TESTS WITH RUELENE, RONNEL AND CO-RAL FOR SYSTEMIC CONTROL OF *Hypoderma lineatum* (DeVill.)

By

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PREFACE

The author, in conference with Dr. D. E. Howell, decided that the study of Ruelene, a new systemic insecticide, would be an interesting and worthwhile thesis problem.

The author is indebted to many for the help received during the course of this study. Special appreciation is especially expressed to Dr. D. E. Howell, head of the Department of Entomology and thesis adviser, who furnished many helpful suggestions for designing the tests and preparing this paper. Appreciation is also due to Dr. H. I. Featherly, Professor of Botany, Dr. R. R. Walton, Professor of Entomology, Dr. D. E. Bryan, Associate Professor of Entomology and Mr. C. F. Henderson, Associate Professor of Entomology, committe members, for their assistance in the preparation of this manuscript.

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INTRODUCTION

It has been estimated that insects cause $383,300,000 damage to cattle each year in the United States alone. $100,000,000 of this damage is attributed to cattle grubs, making them one of the most damaging animal parasites in the United States today. (U. S. D. A., 1954)

Life History

There are two species of cattle grubs, the common cattle grub, Hypoderma lineatum (DeVill.), found in the southern United States, and the northern cattle grub, Hypoderma bovis (L.), which is found in Canada and northern United States. The adult of the common cattle grub is a small bumblebee-like fly approximately three times the size of a common house fly. It is hairy, black and striped with yellow. H. bovis (L.) is similar to the common cattle grub but is larger and stouter bodied. A generalized life history of the cattle grub follows.

The common cattle grub lays its eggs on cattle early in the spring by quickly darting in and cementing them securely to the base of a hair, generally in the hock region. Many eggs may be placed on a single hair. In two or three days, they hatch into first instar larvae which bore through the skin.

They then begin travelling through the body, feeding as they go, until they finally reach the region of the esophagus approximately five months later. They congregate in the esophageal region for around three months and then continue their migration to the region of the back where they almost immediately make breathing holes in the skin of the host. Here they molt into second instar larvae. Within a few days a cyst is formed around the grub by the host tissue. The larvae lie in the cyst with the spiracles, located at the posterior portion of the body, close to the hole. They molt for the third and last time. When the third instar larva matures, it enlarges the hole, dehydrates slightly, works its way through the hole and falls to the ground where it seeks protection in organic matter and debris (Laake, 1952). Here it changes to the pupal stage, and then in early spring to the adult fly. The fly escapes from the pupal case in a very short time. If the environmental conditions are right, it may emerge, mate, and lay eggs within the same day. The life history of the H. bovis (L.) is very similar to that of the H. lineatum (DeVill.) except that H. bovis (L.) lays only one egg per hair, and in the portion of the United States in which both species occur, the northern cattle grub generally appears in the backs of the animals after the common cattle grub larvae have already emerged.

Damage Due to Grubs

Cattle grubs cause damage in several ways. When the

adults attach the eggs to the hocks, they excite the animals, causing them to run with the tail raised in the air in a characteristic manner, to shelter, such as a shaded area or pond, where they can stand unmolested by the flies. It has been estimated that milk production may drop 10% to 25% during the season when heelflies are active (Roberts and Lindquist, 1956). The grubs migrating through the skin cause damage and irritation to the animal that cannot be evaluated. When the grubs reach the back and bore holes in the skin, considerable damage to the hide and carcass results. The meat around an encysted grub becomes a yellow gelatinous mass that must be trimmed from the carcass. As a result of this damage, an estimated 14 million pounds of meat were trimmed in 1948. The presence of only a few grubs will result in downgrading of the carcass. A third of all the hides produced in the United States in 1948 had five or more holes caused by grub punctures and were sold at a discount price (Roberts and Lindquist, 1956).

History of Control

It is easy to understand why a pest with such a life cycle is difficult to control. For only a few days of the year this insect is in the adult form. The rest of the time it is protected inside the body of the animal or buried in debris.

For many years the only practical method of control was to apply rotenone dust or spray to the backs of the animals

after the encysted grubs had bored holes in the skin. Rotenone was commonly applied as a powder, wash, spray or dip. To be effective, this compound had to be forced into the cyst and contact the grub. This required hand rubbing with the powder or wash and high pressures with a spray. Dip treatments were ineffective unless the backs of the animals remained submerged long enough to permit penetration of the insecticide into the cysts.

The initial treatment was applied 30 to 45 days after the first grubs appeared in the backs of the animals, and every 30 to 40 days thereafter during the grub season.

This type treatment on a well-organized community-wide basis over a period of years did materially reduce populations in some areas, but at best it did not prevent the irritation to the animal due to egg laying or the damage to the meat or hide.

Tests were run for many years in an effort to discover a systemic insecticide that would kill cattle grubs in the animal before they encysted in the backs. A few of the materials tested would kill grubs, but the required dosage used was too close to the tolerance limits of the animal. It was not until the development of ronnel and Co-Ral that widespread economic grub control with a systemic insecticide became a reality.

REVIEW OF LITERATURE

The search for an animal systemic insecticide goes back many years. Among the earliest workers, Parman et al. (1928) fed flowers of sulphur to chickens in an effort to control their ectoparasites, with no apparent success.

Thirty-three drugs and insecticides were tested by Knipling et al. (1944) to determine their value as chemotherapeutic agents against the body louse, Pediculus humanus humanus L., and the yellow fever mosquito, Aedes aegypti (L.), fed on rabbits. Only the indandione compounds produced complete kills of the body louse. Lindane (gamma isomer of BHC [1, 2, 3, 4, 5, 6-hexachlorocyclohexane]) was the only chemical that produced any significant toxic effect to mosquitoes.

DeMeillon (1946) reported that some bed bugs, Cimex lectularius L., and mosquitoes, Aedes aegypti (L.), were killed after feeding on rabbits that had been given an oral dose of lindane.

Lindane, dieldrin, chlordane, aldrin, toxaphene and BHC were fed to cattle at Kerrville, Texas, by Eddy et al. (1954). Some reduction in populations of the stable fly, Stomoxys calcitrans (L.), and the yellow fever mosquito, Aedes aegypti (L.) was noted when these insects were allowed to feed on

animals that had been fed lindane; however none of the chemicals showed systemic action against cattle grubs.

McGregor et al. (1954) were able to produce significant control of cattle grubs by injection or oral application of diazinon (O, O-diethyl O-[2-isopropyl-4-methyl-6-pyrimidinyl]) and oral application of Dipterex (O, O-dimethyl 2, 2, 2-trichlore-1-hydroxyethyl-phosphonate), but it was necessary to apply these materials at a rate close to the MLD for the cattle in order to secure good control. Also, after the initial kill, migrating grubs continued to encyst in the backs of the cattle.

Roth et al. (1955) were able to kill a high percentage of grubs in the backs of cattle with a 5% suspension of dieldrin in peanut oil injected subcutaneously, but it took from two to twenty-eight days to show its effect and did not prevent the grubs from encysting.

Adkins et al. (1957) administered thirteen chemicals orally to rabbits to determine their effect on fifth instar bed bugs, Cimex lectularius L., and nymphs of the lone star tick, Amblyomma americanum (L.), which were allowed to feed on these rabbits. Dipterex, Bayer 18/178 (O-[2-(ethyl mercapto) methyl]-O, O-diethyl thiophosphate), and Bayer 21/116 (O-[2-(ethyl mercapto) ethyl]-O, O-dimethyl thiophosphate) caused 100% mortality to both the bed bugs and ticks. Hexamethyl-phosphoramide caused death to 63% of the bed bugs and 100% mortality to the ticks. Schradan (octamethylpyrophosphoramide bis[dimethylamino]phosphoric anhydride) had no effect on ticks

but produced 100% mortality to the bed bugs. Eight other chemicals failed to produce significant results. All these chemicals were administered at dosages rather close to host tolerance rates.

Schwartz et al. (1957) reported that the free choice administration of phenothiazine caused a reduction in the number of grubs appearing in the backs of cattle, but Howell (1957) and Cobbett (1957) were unable to show significant differences between the grub populations of phenothiazine treated and untreated animals.

Roberts (1957) also showed negative control with phenothiazine in 120-day tests. Tests with 10 mg./kg. daily doses of stilbesterol for 120 days and a combination of stilbesterol and phenothiazine for the same period also failed to show any decrease in grub population.

Crenshaw (1956) reported ronnel (O, O-dimethyl O-2,= 4, 5-trichlorophenyl phosphorothioate) as a systemic insecticide capable of killing cattle grubs in the early larval stages. It has a very low mammalian toxicity (3,000 mg./kg. in rats) but is very toxic to parasitic arthropods. Cholinesterase depression in cattle rose to 30%-50% and returned to normal in three to six weeks.

Since the day it was realized cattle grub control was possible with systemic insecticides, many workers have begun to explore the field.

Raun et al. (1957) tested ronnel on 77 yearlings at the rate of 110 mg./kg. to determine its effectiveness for grub control. Approximately an equal number of animals were retained as a check, and both groups, although separated, received identical rations, housing and management. Treatment resulted in good control. There was significant economic gain as judged by weight gains, feed conversion and final grade of the carcass in the treated lots. The treated animals showed evidence of sensitivity to the compound and exhibited inappetence for two to three days after treatment. The toxicity in this case was observed to be temporary and no serious results could be detected.

Tests were run by Adkins (1957) with bed bugs, Cimex lectularius L., and Gulf Coast ticks, Amblyomma maculatum Koch, by feeding them on rabbits that had been dosed orally with Dipterex. Control of the bed bugs ranged upward to 97% in the rabbits dosed at 40 mg./kg. Mortality in the ticks ranged from nil in the checks to 100% on the rabbits dosed at 110 mg./kg.

Laboratory tests by McGregor (1957) showed that ronnel would effectively kill screw-worms, Callitroga hominovorax (Cqrl.), and stable flies, Stomoxys calcitrans (L.), that fed on guinea pigs dosed at 110 mg./kg. The same material given orally to 35 steers gave approximately 97.2% control of grubs and completely prevented further encystment.

Roth (1957) reported 100% control against cattle grubs,

Hypoderma lineatum (DeVill.), with ronnel applied as a spray at 2.5% concentration, but had only 50% or less control with 1% concentrations. When administered orally, ronnel killed grubs encysted in the backs of the cattle, except for a few that were within two weeks of emergence at time of treatment. Grubs in the second instar were killed more quickly than third instar grubs.

Norris et al. (1957) reviewed the work done on ronnel in experiment station tests and commercial use. It apparently had given better than 90% control when administered as a drench or a bolus in the majority of these tests.

Ronnel applied as either drench, bolus or capsule before the grubs appeared in the backs of the animals gave fair to excellent control of the common cattle grub in Oklahoma (Howell, 1957). No appreciable difference in control was noted in different age groups, sex, calving dates or locality.

Wyoming Herefords given 110 mg./kg. ronnel in bolus form had 100% grub control. Drenches of from 10 to 100 mg./kg. failed to give satisfactory control of cattle lice in the same area. In all tests some adult lice survived the treatment. It was concluded by De Foliart (1957) that ronnel is not suited for louse control in cattle.

Taylor (1957) tested ronnel, Dow ET-58 (O-methyl O-[2, 4, 5-trichlorophenyl] N-ethyl phosphoramidothioate) and Dow ET-59 (O-methyl O-[2, 4, 5-trichlorophenyl N-methyl= phosphoramidothioate) against the common cattle grub in

Oklahoma. Ronnel administered orally gave approximately 82% control in animals under two years of age, and 75% control in animals over two years old. Dow ET-58 gave approximately 70% control when given at the rate of 40 mg./kg. Although the Dow ET-59 gave 90% or better control at 35 mg./kg., severe toxicity was noted in one lot in which two steers died.

A group of 207 cattle of mixed ages, treated with ronnel at 110 mg./kg. by Jones et al. (1957) had an average grub control of 86.9%.

Brundrett et al. (1957) tested Co-Ral (O, O-diethyl= O-3-chloro-4-methyl-2-oxo-2H-1-benzopyran-7-yl phosphoro= thioate) for grub control in the grub seasons of 1955 and 1956, and ronnel in 1956 only. Co-Ral applied as a 0.75% spray gave almost a 100% control both years. Ronnel applied also as a spray at the same concentration, gave poor to no control.

Co-Ral applied to South Dakota cattle as 0.25%, 0.50% and 0.75% sprays gave excellent control at all three levels. An oral dose of 25 mg./kg. gave some control but was not comparable to the spray (Graham, 1958).

Knapp (1958) reported tests made in Kansas with ronnel administered in bolus or as a feed additive. At the Fort Hays Agricultural Experiment Station, 118 steers were treated by bolus at 110 mg./kg. and at the Gooch Mills Juniata Experiment Station, 86 were treated by 110 mg./kg. bolus and 80 were treated with 110 mg./kg. feed additive.

In each test, an equal number of animals was used for the untreated checks. All above named treatments resulted in 87% or better control of grubs. Weight gains of the control and test groups were not significantly different. The blood cholinesterase level of ten animals treated with the ronnel was significantly depressed. No serious symptoms were noted in any of the animals, however.

Only five of 27 synthetic organic compounds tested by Flynn (1958) in rabbits showed systemic action at dosages that failed to produce toxic symptoms to the rabbits. The five compounds and the dosages at which they exhibited toxic action to bed bugs feeding on the rabbits, but not the rabbits themselves were: Bayer 18613 (O-ethyl-O-isopropyl= O-phthaloximido thionophosphate) at 1100 mg./kg., Bayer 19596 (S-aceto-ethyl-carbamate-O, O-diethyl-phosphorodithioate) at 625 mg./kg., Bayer 19994 (mixed anhydride of O, O-diethyl= thiono-phosphoric acid and bis-dimethylamidophosphoric acid) at 25 mg./kg., and Bayer 17364 (O, O-diethyl-O-phthaloximido= thionophosphate) at 7 mg./kg. These compounds were also tested on the Gulf Coast tick, Amblyomma maculatum Koch, the yellow fever mosquito, Aedes aegypti (L.), and the stable fly, Stomoxys calcitrans (L.). There were no conclusive data to indicate that these compounds exhibited any systemic action against the three parasites given above.

Turner (1958) studied the effectiveness of several systemic insecticides in Virginia during the year 1957-58.

He administered Dowco 109 (O-4-tert-butyl-2-chlorophenyl= O-methyl methylphoramidothioate) at 15 mg./kg., ronnel at 110 mg./kg. and dimethoate (O, O-dimethyl S/N-methyl= carbamoylmethyl/phosphorodithioate) at 8-15 mg./kg. as a bolus, and Dowco 109 and Co-Ral as a spray. These compounds were applied at various dates to determine best time of application for control. Dowco 109 and Co-Ral as a bolus gave satisfactory grub control, and Dowco 109 and Co-Ral as a spray gave excellent control but dimethoate gave only moderate control. There was no difference in effectiveness at different treatment times. No weight gain due to treatment was noted in cattle on a winter subsistence diet, but animals on full fattening ration showed significant weight gain over untreated animals.

Tests were run by Wade (1958) to determine the best time to apply systemic insecticides for cattle grub control. Groups of cattle were treated each month from May to November with ronnel at 75 or 100 mg./kg. or ronnel plus purified phenothiazine at 75 mg./kg. There was no significant difference between grub control in the different month treatments, nor was there any difference between the two levels of insecticide applied.

Neel (1958) administered ronnel as a bolus, Co-Ral as a spray and dimethoate as a bolus and intramuscularly to determine their relative effectiveness for grub control. Dimethoate reduced the grub population somewhat but not as

much as ronnel or Co-Ral, both of which gave good control.

Rogoff (1959) tested ronnel, dimethoate, Dowco 109 and Co-Ral to determine their effectiveness as grub control agents. Ronnel as a drench or bolus at the rate of 110 mg./kg. gave around 99% control. Dowco 109 as a 0.75% over-all spray gave 100% control, but applied as a top-line or over-all spray of 0.50%, it failed to give control (27-76%). Co-Ral as a 0.50% spray gave good control (91-97%) to poor control (61%) in some lots. At 0.25%, it gave 27 to 76% control. Dimethoate, given orally or intramuscularly at 15 mg./kg., gave good control but the cholinesterase level in the treated animals was depressed to as low as 56% of normal, and there was at least a temporary effect on weight gains.

No significant differences were detected in grub control, weight gain, feed efficiency or carcass grades between treatments of ronnel administered at two levels (15 mg./kg. for seven days or 25 mg./kg. for six days) and Co-Ral as a 0.50% suspension applied as a spray in a test by Raun (1960). Grub control averaged 77%. Ronnel at 15 mg./kg. for seven days gave 91% control, and Co-Ral gave 98% control. In one test lot in which ronnel had been mixed with corn meal and added to the daily ration, the animals consumed 25% less feed the first three days of the test than did the checks. This did not occur when the same material was mixed with soybean meal. One steer in the ronnel test became paralyzed during the first day and had to be killed. The reason for the paralysis could not be found.

The mechanics, time and effort of treatment constitute an important problem when animals must be corralled in order to apply treatments as a spray or drenches. Rogoff (1959) attempted to provide an answer to this problem by incorporating technical ronnel in salt and bone meal mixture to be fed to cattle on a free choice basis. Ronnel was tested at the rate of 48, 40 and 16 grams per pound of mixture and fed for varying periods of time of from 28 to 66 days. He reported outstanding control at the higher levels, but they were accompanied by transient weight depression and erythrocyte cholinesterase activity reduction to as low as 21% of pre-treatment levels. No conclusive recommendations were made on the basis of this study.

Drummond (1959) found that grub control with dimethoate was better at high dosages, but that the dosage required to give satisfactory control was too close to the limit that could be safely given to animals. That is to say that the margin of safety is not enough to consider this material as a practical control agent.

Drummond (1959) found Dowco 109 to be a highly effective systemic insecticide against first instar larvae when administered dermally as a 1% suspension and intramuscularly or orally at 15 to 25 mg./kg. Control in these tests ranged from 76% to 99%. He reported 100% control with Co-Ral at a concentration of 0.50 to 0.75% but showed a substantial reduction in control when the dosage was dropped to 0.25%. One lot of cattle treated with Co-Ral was worth an estimated

$12 more per head than the untreated checks.

Jones et al. (1959) found that ronnel applied as a bolus at 100-110 mg./kg. three weeks before grubs encysted in the backs gave excellent control. As a 92-99 mg./kg. drench administered after a few larvae had encysted in the backs, an emulsion failed to kill the already encysted larvae and three more encysted. However, when this insecticide was used as a suspension, the encysted larvae were killed and only one more grub encysted. The bolused animals that were on a fattening ration showed a 24-pound increase over the untreated animals, but this difference was not statistically significant. Treated animals on a silage ration did not show any weight gain.

Harris (1959) showed that ronnel and Co-Ral were both effective in controlling cattle grubs although the latter gave generally better control at all treatment dates (May through September) except September. According to him, the best time to apply the treatment is as early after encystment as possible and yet late enough to prevent reinfestation after the chemical has ceased to be active within the body of the animal.

Roth (1958) received excellent grub control with Dowco 109 as a spray at 0.75% and orally at 20 to 25 mg./kg. He concluded that since Dowco 109 appeared to be as effective as Co-Ral as a spray and as effective as ronnel as an oral treatment, it was more versatile as a systemic in the control of cattle grubs.

Allison (1958) in extensive tests on the control of the common cattle grub in Oklahoma worked with several systemic insecticides. Dowco 109 given as a feed additive to yearlings resulted in 96% grub control; as a bolus it provided 81% control in yearlings; and 85% control in mature cows. As a spray, control was 95% in yearlings; and 77% in mature cows. Co-Ral administered as a spray gave 84% control in mature animals and only 77% control in yearlings (probably due in this case to the long-haired coat which they were carrying at the time of the treatment, which prevented adequate penetration of the spray). Ronnel as a bolus gave 74% control in yearlings and 87% in mature cows. Dimethoate administered as a bolus provided somewhat less control than the other compounds. There was no statistical difference between treatments in these tests. Allison concluded that the best grub control treatment was the one most easily applied and the cheapest.

Knapp (1956), in two separate tests, treated animals with ronnel boluses, and approximately an equal number were retained as controls. Good control resulted. In both cases in the year following the treatment, the treated animals had a lower incidence of grubs than did the ones that had received no treatment. This seems to indicate that cattle acquire resistance to grubs when the larvae are killed in their backs.

Tests were run by Howell et al. (1958) in Oklahoma involving 2,800 cattle over a three-year period to determine the value of several systemic insecticides and various

methods of application. During the 1955-1956 season, ronnel was applied as a drench, which provided approximately 78% control. In the grub season of 1956-1957, ronnel was applied at the rate of 100 mg./kg. at six separate locations within the state. Animals under two years had an average of 82% control, and mature cows exhibited less control. In 1957-1958, tests were on a broader scale with four compounds being tested at different levels and formulations again in widespread locations throughout the state. Ronnel, as a feed additive, gave fair control when fed over a 12-25 day period, but almost no control when fed for two to five days. As a spray, regardless of concentration or coverage, the control was poor. As a bolus used at the rate of 110 mg./kg., ronnel gave good control. Dowco 109, when administered to yearlings as a feed additive, gave 96% control; as a bolus, 81% control; and as a spray, 95% control. When administered to cows as a bolus it produced 85% control; and sprayed on cows, it showed 77% control.

Co-Ral produced 76% control in yearlings and 84% in mature animals. Low control in yearlings was probably due to inadequate penetration of spray because of the heavy winter coat they were carrying.

Treatment of cows with dimethoate resulted in 79% control; yearlings had only 62% control. This was probably due to the large number of grubs present two to three months after treatment. There was essentially no difference between

weight gains in treated and untreated animals (Howell et al., 1958).

Norris (1959) reviewed the results of 32 weight gain experiments in which ronnel was administered to animals at 5 grams per 100 pounds of live weight. When the compound was administered as a bolus or feed additive, the grub control was better than 90% for the tests. The treated animals showed weight gains over the untreated in 18 of the tests, and in three of the tests, there was no difference. The remaining six test groups could not be considered because of slaughter date or lack of weights. Generally, the earlier application resulted in better control and weight gains.

Preliminary laboratory and field trials indicated that Ruelene was a promising animal systemic insecticide capable of controlling a wide spectrum of parasites. As a drench it gave good anthelmintic activity in cattle, sheep, and goats, and administered as a spray or feed additive, it provided good cattle grub control. Limited studies indicated that the material is rapidly hydrolized and disappears from the animal tissue per se in a short time. The products of hydrolysis are rapidly excreted from the animal and there is no storage in the tissue, including fats (Anonymous, 1959).

Tests in Texas, Michigan, Nebraska and Montana indicate that Ruelene is an effective material for controlling both

species of cattle grubs (McGregor, 1958). Single oral treatments failed to give as good control as did multi-day feed treatment or spray, but when administered in 30-50 mg./kg. doses for one day, significant grub control resulted, as well as anthelmintic activity. Multi-day feed additive treatments over a period of three to 15 days at varying doses, with a total intake ranging from 9 to 75 mg./kg. resulted in 88% to 99% control. Spray applications of 0.25% Ruelene gave good grub control (98 to 100%). These tests also indicate that sprays of 0.50% Ruelene will give satisfactory control of external parasites.

Side reactions have been noted in some animals treated with Ruelene. They usually are manifested in one of several ways: lethagy, inappetence, tympany, salivation, dragging of hind feet, general stiffness, traces of blood in the feces, frequent defecation or strangling. These side reactions occur most often in animals treated late in the season.

Douglas (1960) tested Ruelene for anthelmintic activity on 20 naturally infested lambs. They were divided into three lots according to pretreatment egg counts. One lot was treated at 110 mg./kg.; one at 200 mg./kg.; and one retained as a check. The higher dosage was highly efficient against Osterangia, Trichostrongylus axei, T. vitrinus, and Nematodirus. It was less effective against Trichostrongylus colubriformis but still gave good control. No toxic symptoms were observed.

Shaver (1959) reported that cattle drenched with 43 to 57 mg./kg. of Ruelene showed a reduction of 98% in the fecal egg count of intestinal parasites 14 days after treatment. Phenothiazine at 235 mg./kg. showed an 88% reduction. Similar results were noted when sheep were drenched with 2 to 8 grams of Ruelene (depending on weight of animal). The 14 days fecal egg count showed 94% to 100% reduction.

Such a material as Ruelene would have decided advantage if it could be administered late in the season, especially in the South, because of its anthelmintic as well as grub control action. This practice would be ill-advised according to results with other systemics. Swanson (1960) reported on tests in which this material was administered late in the grub cycle to determine efficiency and safety of such a practice. Cows in the advanced stages of pregnancy were treated at 30 and 50 mg./kg. in October and November. Grub control was excellent (95.8% to 100%). No symptoms of adverse reactions were noted and calving was normal.

The task of proving or disproving the theory that piperonyl butoxide (a-[2-(2-N-butoxyethoxy) ethoxy]-4, 5-methylenedioxy-2-propyltoluene) administered with Co-Ral increased the toxicity of the latter was undertaken by Robbins, Hopkins, Darrow and Eddy (1959). It was found that the joint application of these two compounds did increase the toxicity four to six times. It is believed that piperonyl butoxide inhibits the metabolism of Co-Ral to more polar metabolites.

Monroe (1959) found that Co-Ral and its corresponding phosphate administered jointly with piperonyl butoxide was 2.8 times as toxic to house flies as Co-Ral alone. The phosphate of Co-Ral, designated as 0-21/199 is 435 times more potent anti-cholinesterase agent *in vitro*, but when administered topically to flies, both compounds have the same toxicity. The addition of piperonyl butoxide to the phosphate did not increase its *in vitro* cholinesterase inhibition, but when administered in connection with Co-Ral, it markedly synergized the anticholinesterase activity. "Co-Ral was apparently converted to its corresponding phosphate *in vivo* and piperonyl butoxide did not appear to be associated with its oxidative metabolism."

Radeleff (1957) studied the toxicity of ronnel to cattle and sheep. A mild reaction to the material was first noted at the 125 mg./kg. level in cattle and became more severe as the dosage was increased. Sheep were able to tolerate a much higher dosage than cattle. Toxic symptoms observed in sheep at the 400 mg./kg. dosage were, as Radeleff described them,

> "...similar to chlorinated phenols, then of organic phosphorus insecticides. First there was muscular weakness, incoordination, prostration and diarrhea, occasionally salivation and dyspnea. The whole accompanied by severe weight loss at higher dosages."

Norris et al. (1957) pointed out that care should be exercised in administering systemic compounds with a balling gun to avoid injuring the throat of the animal. Directions

should be followed carefully and the compounds administered during the recommended period for the respective areas. In the southern United States, the recommended period for administering compounds is from July through September, and in the northern United States from August through October.

Skaptason (1959) gave explanations for failure of some treatments of systemic insecticides; there were not enough chemicals in the sprays, not enough spray per animal, or inadequate penetration through the hair to the skin due to inadequate pressure.

Robbins, Hopkins and Darrow (1959) studied P-32 labeled Co-Ral administered as a spray emulsion to one Hereford bull and as a suspension to another. The acetycholinesterase level was depressed to about 35% of normal in both animals after two weeks. The skin was the site of the heaviest residues of unchanged Co-Ral. The compound was sparingly absorbed, only about 2.4% of the suspension application and 6.3% of the emulsion application accounted for in the urine two weeks after treatment. Only low levels of the radio-active insecticide were found in the blood, none of which behaved like the parent compound. The emulsion-treated animal had approximately four times more radio active material in the blood than did the suspension treated bull. The liver and kidneys contained the highest level of radio active insecticide of any of the tissues analyzed.

Kaplanis (1959) studied the metabolism of P-32 labeled dimethoate following oral and intramuscular doses at 10 mg./kg. to cattle. Radioactivity was noted in the blood of both animals shortly after treatment, but it was observed earlier and dissipated faster in the animal treated intramuscularly. Analysis of the blood revealed the presence of dimethoate plus some derived compounds several times more toxic than dimethoate. Eighty to ninety per cent of the total dosage was eliminated via the urine in the animal treated intramuscularly. Only a small amount of the compound was eliminated in the feces. "The main metabolic products were dimethyl phosphate, dimethyl phosphorothioate and several unknowns."

Examinations were made by Harris (1960) to determine the histopathological effects of Co-Ral on the gullet tissue of cattle sprayed with a 0.50% concentration and drenched with the same material at 10 mg./kg. Good control resulted with the spray but the drench produced no control. Prepared sections of the tissue from around the grubs showed that gullet tissues in the sprayed animal were normal but that the tissue of the drenched animals showed active inflammation due to host reaction to foreign agents, i.e., the drench itself and the larval stages of Hypoderma lineatum (DeVill.) when affected by the systemic insecticides. This probably indicates that drenching with Co-Ral not only doesn't give control but is actually detrimental as well.

Co-Ral was rapidly metabolized and excreted in cattle treated orally at 20 mg./kg. (Lindquist, 1958). About 90% of the radio-activity of the dose was passed in the urine in 24 hours. Small amounts were in the feces, bile, lymph, blood, bone, liver and kidney. Analysis indicated that none of the radio-active compounds was the original Co-Ral but were associated polar compounds.

O'Brien (1959) reported that the liver is the primary site in which metabolism of Co-Ral is carried on. In the house fly, grub and in mouse livers, there is an activating mechanism but not a degrading system. The ox and rate have both systems but the degrading system is more potent. This explains why systemics will kill internal parasites and not the host. It may also offer an explanation for control with dermally applied Co-Ral and no control with the same material applied orally. That is because the orally applied material reaches the liver before the grubs and is detoxified, but the dermally applied Co-Ral reaches the grubs first.

McGregor et al. (1957) worked with ronnel to determine its possible effectiveness against several parasites of sheep. When applied at 0.50% as a wettable powder solution to 43 head of sheep (ewes and lambs), it completely controlled the screw worms present in seven of the sheep at time of treatment and kept the herd screw-worm-free the rest of the summer. Two similar tests in Alabama with 5% emulsion sprayed on sheep gave five months protection against screw-

worms as compared to a 15% infestation in the check animals in one test, and complete control of fleece-worm as compared to a 10% infestation in the checks in the other test.

Tests in Texas indicate that Co-Ral gives good control of horn flies, Siphona irritans (L.), at from 0.25% to 0.50% concentration, and that the control lasts for a period of three weeks to 48 days after application (Brundrett, 1958).

Brundrett et al. (1958) used Co-Ral to determine its value as a deterrent to screw-worm Callitroga hominovorax (Cqrl.) attack to animals that had received a wound due to shearing, castration, docking, ear tagging, etc. The material was applied to nearly 1500 sheep at the rate of one quart of 0.25% or 0.50% solution per animal. Most of the sprayed animals were protected for a period of two to three weeks. In the few instances that the material failed, it was after a ten-day period. The two or three-week period was generally enough time for the wounds to heal enough to prevent infestation.

Systemic insecticides offer substantial side benefits other than grub control. Control of the human bot fly in some South American countries has been almost non-existent. McGregor (1958) has shown that this pest could be economically controlled by a single oral dose of 20 mg./kg. or a 0.50% to 0.75% spray of Dowco 109.

Raffensperger (1958) was able to show satisfactory control of chicken shaft louse, Menopon gallinae (L.), with ronnel when given orally. At 250 mg./kg. most of the

lice were killed after four days even though exposed to reinfestation. At 500 mg./kg. they were kept free from reinfestation for 8 days after treatment. Tests in which ronnel was incorporated into the feed showed that intake dropped off at the higher levels. Intake dropped rapidly before the 25 mg./kg. per day level was reached.

Dorney (1958) reported that ronnel demonstrated anthelmintic activity against members of the genera Heamonchus, Osteragia, Strongyloides and Nematodirus when given as a drench at 200, 400 and 600 mg./kg. to sheep. Toxic symptoms were observed at the higher doses with death occurring in one of the several lambs treated at the 600 mg./kg. level. The results seem to indicate that the 200 mg./kg. level is the one that should be used.

Kreamer (1959) found that Sevin (1-naphthyl-N-methyl= carbamate) given to chickens as part of their feed ration gave satisfactory control of the northern fowl mite, Ornithonyssus sylviarum (C. & F.), for up to 21 days. When incorporated in the feed at the extreme dosage of 3,000 parts per million there was no apparent toxicity, nor did it have any noticable effect on palatability.

Tests by Burns (1959) using Co-Ral at 0.25% and ronnel at 1% as the toxicant material in back rubbers gave results comparable to toxaphene (chlorinated camphene containing 67-79% chlorine), used as a standard.

MATERIALS AND METHODS

Early in 1959 the Dow Chemical Company announced the development of a new systemic insecticide, Ruelene[1] (4-tert-butyl-2-chlorophenyl O-methyl methylphosphoramidate). In preliminary laboratory and field tests conducted by Dow, this chemical demonstrated anthelmintic activity, cattle grub control and some degree of protection against external parasites. Extensive tests were undertaken by the author to evaluate this compound in the fall of 1959, with emphasis on the grub control aspects.

Older "tried and proved" compounds were used as a standard of comparison. They were Co-Ral[2] (O, O-diethyl= O-3-chloro-4-methyl-2-oxo-2H-1-benzopyran-7-yl phosphorothioate), a Chemagro product, ronnel[3] (O, O-dimethyl O-2= 4, 5-trichlorophenyl phosphorothioate), a Dow Chemical Company product, and phenothiazine.

Most of these tests were run on Experiment Station cattle and superimposed on carefully designed feeding tests or breeding studies. The spray tests applied to Woodward

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[1]Also known as Dowco 132.

[2]Also known as Bayer 21/199 and Muscotox.

[3]Also known as Dow ET-57, Dow ET-14, Korlan, Nankor and Trolene.

and Fort Supply steers were on "matched pairs", one of which was treated and one of which was retained as a check. Some of the Lake Carl Blackwell experimental lots were divided; one-half treated and one-half retained as checks. Others were divided into several closely identical lots which were treated with different insecticides or different concentrations of insecticides, or both. This allotting was done by personnel normally experimenting with the animals. The El Reno feeder lambs used in anthelmintic tests were allotted in the same manner.

Lotting at Fort Reno consisted of gate cutting the existent experimental lots in two or more equal groups and treating each one in a separate manner. The Wewoka animals were selected at random.

All the cattle in these tests were carrying a permanent identification number, either as a hip or horn brand, or on a metal tag securely attached to the animal by means of a chain around its neck. The sheep were ear tagged.

Grub counts were made by palpation on the days the animals were normally weighed and worked (generally once a month). The weights were recorded at the date of treatment and as near as possible to March 1, and the difference was recorded.

Most of the animals in these tests were observed daily by competent personnel accustomed to working with cattle, and any sign of toxicity due to the treatments was noted.

Spray Application

Spray tests were conducted at the Lake Carl Blackwell range area, Stillwater, Oklahoma; U. S. Southern Plains Experimental Range, Fort Supply, Oklahoma; U. S. Southern Great Plains Field Station, Woodward, Oklahoma; and the Fort Reno Agricultural Experiment Station, El Reno, Oklahoma.

A total of 975 animals was treated with a spray application at these locations. In all cases, the material was administered to the animals with a portable fifty-gallon John Bean sprayer having a pump capacity of four gallons per minute. At least 200 pounds of pressure were maintained. A Spraymaster drive nozzle, adjusted to deliver a narrow penetrating stream, was held from six to ten feet from the animal to insure efficient penetration of the hair coat. Care was taken to insure that every animal received thorough coverage.

Sprays were of two types, i.e., over-all spray and top-line spray. The animals were completely covered with the over-all sprays. Top-line sprays were applied only to the back line of the animals. In all cases, top-line sprays were applied at the rate of two quarts per animal. Over-all sprays were applied at one gallon per animal.

The concentrations of sprays and the amount of actual 0.25% Ruelene wettable powder formulation per animal used in spray tests were as follows: 0.25% top-line, 18.9 grams; 0.25% over-all, 37.9 grams; 0.50% top-line, 37.9 grams;

0.50% over-all, 75.5 grams; 0.75% top-line, 57.6 grams; and 1.0% top-line, 75.5 grams.

The amount of insecticide needed to spray a group of cattle was mixed according to the number of animals contained therein. The animals were sprayed as evenly as possible until there was no material left in the tank. When different concentrations of the material were used consecutively, the tank was not flushed between treatments as it was when different chemicals were used consecutively.

All spray lots designed to give comparative data were treated the same day. For a complete outline of spray treatments, concentrations, coverage, location and number of animals treated, see table 1.

Feed Additive

Only Ruelene was tested as a feed additive. The 0.25% wettable powder was mixed with cotton seed meal that was fed to the animals at a rate of two pounds per day. All these tests were designed for a five-day period. In the case of feed lot animals on full feed, the material was first mixed with cotton seed meal which was, in turn, mixed with the rest of the ration. A total of 197 animals was treated in this manner. The animals at Lake Carl Blackwell were fed from large troughs on a first-come first-served basis. Fort Reno animals were fed from self-feeders or individual self-feeders. Table 2 gives location, treatment, dosage and number of animals treated with Ruelene as a feed additive.

Drench Application

Both cattle and sheep were drenched. Five hundred feeder lambs from New Mexico were divided into four groups and drenched with phenothiazine or one of two levels of Ruelene while one group remained as a check at the Fort Reno Research Station. Thirty-eight cattle were drenched with Ruelene at Wewoka, Oklahoma. An outline of the drench treatments is given in table 3.

RESULTS

Effectiveness of Ruelene as a Spray

Summary of Tests with Control Groups

Ruelene was applied to 353 animals in tests designed to compare treated animals with a control group to determine the grub reduction. The animals involved were all range animals on native grass winter pasture. A compilation of all the tests involving these animals is presented in table 25.

Ruelene applied to 24 head of cattle as an over-all spray (1 gallon per animal) at 0.125% gave an average of 86% control of cattle grubs. A 0.25% top-line spray (2 quarts per animal) applied to 55 animals gave only 55% control, but the same concentration as an over-all spray applied to 46 cattle gave 84% control. Thirty-eight animals treated with a 0.50% top-line had 86% fewer grubs than did the checks. Ninety-five per cent control resulted when 88 cattle were treated with a 0.50% over-all spray.

Seventy-eight animals sprayed with 0.50% Co-Ral and 24 sprayed with 1.0% ronnel averaged 81% and 47% control respectively.

Direct Comparison Tests

Several tests were conducted in which a group of cattle composed of very similar individuals and exposed to identical environmental conditions was divided into two or more units of equal size and treated with different insecticides and/or different concentrations of an insecticide. The purpose of this type test was to provide direct comparison of the insecticides or of the effects of varying doses, or both.

Ruelene was applied to 71 weanling Angus heifers at Fort Reno on October 20 as a 0.25% top-line spray, 0.25% over-all spray, 0.50% top-line spray, 0.50% over-all spray and 0.75% top-line spray. All these animals were grub free except the 0.25% and 0.50% top-line treated ones, which averaged less than one grub per animal. An additional comparable group of 62 heifers was treated on November 25 with 0.50% Co-Ral. The poor control obtained in this test is believed due to longer hair coats and inadequate penetration. These Co-Ral treated animals averaged 12.74 grubs per animal at the December count (table 12).

One hundred twenty-three mature Hereford and Angus cattle were treated in six lots at Fort Reno (table 13). Twenty animals treated with 0.25% Ruelene as a top-line spray had an average of 0.66 grub per animal. Ruelene as 0.25% over-all spray decreased the average population to 0.14 grub. As a 0.50% top-line spray the same material

left 20 animals with an average infestation of 22 grubs per animal. Forty cows treated with 0.50% Ruelene over-all and 20 treated with 0.75% top-line spray had an average infestation of 0.38 and 0.39 grub respectively. Twenty-three animals treated with 0.50% Co-Ral over-all spray showed an average infestation of 4.6 grubs per animal. Table 13 gives the variation in population and percentage of grub free animals.

December grub counts on fall-calving mature cows showed that Ruelene as a 0.50% over-all spray reduced the average number of grubs to 0.23 grub per animal as compared to 3.22 grubs per animal in the 0.125% over-all treated animals (table 14). Animals treated with 0.125% solution were 33% grub free in December and 50% grub free in February compared to 92% and 50% grub free animals treated with 0.50% spray on the same dates.

A similar comparison test (table 15) in which Ruelene was administered as a top-line spray at 0.125% and 0.50% to spring-calving cows showed essentially the same results, the lower dosage having approximately twice the infestation of the higher dose.

Ruelene as a 0.50% over-all spray to heifer calves reduced the grub population to approximately 0.50 grub per animal. An over-all spray application with 1.0% ronnel reduced the population to 4.31, 8.08 and 3.41 grubs per animal when counted in December, January and February,

respectively (table 16). The Ruelene-treated animals were 82% grub free whereas over 50% of the ronnel-treated animals were infested.

Yearling heifers treated with Ruelene applied as a 0.75% top-line spray showed 0.16, 0.36 and 0.28 grub per animal for December, January and February counts, respectively, whereas a 0.50% top-line spray resulted in 1.34, 1.44 and 1.18 grub per animal for the same dates. The higher dosage also resulted in a considerably higher percentage of grub-free animals (table 17).

Ruelene and Co-Ral administered as 0.50% over-all sprays to two-year old cows (table 18) demonstrated excellent control. Co-Ral-treated animals showed more variation in grub population and the infestation was slightly higher, i.e., 0.31, 0.55 and 0.14 per animal for December, January and February, as compared to 0.11, 0.14 and 0.07 per animal in the Ruelene-treated animals. The percentages of grub-free animals were essentially the same for both materials.

Three-year old Hereford cows treated with Ruelene as 0.25% over-all spray at Fort Reno had an average of only 0.52, 0.83 and 0.94 grub per animal in December, January and February counts, respectively, whereas 0.50% over-all treated cattle had 1.15, 2.30 and 1.90 for the same period (table 19).

Ruelene, as a 0.50% over-all spray applied to 43 mature cows at Fort Reno, produced slightly poorer control (0.16 and 0.58 grub per animal in December in February) than did

the same amount of toxic material administered as an 1.0% top-line spray (0.07 and 0.02 grub per animal in December and February).

Complete Coverage Compared to Top-Line Spray

Results of the tests designed to determine the relative effectiveness of Ruelene applied as top-line and over-all sprays are given below.

When applied to four-year old cows at Lake Carl Blackwell, a 0.50% Ruelene top-line spray gave essentially the same control as 0.50% Ruelene applied as an over-all spray, that is 95% control for the top-line and 90% for the over-all (table 7.)

In a test with mature cows at Lake Carl Blackwell, 0.25% Ruelene top-line resulted in 55% control, and 0.25% over-all gave 59% control. Eighty per cent control was realized with a 0.50% top-line spray (table 8).

Ruelene produced 100% grub mortality as an over-all spray at 0.25% and 0.50% and as a top-line spray at 0.75% when applied to weanling heifers (table 12). Animals treated with a 0.25% and 0.50% top-line were 86% and 71% respectively in December counts (table 12). In this test, the 0.25% over-all spray produced more mortality than did the same amount of toxic material given as a 0.50% top-line application.

Mature cows treated with Ruelene at 0.25%, 0.50% and

0.75% top-line, and 0.25% and 0.50% over-all spray had essentially the same grub population (table 13).

Ruelene applied to 43 old cows as a 1.0% top-line spray produced slightly less grub population than did 0.50% over-all spray (table 20). The top-line sprayed animals were 86% and 97% grub-free in December and February, respectively. The over-all treated animals were 88% grub-free on both dates.

Effectiveness of Ruelene as a Feed Additive

The results of the three tests in which Ruelene was administered as a feed additive at the Lake Carl Blackwell range area is given below.

One lot of yearling heifers was fed 8.8 mg./kg. of Ruelene per day for five days (44 mg./kg. total); another was fed 13.2 mg./kg. Ruelene per day for five days (66 mg./kg. total); a third lot served as the control. The treatment began on October 19. Variation of the grub population between the two treatments was very slight (table 21), but the group treated with 66 mg./kg. had a much higher percentage of grub-free animals. The average seasonal grub control for the lower dosage was 48%, and for the higher dosage was 65%.

A multi-dosage feed additive test involving two-year old cows was begun on October 8. At a dosage of 8.8 mg./kg. per day for five days, the average seasonal grub control was 83%, and at 13.2 mg./kg per day for five days, it was 99% (table 22).

A similar test was conducted with three-year old cows fed at 11.0 mg./kg. per day for five days (55 mg./kg. total). This dosage produced 96% grub control in the 16 animals tested (table 23).

No indication of reduced palatability of the feed due to the presence of Ruelene was noted, nor was there any indication of toxicity due to the treatment.

Feed additive tests at Fort Reno involved only feed lot animals on full feed. The Angus steers, Hereford and Angus bulls were receiving a ration consisting of 30% ground corn, 20% cotton seed hulls, 10% ground alfalfa, 10% whole oats, 10% wheat bran, 10% cotton seed meal and 5% blackstrap molasses.

One batch of feed was mixed so that the 475-pound Angus steers would take in 11.0 mg./kg. Ruelene with his normal daily feed consumption (15 pounds) from self-feeders. The steers began feeding on the treated ration around noon, November 2. Slight salivation was observed by Experiment Station personnel late in the afternoon. The next morning, one steer was dead, three severely bloated and all showed heavy salivation, and about half of the animals showed slight incoordination. The three bloated animals required medical attention and were relieved by a veterinarian. The treated feed was replaced by untreated feed and all but one animal was normal in approximately 24 hours. A detailed examination of the dead steer was made by a representative of the Dow Chemical Company and an El Reno veterinarian. No

explanation could be given for the hypersensitivity of the steer to the compound.

Angus bull calves weighing approximately 500 pounds were fed the Ruelene feed mix as were the steers described above. The animals in this test were individually fed and were allowed to feed from 4 P. M. to 8 A. M. Nine of the animals were dosed to receive 8.8 mg./kg. with the consumption of 15 pounds of feed, and nine were dosed to receive 13.2 mg./kg. per 15 pounds of feed. The morning after initial treatment, three of the bulls receiving the low level dose were severely bloated and one was salivating excessively. Two which received the highest dosage showed severe salivation and one exhibited incoordination. The affected animals quickly returned to normal with the removal of the treated feed.

Twenty-three Hereford bulls received the same treatment as described above. One animal showed mild salivation and stiffness which persisted for several days after treatment. The others were apparently unaffected. The affected animal had a case of lead poisoning the previous summer.

Eight lots of eight feed lot Hereford steers were being used in feed tests at Fort Reno. Four lots were receiving cotton seed hulls and milo and either urea, urea plus trace minerals, soybean meal or soybean plus trace minerals. The other four lots were receiving sorghum silage and milo plus either urea, urea plus trace minerals, soybean meal or soybean meal plus trace minerals.

One half of the lots received 4.4 mg./kg. for five days (22 mg./kg. total), and the other half received 8.8 mg./kg. for five days (44 mg./kg. total). A slight salivation was noted in a few of the animals in all the pens by Experiment Station personnel. These symptoms continued to some degree through the five-day period and stopped when the test was completed.

All the animals that demonstrated toxic symptoms due to Ruelene treatment recovered normally when the medicated feed was removed, and no permanent effect could be detected.

Ruelene as a Drench

Ruelene was administered as a drench to 38 mature cows at Wewoka, Oklahoma, on November 2, 1959. Thirteen animals remained untreated as a check in which an average of 6.92 grubs were found. Only 0.89 grub per animal was found in the treated animals, or 87% reduction from the check.

At the end of a 90-95 day feeding period, a control lot of feeder lambs had gained approximately one pound more per animal than the animals in the test lots drenched with phenothiazine at one ounce per animal or Ruelene at 75 or 125 mg./kg.

An examination was made of the abomasum of a few lambs from each lot. The presence of internal parasites could not be detected.

Weight Gains

All the animals treated at the Lake Carl Blackwell area were studied to determine the effect of grub control treatment on weight changes from the time of treatment until the grubs were gone from the back. The animals were on a native grass winter pasture, a few were receiving a winter subsistence ration, but in no case were any on a fattening ration. As a consequence, the majority of the animals lost weight. Detailed weight gain data for Lake Carl Blackwell cattle may be found in table 28.

Three-year old cows given a total of 55 mg./kg. of Ruelene as a five-day feed additive lost 25 pounds more than the control animals. Two-year old cows had identical weights as checks when dosed with a total of 44 mg./kg. Ruelene, but the 66 mg./kg. treated animals had a 25-pound advantage. Yearling heifers dosed at 66 mg./kg. showed a 12-pound higher weight than did the control animals, whereas the 44 mg./kg. treated animals lost 22 pounds more than did the control lot.

Four-year old cows sprayed with 0.50% Ruelene showed a weight advantage over checks of 32 pounds. With 0.50% Co-Ral treatment, the cows had an 11-pound weight advantage.

Mature cows treated with 0.25% Ruelene top-line and 0.50% Co-Ral over-all lost 20 and 13 pounds, respectively, as compared to the checks. The 0.25% over-all and the 0.50%

top-line Ruelene-treated animals showed a 7 and 5 pound weight advantage, respectively. Ruelene over-all treated year-old heifers lost weight in relation to the check at 0.125% over-all and 0.25% over-all. The 0.50% treated lot showed a three-pound weight advantage over the untreated control group.

When applied to spring calves, Ruelene-treated lots showed a 22-pound weight gain over checks at 0.25% over-all and a 6-pound weight loss at 0.50% over-all. Animals treated with 0.50% Co-Ral over-all gained 21 pounds, and 1.0% ronnel-treated animals showed a weight loss of 6 pounds.

Steer calves treated at 0.125%, 0.25% and 0.50% Ruelene over-all, 0.50% Co-Ral over-all and 1.0% ronnel over-all had essentially the same weight changes.

Three-year old cows treated with Ruelene at 0.50% top-line and 0.50% over-all spray showed a 9 and 14 pound advantage, respectively.

The weight gains were recorded for 96 steer calves at Woodward. Twenty-four calves treated with a 0.50% Ruelene over-all spray gained three pounds more than did the 24 check animals. The twenty-four animals treated with Co-Ral in the same type test but on different type pasture (at Fort Supply) lost seven pounds per animal as compared to control animals. No significant weight advantage was detected for any treatment.

Lambs dosed with one ounce phenothiazine, 75 mg./kg. and 125 mg./kg. Ruelene lost an average of approximately one pound per animal more than did the checks.

Dosage in Relation to Control

One lot of steer calves treated with 0.125% Ruelene over-all spray showed a high initial grub control (86%) in December. January and February counts, however, showed that control became poorer as the grub season progressed i.e., 46% and 17% respectively. Similar results were obtained in another lot of comparable animals that were treated with 1.0% ronnel, the control being 78%, 57% and 22% for December, January and February respectively.

This progressive decrease in control was not noted in other treatments of 0.25%, 0.50% Ruelene and 0.50% Co-Ral applied as an over-all spray.

Ruelene as a 66 mg./kg. feed additive fed to yearling Herefords showed 85%, 65% and 46% control for December, January and February, respectively. At 44 mg./kg., the control was 73%, 46% and 15% for the above mentioned months.

Grub control with two-year old cows treated at 44 mg./kg. became progressively lower. No such decline was evident with the 66 mg./kg. dose.

Three-year old cows treated at 55 mg./kg. showed 100% control for December but had dropped to 71% in February.

These data seem to indicate that lower dosages of Ruelene i.e., 0.125% spray and under 55 mg./kg. (administered

over a five-day period) will not give efficient grub control for the entire grub season.

DISCUSSION

Effectiveness of Ruelene as a Spray

A summary of grub control as a spray for cattle (under and over two years of age) is given in table 26. Ruelene as an over-all spray to cattle under two years of age at 0.125%, 0.25% and 0.50% showed 68%, 90% and 95% control, respectively. To cattle over two years (table 27), 0.25% top-line, 0.25% over-all, 0.50% top-line, and 0.50% over-all gave 55%, 59%, 86% and 94% control, respectively. Generally, the same concentration of insecticide will kill a greater percentage of grubs in younger animals.

In one series of tests at Fort Reno, Ruelene was applied to weanling Angus heifers. At the 0.25% and 0.50% concentrations with both top-line and over-all sprays, grub control was excellent. In the middle of November, an additional 62 animals of similar weight, breeding and background were treated at Fort Reno with 0.50% Co-Ral. Grub control in this case was poor, there being approximately 13 grubs per animal in the December counts (table 12). The reason for such control with the second application is not clearly understood. There is a strong possibility, however, that the longer hair or inadequate pressure prevented the spray from reaching the skin.

In all tests in which Ruelene, ronnel and Co-Ral were applied, Ruelene appeared to be the superior material.

As a 0.25% top-line, 0.25% over-all, 0.50% top-line, 0.50% over-all and 0.75% over-all spray, Ruelene-treated mature cows all had very low grub population (all less than 0.66 grub per animal). Co-Ral dosed animals, on the other hand, had 4.6 grubs per animal (table 13).

Ruelene showed a slight advantage over Co-Ral when both materials were applied to two-year old cows as 0.50% over-all sprays. The Ruelene-treated animals had only 0.11, 0.14 and 0.07 grub per animal for December, January and February, as compared with 0.31, 0.55 and 0.14 for Co-Ral. Co-Ral-treated animals also demonstrated a greater variation in population (table 18).

A 0.50% over-all application of Ruelene reduced the grub population to approximately one-tenth that found in the 1.0% ronnel-treated heifer calves.

A sizeable portion of the cattle in the western half of the United States are of the range type. Treatment of this type cattle for grub control generally is most easily accomplished if the insecticide is in the form of a spray. To apply a spray requires less labor and handling of the cattle than does a drench. This is especially important when the animals are in a late stage of pregnancy. Treatment with feed usually isn't practical with range cattle, unless they have been on some type of supplementary ration such as

cotton seed meal. Even so, there is usually the timid animal that would get an inadequate amount of the medicated feed and the aggressive one that might get a hazardous overdose.

Care should be taken, especially in the north where animals have a long haircoat and the grub season is later, to insure that the insecticide penetrates the hair and reaches the skin. This is easily done if the pressure is kept high and the spray delivered in a relatively narrow penetrating stream. The nozzle should be held six to ten feet from the animal.

Top-line vs. Over-all Coverage

Top-line application covers only the back line of the animal. Two quarts of liquid per animal were used in all top-line spray tests. As over-all coverage sprays, which are applied to the entire animal, one gallon of liquid was used.

Top-line application has the advantage of being more easily applied. It does not require the shuffling of the animals back and forth to insure coverage to both sides of the animal that is required with over-all sprays. Over-all sprays have the disadvantage that not all the insecticide is utilized; that is, with the one gallon per animal dose, some of the material is wasted as runoff. Also, in attempting to cover parts of the animal such as its head and legs, a portion of the spray stream misses the animal

entirely. With top-line spray, on the other hand, most of the spray material stays on the back of the animal until the spray is dry. If the same control could be attained with a top-line spray as with a complete coverage spray of the same concentration, the cost would be cut in half. If equal control could be attained with top-line spray of twice the concentration as a complete coverage spray, the total amount of actual insecticide applied to the animal would be the same. Top-line application in this case would be the more efficient due to easier application.

Applied to four-year old cows at Lake Carl Blackwell, a 0.50% Ruelene top-line spray gave essentially the same control as a 0.50% over-all spray. With mature cows at Lake Carl Blackwell, essentially the same control resulted with over-all and top-line application at 0.25%, but a top-line spray of 0.50% (equal amounts of actual toxicant as in the 0.25% over-all) showed much better per cent control, i.e., 80%. In one test involving eighty old cows, Ruelene as a 1.0% top-line spray out-performed the material at 0.50% over-all spray. Both sprays in this case, however, were applied late in the evening when lighting was inadequate. It was felt at the time of application that the coverage with the top-line spray was adequate due to the ease of application, but that at least some of the animals were partially missed in the over-all treated lots. The grub counts seem to substantiate this, there being a

variation of 0-1 grub per animal in the top-line treated lot and 0-14 in the over-all treated lot. This may account for the better control with top-line application.

In yearling heifers, a slight control advantage was noted with over-all application of the same amount of actual insecticide. When grub control is the only consideration, top-line application is probably equal or even superior to over-all coverage, considering the labor, time and cost involved with each method of application. Of course, if the compound were being used as a multi-purpose treatment for louse and grub control, the over-all spray would probably be superior.

Ruelene as a Feed Additive

Ruelene as a feed additive gave less than satisfactory control in yearling heifers at Lake Carl Blackwell. Total five-day dosages of 44 mg./kg. and 66 mg./kg. gave only 48% and 65% control respectively. In mature cows, however, five-day dosages of 44 mg./kg. produced good control. Lots dosed at 55 mg./kg. and 66 mg./kg. showed excellent control (87% to 99%). An examination showed that there was considerable variation in the grub population in the heifers. No such variation was recorded for the mature animals (tables 22 and 23). This might indicate that some of the heifers did not eat an adequate amount of the material. This could have easily happened as all of the animals were fed in one

large trough. If this were the case, it would explain the poor control. These animals were observed daily by competent personnel who detected no toxic symptoms due to the insecticides.

Five-day feed additive tests at Fort Reno involving 46 individually fed Angus and Hereford bull calves and 62 Angus steer calves, all of which were on a fattening ration had to be discontinued after the first day as the animals showed hypersensitivity to the compound.

Why the sensitivity of the Ruelene feed mix occurred with the animals at Fort Reno but did not occur at Lake Carl Blackwell is not fully understood. Some considerations are: 1. That all the animals at Lake Carl Blackwell were range animals on native grass pasture. Any other feed they received was strictly of the maintenance nature whereas the Fort Reno animals were on a fattening ration. 2. That the Lake Carl Blackwell yearlings were treated October 10 and the mature animals on October 8, whereas the Fort Reno steer and bull calves were treated on November 2. Thus, it might be that the grubs were in a more advanced state, and when they were killed by the systemic, they produced an antiphylactic reaction within the animals. This hardly seems possible, however, because toxic symptoms appeared within approximately 12-14 hours after treatment, which is probably too soon for such a reaction to occur.

The Hereford steers treated at Fort Reno showed less

reaction than did the treated Angus. However, they were treated with a slightly lower dosage. Whether or not there was a different reaction due to breed was not determined.

These data indicate that Ruelene as a feed additive will do a good job of controlling grubs. Further tests will be necessary before any definite conclusion or recommendations can be made with regard to Ruelene as a feed additive, due to the toxic effects it produced to the animals at Fort Reno.

Ruelene as a Drench

Ruelene, administered to 38 mature cows at Wewoka, Oklahoma, on November 2, resulted in 87% grub control. This test was not adequate for drawing conclusions as to the value of Ruelene as a drench, but it seems to indicate that it will kill grubs when administered in this manner. This is important as Ruelene demonstrates anthelmintic activity (Shaver, 1959). Further tests may prove Ruelene capable of a double role, i.e., grub control and helminth control.

Four lots, each containing 125 lambs were drenched with one ounce of phenothiazine per animal and 75 mg./kg. or 125 mg./kg. Ruelene per animal. One lot was retained as a check. These lambs were shipped direct from New Mexico, where they were on open range, to El Reno for feed tests. Weight gains were kept from treatment until slaughter.

The Ruelene and phenothiazine-treated animals showed approximately one pound less weight gain during the fattening period than did the non-treated animals. A microscopic examination was made of the contents of the abomasum of a few animals from each group. No evidence of parasites could be detected.

It is logical to assume that the treated animals received a slight setback due to treatment. As there were no parasites present, the untreated animals finished the test with a slight weight advantage.

Weight Changes with Ruelene-treated Animals

Weights were obtained at time of treatment and at the end of the grub season for all cattle at Lake Carl Blackwell, Fort Reno and Fort Supply (tables 28 to 31). These were the only tests designed with a control group on which it was possible to keep weights. It is felt that these were the only animals of the test where the true weight changes could be carefully studied.

No logical pattern could be established in a study of the weight changes in connection with treatment, and significant weight changes were not noted.

Ruelene-sprayed animals at the Woodward Experiment Station did, however, show a weight advantage over checks of 13 pounds as compared to a three-pound loss over checks

in the Co-Ral-treated animals at Fort Supply. Because these animals were on two different types of pasture, no significance can be attached to these data.

SUMMARY

Early in 1959 extensive tests were undertaken to evaluate the effectiveness of Ruelene, a new systemic insecticide for the control of cattle grubs and internal parasites. The tests involved a total of 1611 animals at five locations in Oklahoma.

As an over-all spray, Ruelene was administered to animals under two years old as 0.125%, 0.25% and 0.50% sprays gave 68%, 90% and 95% fewer grubs, respectively. To cattle over two years of age, 0.25% top-line and 0.50% over-all, 0.50% top-line and 0.50% over-all sprays gave 55%, 59%, 86% and 94% control respectively.

In all cases, Ruelene-treated animals had significantly lower grub populations than did the Co-Ral or ronnel-treated animals.

Generally, top-line application resulted in slightly less control than did an over-all application of the same concentration. Top-line application of twice the concentration of over-all spray (i.e., the same amount of actual active ingredient) gave about the same degree of control. When grub control is the only consideration, top-line application is probably the most practical.

Ruelene demonstrated only moderate grub control as a feed additive when given to yearling heifers. It is believed that this was due to failure of all the animals to eat adequate amounts of the Ruelene feed mix. Good control resulted, however, with all mature animals treated by this method (87% to 90%). Feed additive tests were initiated with feed lot animals at Fort Reno, but they were discontinued after the first day, due to a severe reaction to the compound by approximately one-half the animals. One steer died.

Tested as a drench in 38 mature cows, Ruelene demonstrated good grub control (87%).

Five hundred Ruelene and phenothiazine drenched feeder lambs showed slightly lower weight gains than did untreated animals. An examination of the stomachs of a few lambs receiving each treatment and the check group failed to show the presence of any parasites.

No consistent weight advantage or disadvantage could be detected in cattle due to treatment with Ruelene.

Grub control became progressively poorer as the season progressed in groups treated with lower dosages of Ruelene, i.e., 0.125% spray and under 55 mg./kg. as a feed additive. No such reduction was noted with dosages of 0.25% sprays and over 55 mg./kg. feed additives.

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APPENDIX

Table 1. Outline of spray tests against common cattle grub, Hypoderma lineatum (DeVill.), with Ruelene, Co-Ral and ronnel at Fort Reno, Woodward, Fort Supply and Lake Carl Blackwell, Oklahoma, 1959.

Treatment	Concentration	Coverage	No. of Animals	Type of Animal
Ruelene	0.125	Top-line	29	Mature Cows
Ruelene	0.125	Over-all	13	Mature Cows
Ruelene	0.125	Over-all	24	*Under 2 Years
Ruelene	0.25	Top-line	10	Mature Cows
Ruelene	0.25	Top-line	35	*Under 2 Years
Ruelene	0.25	Over-all	10	Mature Cows
Ruelene	0.25	Over-all	15	Under 2 Years
Ruelene	0.25	Over-all	39	*Mature Cows
Ruelene	0.25	Over-all	36	*Under 2 Years
Ruelene	0.50	Top-line	67	*Mature Cows
Ruelene	0.50	Top-line	20	Mature Cows
Ruelene	0.50	Top-line	44	*Under 2 Years
Ruelene	0.50	Top-line	27	*Mature Cows
Ruelene	0.50	Over-all	27	*Mature Cows
Ruelene	0.50	Over-all	165	*Mature Cows
Ruelene	0.50	Over-all	84	*Under 2 Years
Ruelene	0.50	Over-all	36	*Under 2 Years
Ruelene	0.50	Over all	24	Under 2 Years
Ruelene	0.75	Top-line	43	*Under 2 Years
Ruelene	0.75	Top-line	20	Mature Cows
Ruelene	1.00	Top-line	43	*Mature Cows
Co-Ral	0.50	Over-all	29	*Mature Cows
Co-Ral	0.50	Over all	22	*Mature Cows
Co-Ral	0.50	Over-all	24	*Under 2 Years
Co-Ral	0.50	Over-all	24	Under 2 Years
Ronnel	1.00	Over-all	68	*Under 2 Years
Ronnel	1.00	Over-all	24	*Under 2 Years

*These lots are a composite of one or more smaller groups.

Table 2. Outline of treatments with Ruelene as a five-day feed additive for the control of the common cattle grub, Hypoderma lineatum (DeVill.). Oklahoma, 1959.

Treatment	Total Five Day Dosage mg./kg.	No. of Animals	Type of Animal	Location
Ruelene	66	12	Yearling Heifers	Lake Carl Blackwell
Ruelene	44	12	Yearling Heifers	Lake Carl Blackwell
Ruelene	44	7	2 Year Old Cows	Lake Carl Blackwell
Ruelene	66	7	2 Year Old Cows	Lake Carl Blackwell
Ruelene	55	16	4 Year Old Cows	Lake Carl Blackwell
Ruelene	55	61	Steer Calves	Fort Reno
Ruelene	44	23	Bull Calves	Fort Reno
Ruelene	66	23	Bull Calves	Fort Reno
Ruelene	22	23	Steer Calves	Fort Reno
Ruelene	44	23	Steer Calves	Fort Reno

Table 3. Outline of drench treatments with Ruelene and phenothiazine for the control of the common cattle grub, Hypoderma lineatum (DeVill.). Oklahoma, 1959.

Treatment	Dosage	No. of Animals	Type of Animals	Location
Ruelene	11 mg./kg.	38	Mature Cows	Wewoka
Ruelene	75 mg./kg.	125	Feeder Lambs	Fort Reno
Ruelene	125 mg./kg.	125	Feeder Lambs	Fort Reno
Phenothiazine	1 ounce	125	Feeder Lambs	Fort Reno

Table 4. Effectiveness of Ruelene, Co-Ral and ronnel applied as over-all spray to groups of twelve spring calves for the control of the common cattle grub, Hypoderma lineatum (DeVill.). Lake Carl Blackwell, Oklahoma. November 7, 1959.

Treatment	Avg. No. Grubs Per Animal				Variation in Grub Population				Per Cent of Animals Grub Free				Per Cent Seasonal Grub Control
	Dec	Jan	Feb	Mar	Dec	Jan	Feb	Mar	Dec	Jan	Feb	Mar	
Ruelene 0.25%	0.25	0.08	0.66	0.00	0-2	0-1	0-4	0-0	83	92	75	100	97
Ruelene 0.50%	0.00	0.08	0.08	0.00	0-0	0-1	0-1	0-0	100	92	92	100	99
Co-Ral 0.50%	0.41	1.00	0.66	0.00	0-3	0-8	0-3	0-0	83	67	58	100	94
Ronnel 1.00%	4.75	8.33	4.08	0.58	0-14	0-23	0-16	0-7	17	17	42	92	34
None	10.83	17.00	4.54	0.50	0-30	0-34	0-22	0-3	8	17	18	67	-

Table 5. Effectiveness of Ruelene applied as an over-all spray to year old heifers for the control of the common cattle grub, Hypoderma lineatum (DeVill.). Lake Carl Blackwell, Oklahoma. October 27, 1959.

Treatment	No. of Animals	Avg. No. Grubs Per Animal				Variation in Grub Population				Per Cent of Animals Grub Free				Per Cent Seasonal Grub Control
		Dec	Jan	Feb	Mar	Dec	Jan	Feb	Mar	Dec	Jan	Feb	Mar	
Ruelene 0.125%	12	1.41	4.00	2.83	0.08	0-5	0-13	0-10	0-0	58	36	17	92	76
Ruelene 0.25%	12	0.00	0.50	0.45	0.00	0-0	0-2	0-2	0-0	100	75	73	100	97
Ruelene 0.50%	12	0.33	0.00	0.08	0.00	0-3	0-0	0-1	0-0	83	100	92	100	99
None	18	15.77	15.83	2.55	0.16	2-30	6-38	0-11	0-1	0	0	11	83	-

Table 6. Effectiveness of Ruelene and Co-Ral applied as over-all sprays to four-year old cows for the control of the common cattle grub, Hypoderma lineatum (DeVill.). Lake Carl Blackwell, Oklahoma. October 8, 1959.

Treatment	No. of Animals	Avg. No. Grubs Per Animal				Variation in Grub Population				Per Cent of Animals Grub Free				Per Cent Seasonal Grub Control
		Dec	Jan	Feb	Mar	Dec	Jan	Feb	Mar	Dec	Jan	Feb	Mar	
Ruelene 0.50%	10	0.00	0.00	0.00	0.00	0-0	0-0	0-0	0-0	100	100	100	100	100
None	8	3.62	7.00	2.63	0.00	0-13	0-19	0-9	0-0	50	13	38	100	-
Co-Ral 0.50%	10	0.55	0.55	0.22	0.00	0-2	0-2	0-1	0-0	67	56	76	100	86
None	9	3.22	4.33	2.11	0.00	0-11	0-11	0-8	0-0	34	11	55	100	-

Table 7. Effectiveness of Ruelene applied as a spray to three and four-year old cows for the control of the common cattle grub, Hypoderma lineatum (DeVill.). Lake Carl Blackwell, Oklahoma. November 19, 1959.

Treatment	Coverage	No. of Animals	Avg. No. Grubs Per Animal		Variation in Grub Population		Per Cent Animals Grub Free		Per Cent Seasonal Grub Control
			Dec	Jan	Dec	Jan	Dec	Jan	
Ruelene 0.50%	Top-line	18	0.47	0.73	0-2	0-5	58	73	92
Ruelene 0.50%	Over-all	18	1.05	0.37	0-5	0-5	58	87	90
None	-	23	8.17	6.48	0-29	0-19	4	8	-

Table 8. Effectiveness of Ruelene and Co-Ral applied as a spray to mature cows for the control of the common cattle grub, Hypoderma lineatum (DeVill.). Lake Carl Blackwell, Oklahoma. October 13, 1959.

Treatment	Coverage	No. of Animals	Avg. No. Grubs Per Animal		Variation in Grub Population		Per Cent Animals Grub Free		Per Cent Seasonal Grub Control
			Dec 16	Feb 4	Dec 16	Feb 4	Dec 16	Feb 4	
Ruelene 0.25%	Top-line	10	2.30	1.11	0-8	0-10	20	89	55
None	-	10	3.87	3.90	0-8	0-11	20	40	-
Ruelene 0.25%	Over-all	10	1.40	1.86	0-6	0-6	60	43	59
None	-	10	4.25	3.60	0-13	0-9	8	10	-
Ruelene 0.50%	Top-line	20	0.77	0.65	0-4	0-5	55	65	80
None	-	20	4.15	3.00	0-12	0-11	11	24	-
Co-Ral 0.50%	Over-all	20	0.26	0.13	0-3	0-1	84	87	95
None	-	20	4.45	4.41	0-14	0-13	5	24	0

Table 9. Effectiveness of Ruelene, Co-Ral and ronnel applied as an over-all spray to groups of twelve steer calves for the control of the common cattle grub, Hypoderma lineatum (DeVill.). Lake Carl Blackwell, Oklahoma. November 19, 1959.

Treatment	Avg. No. Grubs Per Animal			Variation in Grub Population			Per Cent of Animals Grub Free			Per Cent Seasonal Grub Control
	Dec 5	Jan 10	Feb 9	Dec 5	Jan 10	Feb 9	Dec 5	Jan 10	Feb 9	
Ruelene 0.125%	3.25	11.91	7.33	0-27	0-32	0-19	42	25	20	59
Ruelene 0.25%	4.60	5.00	2.91	0-16	0-28	0-20	40	58	50	77
Ruelene 0.50%	5.27	1.00	0.90	0-16	0-9	0-9	36	58	82	87
Co-Ral 0.50%	5.33	3.25	1.91	0-19	0-11	0-13	34	42	42	81
Ronnel 1.0%	5.27	9.50	6.90	0-13	0-40	0-27	45	42	64	60
None	23.77	22.20	8.83	0-58	0-45	0-23	15	7	21	-

Table 10. Effectiveness of Ruelene applied as an over-all spray to groups of twenty-four steer calves for the control of the common cattle grub, Hypoderma lineatum (DeVill.). Woodward, Oklahoma. November 20, 1959.

Treatment	Avg. No. Grubs Per Animal		Variation in Grub Population		Per Cent of Animals Grub Free		Per Cent Seasonal Grub Control
	Dec 31	Jan 31	Dec 31	Jan 31	Dec 31	Jan 31	
Ruelene 0.50%	1.29	0.04	0-13	0-1	75	96	96
None	14.66	8.54	0-35	0-19	4	17	-

Table 11. Effectiveness of Co-Ral applied as an over-all spray to groups of twenty-four steers for the control of the common cattle grub, Hypoderma lineatum (DeVill.). Fort Supply, Oklahoma, November 20, 1959.

Treatment	Avg. No. Grubs Per Animal		Variation in Grub Population		Per Cent of Animals Grub Free		Per Cent Seasonal Grub Control
	Dec 31	Jan 31	Dec 31	Jan 31	Dec 31	Jan 31	
Co-Ral 0.50%	9.41	2.45	0-33	0-8	21	38	60
None	17.04	7.33	0-40	0-18	4	17	--

Table 12 Results of tests in which Ruelene and Co-Ral were applied as a spray to weanling heifers for the control of the common cattle grub, Hypoderma lineatum (DeVill.). Fort Reno, Oklahoma, 1959.

Treatment	Coverage	No. of Animals	Date of Application	Avg. No. Grubs Per Animal		Variation in Grub Population		Per Cent of Animals Grub Free	
				Dec 12	Mar 7	Dec 12	Mar 7	Dec 12	Mar 7
Ruelene 0.25%	Top-line	15	Oct. 20	0.78	0.00	0-6	0-0	86	100
Ruelene 0.25%	Over-all	13	Oct. 20	0.00	0.00	0-0	0-0	100	100
Ruelene 0.50%	Top-line	15	Oct. 20	0.71	0.00	0-6	0-0	71	100
Ruelene 0.50%	Over-all	15	Oct. 20	0.00	0.00	0-0	0-0	100	100
Ruelene 0.75%	Top-line	13	Oct. 20	0.00	0.00	0-0	0-0	100	100
Co-Ral 0.50%	Over-all	62	Nov. 25	12.74	0.04	0-33	0-1	10	00.04

Table 13. Results of tests against the common cattle grub, Hypoderma lineatum (DeVill.), with Ruelene and Co-Ral applied as a spray to mature cows. Fort Reno, Oklahoma. October 20, 1959.

Treatment	Coverage	No. of Animals	Avg. No. Grubs Per Animal	Variation in Grub Population	Per Cent of Animals Grub Free
			Dec 21	Dec 21	Dec 21
Ruelene 0.25%	Top-line	20	0.66	0-4	67
Ruelene 0.25%	Over-all	20	0.14	0-2	93
Ruelene 0.50%	Top-line	20	0.22	0-2	84
Ruelene 0.50%	Over-all	40	0.38	0-3	73
Ruelene 0.75%	Top-line	20	0.39	0-3	71
Co-Ral 0.50%	Over-all	23	4.6	0-4	77

Table 14. Effectiveness of 0.125% and 0.50% over-all Ruelene sprays applied to fall calving cows for the control of the common cattle grub, Hypoderma lineatum (DeVill.). Fort Reno, Oklahoma. October 27, 1959

Treatment	No. of Animals	Avg. No. Grubs Per Animal		Variation in Grub Population		Per Cent of Animals Grub Free	
		Dec 21	Feb 17	Dec 21	Feb 17	Dec 21	Feb 17
Ruelene 0.125%	13	3.22	1.50	0-30	0-6	33	50
Ruelene 0.50%	13	0.23	0.66	0-3	0-2	92	50

Table 15. Effectiveness of 0.125% and 0.50% top-line Ruelene sprays applied to fall calving cows for the control of the common cattle grub, Hypoderma lineatum (DeVill.). Fort Reno, Oklahoma. October 27, 1959.

Treatment	No. of Animals	Avg. No. Grubs Per Animal		Variation in Grub Population		Per Cent of Animals Grub Free	
		Dec 21	Feb 17	Dec 21	Feb 17	Dec 21	Feb 17
Ruelene 0.125%	29	2.41	2.07	0-12	0-16	52	41
Ruelene 0.50%	29	0.70	1.04	0-11	0-8	81	60

Table 16. Effectiveness of ronnel and Ruelene over-all sprays applied to heifer calves for the control of the common cattle grub, Hypoderma lineatum (DeVill.). Fort Reno, Oklahoma, October 23, 1959.

Treatment	No. of Animals	Avg. No. Grubs Per Animal			Variation in Grub Population			Per Cent of Animals Grub Free		
		Dec 19	Jan 15	Feb 17	Dec 19	Jan 15	Feb 17	Dec 19	Jan 15	Feb 17
Ronnel 1.0%	41	4.31	8.08	3.41	0-24	0-21	0-17	43	28	48
Ruelene 0.50%	41	0.37	0.67	0.59	0-5	0-8	0-6	82	82	84

Table 17. Effectiveness of Ruelene 0.50% and 0.75% top-line sprays applied to yearling heifers for the control of the common cattle grub, Hypoderma lineatum (DeVill.). Fort Reno, Oklahoma. October 23, 1959.

Treatment	No. of Animals	Avg. No. Grubs Per Animal			Variation in Grub Population			Per Cent of Animals Grub Free		
		Dec 19	Jan 15	Feb 17	Dec 19	Jan 15	Feb 17	Dec 19	Jan 15	Feb 17
Ruelene 0.50%	29	1.34	1.44	1.18	0-18	0-11	0-10	66	48	63
Ruelene 0.75%	25	0.16	0.36	0.28	0-3	0-2	0-2	92	96	96

Table 18. Effectiveness of Ruelene and Co-Ral applied as an over-all spray to two-year old cows for the control of the common cattle grub, Hypoderma lineatum (DeVill.). Fort Reno, Oklahoma October 23, 1959.

Treatment	No. of Animals	Avg. No. Grubs Per Animal			Variation in Grub Population			Per Cent of Animals Grub Free		
		Dec 19	Jan 15	Feb 17	Dec 19	Jan 15	Feb 17	Dec 19	Jan 15	Feb 17
Ruelene 0.50%	28	.11	.14	.07	0-1	0-2	0-1	89	89	93
Co-Ral 0.50%	29	.31	.55	.14	0-5	0-8	0-3	93	83	93

Table 19. Effectiveness of Ruelene 0.25% and 0.50% over-all sprays applied to three-year old cows for the control of the common cattle grub, Hypoderma lineatum (DeVill.). Fort Reno, Oklahoma. October 23, 1959.

Treatment	No. of Animals	Avg. No. Grubs Per Animal			Variation in Grub Population			Per Cent of Animals Grub Free		
		Dec 19	Jan 15	Feb 17	Dec 19	Jan 15	Feb 17	Dec 19	Jan 15	Feb 17
Ruelene 0.25%	19	0.52	0.83	0.94	0-8	0-8	0-8	89	67	56
Ruelene 0.50%	19	1.15	2.30	1.90	0-9	0-15	0-9	79	65	47

Table 20. Effectiveness of Ruelene applied as a spray to mature cows for the control of the common cattle grub, Hypoderma lineatum (DeVill.). Fort Reno, Oklahoma. October 23, 1959.

Treatment	Coverage	No. of Animals	Avg. No. Grubs Per Animal		Variation in Grub Population		Per Cent of Animals Grub Free	
			Dec 22	Feb 12	Dec 22	Feb 12	Dec 22	Feb 12
Ruelene 0.50%	Over-all	43	0.16	0.58	0-2	0-14	88	88
Ruelene 1.0%	Top-line	43	0.07	0.02	0-1	0-1	86	97

Table 21. Effectiveness of Ruelene applied as a five-day feed additive to groups of twelve yearling heifers for the control of the common cattle grub, Hypoderma lineatum (DeVill.). Lake Carl Blackwell, Oklahoma. October 19, 1959.

Treatment	Total Five Day Dosage mg./kg.	Avg. No. Grubs Per Animal			Variation in Grub Population			Per Cent Animals Grub Free			Per Cent Seasonal Grub Control
		Dec 5	Jan 9	Feb 9	Dec 5	Jan 9	Feb 9	Dec 5	Jan 9	Feb 9	
Ruelene	66	1.25	6.25	2.91	0-5	0-31	0-9	50	42	25	65
Ruelene	44	2.16	8.91	4.58	0-5	0-29	0-12	25	17	17	48
None	-	8.00	16.54	5.36	0-20	4-41	0-18	9	0	18	-

Table 22. Effectiveness of Ruelene applied as a five-day feed additive to groups of seven two-year old cows for the control of the common cattle grub, Hypoderma lineatum (DeVill.). Lake Carl Blackwell, Oklahoma. October 8, 1959.

Treatment	Total Five Day Dosage mg./kg.	Avg. No. Grubs Per Animal				Variation in Grub Population				Per Cent of Animals Grub Free				Per Cent Seasonal Grub Control
		Dec 5	Jan 7	Feb 12	Mar 12	Dec 5	Jan 7	Feb 12	Mar 12	Dec 5	Jan 7	Feb 12	Mar 12	
Ruelene	44	0.14	1.00	0.83	0.00	0-1	0-3	0-2	0-0	86	57	33	100	83
None	-	2.43	10.30	3.14	0.14	0-6	2-30	0-7	0-1	29	0	14	86	-
Ruelene	66	0.00	0.14	0.14	0.00	0-0	0-1	0-1	0-0	100	86	86	100	99
None	-	6.71	12.43	3.57	0.00	2-10	5-21	1-9	0-0	0	0	0	100	-

Table 23. Effectiveness of Ruelene applied as a five-day feed additive to three year old cows for the control of the common cattle grub, Hypoderma lineatum (DeVill.) Lake Carl Blackwell, Oklahoma. October 8, 1959.

Treatment	Total Five Day Dosage mg./kg.	No. of Animals	Avg. No. Grubs Per Animal			Variation in Grub Population			Per Cent of Animals Grub Free			Per Cent Seasonal Grub Control
			Dec 13	Jan 15	Feb 13	Dec 13	Jan 15	Feb 13	Dec 13	Jan 15	Feb 13	
Ruelene	55	16	0.00	0.25	0.43	0-0	0-2	0-4	100	81	69	96
None	-	20	7.90	6.55	1.50	0-26	0-15	0-10	5	17	41	-

Table 24. Effectiveness of Ruelene applied as a drench to mature cows for the control of the common cattle grub, Hypoderma lineatum (DeVill.). Wewoka, Oklahoma. November 2, 1959.

Treatment	Total Five Day Dosage mg./kg.	No. of Animals	Avg. No. Grubs Per Animal	Variation in Grub Population	Per Cent Animals Grub Free	Per Cent Control
			Jan. 15	Jan. 15	Jan. 15	Jan. 15
Ruelene	55	38	.89	0-8	54	87
None	-	13	6.92	0-18	8	0

Table 25. Summary of results for all spray tests* against the common cattle grub, Hypoderma lineatum (DeVill.), containing an untreated control group. Oklahoma, 1959.

Treatment	Coverage	No. of Cattle	Per Cent Control
Ruelene 0.125%	Over-all	24	68
Ruelene 0.25%	Top-line	55	55
Ruelene 0.25%	Over-all	46	84
Ruelene 0.50%	Top-line	38	86
Ruelene 0.50%	Over-all	88	95
Co-Ral 0.50%	Over-all	78	81
Ronnel 1.0%	Over-all	24	47

*Summary of data appears in tables 4 through 11.

Table 26. Summary of grub control tests* with Ruelene as a spray and feed additive for the control of the common cattle grub, Hypoderma lineatum (DeVill.), in cattle under two years of age. Oklahoma, 1959.

Treatment	Dosage	Coverage	Length of Treatment	Per Cent Control
Spray	0.125%	Over-all	1 day	68
Spray	0.25%	Over-all	1 day	90
Spray	0.50%	Over-all	1 day	95
Feed Additive	44 mg./kg.	-	5 days	48
Feed Additive	66 mg./kg.	-	5 days	65

*This data includes only lots which contained a control group.

Table 27. Summary of grub control tests* with Ruelene as a spray, feed additive and drench for the control of the common cattle grub, Hypoderma lineatum (DeVill.), in cattle over two years old. Oklahoma, 1959.

Treatment	Dosage	Coverage	Length of Treatment	Per Cent Control
Spray	0.25%	Top-line	1 day	55
Spray	0.25%	Over-all	1 day	59
Spray	0.50%	Top-line	1 day	86
Spray	0.50%	Over-all	1 day	94
Feed Additive	44 mg./kg.	-	5 days	83
Feed Additive	55 mg./kg.	-	5 days	96
Feed Additive	66 mg./kg.	-	5 days	99
Drench	11 mg./kg.	-	1 day	87

*This data includes only lots which contained a control group.

Ruelene 0.125%	Over-all	Nov. 19	Steer calves	12	395	408	+13
Ruelene 0.25%	Over-all	Nov. 19	Steer calves	12	388	392	+4
Ruelene 0.50%	Over-all	Nov. 19	Steer calves	12	422	413	-9
Co-Ral 0.50%	Over-all	Nov. 19	Steer calves	12	385	400	+15
Ronnel 1.00%	Over-all	Nov. 19	Steer calves	12	408	417	+9
None	-	-	Steer calves	15	397	408	+11
Ruelene 0.50%	Top-line	Oct. 8	3 & 4 yr. old cows	18	1099	843	-256
Ruelene 0.50%	Over-all	Oct. 8	3 & 4 yr. old cows	18	1108	847	-261
None	-	-	3 & 4 yr. old cows	21	1108	861	-247

Table 29. Weight changes of steer calves sprayed with Ruelene or Co-Ral for the control of the common cattle grub, Hypoderma lineatum (DeVill.). Woodward or Fort Supply, Oklahoma, November 19, 1959.

Treatment	Coverage	Location	No. of Animals	Avg. Wt. at Treat Date	Avg. Wt. at End of Season	Average Wt. Gain
Ruelene 0.50%	Over-all	Woodward	24	493	523	30
None	-	Woodward	24	490	516	27
Co-Ral 0.50%	Over-all	Ft. Supply	24	502	525	23
None	-	Ft. Supply	24	478	510	32

Table 30. Average weight change in animals treated with Ruelene as a five-day feed additive for the control of the common cattle grub, Hypoderma lineatum (DeVill.). Lake Blackwell, Oklahoma, 1959.

Treatment	Total Five Day Dosage mg./kg.	Date of Treat	Kind of Animals	No. of Animals	Avg. Wt. at Treat. Date	*Avg. Wt. at End of Season	Avg. Wt. Change
Feed additive	55	Oct. 8	3 yr. old cows	15	1077	740	-337
None	-	-	3 yr. old cows	20	1032	720	-312
Feed additive	44	Oct. 8	2 yr. old cows	7	961	849	-112
None	-	-	2 yr. old cows	7	962	850	-112
Feed additive	66	Oct. 8	2 yr. old cows	7	973	912	-61
None	-	-	2 yr. old cows	7	974	889	-85
Feed additive	66	Oct. 19	Yearling heifers	12	695	662	-33
Feed additive	44	Oct. 19	Yearling heifers	12	688	621	-67
None	-	-	Yearling heifers	11	713	668	-45

*Weight was taken as close as possible to March 1.

Table 31. Weight change in feeder lambs drenched with Ruelene and phenothiazine for the control of the common cattle grub, Hypoderma lineatum (DeVill.). El Reno, Oklahoma, November 19, 1959.

Treatment	No. of Animals	Avg. No. Days Fed	Average Daily Gain	Average Gain Per Animal
Phenothiazine 1 oz./animal	119	94.5	.408	38.6
Ruelene 75 mg./kg.	122	93.0	.412	38.3
Ruelene 125 mg./kg.	123	91.1	.423	38.5
None	119	93.3	.425	39.7

VITA

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Master of Science

Thesis: TESTS WITH RUELENE, RONNEL AND CO-RAL FOR SYSTEMIC CONTROL OF *Hypoderma lineatum* (DeVill.)

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