THE BEARING OF THE OXYTOFACTOR IN INSECT CONTROL

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A number of years ago the writer called attention to the Law of Happy Medium of Temperature in its bearing upon insect life. Later he was able to add that there was a happy medium of humidity, pressure, light, atmospheric gases, and acidity-alkalinity.

Acidity-alkalinity is expressed by a logarithmic factor called pH, an expression of the hydrogen ionization, but the writer has chosen to express this factor as the oxytofactor.

The essence of the theory is that each species of animal or plant has its typical soil, its proper environment of all factors, and hence if it is a soil dweller it will respond favorably to a certain range of oxytofactors, and outside of this range at either end of the scale its reaction will be that of anesthesia, while a greater departure will result in death.

We have animals that live in highly acid conditions, and also plants; and on the other hand there are forms found in highly alkaline conditions.

The same thing is true of life in the water and in the air, for there is an oxytofactor to express water or air conditions.

That soil, or water, or air oxytofactor of the environment which is most favorable for the life of a certain species is the typical soil or happy medium as regards the oxytofactors.

Plant and animal life are complex, the animal more than the plant. Each organ in the economy of the creature operates under a typical oxytofactor. So that in the processes of ingestion, assimilation and elimination there are alternating series of oxytoreactions. For example in man the reaction in the mouth is alkaline, in the stomach acid, in the first intestine alkaline, and subsequently acid. These reactions are delicately balanced and it only requires a little excess of certain types of foods to completely overthrow the entire system.

Just as the internal organs have their typical reactions, so also do the surface organs.

Now all of these facts have a decided bearing upon the practises of economic biology, in which I include medicine.

The oxytoreaction is the basic chemical reaction. It is in effect the interchange between two bodies differently electronically charged. In other words no matter what we wish to kill, whether it be a creature on a plant, or in the soil, or in the liquid media, or perhaps within the body of an animal, or man, or in the interior of a plant, if we desire to kill it by bringing about a disintegrating chemical reaction, we must accomplish it by means of an oxytoreaction.

In entomology we kill by chemical reaction, by asphyxiation which in most cases is the same kind of a reaction although it may be a covering up of the breathing apparatus, and by mechanical means. But the greatest portion of our practise is chemical. Until recent years medical practise has largely also been chemical.

There are therefore certain practises and certain principles which if observed will aid materially in the proper solution of problems of control of an undesirable species, organism, plant or animal.

1. The first essential to economic practise is therefore the determination of the typical soil of the organism desired to be destroyed.

2. The second step is the determination of the bounding oxytofactors which merely cause anesthesia, for if we attempt to control by using such factors we have failure.

3. The determination of the limiting oxytofactors for continuation of life. Every organism has its limiting oxytofactors.

4. The determination of the bearing of temperature, humidity, light and pressure upon the practic, anesthetic and fatal zones of oxytofactors. This is imperative. Any one drawing conclusions at a certain temperature-humidity-light-pressure complex, and disregarding the fact that all four of these factors vitally affect reaction and rate of reaction is certain to have trouble when working under another factor complex.

5. Having determined the destructive oxytofactors under the existing other environmental factors it becomes necessary to determine whether you are to use the acid or the alkali fatal oxytofactor.

6. A criterion for this may be found often when you consider the other organism or organisms involved. The purpose of the research is to accomplish the death of certain organisms without injury to certain others. These others may be associates in the same medium, or they may be the hosts whose health is injured by the presence of the organism to be destroyed.

7. Just as the organism to be killed has its practic, anesthetic and fatal zones of all factors, so also does the organism to be saved.

8. As a rule a dependent organism has a more restricted practic zone than its host, and it will usually be found that one of its fatal zones is more favorable to the host than the other. This is the one to be chosen.

9. It will usually be found that the host is only seriously injured when its environment, or the condition of certain of its organs is unfavorable, and hence the indicated direction for treatment is in the direction of normalcy for the entire organism, and all of its organs. In other words a tree may be seriously injured by insects or disease, and another tree of the same kind may be uninjured. In such case there is the possibility that an adjustment of the nutrition of the former will bring about amelioration of the condition, much faster than the destruction of the pest alone, for if you only kill the pest and leave the plant still in a state of improper nourishment it is subject to more damage.

10. Just as a plant can be killed by too much or too little calcium, nitrogen, phosphorus, potash, manganese, magnesium, sodium, iron, sulphur, etc., in the soil, so also can it be made most productive when each of these factors is in the proper ratio. The same thing relates to the functioning of the animal body. Its food elements must be properly balanced, and an excess or deficiency of any food element may be destructive.

11. The insect or other organism feeding at the expense of another living organism, plant or animal has its own boundaries of limiting factors for the food it derives from its host. In other words the welfare of the parasite depends upon the state of health of the host, and it usually happens that the parasite develops best when the host is not in the best health, for if it

were properly functioning in every respect it could throw off its enemies.

12. The host makes an unusual effort to overthrow injurious attack and this wears it down unless it has sufficient resources to tap.

13. A control measure which causes a set back to the host while accomplishing the control of its enemies is undesirable if we can find in another direction a control measure which will be favorable to the host and unfavorable to its enemy.

14. Consequently often the proper control measures are the reconditioning of the environment of the host to enable it to accomplish the destruction of the parasite.

15. A control measure which temporarily accomplishes its purpose of control of the pest, but which leaves residues which will accumulate in subsequent treatments, may become a serious menace not only to the future life of the host that is being protected, but in the case that these residues accumulate in the soil may permanently injure that soil for the growth of future crops. This is one of the greatest dangers in continued use of arsenic, for some plants have a very low tolerance for arsenic in the soil, and the result would ultimately be the impossibility of accomplishing a desirable rotation of crops.

16. It must be remembered that the fertility of soil is to a large extent due to the micro-organisms which bring about the necessary chemical changes. If we use in economic control of pests any substance which in the accumulation of subsequent treatments will tend to destroy the beneficial micro-fauna and flora of the soil, we are solving a present problem and laying up trouble for the future. The responsibility of the economic biologist in whatever branch is not only to the present generation, but also to all future generations.

17. Many tests have already shown that the efficacy of an insecticide depends upon its oxytofactor. Calcium arsenate does not kill just because it is an arsenical, but because it brings about an unfavorable reaction. So too a given strength of nicotine may not kill, and yet the mere alteration of its oxytofactor, without changing the strength may bring immediate results. Does this not to some measure indicate that many substances not

at all considered toxic could be made toxic by a simple change in acidity or alkalinity?

18. Any law proclaiming a substance poisonous merely on the basis of its chemical strength may be an unfair and misleading law. Any board proclaiming that a substance is not a poison may be doing science a great injury. The writer has a personal idiosyncracy against chocolate due to an overdose on one day, so that a small quantity of chocolate acts as a poison although that overdose was taken twenty-five years ago. Many people are poisoned by eggs, some by chicken, some by salt, some by pepper, some by cucumbers, some by tomatoes; are we therefore to declare these things poisons? Or is it fair to say that they are non-toxic? Any substance whatsoever that may accomplish the killing of an organism is a poison to that organism.

19. In some states they claim that calcium is not a fertilizer. They have so limited the political definition of a fertilizer that the law only recognizes nitrogen, phosphorus and potash. This is a positive injury to science. Any chemical necessary for the proper nourishment of a plant is a fertilizer. Often a very slight deficiency of some minor elements in the soil is the cause of plant injury, which makes it more susceptible to disease and pest attack.

20. Economic biological control of pests is not confined to insecticides and fungicides but must also include proper soil treatment.

21. That treatment which accomplishes at the same time the largest number of benefits is the most to be desired. If we can in one treatment use a chemical which, while killing the pest, will also stimulate the plant and do no future injury, we have accomplished a double purpose.

22. Any system of governmental division of functions which makes it impossible for experts to recommend certain treatments because those treatments have been arbitrarily placed under the jurisdiction of some other division is detrimental to the proper rendering of service. If they must be divided in function then there must be such correlation of investigational relations that personal or divisional jealousies cannot prevent the publications of results because not done by the employee of a certain designated governmental branch.

Permit me now to give one or two concrete examples of the above principles from my own practise.

I was called in by a lady in California to bid on the cleaning up of a serious infestation of snails and slugs, which were destroying all of the vegetation on her place. I made a bid, basing it upon the use of arsenical bran bait. She accepted the bid and then said, "I do not want you to use any arsenic, or any bran containing other poison, because my dog and cat will eat bran; and I don't want you to kill any birds. Just destroy the snails and slugs and nothing else." I said, "You have cut me out of my only effective methods, so far known. But I have given my bid, I will take the contract."

I went to the local druggist and said, "Give me samples of every cheap chemical you have on hand." I took these to my laboratory and placed large sheets of paper on the floor and made rings of chemical about a yard wide. Then in the ring were placed many snails and slugs.

A certain series of chemicals caused the snails to become dormant and to seal up their shells. Some remained perfectly dormant for thirty days. For example lime caused a slight suspension of activity; sal soda caused them to encyst for eleven days; ammonium alum kept them in anesthesia for 20 to 30 days after a mere contact; salt caused a suspension of activity in one case of 34 days. Contrary to expectation salt did not kill a single individual of *Helix adspersa.*

Then I found that there were some chemicals which caused death in a few minutes, as copper sulphate and ferrous sulphate. Certain very alkaline chemicals did the same.

The snails and slugs had a slime on the surface of the body which was on the alkaline side of the scale. That was the typical soil of the creature. When they came in contact with chemicals which differed to a considerable degree from the condition of the slime they were anesthetized. But when the difference was a little greater they were killed. A tiny particle of copper sulphate, ferrous sulphate or aluminium sulphate brought about an electric reaction with the slime of a seven inch slug, which resulted in its going into convulsions and dying quickly. They were perfectly mummified, of brown color when the reaction was complete. The other day I saw a mummy in the American Museum of Natural History of a man who perished in a Peruvian mine and he was covered with copper salts, and I thought that perhaps a mummification similar to that taking place in the snail had resulted.

All that was necessary to obtain quick control was to sprinkle small crystals of ferrous sulphate and copper sulphate on the ground around the yard and especially around the plants to be saved. The next day there were many dead snails and slugs at these chemical barriers.

The choice for the practical work fell upon ferrous sulphate, because its price was less than four cents a pound wholesale; it killed the snails and slugs quickly; it acted as a plant food and stimulant; it would assist in the control of soil nematodes; if the dogs or cats ate it or licked it the result would be beneficial if they had intestinal worms. Every requirement was fulfilled.

Another example comes from my practise in the Island of Negros in the Philippines. The dominant soil pest of sugar cane was the white grub. They were only present on soils that had an acid reaction and it was found that the pH of the grubs was usually a little more acid than that of the soil. The proper direction of treatment was to bring the soil condition toward that most suitable for sugar-cane, which is pH 7. For those species present in Negros the writer did not find any in soils above 6.8. So all that was necessary was a heavy dressing of lime.

Many fields of sugar-cane were very yellow. The soil analysis showed that the potash ratio while within the supposed safety-limit was on the verge of deficiency. Nematodes were very bad at the roots, as was the Pythium rootrot. The simple treatment of 250 kilograms of potassium sulphate per hectare remedied the situation and the cane became green and grew rapidly while that untreated did not grow any more. A heavy treatment with lime accomplished the same result although slower in initial action.

These examples are merely given to emphasize some of the points given above.