and preferably only once. It is difficult to prevent bait shyness occurring when acute rodenticides are used because some rats fail to consume a lethal amount before they feel the symptoms. Once a rat becomes bait shy, this shyness may persist. If an acute poison is kept continuously before a rat population, the bait-shy adults will condition their offspring to also shy from that toxic bait. Therefore, if an acute poison must be used more than once a year, it is best to change both the kind of bait and the poison.

- (2) Zinc phosphide (Zn_3P_2). This is the acute rodenticide used most frequently in rat control and for many species of field rodents. Pre-baiting is recommended when zinc phosphide is used in rat control. Where a poor quality of zinc phosphide is used, a shyness to the bait may often develop. Zinc phosphide has a good safety record. Because of its black colour, strong taste, and garlic-like odour many rodents are initially attracted to it, whereas many other mammals, but not birds, find it less attractive. It is effective against both Norway and roof rats, and also house mice, and generally used at strengths of 1-1/2 or 2 per cent.

(3) Sodium fluoroacetate (1080) and fluoroacetamide (1081).

These and related compounds are some of the most effective rodenticides known. Because of their hazards to man and non-target species, they should be used only by professionals who have the necessary resources properly to supervise the operation. In many countries rigid regulations are placed on their use. More research is needed on how these materials can be used more safely.

(4) Red squill or scilliroside. Gives good and safe control of Norway rats if pre-baiting is done first for several days. Red squill is ineffective for roof rats.

(5) ANTU or alpha-naphthylthiourea. As with red squill, ANTU is not effective on roof rats, but will give reasonably good control of Norway rats if pre-baiting is conducted prior to actual baiting.

(6) Norbormide. Safest of all rodenticides because it is toxic to the genus Rattus only. Acceptance by rats is poor and until this is overcome it is of value only in very special situations. Pre-baiting is always a must.

(7) Strychnine. Good for some field rodents but not effective for rats.

(8) Thallium sulfate. Effective with rats and other rodents.

Its use is banned in the United States of America because of its great hazards.

(9) Other acute rodenticides. Materials that are not very effective, too hazardous, or not readily available include arsenious trioxide, barium carbonate, phosphorus, Gophacide^R, and castrix.

- (10) Experimental compounds. There are a number of potential acute rodenticides under investigation. This writer and his colleagues are most excited about a Rohm and Haas Company experimental product (RH-787) which shows great promise as being a quite safe and effective acute rodenticide for rat control, RH-787 has been tested by the writer and colleagues in the U.S.A. and Korea.

- C. Chronic rodenticides -- Most urban rat control in the world today employs multiple-dose anticoagulant rodenticides, which are cumulative and must be consumed daily for several days to produce death. Because normally multiple doses are necessary to be lethal, anticoagulants are reasonably safe for use around children and pets, for rarely will they continue to feed repeatedly without detection. Vitamin K or whole blood transfusions are effective antidotes should accidental ingestion occur. Anticoagulants interfere with the clotting of blood and the rodents bleed to death, usually from internal haemorrhages. Birds are relatively resistant to these compounds.

The fact that there are no symptoms perceived by rodents the first day they feed on anticoagulants makes it difficult for them to identify what eventually makes them sick, so they do not stop eating the bait. Consequently, bait shyness does not develop as with chronic poisons. The roof rat and house mice are not as susceptible to anticoagulants as are Norway rats, but can be readily controlled with anticoagulants.

Anticoagulants can be used in dry baits, and their sodium salts or other soluble salts can be used in water baits. Where a shortage of available water exists, water can serve as an attractive bait. The intervals between feedings should never exceed 2 days at most, or the toxic effect of anticoagulants may be lost.

The chemical structure of anticoagulants places them, for the most part, in two groups; the hydroxycoumarins and indandiones. A few brief remarks will be made about some of the common anticoagulants.

According to Bentley (1966), the kind of anticoagulants used in different countries is quite variable, largely due to currency restrictions, varying patent laws; other commercial considerations, and that Warfarine has become so well established that in many places it is difficult for a new anticoagulant to compete in the existing market. He lists the following anticoagulants, in addition to Warfarine, as being favoured in the countries named.

Canada	lival, Coumachlor
Finland	Dicoumarin
France	Chlorophacinone, LM 83, Coumachlor
Germany	Coumachlor, Coumatetralyl, Fumarin
Israel	Pivalyn
Malaya	Coumachlor
Mexico	Fumarin
Philippines	Fival
U.S.A.	Diphacinone, lival, Fumarin, Valone
U.S.S.R.	Na-valone, Na-diphacinone, Chlorophacinone

No attempt will be made here to discuss the merits of these various compounds, but such a discussion will be appropriate during the Seminar. Two of many references that discuss anticoagulants are Bentley (1966) and Brooks (1973).

- D. Reasons for failures with anticoagulants -- Howard and Marsh (1974) present the following suggestions as to why the desired control may not be achieved with anticoagulant rodenticides.

(1) When baits are well accepted

- a. Time period that bait is exposed is too short.
- b. Insufficient bait is put out, and none remains from one baiting to the next.
- c. Too few bait stations are used, or some not spaced closely enough together.
- d. The control programme does not cover a large enough area, permitting rodents to move in from untreated adjacent areas.
- e. The rodents may be genetically resistant to the anticoagulant.

(2) When baits are poorly accepted

- a. Poor choice of bait or formulated improperly.
- b. Bait station improperly placed.
- c. Too many other palatable foods present.
- d. The bait has become mouldy, rancid, insect-ridden or contaminated.
- e. The anticoagulant is of poor quality and rodents detect it in the bait.

E. Safety precautions with rodenticides -- All rodenticides should be considered dangerous enough to cause death. The main hazard is in bait formulation, because this requires handling of the pure compound, technical grades, or concentrates. Those who formulate baits should use extreme care, wear rubber gloves, apron, and respirator. When formulation permits, dilute concentrates into a solution when the container is first opened. Only responsible people, and as few as possible, should be allowed to handle technical or concentrate rodenticides. See Howard and Marsh (1974) for additional instructions.

V. Rat Resistance to Anticoagulant Rodenticide

Resistance of rats to anticoagulants first appeared in Scotland in 1958, then in other parts of the United Kingdom, in Europe, United States of America, and probably exists elsewhere as well. Such resistance is not an acquired tolerance but the consequence of a few genetically immune individuals surviving anticoagulant poisons and then passing this resistance from generation to generation by heredity. For information on how to determine the susceptibility or resistance of rats or mice to anticoagulant rodenticides, see instructions provided by World Health Organization 1970 Technical Report No. 443: 140-147.

VI. Principal Methods of Rodent Control

There is seldom one method of rodent control that will consistently control all individuals of the target species. Usually even the best method needs to be supplemented with rodent proofing, sanitation, acute poisons, traps, tracking powders or some other form of control.

It is important not to wait until a rodent population builds up before initiating a control operation. If such a build-up can be predicted, then it is much more economical and effective to control the population while it is still low, yet obviously a potential hazard. Very few individuals will have to be destroyed to make the operation successful when the breeding potential of the population is already low.

The success or failure of a control operation is often just the difference of a few individuals per city block or per hectare. For example, if the population of rats to be controlled is about 100 individuals, the operation might be considered successful if there were only about two survivors, but largely a failure if there were ten or so survivors that could quickly

again return the population to the environmental capacity of about 100 rats. Actually, it is not a good measurement to evaluate control operations by using the percentage of rats killed, although this is often the easiest means of expressing the degree of control. As in the above example of 100 rats, to reduce the density to only two individuals it would be necessary to achieve 98 per cent control. However, if the original population consisted of only ten individuals instead of 100 it would then only be necessary to control 90 per cent of the population to reduce it to just two survivors. The correct measure of the success of a control operation is the breeding potential of the survivors. This more than anything else is what determines how quickly the survivors can produce a population density that again is more than can be tolerated for health or economic reasons. The fewer the survivors, the slower will be the rate of recovery. With a reduction of only 60 to 70 per cent of the carrying capacity for rats, the rate of recovery of the population will be fast indeed, if control efforts are discontinued.

- A. Rodenticides -- To be discussed at Seminar.
- B. Baits and baiting
 - (1) Formulating baits. Great care must be taken to make the best baits possible. The ingredients should be selected only after much evidence indicates they are the best materials to use, based on careful research studies.
 - a. Bait enhancers. A number of ingredients, such as sugar or vegetable oils, can improve the acceptability of rodent baits.
 - b. Bait attractants. For a long time people have searched for an "irresistible" odour-lure that could be added to baits. With more research on rodent pheromones, it is possible that chemicals may be isolated that produce odours attractive to specific species of rodents. In brief, do not add any extraneous materials to

baits until careful research has proven that they are not more of a repellent than enhancer or attractant. This includes dyes, emetics, and mould inhibitors.

- c. Colouring baits. Advantages to colouring baits when acceptance is not affected include: 1) helps prevent accidental consumption by people; 2) reduces the hazard of feeding bait to pets and livestock; 3) can be used to indicate which toxicant has been used on a cereal bait; 4) dyes help bait formulators know whether bait ingredients have been thoroughly mixed; and 5) brightly coloured baits are less attractive to many kinds of birds.
- (2) Bait preference tests. A good bait material is often what the species to be controlled is feeding on in that locality. Bait preference tests are not the same as pre-baiting, but tests designed to indicate which type of bait is most preferred. To make this determination 100-gram piles of several potential non-toxic baits should be exposed in from two to ten locations depending on size and variability of the habitats. These should be put out for three days and checked each day.
- (3) Pre-baiting. Pre-baiting is the placement of unpoisoned bait for one to five days to create a high bait acceptance before the toxic bait is exposed. It is often essential for good bait acceptance to pre-bait prior to using acute rodenticides. Often it is not done for economical reasons, but in the long run it would have actually been cheaper to pre-bait since then the success of the control operation may have been so much better that fewer re-treatments would be needed.

Remove uneaten prebait before poisoning. Sometimes one day can be skipped between pre-baiting and the control operations to enhance the appetite of the rodents. The amount of pre-bait consumed will indicate the maximum amount of toxic bait to use, since less of the poison bait will be eaten than of the prebait. If acceptance of the pre-bait is poor, then do not use toxic bait until the acceptance problem has been corrected.

- (4) Bait placement. How to distribute the bait and how much bait to use can be more important than the type of bait used. Overbaiting creates undesirable environmental hazards, and underbaiting with an acute rodenticide leads to bait or toxicant shyness. Baits should never be placed where they create hazards to children, pets, livestock and other non-target species.
- (5) Bait stations (bait boxes). When controlling rodents with anticoagulant baits, it is desirable to do so in some type of device that will provide security for the rodent while it is feeding on the bait, plus reducing the hazard that non-target species will be able to eat the bait.

There are several important reasons for using only non-toxic pre-bait when bait boxes are first set out, and for keeping only non-toxic pre-bait in the bait stations for one week. The best reason is for safety. This provides one week to determine whether children, dogs, cats or other non-target animals might have access to the bait and to determine whether there are other unsuspected hazards of using toxic bait at that location. Secondly, the amount of the non-toxic bait eaten by rats will provide a rough index of the number of rats present (one form of pre-treatment population census). Thirdly, if the rodents do not feed on the non-toxic bait,

either there are non present or a more attractive bait must be obtained; whereas, if toxic bait had been used at the beginning, the mistaken conclusion might have been taken that the poison was ineffective or unacceptable to the rodents. The latter will be true only if the pre-bait is consumed and the toxic bait exposed later is not accepted. Such examples of poor acceptance of a toxicant can best be confirmed by also using a non-toxic flour or talc dust so that the footprints and tail dragging marks will verify that a rodent has entered the bait station but did not consume the bait.

- (6) Water baits. Water containing a rodenticide can be effective in controlling rats in localities where their access to water is limited. Both acute and chronic rodenticides are used in water baits, but close supervision is needed if dangerous acute poisons are used.
- (7) Paraffin bait blocks. Anticoagulant baits embedded in paraffin to form solid bait blocks with wire hooks or stakes attached are useful where for some other reason loose-type baits cannot be used effectively, for example, where there is too much moisture. They are often used to control rats and muskrats along ditches and for rat control in sewers and some buildings. They are useful in roof rat control because they can be fastened to fences, rafters in a building, trees and power poles frequented by roof rats.

VII. Trapping, Tracking Powder and Fumigants

- A. Traps -- In general trapping requires more skill and labour than using poison baits, and is used mainly where for some reason poison is inadvisable. It is an excellent method where the number of animals to be controlled is small, such

as in a house. Advantages of traps in rat control are: 1) no toxicant is used; 2) the user can see the evidence of success, the dead animal; and 3) it eliminates the problem of rats dying in the walls of a building. Leaving rat traps baited but unset until the bait has been removed at least once by the animals to be trapped reduces the hazards to children and pets, and of creating trap-shy rats. Live traps may catch rats but rarely do they control a rat problem. The best traps are guillotine, spring, or break-back traps. Trap placement and the kind of bait used are important factors. Howard and Marsh (1974) discuss the use of traps for controlling rats.

- B. Tracking Powder -- The main advantage of tracking powders is that they are effective even when food is abundant. When rodents walk over the toxic powders, they pick some up on their feet and fur, and they later ingest the material during their normal grooming. There is little likelihood of poison-shyness developing, and by this manner they will ingest compounds that they might not accept in baits.
- C. Fumigants -- Poisonous gases can sometimes be used to advantage in poisoning certain field rodents and rats. Generally, this method is used merely to supplement other methods that in these situations become too hazardous, impractical, or ineffective because of poor bait acceptance. Rodent burrows must be readily accessible. Three common fumigants are calcium cyanide, methyl bromide and carbon bisulfide.

VIII. Community Sanitation and Rat Proofing Premises

The most successful and permanent methods to control rodents are to build them out and to starve them. Rodents cannot survive when they are excluded from food and cover; good

environmental control along ditches, roadways, railroads, and fences may help reduce the number of field rodents that invade an agricultural crop.

IX. Various Other Control Techniques

- A. Chemosterilant -- No rodent control chemosterilant is currently being marketed in the United States, but much research is underway. Once effective chemosterilants (antifertility agents) are available they may be useful where: 1) some individual rodents can be tolerated as long as their reproductive potential is kept low; 2) as a follow-up to use of rodenticides where some survivors can be expected; and 3) some chemosterilants which are well accepted hold promise, if incorporated in anticoagulants, for preventing anticoagulant resistance from developing.
- B. Repellents -- These include chemical substances that are sufficiently noxious to repel rodents, yet are otherwise safe enough to use. More research is needed and rodent repellents are not widely used. Odour-producing substances generally have only a short-term effect, if any. Taste repellents show a little more promise, especially those that create some physiological ill feeling so that they will be avoided the next time they are encountered by the rodent (aversive conditioning).
- C. Diseases -- The only disease that has been really successful in controlling a vertebrate pest is myxomatosis. The myxoma virus has been used in Australia, South America, and Europe to control the European rabbit. Certain food-poisoning bacteria (Salmonella) have been used to control rats, but pathogenic bacteria have not equalled conventional methods and are not recommended because they may contaminate human foods.

D. Predators -- Many kinds of predators feed on rodents.

There is no evidence that natural enemies can be encouraged in order to control rodent pests. Most of the species of rodents that are a pest to man are a pest because the habitat is so suitable that the natural predators cannot keep such a prey population at a low density where it is no longer an economic problem. Cats can reduce the number of rats around a house or farm, but if the environment is favourable to rats, many will survive no matter how many cats are present. If rats are not going to be poisoned, cats may help. But rats can be reduced to a much lower density by controlling them with anticoagulant bait stations than with cats.

E. Bounties -- No system of paying bounties has been successful in controlling rodents. Bounties are like predators, they cause many rodents to be destroyed but do not reduce populations to as low a level as can be achieved with rodenticides. Bounties are expensive and also encourage graft and other dishonesty.

SELECTED REFERENCES

There is no point in listing an extensive bibliography on rodent control here. An extensive review of pertinent references relating to rodent control appeared last year:

Brooks, J.E. 1973. A review of commensal rodents and their control. Critical Reviews in Environmental Control, Vol.3, issue 4, 405-453. For copies write to Mr. Joe E. Brooks, New York State Department of Health, Bureau of Rodent Control, Albany, New York 12200, U.S.A.

Several excellent volumes of a Bibliography on Rodent Pest Biology and Control have also recently been published by FAO/WHO.

The following references were cited in this report:

Bentley, E.W.: Review of currently used anticoagulants, and Gratz, N.G.: A critical review of the currently used acute rodenticides. Both in Seminar on Rodents and Rodent Ectoparasites, October 24, 1966. WHO/VC/66, Geneva, 220 pp., 1966.

Howard, W.E. and R.E. Marsh, 1974. Rat control manual. Pest Control Magazine, Vol.42, No.7, 18 pp. For copies write to authors at the Division of Wildlife and Fisheries Biology, University of California, Davis, California 95616, U.S.A.

ACKNOWLEDGEMENT

The assistance of Mr. Rex E. Marsh in preparing this Seminar outline is greatly appreciated.



**SEMINAR ON PUBLIC HEALTH AND ECONOMIC
ASPECTS OF RODENT CONTROL**

EM/SEM. PH. EC. ASP. ROD. CTL.

6 December 1974

Alexandria, 2 - 8 December 1974

ENGLISH ONLY

**PRINCIPLES OF VERTEBRATE CONTROL
(Definitions of Some Useful Terms)**

by

R.E. Marsh and W.E. Howard

Acceptance

Refers to the palatability and voluntary consumption of baits and toxicants by target organism.

Acclimation

Process by which an individual organism becomes accustomed to a new situation in field or laboratory.

Acclimatization (often called "adaptation" by evolutionary scientists)

An adaptive change in the heredity of a population or section of a species tending to fit it for a particular set of environmental conditions.

Adaptation

The fitness of an organism within its genetic structure for its environment, or the process (acclimation) by which it becomes fit.

Adult

Sexually mature; an animal that has or is capable of contributing new individuals to a population.

Age composition (structure)

The arrangement of age classes in a population which describes the relative frequency of the age classes.

Aggressive behaviour

Includes both combat and aggressive display to drive the stimulus object away or otherwise modify it by intimidating, injuring, or even killing it.

Carrying capacity

The maximum density of a particular species of animal which can be maintained in a given ecosystem on a sustained basis without deteriorating the habitat, i.e., the number of individuals that a habitat can maintain in a healthy condition.

Challenge diet

A food or liquid offered to compare acceptance with a food containing a test ingredient, e.g., a toxicant.

Chemical toxicant (poison)

Any chemical substance, the intended or accidental effect of which, when ingested, inhaled, or absorbed, or when applied to, or injected into the body, in relatively small amounts, by its chemical action may cause significant bodily malfunction, injury, or death to animals or man.

Chemosterilant

A chemical substance which prevents effective reproduction.

Circadian rhythm

Activity cycles approximating 24 hours under constant conditions (circa -- about, diem -- day)

Climax community

A community in a state of relative ecologic equilibrium with its habitat because it is no longer in process of further successional changes. Climatic climax is an equilibrium with the general climate; edaphic climax is modified by substrate where topography, soil, or water are such that the climatic climax cannot develop.

Community

An assemblage of ecologically related organisms composed of two or more species.

Communication signals

A chemical or physical production of an individual that influences the behaviour of recipient individuals of the same species.

Conditioned stimulus

A stimulus which evokes a response (or alters some other condition of behaviour) only because of a history in which it has been paired with a stimulus (often unconditioned) having the same effect.

Conservation

The maintenance of a species at a desired level, or the perpetuation (not preservation per se) and wise use of natural resources and conservative use of nonrenewable resources such as natural gas, oil, and minerals. Control to reduce a population below its carrying capacity for that environment.

Crash

The sudden decline of a population by natural mortality; usually occurs following the peak of a cycle.

Cyclic population

A population with great variation between high and low densities (excluding seasonal fluctuations) which occur with cyclic regularity.

Density-dependent and density-independent factors

Agencies which control a population may be dependent or independent upon the population's density, e.g., the density-dependent agencies are believed to determine the "equilibrium" density of each species.

Deprivation

Withholding food, water, sexual contact, etc.

Dispersal

1. Abandonment of a former home range.
2. "Innate dispersal" -- predisposed at birth with a dispersal instinct usually activated at puberty.
3. "Environmental dispersal" -- result of intraspecific pressures; the selection of a new home range, part of which usually is within the confines of the parental home range.

Distress call

Birds emit distress calls when variously restrained and handled. It is a desperation signal which frightens other birds.

Food Chain

A sequence of species within a community, each member of which serves as food for the species next higher in the chain.

Fumigant

A smoke, gas, or vapour that is lethal when inhaled by target species.

Fur bearer

Any animal sought for its fur.

Game management

The art of making land produce a sustained crop of wild game for recreational purposes.

Graminivorous

An animal that eats grass.

Habitat

It is the environmental situation (usually only climate and physical features of the environment) in which or on which any community, species, or individual lives.

Habitat stability

Natural biomes have a well-established, stable, animal-soil-vegetation complex which is not delicately balanced due to self-limitation of species.

Habituation

The inhibition of a perceptual response as a result of repeated stimulation which is not followed by any kind of reinforcement. It is of relatively enduring nature and is thus regarded as distinct from fatigue and sensory adaptation.

Herpeticide

A toxicant used against amphibians and reptiles.

Homeostasis

The ability of an individual, society, or community to regulate itself so that it is able to exist in a frequently-changing environment.

Home range

The area over which an individual animal habitually travels while engaged in its daily activities.

Imitative behaviour

A response stimulated by the behavioural response of another individual.

Immigration

An individual or species ~~entering~~ a community where previously it was not present.

Immunity

Following repeated exposures to pathogens the organism acquires the ability to resist the agent or infection.

Imprinting

The recognition of parental characters through learning in a brief, usually very early stage in animals' lives. May apply to learning about food, habitat characteristics, and other elements in animals' world.

Indicators

Indicator species of plants or animals often recur again and again in widely separated ecosystems of similar types and serve as an indicator of certain general characteristics of the environment.

Innate

Inborn. In behaviour it refers to genetic differences between responses of individuals or species. In animal behaviour innate and learned are difficult to separate concisely.

Integrated control

Is a management system that, within the area of associated environment and population dynamics of the pest species, uses all suitable techniques and methods in as compatible a manner as possible to maintain pest populations at levels below those causing economic injury.

Interspecific

Inter-relationships between members of different species.

Intraspecific

Inter-relationships between members of the same species.

Invasions

Spread of a species into a community where it was not formerly represented.

Irruption

An unusually high population density of either a cyclic or non-cyclic species.

Land capability

The suitability of land for use without damage; not a clear term.

Latency of response

The measure of time elapsing between onset of stimulus and the beginning of the response to it.

LC50

The statistical concentration that is lethal to 50% of a large population

LD50

The statistical dosage that is lethal to 50% of a population.

Learning

The process which produces change in individual behaviour as the result of experience.

Life cycle

The stages an organism passes through from the fertilized egg to death.

Limit of tolerance

Organisms have an ecological minimum and maximum requirement, with a range in between which represents the limits of tolerance.

Limiting factors

Any environmental factor which limits the distribution and/or the size of a population.

Management

Usually implies maintaining a sustainable population density such as a game species.

Marginal habitat

Where individuals or population live a tenuous existence and seldom successfully reproduce.

Memory

Learning, i.e., a modification of behaviour due to experience.

Migrations

Seasonal migrations, e.g., the regular annual round trips made by many birds and game mammals; geographic migration is a more or less permanent movement into a new geographic area (emigration).

Multiple use

Harmonious use of land for more than one of the following purposes: grazing of livestock, wildlife production, recreation, watershed, and timber production; but not necessarily the combination of uses that will yield the highest economic return or unit output.

Mutagenic

Chemical substance, when brought into intimate contact with the organism, that is capable of producing changes or alterations that are heritable.

Natality

Birth rate.

Natural control

The maintenance of a more or less fluctuating population density with certain definable upper and lower limits over a period of time by the combined actions of abiotic and biotic elements of the environment.

Natural selection

The elimination of the less fit individuals in competition for existence, dependent on successful variation (differential survival).

Neophobia

A negative response upon first exposure to a new item in the environment or a dietary change in a bait.

Niche

That portion of the habitat the species concerned occupies for shelter, for breeding sites, and for other activities; the food that it eats, and all the other features of the ecosystem that it utilizes.

Non-target species

Those species not to be intentionally affected by a control practice aimed at another species in the same environment.

Operant

A behaviour associated with a reinforcement.

Operant conditioning

The experimental procedure of presenting the animal with a reinforcing stimulus (e.g., food) immediately following the commission of a given response to increase the rate of occurrence of the responses.

Overpopulation

A population level which the habitat cannot sustain indefinitely.

Pandemic

Of wide occurrence, such as a disease.

Pathogen

A microscopic or sub-microscopic organism whose presence results in illness or death of host.

Pesticide

A substance or mixture of substances intended for destroying, repelling, or mitigating any vertebrate or invertebrate pest or preventing the species from becoming a pest.

Pharmacodynamic

Pharmacodynamic is the response of living organisms to chemical stimuli, or the reaction occurring between these chemicals and living structures.

Pheromones

Intraspecific chemical stimuli (e.g., sex odours) perceived from the external environment (pheromones, to carry, and hormones, to excite).

Physiologic homeostasis

The maintenance of the internal environment (both intra- and extra-cellular) within limits conducive to the survival of the organism.

(See homeostasis).

Piscide

Toxicant used against fish.

Placebo

An inactive substance; in choice tests a diet that contains all of the same ingredients except the toxic or test material present in the bait.

Plague

1. A drastic increase in the population, and "outbreak" as a plague of mice or locusts.
2. Commonly used in reference to the disease, bubonic plague, caused by Yersinia pestis.

Pollution

Environmental (air, water, land, cities, etc.) contamination.

Polyandry

The mating of a single female with several males.

Polygamous

The mating of one male with several females.

Population

A group of individuals of the same species.

Population

Environmental pollution resulting from too many people.

Population density

The primary factors determining the density of a vertebrate species are the suitability of the habitat conditions and self-limitation.

Predacide

Toxicant used to poison predators.

Predator

An animal which habitually preys upon other animals for food.

Primary poisoning

Sickness, pathologic changes, or death resulting from direct ingestion, inhalation, or contact toxicant by a non-target species.

Rare species

A species or sub-species that although not presently threatened with extinction, is in such small numbers throughout its range that it may be endangered if its environment worsens. A Status Undetermined species or sub-species is one that has been suggested as being rare or endangered, but more information is needed. (See endangered and peripheral species.)

Recruitment

Increment to a population by natural reproduction and immigration.

Reinforcement (reward)

After an animal has made a response, presenting it with a reinforcing stimulus (such as food to a non-satiated subject) or of withdrawing a negative reinforcing stimulus (such as an electric shock).

Releaser

A stimulus presented by one animal that controls a response or responses of another.

Renewable natural resources

Those parts of man's environment which have utility for him and which even though used, may be his actions he maintained or increased in quantity, and/or quality. It excludes man and non-renewable natural resources such as minerals, but includes air and water with all of their components.

Repellent chemical

See "Attractant"

Repelling or attracting biosounds

Sounds produced by any animal which influence the behaviour of a pest species.

Reproduction inhibitor

A chemosterilant.

Resistance

The natural or genetic ability of an organism to ward off the deleterious effects of such noxious agents as poisons, toxins, irritants or pathogenic microorganisms.

Rodenticide

A pesticide applied as a bait, dust, or fumigant to destroy or repel rodents and other animals such as moles, rabbits and hares.

Rope firecracker

Slow burning rope fuse in which firecracker fuses can be inserted at irregular intervals to frighten birds.

Sanitation

The establishment of environmental conditions favorable to health or to reduce pest problems.

Satiation

Making food available to an organism until it stops eating.

Scavenger

An animal that feeds principally on already dead animals or garbage.

Secondary poisoning

The result attributable to a chemical toxicant which, after being ingested, inhaled, or absorbed by or into, or when applied to or injected into a mammal, bird, or reptile, is retained in its tissue, or otherwise retained in such a manner and quantity that the tissue itself or retaining part if thereafter ingested by man or animal, produces the effects of a chemical toxicant.

Selective pesticide

A pesticide which while killing the pest individuals spares much or most of the other fauna, including beneficial species, either through differential toxic action or through the manner in which the pesticide is utilized (formulation, dosage, timing, etc.)

Self-limitation

Species involuntarily prevent their population densities from exceeding certain levels by the interaction of intraspecific stress factors (e.g. psychological, competition for food or mates, territoriality, weather, disease, or other vicissitude of life) which cause various increase in mortality, reductions in natality, or emigrations from the overpopulated areas.

Social behaviour

Behavioural interactions between individuals of the same species, but in some cases with another species.

Social dominance or rank

Certain individuals dominate the others in the group by their strength or aggressiveness.

Society

An assemblage of individuals all of the same species.

Sound frequencies

Cycles per second now referred to as Hertz (Hz or kHz) instead of cycles/second or kilocycles/second.

Species

A group of interbreeding populations (actually or potentially) reproductively isolated from other such groups.

Stupefacients

Drugs used as a pesticide to cause birds to go into a state of stupor so they can be captured and removed or to frighten other birds away from that area.

Subclimax

Any important successional stage below the climatic climax.

Succession

The replacement of one community by another.

Surfactant

A wetting agent that causes heat loss from the body of the treated (sprayed) birds or mammals.

Synergistic effects

Where the degree of control achieved by a combination of methods exceeds the sum of the independent effects of each method.

Target organism or species

The intended individual or population to be dealt with.

Territory

That portion of a home range that is defended against trespass by other members of the same species.

Threshold density

The minimum population level at which a population can maintain itself.

Threat

That behaviour which has been shown to produce flight in another animal.

Tolerance

An organism's ability to endure a pesticide or drug without ill effect, e.g. the state of its innate resistance or acquired immunity.

Trap night

Used to express the ratio of individuals captured depending upon the number of traps and length of time they were set. One trap night equals one trap set for one night.

Trophic levels

They distinguish the more important levels of food production and utilization, e.g. primary producers (usually green plants) than primary (herbivorous) and secondary (predators) consumers, each being a trophic level.

Vertebrate control objectives

To accomplish the desired effect with a maximum of safety to man and to forms of life useful or of neutral value to him, and that it be carried out with a minimum of disturbance to the biotic community. It is the alleviation of the problem to a tolerable level, not necessarily the destruction of vertebrates.

Vertebrate pest

Any native or introduced, wild, or feral species of vertebrate animal that is currently troublesome locally, or over a wild area, to one or more persons, either by being a health hazard, a general nuisance, or by destroying food, fiber, or natural resources. A pest to one person may at the same time have aesthetic or recreational value to others.

Wilderness

In contrast to those areas where man dominates the landscape, a wilderness is a relatively unaltered ecosystem of any size where man is a visitor who does not remain.