Drugs To Control Parasites

by BENJAMIN SCHWARTZ

Parasites are relatively low forms of animal life that live on or in the bodies of larger animals. There are about 100,000 kinds, and they do untold harm. One group includes insects, ticks, and mange or scab mites and are known collectively as arthropods. Another group, called helminths, or worms, include cestodes, or tapeworms; trematodes, or flukes; nematodes, or roundworms; and thornyheads, or acanthocephalids. A third class comprises single-celled microscopic organisms known as protozoa. Most of the arthropod parasites of livestock occur on the skin or in its layers. The worms and protozoa that affect domestic animals and poultry occur inside the body.

The relation between a parasite and its host is one-sided. The parasite gets food from the being that shelters it, but may cause its host's death (particularly if the host is a young animal or bird), or stunt its growth and reproductive capacity, or lower its vigor. The parasite can ruin hides used for leather; spoil meat and render it unfit for food; damage intestines needed for surgical sutures and other purposes; and hurt livers needed for food and medicinal preparations. It lowers production of fiber, causes uneconomical use of feed, and brings about other injuries. All this it does in its normal life processes of growing, feeding, and reproducing, or through specific destructive action.

Because so many kinds of parasites infest so many animals the world over and because they have tremendous reproductive capacity and have adapted themselves to our most useful animals, producers of livestock and poultry would be helpless without the weapons that have been developed to control parasites.

Parasiticides—drugs designed to destroy external and internal parasites—are among the most effective weapons. During the war years espe-
cially, when farmers had to meet unusual demands for animal food and fiber, drugs were used widely. New treatments were made possible by a backlog of scientific work conducted in peacetime by Federal, State, and other agencies, and by accelerated wartime research. As a result, producers had the advantage of a big and growing storehouse of practical knowledge.

Controlling Cattle Grubs

Soon after war came, we discovered that the domestic supply of leather would not meet the military and civilian demands for shoes and other leather articles. We went after cattle grubs, the worst enemy of cattle hides. The grubs, the larvae of heel flies, develop rather slowly in the bodies of cattle before they migrate to the back and puncture the skin. After a period of development in cysts under the skin, when the grubs increase greatly in size, they drop out, pupate on the ground, and emerge from their pupal cases as adult flies. The latter soon mate, and the females deposit eggs on the hair of cattle. The young grubs enter the skin through the hair follicles, and start the vicious annual cycle all over again.

The research that had been going on in the Department's laboratories, State agricultural experiment stations, and elsewhere showed that rotenone-containing materials, like derris powder and cube powder, are more destructive to grubs in their cysts than any other preparation tested for the purpose. The knowledge was quickly and widely disseminated, and research to improve control procedures were stepped up in order to conserve rotenone and to improve ways of applying it most economically and effectively. Normal imports of rotenone from Japanese-invaded countries of the Far East were cut off and only a limited supply could be had from South America.

Adding more urgency to the work were these facts: 35 percent of all cattle hides in this country are classed as grubby by the tanneries, meaning they have more than five grub holes each; grubs cause an annual loss of approximately 12,000,000 pounds of beef, because parts affected by the grubs are trimmed off; adult flies sometimes annoy cattle so severely as to interfere with grazing and proper growth.

We knew that the rotenone-containing material could be applied dry to the backs of cattle or in water suspensions as a wash, as a spray under high pressure, or as dips. We could do little to lower the amount of material needed by the water suspension, but we found out that the dry cube or derris powder could be used more economically by mixing it with inert matter in the ratio of one part of the medicament and two parts of inert powder, the mixture being applied to the backs of cattle with a shaker can and thoroughly rubbed into the grub sacs. The dusts used during the war, instead of being mixed with sulfur and talc, as had been
the common practice in prewar years, were mixed with either double-ground cream Tripoli earth, or a micronized volcanic ash known commercially as Friantite M3x, or pyrophyllite, a clay-like substance, ground so fine that 90 percent of it will pass through a 325-mesh screen. The mixtures so prepared were more effective than those used before.

The rotenone-containing wash, developed before the war, was more critically tested to determine its usefulness in reducing the number of cattle grubs and to gage its practical value in grub eradication. In tests conducted by parasitologists of the Bureau of Animal Industry in Colorado in 1944 and 1945 on about 2,500 head of cattle over 120 square miles, the grub kill was approximately 95 percent in a single application. The wash was prepared by dissolving 12 ounces of derris powder or cube powder, having a 5-percent rotenone content, and 4 ounces of granular laundry soap in 1 gallon of water. The benefits of the treatment lasted; a year later the grub population in the cattle was about 70 percent lower than in previous years.

On the basis of experience gained during the war, we learned that the cheapest and easiest preparation to use in pressure sprayers should contain at least 71/2 pounds of cube powder or derris powder having a 5-percent rotenone content to 100 gallons of water. No other ingredients are needed. Best results were had by applying the preparation to the backs of cattle as a fine spray with a power-operated orchard sprayer capable of obtaining a pressure of at least 400 pounds at the nozzle.

Dipping in rotenone-containing solutions, a procedure that likewise was critically tested during the war, proved to be practical and the preferred method of treating large herds in areas where the winters are not too severe. Not less than 10 pounds of derris or cube powder, having a 5-percent rotenone content, and 2 ounces of a suitable wetting agent, such as sodium lauryl sulfate, are needed for 100 gallons of water.

**Rotenone for Lice and Ticks**

Dip containing rotenone that is used to kill cattle grubs also destroys lice—pests that have become of increasing concern to cattlemen all over the country. Rotenone-containing materials, however, destroy only the motile lice; the eggs, or nits, escape and hatch at various intervals after dipping. The 30-day interval between two successive dippings for grubs will not eradicate lice. To destroy them, as well as grubs, one extra dipping, about 16 days after the first dipping for grubs, has to be given. The quantity of rotenone-containing powder for the extra dipping may be reduced to 1 pound to 100 gallons of water, because lice are more easily killed by rotenone than grubs.

Another important and economical use of derris and cube powder came to light in connection with the control of so-called sheep ticks, or
keds. We made tests with weak solutions of the rotenone materials, prepared by adding small quantities of the medication to water, with a maximum of 6 ounces (5-percent rotenone content) to 100 gallons of cold water. A single dipping of tick-infested sheep, after all the shear cuts had healed, killed the pests. Because it is easy and cheap to make this dilute dip—it costs less than a cent a head—it will be possible for sheepmen everywhere to take common action and eradicate sheep ticks altogether.

**Versatile Phenothiazine**

Phenothiazine is a synthetic organic chemical, prepared commercially by combining diphenylamine—a synthetic coal tar product—with sulfur, under the influence of heat and a catalyst. Up to 1938, phenothiazine was known to organic chemists only as a chemical curiosity that had been synthesized in Europe in 1885, and to entomologists as an experimental insecticide for destroying mosquito larvae and controlling the codling moth. In December 1938 the Department, after considerable experimentation, first announced the discovery of the value of phenothiazine as an anthelmintic, or worm medicine, for swine. In the next 3 years the drug was found to possess exceptional merit in ridding farm animals, especially horses, cattle, sheep, and goats, of gastrointestinal roundworms.

A significant development in connection with the use of the drug as a worm killer was our wartime discovery that phenothiazine could be mixed with ordinary granular salt, and the salt mixture used safely to control sheep roundworms, the most injurious of the disease-producing agents that plague sheep.

Besides destroying most of the common stomach worms and nodular worms, phenothiazine has a significant anthelmintic action against other kinds of roundworms that live in the intestines of sheep and also kills the eggs of roundworms. About half of the drug passes unchanged through the sheep's digestive tract, and is, therefore, present in the droppings that contain the parasite eggs. So, it appeared logical and desirable to try to develop a scheme of self-medication that would insure that the sheep could take in the drug more or less continuously and at the same time eliminate small quantities of it with the droppings. Accordingly, our first experiments to test the possibility were designed shortly after the discovery of the anthelmintic values of the drug. Mixtures of phenothiazine in feed were tested. Later we used phenothiazine in salt in various ratios, on the assumption that a sheep's natural craving for salt might insure a sufficient intake of the drug to reduce the animal's worm population and, at the same time, kill the eggs in the droppings.

Considering the large numbers of eggs produced by parasitic roundworms and the relatively short period required for their development, it is quite evident that even a small number of worms not removed by treat-
ment could pyramid to significant levels in a relatively short time in the late spring, summer, and early fall. In the past, stockmen had to resort, therefore, to the tedious task of costly and possibly dangerous treatment at 2- to 3-week intervals all summer. But a routine involving the more or less continuous intake of even small doses of a potent drug, however effective it might be to control parasites, could not be considered as being altogether free of chance, without extensive experimentation. Therefore, various possible risks had to be considered.

It was necessary to determine through long and painstaking tests the effects on the health of adult sheep and lambs of a continuous intake of small doses of phenothiazine, to ascertain whether such treatments would arrest growth, injure the wool, impair reproductive functions, interfere with gestation, or prove injurious in other ways. Not until after 2 years of continuous experimentation with a flock of Government-owned sheep at Beltsville did we announce the value and safety of a phenothiazine-salt mixture, in the ratio of 1 to 9 to control sheep roundworms.

This self-medication, at once curative and preventive, is not to be regarded as a substitute for the full therapeutic treatment with the drug, but rather as an adjunct to it. Heavily infested sheep should be treated early in the spring with a full therapeutic dose—about 1 ounce for adult sheep and one-half ounce for lambs weighing less than 60 pounds. Following this treatment, the phenothiazine-salt mixture should be placed in an open container or trough that is protected from the weather. The entire flock should have access to it during the pasture season, when the weather is sufficiently mild to permit the normal development of roundworm eggs and the transformation of the larvae to the infective stage.

In most cases this procedure will keep lambs from getting an injurious load of parasites, but as an additional precaution the flock should be treated with a full therapeutic dose whenever it appears that the medicated salt is not holding the parasite in check. Also, the breeder flock should be treated again with the full dose early in the winter to condition ewes for the cold months. To show how extensively sheepmen have adopted the practice: In 1939—just after phenothiazine was shown to have value as an anthelmintic—only 900 pounds was used; in 1944, total consumption was nearly 3,000,000 pounds.
The life cycle of the common liver fluke: A. An adult fluke about natural size. While in the liver of an animal it produces many eggs that are expelled in the droppings; B. An egg, enlarged about 100 times. It develops in wet places of pastures; C. A free-swimming larva (enlarged about 100 times) that comes from each egg; this larva is attracted to and penetrates certain aquatic snails, D. After development in the snail, a new type of larva with a tail, E, (enlarged about 30 times) emerges and settles on the grass, F, and becomes encysted there. Cattle eat the contaminated grass and the life cycle starts all over again.

Liver Flukes

Liver flukes are the most deadly of the trematodes that affect livestock. Cattle, sheep, goats, and wild ruminants are particularly susceptible, and acquire the parasites while grazing on low, wet pastures that harbor certain species of fresh-water snails that serve as intermediate hosts. The flukes, by their presence or the lesions they produce, make the livers unfit for food, bring about unthriftiness and loss of flesh in all domestic ruminants, and cause death, especially of sheep. European investigators say
also the flukes impair reproductive capacity in cattle, reduce milk flow, and cause other damage.

Of these losses, only those resulting from the condemnation of livers for food and for medicinal use are well known. The figures obtained from meat packers operating under Government inspection show that the annual average infection of cattle with liver flukes in the Gulf Coast area is 37.5 percent in adult cattle and 6 percent in calves. The loss of beef and calf livers must be enormous, because flukes in cattle are prevalent in parts of the South, the Southwest, the Rocky Mountain States, and the Pacific Coast States. It is estimated that nearly 90,000 pounds of beef and calf livers are lost annually in the Gulf Coast area. The loss of beef livers in 1945 amounted to more than a million dollars.

During the war we prepared a medication based on hexachlorethane, a solid that is related chemically to carbon tetrachloride and tetrachlorethylene, drugs developed in the Department about 25 years ago for removing internal parasites from various classes of farm animals. Because hexachlorethane is insoluble in water and can be dissolved only in solvents that are more or less injurious to cattle, sheep, and goats, we combined it with bentonite, a finely powdered clay, to form an aqueous anthelmintic drench. It was determined that, in proper combination, hexachlorethane and bentonite form a stable suspension in water, suitable for administration with a dose syringe.

The ingredients are mixed thus: 1 pound of finely ground hexachlorethane, 1 1/2 ounces of bentonite, and 25 ounces of water. The addition of a quarter-teaspoon of white flour facilitates the mixing, which is done either with a power-driven apparatus of sufficient speed to insure even distribution or by passing the freshly prepared mixture twice through a 20-mesh screen. A dose of 6 1/2 ounces for cattle and half that amount for calves more than 3 months old is administered. Younger calves need not be treated. The treatment is especially effective in removing about 70 percent of the adult flukes and about half of the immature flukes.

The treatment was tested successfully in sheep and goats, but in a few instances cattle and sheep tolerated the drug rather poorly, and some died. Much work remains to be done, therefore, to perfect the treatment.

**Roundworms in Hogs**

We also found a simple, inexpensive, and practical method of ridding pigs of large intestinal roundworms or ascarids, the most widespread and most injurious parasites affecting swine. Nearly all swine producers are familiar with the worms, and parasitologists have studied them for decades without finding a really good treatment. American wormseed oil—oil of chenopodium—was about 70 percent effective, but it is rather toxic and involves the usual difficulties of treating swine individually. Early
enthusiasm for phenothiazine as a substitute for oil of chenopodium—especially because phenothiazine could be administered with the feed—unfortunately was not sustained. Later investigations disclosed that phenothiazine was about as toxic to swine as oil of chenopodium, it sometimes produced rather alarming symptoms, and was less effective.

In 1944 and 1945 we tested a number of fluorine compounds. Sodium fluoride, a cheap and readily available chemical used to eliminate cockroaches and remove lice from livestock and poultry, pretty well filled the rigid requirements of the ideal remedy for large roundworms. When mixed with the feed in the proportion of 1 part by weight of the chemical to 99 parts of the feed, sodium fluoride was generally eaten by swine. One day's normal feeding with this medicated feed ration was enough, in most cases, to remove nearly all the ascarids.

In practice, a successful method of treating pigs with sodium fluoride is: On the day before the medicated feed is given, the pigs are slightly underfed; on the day of treatment, the medicated feed is given in the morning in amounts the animals normally consume in 1 day; the next morning, regular feed is mixed with any left-over medicated feed and the usual feeding continued thereafter.

Whether fed to suckling pigs, to pigs shortly after weaning, or to pigs ready for market, the medicated feed caused expulsion of from 90 to 100 percent of all the roundworms. The treatment was effective whether given to pigs individually or to groups up to 30, and was nontoxic, except to pigs suffering from intestinal inflammation or other serious disorders.

Skim Milk and Whey for Internal Parasites

When fed liberally, skim milk and whey were found to be effective in protecting swine from internal parasites. Either was fed to pigs for 3 days in succession at intervals of 2 weeks, in place of all other feed, or was fed once daily instead of the regular afternoon feeding of grain. Otherwise, the pigs got a balanced ration of grain, tankage, and minerals. Although the treated pigs were kept under conditions that favored the acquisition of heavy loads of internal parasites, they escaped, for the most part, from acquiring any large number of stomach worms, ascarids, nodular worms, and whipworms—parasites that localize in the alimentary canal.

This special feeding did not keep them from getting lungworms and other parasites that live outside the alimentary canal. Comparable pigs, fed only the balanced ration, became rather heavily parasitized with stomach and intestinal worms. Although our evidence is that pigs fed whey or skim milk acquired ascarids, which migrated in the usual way to the liver and lungs, the worms that reached the alimentary canal following the early migrations were evidently swept out by the purgative action of the whey and skim milk.
It is known, however, that cathartics of various kinds do not exert any significant anthelmintic action, and it cannot be concluded that only the purgative action of the dairy products used was largely responsible for the removal of the parasites from the alimentary canal. Whatever the nature of the vermifuge action of skim milk and whey, the fact is that, when used as indicated, these dairy products prevented the accumulation in the stomach and intestines of pigs of the various species of the nematode parasites. Pigs thus kept free of worms grew better than their litter mates that were not fed skim milk or whey. The difference in gains is evidence of how parasites cut pork production.

We do not recommend the indiscriminate feeding of dairy products to pigs as a substitute for sound management to control parasites, but this method should be useful where skim milk or whey is available and where other practices designed to control parasites are not instituted, or for special reasons cannot be.

**Sulfa Drugs and Coccidiosis**

Coccidiosis, a disease of livestock and poultry, is caused by protozoan parasites known as coccidia. The organisms are highly injurious to poultry, the average mortality in affected flocks sometimes reaching 50 percent.

A few years after the sulfa drugs began to be used in human medicine, parasitologists began to experiment with some of them. Three of them, sulfaguanidine, sulfamethazine, and sulfamerazine, were tested extensively with considerable success, to see if they could cure or prevent coccidiosis in poultry.

In the control of cecal coccidiosis, the most severe form of the disease, satisfactory results were obtained by feeding mash containing 1 percent by weight of sulfaguanidine, as soon as bloody droppings—the characteristic symptom of poultry coccidiosis—were detected. The medicated mash is fed for 2 days and is then replaced by regular mash for the next 3 days. The medicated mash is fed again the sixth day. If bloody diarrhea is not completely checked, a third feeding of medicated mash for 1 more day is given following 3 days' feeding of regular mash.

To control intestinal coccidiosis, a disease not characterized by bloody droppings but by a steady decline in condition, medicated mash is fed for 3 days in succession, as soon as a correct diagnosis is made. Ordinarily a poultryman cannot make the diagnosis because it involves a careful post-mortem examination of one or more birds in an affected flock and the finding of the causative organisms in sufficient numbers in scrapings of the intestinal lining.
THE AUTHOR

Benjamin Schwartz has been the head of the Zoological Division of the Bureau of Animal Industry since 1936 and has done parasitological research in the Department since 1915. He is the author of more than 100 scientific papers giving results of original investigations, and of many other papers dealing with various aspects of agricultural parasitology.

FOR FURTHER READING


ALSO, IN THIS BOOK

Advances in Feeding Calves, by Henry T. Converse, page 159.
Keeping Poultry Healthy, by Theodore C. Byerly, page 231.
THE SHAPE OF RESEARCH

The tools required for modern agricultural research are many and varied. To get worthwhile results, experiments are carried on in many places and under all sorts of circumstances. Beltsville, Md., is but one of many places in the United States where problems are worked out that help the farmer, and contribute immeasurably to business and industry.

Because Bang's disease has been one of the dairyman's worst enemies, more study has been given to its control than any other disease. Department veterinarians have developed a vaccine for calves that insures a high degree of immunity against this disease.
For 75 years the usual practice has been to feed calves whole milk for a month, then skim milk for 5 to 7 months. Tests indicate that calves can safely be weaned from milk much earlier than this. By using the methods described on page 159, some 40 million more pounds of butter and 8 billion pounds of milk would be available, if needed, for humans.

Crossbreeding and hybridization are important in animal research—with chickens as well as hogs, cattle, sheep, and horses. A hen used to lay about 86 eggs a year. These hens, a cross between inbred Rhode Island Reds and White Leghorns, average 225 eggs a year.
By cooperating with nature, researchers have found ways to grow bigger flowers and vegetables—a common ambition of gardeners everywhere. The process explained by S. L. Emsweller on page 284, caused the Easter lily on the right to grow to twice the usual size.

The Department, in cooperation with State experiment stations, has scientifically developed grain varieties that resist hazards like insects, drought, winterkill, and others. Seed of more than 50 better varieties of wheat have been made available to farmers in the past 10 years.
Heavy hangs the corn in this test planting of North Carolina Hybrid No. 1032. It is one of many varieties developed in cooperation with experiment stations of the Southern States. Adapted to the soil and climate of the State, it outyields standard kinds by about 20 percent. From 1942 to 1946 hybrid corn acreage in the South increased from 1½ to 5½ million acres.
To know the soil is a long step toward taking care of it. And, from its color, texture, depth, and other information a soil survey gives him, the farmer can be fairly sure as to what crops and practices are best for his farm. Soil surveys have been made in nearly 1,600 counties.

Besides knowing what is under the surface of their land, farmers can now use a system of land classification—slope, fertility, and so on—that helps them fit each acre to its best use without robbing the land. There are eight classes of land approximately as shown here.
At Vincennes, Ind., work goes on to find a satisfactory insecticide to control the codling moth and other orchard pests. Experiments with DDT show encouraging results, not only against codling moths, but leafhoppers, oriental fruit moths, pear thrips, and Japanese beetles.

Improved equipment for applying insecticides is important, too. This new machine can be used for dusts or liquid, or a combination of both. Chief advantage is to save weight of materials; a tree once needing as much as 40 gallons may, with this machine, need only a quart.
At the Department’s laboratory at Peoria, Ill., methods have been developed for stepping up production of penicillin. The result: A new outlet for farm products and another large industry. Peacetime uses of it include treatment of bovine mastitis and swine erysipelas of turkeys.

Agricultural chemists at the Peoria laboratory have perfected a way to use ground corncobs and rice hulls to clean carbon from internal combustion engines. This and other new uses offer a peacetime outlet for the some 16 million tons of corncobs once considered a nuisance.
The estimated time for harvesting an acre of peanuts by hand is 32 man-hours. With this tractor attachment the same operations—lifting, shaking, and windrowing—can be done in 3 3/4 hours. Similar machinery improvements are being studied by the Department.

During the war American housewives each year canned from 3 to 4 billion quarts of food. For some reason about 45 million containers of it spoiled. Here Katherine Taube of the Department runs a test on string beans to aid in cutting down spoilage of home-canned foods.
RESEARCH to prevent, cure, or control diseases of livestock is unceasing. Although much progress has been made toward finding practical ways and means of cutting down livestock losses, test-and-slaughter is still the most effective method of controlling some of our most serious animal diseases—tuberculosis and brucellosis, for example. With the help of a new tuberculin, developed by Department scientists for detecting TB-infected animals, bovine tuberculosis is gradually reaching the vanishing point. The following series of pictures shows how tuberculin is prepared in the laboratories of the Department's Bureau of Animal Industry.

The first step is to prepare the culture medium on which the tubercle bacilli will be grown. The mixture consists of asparagin, glycerine, dextrose, magnesium sulfate, potassium phosphate, and sodium and iron citrates. Large lots are made up and poured into sterile flasks. The flasks are then put into a steam sterilizer to destroy any bacteria that might be present.

In a glass-enclosed room, the culture is seeded with tubercle bacilli (above) and placed in an incubator where it is held at a temperature of 37.5° C. for 12 weeks. During this time the bacteria will make a heavy growth and release products of growth in the culture fluid. After incubation the tubercle bacilli are completely destroyed by steam sterilization. The dead tubercle bacilli are strained from the culture fluid (above), which is then transferred to an evaporator and processed to a specified concentration to produce tuberculin, the final product.
The evaporated tuberculin is measured out to be mixed with glycerine and phenol to make the fluid which, after further processing to remove all bacteria of any kind, is used for under-the-skin injections of cattle suspected of tuberculosis. L. A. Baisden does the measuring.

After the tuberculin has passed all tests for purity it is run into vials under the most sanitary of conditions. Then they are hermetically sealed by a machine designed for the purpose by P. W. LeDuc (left) of the Bureau of Animal Industry. W. B. Buckman is assisting him. The sealed vials are labeled to show the type and amount of tuberculin each contains. They are packed in cartons (above) for distribution to veterinarians in all parts of the United States.
Veterinarian A. H. Frank tests a cow for tuberculosis by injecting the tuberculin into the cow's skin on the underside of the tail. These tests are made on thousands of cattle each year.

Seventy-two hours after the injection, Dr. Frank observes a small lump where the injection was made, meaning that this cow is tuberculous. Despite all precautions there is still some TB infection in nearly every State. For a more complete word description concerning the status of animal disease control see the article on page 81 of this volume by L. T. Giltner.
ANIMAL PARASITES EACH YEAR take a startling toll, not only in lives of animals, but in reduced quality and quantity of milk, meat, hides, and other livestock products. Some of the more recent developments on how to control parasites with drugs is discussed on page 71 by Benjamin Schwartz; a visual glimpse of the subject is presented in the next few pages.

In an effort to find a better remedy for stomach worms in calves, John Bowling and Joseph Branson experimentally infect a calf with worms at the animal disease laboratory at Auburn, Ala.

In specially built equipment (below), worms are isolated from a culture medium. George E. Cauthen of the Auburn laboratory collects the worms for research on drugs to control them.
One of the most significant developments to come from recent animal parasite research is the use of phenothiazine in ridding sheep, cattle, horses, and goats of stomach worms. The swelling on this sheep's lower jaw is a characteristic symptom of stomach-worm infestation.

A treatment consists of about 1 ounce of phenothiazine which, for adult sheep, is considered a full therapeutic dose. In this case (right) the drug is administered in a soft gelatin capsule.

Nineteen days after treatment the jaw swelling has gone down and, although apparently not yet well, the sheep is on the road to better health.
In a test with phenothiazine to remove nodular worms and hookworms from sheep, one therapeutic dose, as shown by a post-mortem examination, removed all but 2 of the animal's 298 nodular worms (left), and 125 of its 134 hookworms. Worms are about one-half natural size.

These two pigs are the same age. The larger one is normal size; the other was stunted by roundworms, one of the most serious parasites of swine. Recent research shows that sodium fluoride fed to pigs with their feed will result in 90 to 100 percent expulsion of roundworms.

Coccidiosis, a parasitic disease more perilous to poultry than to other farm animals, sometimes causes 50 percent mortality in chicken flocks. Extensive tests with sulfaguanidine has produced satisfactory results in controlling cecal coccidiosis, the most severe form of the disease.
BUT NOT ALL OF OUR LIVESTOCK LOSSES are caused by specific diseases or parasites just mentioned. Recent research has definitely shown the need for some new ideas about nutrition for farm animals—cattle, sheep, swine—if they are to be healthy and produce efficiently.

Because of vitamin A (carotene) starvation, this animal (above) has poor vision and appetite, is unsteady on his feet, and is sexually impotent; he has convulsions and anasarca. After 4 months of carotene therapy, the same animal (below) apparently has regained all of his faculties.

Pregnancy disease is most common among poorly fed ewes. Studies indicate that the disease is associated with, or caused by, the animal's unsatisfied demand for feed of high caloric content. It can be prevented by proper flushing and by feeding carbohydrate-rich feed.
Mottled and irregularly worn teeth (above) are symptoms of fluorine poisoning in sheep, cattle, and swine. The intake of this element should not be permitted to exceed 0.003 percent of the total dry ration for larger farm animals and for poultry it should not exceed 0.015 percent.

Nicotinic acid is vital to the diet of swine as evidenced by these two groups of pigs. The above group was fed a purified diet that excluded nicotinic acid, while the group below had liberal amounts of the vitamin. As a part of their feed both groups received thiamine, riboflavin, piridoxine, pantothentic acid, and choline. For New Ideas in Feeding, see page 95.