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BEHAVIOURAL AND PHYSIOLOGICAL PROBLEMS ASSOCIATED WITH THE DEVELOPMENT OF CURB

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CURB is a harmless chemical repellent formulated and prepared to control avian and mammalian behavior which may result in losses of cultivated crops at all stages of growth, of food in storage, and also in behavior which may endanger health (e.g. dogs fouling) or life (e.g. birds on runways at airports). It is a fine powder, which may be wettable for spraying when mixed with water; or it may be prepared for dry application.

It is synergised aluminum ammonium sulfate. Its LD_{50} is greater than 5 gr/kg; it has passed the U.S.A. and French skin and eye mucosa tests on rabbits, and it is found ecologically and environmentally acceptable. In the U.K. and some other countries, it is fully cleared for use in homes to control rodent damage and to train kittens and puppies, for spraying on all edible crops and fruit, both growing and in store, and for use on animals' wounds to prevent biting and pecking.

The mode of action of CURB is thought to be mainly via the three chemical senses. But, because it is preferable that birds and mammals be kept away from the areas to be protected, its recent development has been directed towards control via the olfactory sense. Moreover, because in many regions mammals constitute a greater menace to crops (e.g., in Venezuela and many South American countries) and also because it is now generally accepted that the neurophysiological structure relative to olfaction is basically similar in all vertebrates, my tests in the control of behavior in birds and mammals have been carried out indiscriminately: the same repellent has been applied in each case and with, roughly, the same rates of successes and failures.

Indeed, there appears to be little difference between the problems of gustation and olfaction, whether among birds or mammals. Little is known about the common chemical sense, but I find it difficult to separate it from the other two in practice; and I believe that the three chemical senses are very closely allied throughout the avian and mammalian species.

In the course of dealing with the practical aspect of these problems over the past fourteen years, I have gradually developed a product, originating from the base aluminum ammonium sulfate, through hit-or-miss additions and rejections of various organic and inorganic materials and various methods of preparation with all the experimentation and test work involved, and arrived at the present position, where I can reasonably claim the ability to vary the spectrum and potency of the repellent action of CURB in such manner and to such degree as to match the variations in special and individual variations in chemo-reception in most species.

Generally speaking, the variations in responses to chemical repellents is greater among birds than among mammals, probably because among the species of birds there are wider variations in taste preferences and food requirements and in the development of the olfactory pathways of the brain. Moreover, the thresholds of taste and smell will vary more in birds, according to their habitat and food, which change during migration.

Generally, bird behavior appears to be activated primarily by some innate instinct or sense, as in migration, and by their feeding and mating habits. Feeding habits, with which we are concerned, vary widely even among those of the same species. In some regions, habitat and food appear rigidly fixed, while elsewhere there is no apparent pattern. For example, in the U.K. county of Kent where there are large orchard areas, I have seen bullfinch damage to top fruits commence as early as October and November, while a few miles distant their damage has never been known to commence before Easter of the following year. Also, bullfinches are classed as mainly seed eaters -- ashe and dock. But I have seen both near the birds' nests left in favor of fuit buds.

M. Kare (1) has pointed out the difficulties in the determination of taste, and he shows

that chemicals are not necessary to evoke a taste sensation in mammals; it can be aroused by electrical stimulation. He also has shown that among birds taste preferences can be radically altered in a few generations by selective breeding. The problems that can arise from these factors are enormous in both number and degree.

I have found it impossible to differentiate between the repellent functions of taste and smell, except in a few cases. For example, in one test involving thrushes (2), the birds, having eaten all the untreated grain, showed no aversion to the smell of the grain treated with CURB. They picked it up in their beaks, wiped each grain on the grass, and then appeared to throw it right to the back of their throats, presumably to miss the taste buds on the tongue.

From my tests carried out on many species of birds in various parts of the world, I have found that most avian species have a good sense of smell. For example, oyster beds around the French coasts are regularly raided by oystercatcher birds. These have now been repelled by putting a high grade of CURB on plates hung from poles stuck in the sand among the oysters. Also, birds have been recorded in tests as refusing to land on ground in which treated seed has been sown. But it has not yet been possible to determine what grade of CURB is necessary to obtain the required response of flight from all areas where the repellent has been used.

Field and laboratory tests have thrown up many and varied problems normally presumed to be unsolvable because of the lack of scientific knowledge of chemo-reception and response to it. But, irrespective of the lack of knowledge, I have found that practical problems predominate, for example:

a). What chemical or mixture of chemicals and in what quantity are needed to obtain positive responses among the species to be controlled under all the conditions normally expected?

b). Will resistance be engendered in any species to such repellents and, if so, over what period of time?

c). What part, if any, does will, volition, or aggressive action due to frustration at interference with food have in any negative response? For example, in one garden, the buds of a forsythia bush were taken every year by sparrows and finches. One year, when damage commenced, the buds and flowers were sprayed with CURB. Damage ceased for three days, after which all the buds were stripped from the bush and left on the ground (3). A similar response was observed at a kennels where two dogs were badly chewing a kennel which they shared. A heavy application of a "taste grade" of CURB controlled the damage for three days, but on the fourth morning the kennel was found almost destroyed and the dogs sick all over the yard. They would not go near a kennel for about six months afterwards (4).

This year, at a plant breeding institute, house sparrows were seriously damaging maturing ears of barley. A standard grade of CURB was quite ineffective. A higher grade certainly affected the birds' olfactory organs, because they would at first go nowhere near the treated area, keeping to the control. Then they formed in groups and dived down to the grain as if determined to land on it; but a foot or two above it, the birds swooped up again. An occasional bird would fly from the control into the treated area, only to fly out again immediately. However, this effect lasted only for about two days, when the birds returned to the treated plots. The identical responses were observed after two further sprayings with higher grades of CURB. Finally the birds flew off to another area a short distance away (5).

These appeared to be instances of repellents, firstly of taste and then of taste taste and smell, being effective for a short period then ineffective because of the determination of the birds to get on that food.

d). Following this, how does one determine the degrees of response to a chemical repellent acting via the chemo-receptors? The cause of flight from an area may well be due, for example, to uncertainty and fear because of something unusual. This may explain the total successes one year being succeeded next year by total failures

e). It is necessary to know what degree of behavioral control is financially viable for each crop, because the grade of CURB needed for protection appears generally to vary with the nutritional and cost values of the crops. For example, the high value crops, such as oil seeds, sunflower, vegetables and fruit, appear to need a higher and more expensive grade of CURB than the lower value cereals for protection from both birds and mammals.

Cost and profit margins to users are of primary consideration today; but if the world population doubles, as predicted, in the 1980s, particularly in the under-developed countries of Asia, Africa, and South America, then the problem of food supplies will become more acute, and this factor may have less consideration.

f). The hierarchy of bird communities and their methods of communication may

well affect flock responses to chemicals, as, for example:

(i). Twelve sparrows were found shredding crocus petals in a small flower bed and flew off temporarily when the flowers were sprayed with a "taste grade" of CURB. After returning, one bird hopped to the flowers, while the others watched. It started to shred a petal, as before, then stopped, shook its head violently, and hopped back to the others. Then two other birds tried to shred a petal and with exactly the same result, whereupon all the birds flew into the surrounding trees; and, although birds caused damage in adjoining gardens, no further damage was done during that season to the garden where the flowers had been treated (6).

(ii). At Ben Gurion International Airport, Israel, up to 2000 birds, including starlings, lapwings, partridge, and seagulls, arrived each morning to feed upon the city refuse deposited throughout each day around the perimeter fence of the airport and often caused dangerous strikes to aircraft landing and taking-off. The 200-300 seagulls which arrived were preceded by a "scouting party" of about 50 gulls. For the tests, the refuse was sprayed, when deposited, with the lowest grade of CURB under the trade name RETA; and a loud fog-horn, previously found useless as a repellent, was used.

After this, and for the remainder of the season, only one gull was observed to come to the airport each morning. It did not land but returned to the coast presumably to warn the others of the continuing repellency.

The method of selection of the scout and the communication of the information to all the other birds over a coastal strip of several miles is not understood. But, if the chemical receptors of that one bird had not properly received the smell of the CURB, then the whole test might have been a complete failure (7).

g) The above test raises the query as to the possible heightening of other senses -- sight and hearing -- by the use of a chemical repellent acting on the chemical senses, because the fog-horn, brought out every morning when the gull appeared, was painted in "violent red and blue". G. Dar reports, "several times the mere sight of the equipment even before its laborious starting-up, was enough to cause the gull to leave."

It must also be mentioned that at the commencement of the following season, RETA (CURB) was not used, but only the fog-horn; and during the first week there were four bird strikes to aircraft. All the gulls and other birds had returned to the airport. Then mechanical, electrical, electronic, and other repellent devices, together with falcons, both live and simulated, were brought into use but with, apparently, nil effect (8).

The behavioral patterns described have been attributed to reception of and response to the chemical repellent CURB. But its action may be augmented by other factors about which little is known as, for example, possible electro-physiological action which may occur between the strong electrollte CURB and the electrical forces within the gustatory and olfactory systems.

CURB is hygroscopic and a strong electrolite with three positive electrons or positrons. Also, in all birds and mammals, of the four tastes, sweet is of no interest to us; but sour needs an H + ion, salty needs an anion (negative ion), and bitter has some ionic activity mediated, perhaps, by enzymatic reactions (Christian, 1971 - SENSORY EXPERIENCE). Furthermore, B. Wenzel in AVIAN BIOLOGY states that the olfactory receptor cells in birds and mammals are bipolar neurons or nerve cells, and that electrical activity In response to odorous stimuli has been recorded from both peripheral and central sites in the avian olfactory system.

The electrons of CURB may possibly throw out of balance, or in some way short the circuit of the electrical system within the chemoreceptors, and thus may cause a possible cauterisation at the ends of the nerve sensors and feeling of some pain. If this does occur, a bird or mammal may well become bewildered, experience the sensation of fear, and finally escape from the area.

Mammals and insects are known to leave chemical messages, understood by their species, called "pheromones", which are usually associated with sex attraction and the marking of personal tracks and boundaries. Nothing has yet been published on such ability among birds; but I surmise that the ability on the part of birds and mammals to leave chemical messages of fear of an area or of unacceptable food may well be the reason for some of the very long periods of repellence achieved by using CURB, which, in some cases, have lasted for twelve months from just one spraying of the repellent.

Examples of this long-term repellency from one spraying of CURB, Grade 10, at the

rate of 20-kg per acre are:

1. Wood pigeons, rooks, and crows were kept from a field of maize from emergence to harvest, where previously there had been a history of excessive damage to the crop at all stages of susceptibility to attack (9).
2. Bullfinches were repelled from the buds of cherries, damsons, plums, apples, pears, gooseberries, red and black currants during the winter months from November, when attacks occurred, to May (10) (11).
3. Dogs were kept from fouling in London public parks, gardens, and housing estates during each of five annual periods as follows:-to 3 months, 98 to 100%; 3 6 months, 80 to 100%; 6 - 12 months, 60 to 100% (12).
4. Rabbits and birds, mainly starlings, sparrows and pigeons, repelled from a market garden area of salad and vegetable plants for over six months (13).
5. Deer kept from eating roses and other flowers in a forest garden for six summer months. The flowers previously had always been eaten. The deer had cropped them at the beginning of their flowering period, and they were seen in the garden at least three times during each week of the six month period of observation (14).

In each of these cases there was only one spraying, and chemical tests of the soil and plants showed no evidence of the chemical remaining eight weeks after application. Moreover, the birds and mammals were seen in the vicinity of the tests throughout the periods of observation.

In three large turkey breeding centers, rats bit the cloaca and tails of the breeding birds and caused heavy incidence of *Streptococcus moniliformis* with consequent reduction in breeding performance. One heavy application of CURB powder to the backs of the birds resulted in immediate and permanent vacation of the buildings by the rats (15).

These are some examples of long-term chemo-repellency, which appear to result from the leaving of information via pheromones. It has been suggested that in some instances memory may play a part, but that could not account for the repellent effect on new arrivals.

The life span of receptor organs may also be a factor in the degree and quality of sensory perception. Beidler, 1963, found that the sensory cells of taste, which are within the taste buds located on the papillae, have but a short life span of some 3 - 5 days in cats and rabbits and, possibly, in humans, after which time they are replaced. Then, later investigators showed that the same cell responds differently in accordance with its developmental status. Thus, discriminability in taste appears to be a function, not of which cells are stimulated, but rather at what stage of development they are in when activated.

Such activity in, say, the dendrites of the olfactory receptors, could be one reason for the wide variations in responses to olfactory chemo-stimulants and the frequent need for the heavy applications of the higher grades of CURB. But nothing is yet known of such possible action.

Other possible physiological problems may arise from acquired hyposmia (impaired olfactory sensitivity) and parosmia (distortion or changes in perceived quality of an odor). If, as suggested above, the electrons of CURB do indeed affect the electrical activity within the olfactory and/or gustatory nerve cells, then the birds and mammals may be so affected on the occasion of their first contact with the repellent that hyposmia or parosmia may result; and, consequently, they may not be similarly affected on future occasions. In that event, the responses from the creatures previously repelled would be nil, and this could account for the very wide variations in responses to the repellent from year to year in some areas.

In previous papers I have referred to problems of response variations arising, possibly from such factors as variations in the infra-red content of the sun's rays, pH of the water used for spraying, pH and nature of the soil, and ambient climatic conditions. All of these factors may affect the degree of chemo-reception from season to season and consequent responses. The answer would appear to lie in conducting tests in completely controlled environments, but it is doubtful if tests under unnatural conditions will result in natural responses.

Finally, one of my greatest problems has been to overcome personal prejudices of investigators. As examples: In a test with CURB on wheat where the Latin Square method was used, when the birds and rabbits reached a treated square, they left the field for the remainder of the season. To the farmer this was unqualified success, for in every previous year most of the crop there had been lost; but to the investigators the result was inconclusive. This autumn, trials were carried out at two European airports where birds were a great hazard to planes. Three of the areas where the largest

numbers of birds congregated each year were sprayed with CURB Grade 10 when the birds arrived. Now, five weeks later, I have been told by an investigator that the results are inconclusive because the birds have gone to other areas. I have not been told what would have been a conclusive result.

These, then, are problems I have encountered in the development of CURB, and they must plague other workers attempting to develop a chemical repellent. It would certainly help if acceptable methods of testing and evaluation of results could be found and acted upon.

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DISCUSSION

Q: Do you expect registration in the U.S.?

A: No, I have not done anything at all about registration in the United States.

Q: You mentioned a kilo application per hectare?

A: No, sorry, per acre. This is the application rate. Because there is a carry-over of the olfactory activity, I find it normally advisable to spray at the rate of 16 kilos per acre in alternate widths of the spray band.

Q: What is the cost of application?

A: Varied from L10-40/acre--$20-80/acre, according, of course, to the rate of exchange.

Q: You mentioned that the stuff was sprayed on the backs of turkeys to keep rats from entering the buildings. This didn't have any effect on the turkeys?

A: No, It is used by a number of poultry keepers to stop feather pecking, and a couple of research workers at Bristol University (in their paper given to the Seventh International Poultry Congress in Malta) indicated they had had complete success with it when everything else had failed. Also, the feathers grew again very, very quickly in the areas which had previously been pecked, irrespective of the degree of wounding.

Q: You mentioned that Curb worked on three chemical centers. What are these?

A: These were taste, smell, and the common chemical sense, which is associated with the irritation of the free nerve endings of the body. Let me say this, if I cut myself, I always put some on the cut, because it immediately stops the bleeding. I get no septicemia at all, and healing is very, very quick. You see, it is based on aluminium ammonium sulfate, which for the past 150-200 years has been used as internal douches, mouthwashes, gargles; you probably use it every morning in some of your toothpaste. In the U.K., it is used for the purification of drinking water. It is quite a useful product. I had a telephone call from a retailer in Bristol, England, asking if it was safe, because he had six women who bought Curb and put it on their babies' fingers to stop sucking and nail biting. I got on to the Minister of Toxicology in London, who deals with all pharmaceutical products; and he said not to worry--he wished to devil many more mothers would give that to their children instead of the sweets and chocolates. It would do them a lot more good. The amount that they would ingest would be infinitesimal. There is no question of any build-up.