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# ALPHA-CHLOROHYDRIN (EPIBLOC®): A TOXICANT-STERILANT AS AN ALTERNATIVE IN RODENT CONTROL

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ABSTRACT: Alpha-chlorohydrin (EPIBLOC) introduces a new form of rodenticide - the toxicant-sterilant. EPIBLOC, as a pest control product registered and used in some countries, changes the concept of chemosterilants from theoretical to practical. The active ingredient also acts as an acute toxicant in the control of rodents. It is effective on both sexes and all age groups. Alpha-chlorohydrin is rapidly absorbed and metabolized; therefore, it is neither a secondary toxicant nor a cumulative toxicant. Another unique biological characteristic of this compound is its species specificity with regards to male sterility. First, only sexually mature males are rendered sterile through the development of lesions in the epididymis, and second, male sterility is restricted to rodent species. Adult males of some mammalian species become temporarily infertile when treated with nonlethal doses of alpha-chlorohydrin. These males regain their fertility shortly after the end of treatment. Males from seven rodent species are known to develop permanent sterility. Of all the species tested Rattus norvegicus has been subjected to the most research. The single oral dose which produces temporary infertility in this species is 15-20 mg/kg of body weight; the dose that produces permanent sterility is 90-100 mg; and the LD50 is 150-160 mg. Field tests with EPIBLOC on a variety of rodent pests have provided a body of practical information. Namely: (i) effective as a toxicant-sterilant with a single administration of bait; (ii) reduction in the rodent population due to death ranges from 70-95%; (iii) the reproductive rebound phenomenon commonly observed after baiting with toxicants is prevented due to the sterilant property; (iv) 80-95% of surviving adult males are sterile and act as a deterrent to repopulation; and (v) the species specificity for sterility, the metabolic activity and the biodegradable characteristics allow it to be used under many environmental conditions.

## INTRODUCTION

Scientists and individuals interested in vertebrate pest problems have been speaking and writing for many years about the potential of chemosterialnts to control mammalian species. The availability of these chemosterilants was always projected to some time in the future. The future has now arrived with the approval in many countries to market alpha-chlorohydrin (3-chloro-l, 2-propanediol) as a toxicant-sterilant. Alpha-chlorohydrin, under the trademark EPIBLOC, is presently available for the control of rodents both as an acute toxicant, in some species, and as a toxicant-sterilant in other species. The introduction of this compound to the roster of rodenticides provides an alternative to established methods of control.

Human nature dictates that the reader be clearly informed that alpha-chlorohydrin as EPIBLOC is not a research and development project. Too many times chemicals show early promise, but later additional studies do not support the preliminary work. Research on alpha-chlorohydrin dates back to the mid-1960s. Almost two decades and hundreds of published references later this compound has been recognized as the first, and only, of its kind to be registered and approved for market internationally. What started out as a potential human male contraceptive ended up as the equivalent of a chemical vasectomy for rats.

Two review articles (Jones 1978, Lobl 1980) are cited for those who wish to delve more deeply into the biological, toxicological and pharmacological properties of alpha-chlorohydrin. The remainder of this paper is devoted to providing information on the overall characteristics of alpha-chlorohydrin as a toxicant-sterilant.

## STERILANT

The male sterilant property of alpha-chlorohydrin is restricted to rodent species. No nontargets species have shown evidence of sterility even when treated with doses of alpha-chlorohydrin that were, in some cases, lethal. Some nontarget species do, however, become reversibly infertile (male only) when treated with alpha-chlorohydrin. These species include the hamster (Cricetus cricetus), guinea pig (Cavia porcellus), sheep (Ovis aries), swine (Sus scrofa) and Rhesus monkey (Macaca mulatta). The specificity of the sterilant property even divides rodent species into two groups - those species where it is an effective sterilant and those species where it acts as toxicant, but not as a sterilant (Table 1).

The species specificity characteristic of alpha-chlorohydrin is the most important element in its being transformed from an experimental chemical into a usable rodenticide. Indiscriminate sterility of nontarget species would severely restrict its use. The fact that no avian, aquatic, amphibian or reptilian species is known to become sterile when treated with this chemosterilant makes for a made-to-order rodenticide that can be applied under a wide variety of environmental conditions. The field of chemosterilants for use in human beings and animals is the subject of a review by Ericsson (1975).

Several conditions must be present before an animal can become sterile when treated with alpha-chlorohydrin. One, the male must be sexually mature. That is, the testes must be producing sperm and these sperm transmitted to the epididymides. The other condition is that only males, and only males from certain rodent species with gonads external to the body cavity, are susceptible to sterility. Females from all species tested are immune to the sterilant property of alpha-chlorohydrin.



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Table 1. The ability of alpha-chlorohydrin to induce male sterility in various rodent species.

| Species | Epididymal Lesions | Country | Reference |
|---|---|---|---|
| *Rattus norvegicus* | + | Many | Ericsson and Connor 1969 |
| *Rattus rattus* | + | U.S.A. | Kennelly et al. 1970 |
| *Rattus exulans* | ± | New Zealand | Cummins and Wodzicki 1980 |
| *Rattus losea* | + | Taiwan | Unpublished |
| *Rattus argentiventer* | - | U.S.A. | Kennelly et al. 1970 |
| *Microtus montebelli* | + | Japan | Unpublished |
| *Apodemus agrarius* | + | Taiwan | Unpublished |
| *Arvicanthis niloticus* | + | Egypt | Helal and Maher Ali 1982 |
| *Mus musculus* | - | U.S.A. | Ericsson 1970 |

A single oral dose of alpha-chlorohydrin high enough to cause sterility in the Norway rat (*R. norvegicus*) starts having an effect within four hours (Reijonen et al. 1975). The epithelial cells that line the epididymis are damaged and the end result is an irreversible lesion. Sperm from the testes that normally are transported through the epididymides are thereby stopped. Eventually the seminiferous tubules almost cease their production of sperm due to the interruption of sperm transport through the excurrent duct system. The Leydig cells, which are responsible for producing androgens, are not, however, affected. Though the sterile male rat is incapable of producing sperm in an ejaculate, his ability to mate has not been impaired. In fact, close circuit TV studies have shown that chemosterilized Norway rats maintain their normal mating behavior and their social positions within the colony. To impair the male's ability to mate or to lower his position within the social order would seriously detract from the use of any chemosterilant.

TOXICANT

Table 2 lists the acute oral LD50 of alpha-chlorohydrin for some target and nontarget species. The mortality in pest species is better than would normally be expected with such acute rodenticides as arsenic, strychnine, barium carbonate, ANTU, red squill or norbormide and will be more closely comparable to zinc phosphide, thallium sulphate, or sodium fluoroacetate (1080). It requires an equivalent, in one species, or considerably greater amounts of the chemical in some non-target species to cause death (Table 2).

Table 2. Toxicity of alpha-chlorohydrin in target and nontarget species.

| Species | Acute Oral LD50 Dose |
|---|---|
| Target | Mg/kg Body Wt |
| *Mus musculus* | 160 |
| *Rattus norvegicus* | 152 |
| *Rattus exulans* | 195 |
| *Rattus losea* | ca. 250 |
| *Bandicota bengalensis* | 50 |
| *Arvicanthis niloticus* | 58 |
| *Microtus montebelli* | 250 |
| *Apodemus agrarius* | ca. 250 |
| *Sigmomys alstoni* | ca. 150 |
| *Holochilus brasilensis* | ca. 150 |
| Nontarget | |
| Cat (*Felis catus*) | 188 |
| Dog (*Canis familiaris*) | 328 |
| Swine (*Sus scrofa*) | 420 |
| Turkey (*Meleagris gallopavo*) | 524 |
| Mallard duck (*Anas platyrhynchos*) | 331 |

As an acute toxicant alpha-chlorohydrin compares favorably with other similar type rodenticides. Deaths occur between one and five days after ingesting a single lethal amount of EPIBLOC bait. The rapid metabolism of alpha-chlorohydrin (Jones 1975) acts to eliminate secondary and cumulative toxicity, but it also means that a lethal amount of active ingredient be consumed over a relatively short time span. For example, five grams of bait with one percent active ingredient would be a lethal dose if a rat consumed the bait at one feeding. If, however, a rat consumed the same amount of bait over a 24-hour period the metabolic activity of alpha-chlorohydrin would negate its toxic activity. This pharmacological factor necessitates that EPIBLOC be formulated in a meal-type bait and packaged in individual size sachets of five grams.

The use of toxicants inadvertently produces an undesired effect that is counterproductive to the long term control of rodents. It is known as the reproductive rebound phenomenon. A significant drop in a rat population places the survivors in an environment with less stress, better habitat and more food. These animals respond by increasing their reproductive efficiency. It is not uncommon for a rat-infested area to reach its pretreatment population density within six to twelve months after successful treatment with a rodenticide. Therein lies the problem of rodent control through the less-than-total kill-off of the population. A chemosterilant alone has a major flaw in that, while the rodent population cannot effectively repopulate themselves, they continue to infest an area until the population declines by attrition. A toxicant-sterilant eliminates the deficiencies of a toxicant or a chemosterilant used singly. One chemical compound, alpha-chlorohydrin, can provide three separate and distinct mechanisms to control rodents. These mechanisms are directly related to increasing doses of the chemical and they are: (i) temporary male infertility, (ii) male sterility; and (iii) lethality.

## ENVIRONMENTAL SAFETY

Alpha-chlorohydrin is degraded rapidly by rats and mice after ingestion (Jones 1975). This means that there is no danger to nontarget species who may eat rats or mice killed by EPIBLOC. There is no secondary toxicity or cumulative toxicity. Alpha-chlorohydrin is also biodegradable in the natural environment. Microorganisms and/or water which have continued contact with this rodenticide will chemically convert the active ingredient to water, carbon dioxide and chloride (Focht 1972). Thus it poses no long-term danger to the environment.

## FIELD STUDIES

Many would-be rodenticides have proven to be successful when tested under laboratory conditions but failed under field conditions. Alpha-chlorohydrin, too, showed promise when tested on Norway rats in the laboratory as a toxicant-sterilant (Ericsson et al. 1971, Meehan and Hum 1979). The unusual aspect of this compound is that it has proven to be more successful in the field (Table 3) than under laboratory conditions. The reasons for this are several. Feral rodents are not as healthy as laboratory

Table 3. Field results with EPIBLOC (alpha-chlorohydrin).

| Location | Species | Condition | % Reduction of Population | % Males Sterile | Reference |
|---|---|---|---|---|---|
| Niger | Gerbillus gerbillus | Crops | 81 | NT* | Brei 1979 |
| Nigeria | Mastomys natalensis | Crops | 82 | NT | Brei 1978 |
| Venezuela | Holochilus brasilensis<br>Sigmomys alstoni | Crops | 87 | NT | Ericsson 1977 |
| New Zealand | Rattus norvegicus | Island | 90 | NT | Keightley 1979 |
| United States | Rattus norvegicus | | | | |
| California | | Dump | 70 | 90 | Marsh and Howard 1973 |
| Nebraska | | Dump and Sewer | 90 | 95 | Andrews and Belknap 1975 |
| Ohio | | Sewer | 85 | 87 | Ericsson and Daugherty 1981 |

*NT = Not tested.

rodents, nor do they have the luxury of eating at will. Laboratory rodents can regulate their feed intake of alpha-chlorohydrin and thereby reduce the toxic effect due to the rapid metabolism, as mentioned earlier, whereas feral rats faced with limited food supplies and under stress to consume bait when available, react differently to EPIBLOC than do laboratory rats under controlled conditions. The feral rats also have less resistance to the toxic properties of alpha-chlorohydrin as their overall standards of health are lower. Bait with 0.5 to 1.0 percent active ingredient is not nearly as effective as a toxicant when tested with laboratory rats as it is when tested in the field (Marsh and Howard 1973, Andrews and Belknap 1975).

EPIBLOC has been field tested in many countries on many rodent pests and with good results (Table 3). In some of the field studies the sterilant aspect of alpha-chlorohydrin was not tested. Nonetheless, rodent control was achieved over an extended period. In Venezuela, for example, a pilot trial gave control of high density populations of Holochilus brasilensis and Sigmomys alstoni with a single baiting. A return to the test site five months postbaiting revealed no rodent activity whatsoever (Ericsson 1977). The same situation occurred when alpha-chlorohydrin was tested in the U.S.A. on feral Norway rats. Two one-year studies were conducted at dump sites (Marsh and Howard 1973) and in both studies the results were the same - no rat activity was observed one year after baiting. A recent trial conducted in a sewer in collaboration with the City of Cincinnati, Ohio, gave unequivocal results that EPIBLOC is an effective rodenticide (Ericsson and Daugherty 1981). Excellent bait acceptance resulted in a rapid and significant drop in the Norway rat population, and 87 percent of the trapped adult males were sterile. EPIBLOC is now marketed routinely in a number of countries.

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