Because some antibiotics have proved active in certain parasitic infections, there appears to be good prospect that this rapidly growing and meagerly tested class of chemotherapeutic agents (there are already some 4,000 known antibiotics!) will some day provide efficient treatments for some of the parasitic diseases of livestock and poultry.

Antibiotics are especially useful for combating bacterial infections that commonly occur in animals suffering from parasitic diseases.

Certain chemotherapeutic agents of comparatively recent introduction have received prompt verification and acceptance. A few have been mentioned. Others of note include 2-amino-5-nitrothiazole (Enheptin) for controlling blackhead, hexamitiasis, and trichomoniasis of poultry; quinacrine hydrochloride, for curing giardiasis and removing tapeworms of dogs, man, and certain other host animals; acriflavine, soluble iodides, and hydrogen peroxide as treatments of a sort for bovine venereal trichomoniasis; antimony potassium tartrate (tartar emetic), for dermal filariasis of sheep; emetine hydrochloride, a promising drug against certain lungworms (Protostrongylus and Muellerius) of sheep; thiacetarsamide, for heartworm infection of dogs; Anthelin, against canine tapeworms; Phthalofyne, against canine whipworms; and di-N-butyl tin dilaurate, for the removal of some species of tapeworms from chickens.

These and many other agents are examples of the developments that are rapidly taking place. The job ahead is a challenging one, however, because present treatments fall far short of the ideal, and no chemotherapeutic agents are yet available for use against the majority of helminthic species and many of the protozoan species that cause loss and damage in livestock.

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Chemotherapeutic Agents for External Parasites

E. F. Knipling

Insecticides employed for many years to control ticks, mites, lice, and other arthropod parasites affecting animals were chiefly dips, sprays, or dusts containing arsenicals, nicotine, sulfur, cresols, rotenone, or pyrethrum.

To them have been added a long list of synthetic organic chemicals, which provide more effective materials than those formerly used to control certain external parasites and make it possible to control a wider range of species.

These newer insecticides, including DDT, methoxychlor, toxaphene, BHC, lindane, and chlordane, have come into prominence for controlling many pests. But we still rely heavily on pyrethrum and rotenone, which have been used for many years and are of proved safety.

A major concern in the development of new chemotherapeutic agents for external parasites is that they be safe. We must be certain that the materials will not harm the animal. It is equally imperative that their use will not lead
to the appearance of harmful residues in the meat or milk products derived from the livestock. The chemicals employed most extensively for the control of the more important external parasites of livestock are discussed here.

Rotenone is the active constituent in ground roots of plants. Sold commercially as cube or derris, these plant products are low in hazard to animals and man and are effective against several livestock pests.

Rotenone insecticides are still the only approved materials for controlling the ox warble or cattle grubs. The insecticide is employed as a dust, wash, or in high-pressure sprayers for destroying the grubs in the backs of the hosts.

Rotenone also is used extensively for controlling lice on cattle and fleas and ticks on pets.

Pyrethrum, another plant product, has an outstanding record for its safety and desirable insecticidal properties. It possesses unusually rapid paralytic action against insects, a property not present in any of the newer chlorinated hydrocarbon insecticides, like DDT. Cost has been the chief drawback to the more extensive use of pyrethrum for controlling some livestock pests.

That objection has been overcome in part by the development of compounds, called synergists, which, when combined with pyrethrum, increase its efficiency to a marked degree. Sesame oil concentrate, pipernyl butoxide, sulfoxide, and n-propyl isomer are the common synergists for pyrethrum.

Pyrethrum is used against livestock pests chiefly as a spray for controlling the hornflies, stableflies, horseflies, and deerflies on dairy animals and also as dusts, dips, or washes to control fleas and lice on pet animals.

After years of research, the Department of Agriculture succeeded in synthesizing allethrin, a compound similar to pyrethrum in chemical properties and in insecticidal properties.

DDT, the first of a series of new chlorinated hydrocarbon insecticides, has proved invaluable to the livestock grower. A white, crystalline, odorless compound, it controls a wider range of external parasites than any previously known chemical. DDT, when properly formulated, may be used as a dust, emulsion spray, or as a spray or dip prepared from wettable powder concentrates. It can also be sprayed in an oil solution.

DDT has a low order of acute toxicity to animals, but is readily absorbed and stores in animal tissues and excreted in milk. The avoidance of residues is, therefore, the chief concern in the safe use of DDT. The insecticide is not recommended for use in dairy barns or on dairy cows for controlling livestock pests.

DDT is employed on livestock, other than dairy animals, for controlling hornflies, the sheep ked, lice, and fleas. In combination with lindane or BHC, it is also used against ticks. DDT alone, at the 0.5 percent concentration usually employed on livestock, is not effective against engorged ticks, but it will protect animals against reinfection with other stages of the parasites. BHC or lindane, on the other hand, kills all stages of ticks readily but the residual action in protecting animals is short. A combination of the two materials is, therefore, desirable.

For a number of years DDT gave good control of houseflies, but the flies became resistant to the insecticide and it is no longer a dependable control agent for them.

Methoxychlor is closely related chemically to DDT and will control a number of the same external parasites. It is of a lower order of acute and chronic toxicity to animals. Because it has little tendency to store in animal tissues or to appear in milk, it is used on dairy cows and beef cattle to control flies and lice.

Toxaphene, another chlorinated hydrocarbon insecticide, is excellent
for controlling livestock pests. It is used as sprays and dips prepared from emulsifiable or wettable powder concentrates.

Toxaphene compares favorably with DDT for the control of hornflies on cattle, the sheep ked, and all of the various kinds of lice that attack livestock. At a concentration of 0.5 percent, toxaphene will destroy all stages of the ticks and provide protection against reinfestation comparable to that obtained with DDT.

**BHC AND LINDANE** are two grades of a chemical that contain the gamma isomer of benzene hexachloride, the active principle of a highly effective material for controlling a wide variety of livestock pests. The commercial product, known as BHC, contains 12 to 40 percent of the gamma isomer. Lindane consists of more than 99 percent of the gamma isomer.

The gamma isomer of benzene hexachloride is used for controlling lice on livestock, the sheep ked, several kinds of mange mites on livestock, poultry mites, lice, and fleas. It is employed in sprays or dips at concentrations ranging 0.025 to 0.075 percent. It is effective against all stages of ticks at a concentration as low as 0.025 percent gamma isomer, although it lacks the desired residual action. It is employed therefore in combination with DDT for controlling different kinds of ticks.

Lindane, in a special preparation known as EQ-335, also is used to prevent screwworm infestations when applied to wounds and to kill maggots present in wounds.

**CHLORDANE** has had somewhat limited use against livestock insects because its chronic toxicity to livestock and the hazard of insecticide residues in meat and milk products from treated animals have not been adequately studied. It is about as effective as DDT, BHC, and toxaphene. It is especially effective against lice on livestock and the sheep ked. It is recommended as 0.5 percent sprays for single applications for louse control and for sheep keds.

Chlordane is also used for the control of lice, ticks, and fleas on dogs and of mange mites on swine.

**OTHER NEW INSECTICIDES** have been under study. Among the materials of special interest are dieldrin, aldrin, heptachlor, permethane, strobane, malathion, Bayer L 13/59, and chlorothion. Further research on them will be needed to establish their safety.

Some of the chemicals will destroy external parasites such as the cattle grubs, screwworms, lice, and blood-sucking flies when injected into the host or when administered orally. Several chlorinated hydrocarbon insecticides, including lindane, aldrin, and dieldrin, and certain phosphate insecticides, including diazinon, Bayer L 13/59, and chlorothion, destroy such pests when administered internally.

**RESEARCH WORKERS** have been trying to formulate a systemic insecticide, which destroys all of the grubs in cattle with a single injection or feeding. The most effective materials under investigation in 1956 killed the grub larvae only during the time that they are in the back of the host, and two or more treatments were necessary in order to destroy all of the parasites. A safe, economical, and effective material, which will kill the grubs in any part of the host, has been the objective of investigators. Such material would make it practical to control or eliminate the cattle grubs.

Before any systemic insecticides can be recommended for controlling external parasites, much fundamental and applied research has to be done to determine how to use them effectively and without harm to the animals. This promising method of controlling external parasites, therefore, must be regarded a challenge for future research workers. This new approach offers such great advantages over conventional methods that scientists are devoting more and more effort to it.
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Veterinary Biological Products

OREN E. HERL AND LEIGH T. GILTNER

TO LOUIS PASTEUR mankind will always be in debt for his momentous work with biological products, which hold first place among medical accomplishments in preventing and treating infectious disease in man and animals.

The noted French chemist and biologist in 1881 published results of his first successful experiment in immunizing sheep against anthrax, an acute infectious disease that is caused by the anthrax bacillus and can attack all mammals, including cattle, sheep, and man.

Pasteur administered vaccine to the sheep. After a definite waiting period, the vaccinated animals were subjected to an infective culture of the anthrax organisms. Pasteur and his skeptical opponents waited to see what would happen. To the surprise of the doubters, the vaccines remained well, but most of the controls, the unvaccinated animals that were kept for comparison and checking, died.

Following his first experiment, Pasteur began to study immunization against rabies. He reasoned that if he followed a pattern of preparation for rabies vaccine like the one he used for anthrax he should get similar results. He was disappointed, however. The new vaccine failed to stimulate immunity. The vaccinated animals, as well as the unvaccinated controls, contracted the disease when rabies virus was injected into them.

The reason was this: In the first instance, with sheep and anthrax, Pasteur was working with a bacterial organism. In the second, he was working with a virus. Later, however, he developed the famous Pasteur treatment for rabies.

Since the great Pasteur’s time, scientists have been working eagerly to develop ways to immunize animals against disease-producing microorganisms and viruses.

Three groups of disease-producing agents—bacteria, viruses, and rickettsiae—include most of the infective pathogens (disease-producing agents) that plague man and animals.

The bacterial organisms, such as anthrax and tubercle bacilli, can be seen under a microscope that magnifies a few hundred diameters.

Viruses, such as of hog cholera and rabies, may be seen only with the aid of an electron microscope, which gives a magnification of many thousands of diameters.

The rickettsiae are smaller than bacteria but larger than viruses; heartwater disease (Rickettsia ruminantium) in ruminants is an example.

Nature has given animals an immunizing mechanism whereby they may acquire immunity or resistance against such infective agents. The