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DAILY AND SEASONAL SUSCEPTIBILITY CYCLES OF THE STARLING

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I would like to review a few of the characteristics of 3-chloro-p-toluidine hydrochloride (DRC-1339) prior to discussion on the daily and seasonal susceptibility of starlings to this avicide. DRC-1339 was screened and developed by the Denver Research Center (U.S.D.I.) and since has been tested in various portions of the country by the Denver Center and other organizations, including the State of California. In California we are much impressed with this compound for a variety of reasons, particularly the specificity of it to birds, ease in handling, ease in formulation, and many other characteristics which make this a highly desirable avicide.

This morning we heard that DRC-1339 is a slow-acting toxicant. This, however, depends on what is meant by slow-acting. In terms of how long it takes an acute dosage to kill a bird, DRC-1339 is indeed much slower than many toxicants now in general use; but the compound itself is biologically quite active. An acute dose administered orally to a starling will cause destruction to kidney tubules within four hours and glomerular damage within ten. The result is that the bird dies with, but not necessarily of, uremic poisoning generally within one to three days depending upon the amount of DRC-1339 ingested.

Death in mammals apparently results from disruption of the blood's capacity to carry oxygen. It is notable, however, that although mammals can die as a result of DRC-1339, the amount necessary to produce death is so great that the compound can be essentially considered as non-toxic to mammals.

The foregoing provides a brief review of some of the interesting characteristics of this compound and serves as an introduction to a discussion of other phenomena associated with DRC-1339.

This afternoon I'm going to suggest that the European starling is more susceptible to the compound DRC-1339 at one time of the day than at another, and further that this phenomenon also has seasonal implications that the susceptibility of the starling to this compound varies seasonally. I'm going to talk only about this one compound, DRC-1339, and one species, the European starling. I do not know whether or not the phenomenon applies to other birds and other compounds. We hope to find out, but to date we have worked only on DRC-1339 and the starling. Time does not permit a complete description of the experimental design and the data which we obtained. One point that I will emphasize is that we

have used only known-age animals. We've worked on a strictly accurate basis in terms of the sex, age, and weight of the animal; each sample we tested was as homogeneous biologically as we could get.

For each test we selected a population and divided them into six 10-bird groups. They were given a dose of 1339 by stomach tube, each group getting the same amount and each bird getting the same amount. The only difference between groups was the time of day the toxicant was administered, i.e., there were four hour intervals between group intubation times so that three groups were intubed during daylight and three groups were intubed during darkness. Generally intubation of the first group began at dawn. Of course, dawn in June is a quite different time than dawn in December; they are not strictly the same time of day on a twenty-four hour clock. Nevertheless, we felt that this was the most accurate way of administering the toxicant. We found that the intubations that were done at 1) dawn, 2) four hours later, and 3) four hours after that were in that order the most critical times of the starling's daily cycle as far as susceptibility goes. In other words, at dawn a starling group was much more susceptible to 1339 than was a comparable group intubed later in the day. During the hours of darkness, a dose that would be 100% effective at dawn did not kill nearly as many birds.

The reason we tested the susceptibility of starlings to this toxicant during hours of darkness is because we were also testing this compound as a roost spray, and this treatment is done in the evening. Similar to the oral administration, we found a roost spray applied at dawn is about twice as effective as the same amount of the compound applied at dusk. In terms of efficiency, it's a lot easier to apply the material by air at dusk that it is at dawn. It is possible, however, that techniques can be worked out so that this material can be applied at dawn to get more efficient results from a smaller dose of the compound.

Back to the intubation experiments: we conducted a test to determine daily susceptibility of the starling to DRC-1339 during December, March, June, and September. In each test the animals which were intubed at or near dawn were by far the more susceptible to this toxicant than those intubed during the night. However, we found that the birds as a population were much more susceptible during June that the population intubed in September. The populations intubed in December and March were more susceptible than those intubed in September but still were not as susceptible as the population intubed in June.

The reason for seasonal changes in susceptibility of starlings to 1339 is as inexplicable as the daily susceptibility differences. We do however have evidence that the differential susceptibility has nothing to do with: 1) the age of the bird, 2) the sex of the bird, 3) the weight of the bird, or 4) anything that we can relate to gross characteristics of the starling itself. We have fairly good evidence that it has nothing to do with 5) feeding habits of the bird, 6) the activity of the bird (there's evidence on this last point, but it's not conclusive yet). In a nutshell, the only thing we can tie the phenomenon to is the duration of daily light and possibly to prevailing air temperature. We have a lot more study to do on this.

We can apply the available information to enhance out control efforts. We know that starlings can detect DRC-1339 on treated pellets, and the degree to which they avoid these pellets is directly proportional to the amount of the compound on the pellet. This means that if we prepare a 1339 treated pellet that is essentially 100% lethal to starlings in the morning, it's not going to be nearly as lethal if the birds are feeding in the late afternoon. If we use twice as much of the toxicant on pellets so that we kill 100% of the starlings that are accepting bait in the afternoon, we find that the birds in the morning tend to avoid it. Thus, in addition to the cost of the compound, we have to consider the avoidance of it. Consequently we have to know the feeding patterns of the birds, when they will accept the compound, and adjust the dose accordingly. Of course, the same thing applies on a seasonal basis. If we're going to kill starlings by this method in June or July, we can use essentially half the amount of the compound that we use for the same results in late October. Although taking this into account involves adjusting seasonal formulations and changing the amount and type of bait, still all our tests point to the advisability of doing it.

DRC-1339 is an extremely good compound when it is used correctly. It's safe and it's practical. But when you start getting avoidance of it simply because your dosage is too "hot" (to say nothing of possible environmental contamination), I think consideration should be given to such things as the susceptibility cycles.

DISCUSSION:

STECKEL: Do the birds see the material on pellets and is it a visual response?

SCHWAB: I'm not at all certain if the response is visual or not. We have color-marked treated pellets and observed starlings picking these up and then quickly dropping the treated pellet in favor of a non-treated pellet. Reversing this procedure we have color-marked the non-treated pellets and observed the birds picking up but not ingesting the non-colored pellets. This suggests that taste is probably more important than the color imparted to baits treated with DRC-1339 with respect to avoidance. Also, it is certainly possible that odor may play a significant role in bait avoidance, especially in light of new findings which indicate that perception of odor by birds may be of a much higher order than was suspected in the past.

DYER: In view of your work on the starlings and susceptibility rhythms and what you know of circadian rhythms from other species of birds, I'd like to ask for a conjecture for other species. What would you predict in population differences in blackbirds or other birds that are geographically widespread? I think this is worth investigating.

SCHWAB: I agree. The only evidence I have which would prompt an affirmative answer is simply this. I've taken birds under the natural photoperiod in June (long day lengths) and artificially given them the photoperiod that they would

experience in December (short day lengths). I've found then that the birds under the artificial regimen did not follow the same susceptibility pattern as the birds under the natural photoperiod, that is, the June photoperiod. Instead, although it actually was calendar June, the animals responded the same as did birds actually treated in December. Conversely, I've taken starlings from the natural December photoperiods and given them artificial daily light approximating that of June. These birds exhibited the same susceptibility to DRC-1339 as did the controls actually treated in June. On this basis, I can say that a starling is going to change the degree of susceptibility to DRC-1339 as a function of daily photoperiod rather than on calendar date. I would suspect, then, that a widespread species inhabiting areas of diverse daily photoperiod would indeed show differences in susceptibility on a geographical basis but that these differences are a function of the duration of daily light.

DYER: There are two ways to control bird populations: one is lethal and the other is cutting down their fecundity, which means birth control. These chemicals by and large aren't developed. It seems to me that your work is extremely important when thinking of chemosterilants, because of the incidence of photoperiodism, development of the gonads, and the breeding cycle. Do you agree with this, and where might we apply your thinking of susceptibility rhythms and lethal compounds to the chemosterilants?

SCHWAB: We have not as yet experimented with the possibility of susceptibility cycles with respect to chemosterilants. My opinion, and its just an opinion, is that the same phenomenon would apply to chemosterilants as well as other compounds. Circadian rhythms have been documented under so many conditions and with so many biological functions that one would suspect the phenomenon to be somewhat "universal."

BECK: You mentioned taste factor. Does your work show any chemoreceptors for taste as we know in mammals?

SCHWAB: We have not explored the possibility of chemoreceptors and associated bait preference. The physiological basis of bait acceptance or avoidance is a subject worthy of considerable investigation, and I predict that much work will be accomplished on this subject in the future. As of the present, however, we remain largely in the dark on this subject. All the bait acceptance studies in my laboratory have been strictly on an observational basis with the result that all we can say with certainty is that the animal either accepts the bait or the bait is rejected.

JACKSON: I think the work of Dr. Morely Care is beginning to show that birds are much more sensitive to taste than previously thought.

BOUDREAU: Your information is very interesting, because it parallels my experience with bird susceptibility to acoustic alarm stimuli. I found that many

species are highly susceptible in the morning right after they leave the roost. In certain cases, a single 30-second application of sound in the field early in the morning suffices to clean that field for the remainder of the day. Now with pigeons, I have found that along towards dusk the response level rose way up. It was impossible to remove the birds with any sort of stimulus other than walking up to them and hitting them with a club. You've got to remember that a bird's behavior changes from day to day, from month to month, and I don't know, maybe from year to year too.

COURTSAL: At what level would you say that DRC-1339 should be in a mixed bait? We're using presently 1%; is this too high?

SCHWAB: In my opinion, yes.

COURTSAL: Then I assume from what you're saying that if we reduce this by half and use it in the morning then we'd be better off than at any other time of day.

SCHWAB: I would say that you could cut the concentration in half and get the same effect and probably better acceptance. I believe that the Starlicide formulation is nearly twice as "hot" as it has to be and that starlings are reluctant, at least to some extent, to ingest the bait for this very reason.