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PROCEEDINGS

OF

SEMINAR/WORKSHOP

ON

TICK ERADICATION MEASURES

SPONSORED BY

THE INTER-AMERICAN INSTITUTE FOR COOPERATION ON AGRICULTURE

IN CONJUNCTION WITH

PUERTO RICO DEPARTMENT OF AGRICULTURE

AND

USDA - APHIS, VETERINARY SERVICES

COMMONWEALTH OF PUERTO RICO
USDA - APHIS, VS HEADQUARTERS

SEPTEMBER 3 - 6, 1985

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INTER-AMERICAN INSTITUTE FOR COOPERATION ON AGRICULTURE

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C O N T E N T S

AGENDA

TUESDAY, SEPTEMBER 3:

08:00 hrs:	Registration - Opening Ceremony	
08:30 hrs:	Taxonomy - Tick Identification	- Dr. Robert Strickland
10:00 hrs:	B R E A K	
10:30 hrs:	Tick Biology - Ecology	- Dr. Glen Garris
12:00 hrs:	L U N C H	
13:00 hrs:	Diseases and Ticks	- Dr. Robert Strickland
14:00 hrs:	Tick Control & Eradication Procedures	- Dr. Glen Garris
15:00 hrs:	B R E A K	
15:30 hrs:	Acaricide Resistance	- Dr. Glen Garris
16:00 hrs:	Research on Amblyomma variegatum Eradication in Puerto Rico	- Dr. Glen Garris
16:30 hrs:	Discussion	

WEDNESDAY, SEPTEMBER 4:

08:00 hrs:	Pesticide Safety and Equipment	- Dr. William Rodgers
10:00 hrs:	B R E A K	

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10:30 hrs:	Puerto Rico Eradication Program Overview	- Dr. Charles Suthern
	Amblyomma and Boophilus Eradication Procedures	- Mr. Carmelo Gonzalez
12:00 hrs	L U N C H	
13:00 hrs	Puerto Rico Eradication Campaign	
	- Equipment used in the Program	- Mr. Julio De Jesus - Mr. Luis G. Rivera
	- Pesticide Use - Effectiveness	- Dr. Reed Rollo - Dr. Ivonne Borras
	- Administration - Problems and Procedures	- Dr. Francisco Zayas
	- Information and Communications	- Mr. Julio Llinas
15:00 hrs:	B R E A K	
15:30 hrs:	New Research	- Dr. Glen Garris
16:00 hrs:	Discussion - Caribbean Country Programs	

THURSDAY, SEPTEMBER 5:

05:00 hrs: Field Visit - Arecibo

- Depart Regency Hotel
- Proper Safety Equipment - Clothing
- Pesticide Application Procedures:
  - John Bean - hand sprayer
  - Spray - dip machine
  - Portable swim vat
  - Hydro vat
- Quarantine and movement control procedures

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FRIDAY, SEPTEMBER 6:

08:00 hrs: **General Discussion**

Questions and Answers

12:00 hrs: **Closing Ceremony**

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P R O C E E D I N G S

The opening ceremony began with a welcome to all participants by Dr. Franz C. Alexander, Regional Animal Health Specialist, on behalf of the IICA. He regretted the absence of Dr. Hector Campos Lopez, Director of the Animal Health Programme, who was unable to attend at the last moment. His expertise would be missed as he had considerable experience in tick eradication having led his country's campaign in Mexico. He reviewed the interest of the Caribbean Region in Tick Control/Eradication Measures and specifically the concerns following the confirmation of Heartwater in Guadeloupe, Marie Galante and Antigua, the spread of the tropical bont tick, Amblyomma variegatum in the region and the tick's relationship to Dermatophilosis. He summarized the events and proposals leading up to the seminar/workshop in Puerto Rico and thanked the Commonwealth of Puerto Rico and The United States Department of Agriculture for their outstanding support and collaboration in hosting the meeting. He noted the very fine expertise provided by the USDA and the staff of the Puerto Rican Tick Eradication Campaign and implored the veterinarians from visiting Caribbean countries to make the most of their opportunity. They were charged to return to their countries to lead the development of national activities in the fight against cattle ticks.

The Under Secretary of Agriculture, Dr. Luis Mejia Mattei, extended a warm welcome on behalf of the Commonwealth of Puerto Rico, stating his delight at the opportunity of hosting this seminar and pledged his country's full support and cooperation. He noted the role that the personnel involved with the eradication campaign would play for the meeting's success and hoped that the participants would also find time to enjoy some of the hospitality of the people of Puerto Rico.

Dr. Thomas Holt, Area Veterinarian in Charge, USDA/APHIS Veterinary Services and US Virgin Islands, endorsed the sincere welcome to participants and stated

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his delight at the opportunity to meet and share ideas with other veterinary colleagues in the Caribbean. He assured everyone of veterinary services support and felt confident that the programme that had been arranged would prove stimulating and rewarding.

Tick Identification

Dr. Robert Strickland, Head, Parasitology Department, NVSL, Ames, Iowa led off on Tick Identification with a comprehensive slide presentation. He illustrated the typical ixodid tick with Amblyomma hebraeum, the vector of Heartwater in Southern Africa and reminded that it had been found on imported rhinoceros in Southern Texas recently. He described the scutum, mouth parts, position of eyes which were either present or absent. From the dorsum - the festoons on the posterior margin of the tick, the basis capituli and the hypostome. From the ventral side - the four pairs of legs, the anus, the anal groove and genital aperture.

In the male, the scutum covered nearly all the body. He compared the basis capituli of the main species of ixodiae viz. Boophilus, Dermacentor, Amblyomma, Haemaphysalis, ixodes. In the Argasidae there were some 150 species. Argas mimeatis was found in Puerto Rico, with capitulum beneath the body. Amblyomma americanum was described with ornate scutum and long mouth parts. The female with ventral coxal spurs, the male with isolated marks on the scutum.

Amblyomma cajennense was not known to be in Puerto Rico. Males and females were beautiful ticks found in Southern Texas, Central America and certain Caribbean Countries. He reviewed certain features of important ticks based on keys for separation of species. Amblyomma sp., the Bont ticks were brightly coloured e.g., Amblyomma gemma, Amblyomma hebraeum - festoons were ornamented, Amblyomma lepidum - stripes in ornamentation of festoons, Amblyomma maculatum - the Gulf Coast Tick, had a striped scutum with spurs on the metatarsus of each leg.

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Amblyomma pomposum, Amblyomma variegatum - in the Eastern Caribbean more than 100 years ago, imported from Senegal - eradicated from St. Croix - found in Puerto Rico in 1974. Produces a severe wound due to extremely long mouth parts - males with banded scutum.

Boophilus sp.

- B. annulatus - spurs on coxae I and II

- B. microplus - caudal process on male
  - hypostome long with six-sided basis capituli

- B. decoloratus was also described

- Dermacentor nitens - a tick nearly like Boophilus with a long hypostome - male had a sporacula plate - known as the "telephone dial" tick due to the arrangement of goblets present; female - an inornate tick with rectangular base capituli.

- D. variabilis - had large spurs - increase in size of coxae from front to rear. (The cause of tick paralysis and Rocky Mountain Spotted Fever).

Haemaphysalis species were eyeless with a candelabra shape of the capitulum.

Hyalomma species or "Bont legged" ticks had well developed ad-anal shields. These long-legged ixodes species were considered primitive. Cause of lime disease in Connecticut - transmission of Borrelia sp.- also transmitted Piroplasmosis and Human Babesiosis in Europe - had anal groove circles in front.

Ornithodoros puertoricensis - found on small rodents, pigs - of importance because of African Swine Fever - was pebble grained.

Other soft ticks - spinose ear tick was a banjo shaped tick with spines on the integument.

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Rhipicephalus appendiculatus - found on the East Coast of Africa. Rather like R. sanguineus - six-sided basis capituli with short palps - flat eyes as opposed to beaded eyes of other R. species.

R. evertsi - pig skin type scutum - saffron coloured legs.

40-50 species of Rhipicephalus. R. sanguineus considered very host specific.

Amblyomma variegatum - very large tick - male was beautifully ornate moreso than female. Hypostome very long causing tremendous wounds.

A. dissimilis - on iguanas. A. cruziferum - on birds. Nymphal stage of A. variegatum less ornamented than male - inornate with beaded eyes present and long mouth parts.

Boophilus - male - caudal tail - mouth palps were short - relatively long hypostome.

Dermacentor nitens - found especially in ears, on manes of horses - prefers horses but will get on cattle - "Telephone" dial sporacula plates - hypostome short in relation to palps - legs relatively thickened as opposed to those of Boophilus species.

Argas mimeatis - causes paralysis in poultry - usually hides in fowl houses - feeds for a few hours at night.

(Pictoral key to Genera of Adult Ticks in USA - Annex I.)

Tick Biology-Ecology:

Dr. Glen Garris, Research Entomologist, ARS, after a short introduction, concentrated on ticks found in the Caribbean.

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B. microplus was the most abundant. Cluster type arrangement noticed during feeding - pheromones produced aggregating males and females. Male feeds for short time then seeks female through complicated sequence of events. Considered future research possibility for control and precedes female engorgement.

In Puerto Rico females will attach and drop off host without mating. This was an unusual event as in the laboratory other species will not attach without the presence of the male. They exhibited instinctive behaviour patterns.

About 65% of B. microplus ticks will drop off host before 2.00 in the afternoons usually while the cow was feeding near cover, which is believed to provide optimal survival conditions for the tick. Too much water or moisture led to fungal disease and death. The ticks produced a waxy material covering for their eggs and this reduced desiccation.

Amblyomma cajennense, found in Jamaica and Trinidad & Tobago, could be found on many hosts - horses, cattle, goats, sheep, etc. A reference had confirmed that it could be a threat to tourist industries.

Amblyomma variegatum - three host tropical bont tick: Garris and Barré reported work in Guadeloupe on possible hosts. They examined Rattus rattus, Rattus norweigicus, the house mouse, mongoose and other species. Out of 104 mongooses examined 56 were positive; out of 46 birds (Cackles) examined 21 were positive and out of 79 cattle egrets examined 21 were positive. They noted a species of racoon in the rain forest area of Guadeloupe which might be a host.

In St. Kitts, there were deer and monkeys.

In Puerto Rico, 13 dogs had been examined and no Amblyomma variegatum were found. This information was not in agreement with previous data. One mongoose had been found infected out of 64 examined.

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In Guadeloupe, the goat acted as the primary host. Larvae were found on the head and neck while the nymph was found in the escutcheon area and the adult on the feet, under the armpits and legs.

He noted that there were limited varieties of small mammals. These hosts could be examined by parting the hair and washing in the laboratory. Chickens and goats harboured larvae and nymphs. Cattle egrets could move ticks around. A. variegatum had different sites on different hosts and this was associated with seasonal variation.

In Puerto Rico, collections had been made every month. Adults appeared before the dry season.

He described the life cycle of A. variegatum based on work done in Puerto Rico and reviewed results of ecological studies done in Guadeloupe which showed that shade was best for survival but excess moisture was detrimental to larvae.

He described B. microplus and its life cycle, its preferred hosts, habitat and predators.

In describing the life cycle of Dermacentor nitens, he observed that it was only found in the Western Hemisphere even though the horse is an old world animal. It was believed that D. nitens was adapted from some related species e.g., tapir to the horse.

The life cycle of Rhipicephalus sanguineus was described. In Puerto Rico, its host specificity for dogs was underlined, rats being the other occasional host. With the exception of the adults, nymphs and larvae would climb up the rafters and they survived in cracks and crevices. (See Annex II).

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Tick Borne Diseases

This topic was covered by Dr. Robert Strickland.

He reviewed Heartwater caused by Cowdria ruminantium and transmitted by the Amblyomma species to ruminants. Cattle, sheep, goats, buffalo, antelope, white tailed deer were susceptible. Heartwater is so called because of the fluid found in the pericardial sac on post mortem. Peracute condition is characterized by sudden death; acute condition by 1-9 days with diphasic fever, CNS signs and pulmonary involvement; subacute by chronic and mild subclinical forms. Heartwater was underreported with no serological test and no vaccine. Treatment was feasible early in the disease. Wild-life reservoirs existed with multi vectors; there were subclinical manifestations and diagnosis of the vectors had to be considered.

Distribution: Heartwater was previously noted inSub-Saharan Africa including Madagascar, Iran and Saudi Arabia.

1830 - First described in South African sheep

1898 - Transmissibility demonstrated

1900 - A. hebraeum established as vector

1925 - Described by Ed Cowdry

1980 - Confirmed in Guadeloupe

The threat of Heartwater is based on:

- non-immune susceptible ruminant populations in the Western Hemisphere
- indigenous vectors e.g., Amblyomma maculatum
- presence of white-tailed deer and other small mammals
- redistribution of agent and vector through increased movement within the Caribbean

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- zoological specimen importation
- favourable ecological setting for A. variegatum
- symptoms of disease unfamiliar to the region

Control and Prevention:

- Vectors: use of acaricides and biological measures
- Host: infect and treat especially for pure bred cattle; chemotherapy, tick dipping and early calfhood resistance.

No vaccine was available and eradication was improbable in very large areas.

Diagnosis was based on clinical signs and herd history assessment. Definitive diagnosis depended on demonstration of Cowdria ruminantium from Giemsa stained brain smears or animal subinoculation. Serological test was in developmental stage and the IFA test at Plum Island was experiencing difficulty in developing a standard antigen. Differential diagnosis included etanus, Cerebral Babesiosis, Rabies and Ngana.

Clinical signs were a temperature of 40-41.5 °C - diphasic with diarrhoea, cough, bronchial râles; CNS - stiff staggering gait, circling, chewing, eyelid twitching, tongue protrusion, tremors, rage, convulsions and death.

Post mortem findings were Hydropericardium, Hydrothorax, Ascites, Pulmonary oedema, haemorrhages in the heart, lungs, GI tract, abomasal hyperaemia, froth in trachea and nostrils. Brain, jugular vein or heart used for demonstration of C. ruminantium colonies in endothelial cells.

With regards to Amblyomma ticks as vectors, a single tick can be effective with a 15 month viability. The species lay a large amount of eggs, up to 20,000 with low tick populations infectivity retained through adaptability and wild life reservoirs. Transmission was transtadial only. Rickettsiae

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replicated in intestinal tract, regurgitated by the tick and transmitted to the ruminant. 9 species of Amblyomma were incriminated including two experimental vectors - A. maculatum and A. cajennense. The pathogenesis in the host is not completely understood.

Babesiosis is caused by Babesia bigemina and B. bovis, both found in Puerto Rico. Blood placed in splenectomized calves resulted in the overgrowth of B. bigemina by B. bovis at Ames NVDL.

B. caballi was a large specie seen in horses and mainly transmitted by D. nitens. Larger babesia organisms tended to be easier to treat. B. equi, with typical Maltese cross-form was more difficult. Some doubt still remains as to tick vectors of B. equi, Dermacentor, Rhipicephalus, Hyalomma species and possibly Boophilus.

Anaplasmosis was well known and the handout refers. (Annex III).

East Coast Fever was caused by the Theileria parva species, vectors being ticks of the genus Rhipicephalus, namely R. appendiculatus. Pulmonary clinical signs with swollen lymph glands. Biopsy showed T. parva in lymphoid cells. This disease is still confined to Africa.

Dermatophilosis is caused through transmission of Dermatophilus congolense by Amblyomma variegatum.

He reviewed the 7 essential needs for an eradication programme:

1. Scientific knowledge - Tropical Bont Tick
2. Support of livestock industry - Publicity
3. Legal and Political Support - Laws & Regulations
4. Comprehensive Health Infrastructure - Laboratories
5. Long term commitment
6. Prevention of reintroduction
7. Team effort and good management

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Unfortunately, Dr. John George had been unable to attend, so Dr. Garris dealt with Tick Control and Eradication Procedures and Acaricide Resistance. (Annex IV and V).

He reiterated the 7 essential points for an eradication programme. He stressed several points:

Epidemiological considerations in respect of tick species must be looked into. Enzootic stability, he reminded, occurs when tick populations are in sufficient number to inoculate new-born calves.

Constant monitoring was required to control acaricide resistance. Legal and political support were essential.

The programme should start with a detailed farm to farm survey. Once a farm was found to be infested, quarantine restrictions were to be applied and movement controlled.

Treatment schedules with acaricides had to be established. In Puerto Rico, using organo-phosphates, these had been two weeks for B. microplus and one week for A. variegatum. Treatments varied according to species, biology and ecology of ticks. The discipline required strict adherence to the period of tick treatment with punctual applications.

Surveillance of adjacent herds and those under treatment had to be carried out. In Puerto Rico, treatment and surveillance by two teams were established. These two teams were interchangeable. Good strategy was starting in one area and then spreading out. This provided opportunity to iron out snags in procedures and provided a limited area for farmers to observe as a demonstration unit.

Animals in quarantine areas were only allowed to move after being freed from ticks or sprayed or moved wet. Problem situations would arise and be handled as teams saw fit. In Puerto Rico, Treatment schedules varied from

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6-18 months every 14 days. The next six months were used for surveillance and scrutiny. Bird migration and pastures being grazed came under consideration. A decision is then taken whether quarantine could be lifted. If areas are declared free, these must then be protected adequately.

He reviewed itemized costs for Puerto Rican Treatment and Surveillance Teams including maintenance and depreciation costs for equipment and vehicles.

Strategy for control programme: It must be cost effective, involving the use of tick resistant breeds, pasture spelling and strategic dipping. The information could be extrapolated but is somehow never exactly the same from one country to another. He suggested the need for an epidemiological study.

Pasture spelling could mean a 60 day return cycle following treatment of animals. He reviewed factors involved from larvae on pasture to parasitic stages on the host - dependence on the host finding the larvae, the host resistance, the seasonal stress and the competitive environmental factors. He considered the status of education of the extension personnel and the local producers.

Acaricide effectiveness depended on the complete covering of the animal with spray or dip following proper mixing at optimal level for effective control. Rainfall and access to ponds or streams shortly after spraying had to be observed. Tick resistant cattle was based on establishing Brahman qualities through cross-breeding.

Acaricide resistance: Dr. Garris noted a great increase in the number of resistant tick species in the last 20 years. Factors were:

1. Build up in tick numbers due to ecoclimate.
2. Mistaken identification of tick species leading to an improper programme.
3. Improper application of acaricide.

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If resistance is in population, he advocated:

a. Detailed investigation into pesticide application, noting correct dilution, mixing, concentration, application, method and coverage of animal.

b. Running a field test at labelled concentration on a selected group of animals, counting ticks expected to drop off in 3 days. Counting the same area designated on each animal after three days and 7 days should indicate effectiveness.

True resistance determination required laboratory trained personnel. In vitro methods involved larval or adult ticks, larval or nymphal ticks by immersion techniques, filter paper impregnation or pasteur pipette application. WHO standards were also in effect. Interpretation was based on LC 50, LD 50 and comparison of values. He referred to the work of Dr. Sam Rawlins in Jamaica, who concluded that some populations were more tolerant of higher concentrations than recommended.

He discussed his experiences of resistance in Puerto Rico and Guadeloupe. Different methods might lead to different results as he had shown in Puerto Rico using Pasteur pipette technique on nymphs of A. variegatum strain reported resistant to Coumaphos (Co-Ral) and he demonstrated full susceptibility. An age effect with toxaphene had been demonstrated in Guadeloupe. Less insecticide was needed to kill older ticks than was needed to kill nymphs.

Residue tests were considered. Bercotox (Dioxathion) required a post treatment period of 3 weeks in beef cattle and a recommendation not to be used in milking cows. Amitraz (TAC-TIC) gave no residues in milk and residues were very low in beef. A nominal one day waiting period which also applied to sheep and goats was advocated.

Cross resistance was a phenomenon also noted. Gamma Benzene Hexachloride with toxaphene; DDT with pyrethrins; Carbonyl with organophosphates.

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After 12 years of use in Australia, Amitraz (TAC-TIC) had been reported in three herds only, as associated with suspected resistance. It was very effective against Sarcoptic Mange in pigs and dogs and Demodectic Mange in dogs. Small dogs might experience some toxic problems. Its use in horses was contra-indicated. It caused antiperistalsis leading to impaction Colic in horses. Atroban, a synthetic pyrethrin, was used in horses. It is not a cholinesterase inhibitor.

Amitraz was seen to clean animals in 24 hours with rapid detachment and produce non-viable eggs from engorged females, in comparison with organo-phosphates in which a small percentage of engorged females will hatch.

After a question and answer period, the meeting concluded for the day.

On the morning of the second day, Mr. Bill Rodgers, USDA Specialist technician made his presentation on Dip Vat Management.

He stressed that whatever the compounds, certain basic principles always applied. The capacity of the tank was equal to Length X Width X Depth. Length was obtained by finding the average measurement of the level of the water-line at the top and at the bottom of the tank. The width was obtained in the same manner. Depth was measured from the height of the water-line.

The volume of a Dip Vat is calculated as 231 cu. ins. to a gallon.

In scabies control, the following dilutions were used:

- Toxaphene - 3 quarts per 100 gallons of water
- Asuntol (Co-Ral) - 10 pounds per 100 gallons of water
- TAC-TIC - 5½ pounds per 100 gallons of water

He emphasized the need for proper mixing of the concentrate in the Dipping Vat. Premixing will often reduce these problems.

Vat agitation could be achieved by:

1. Compressed air)
2. Agitation can) At least 30 minutes required.
3. Paddle board)
4. Permanent air installation

The vat should not be replenished to more than seven eighths of the capacity level. Replenishment methods were:

1. Constant replenishment
2. Replenishment tank at or near vat
3. Replenishment directly into vat
4. Always pre-mix pesticides

A constant operation was provided where mixed material keeps running into the vat or spray dip machine without stopping the dipping operation.

Recharging dips with emulsifiable compounds will require more of the compound than when the vat was charged.

Samples should be taken for the purpose of law suit requirements in case something goes wrong. Records need to be kept on the name of the chemical compound and concentrations used. Samples should be taken from the centre of a well agitated vat. Air space should be left in the sample bottles which could be properly labelled plastic or glass bottles. Samples should be mailed promptly.

Records should be kept especially for litigation. USDA uses the VS Form 514 which requires information on the location of the vat, name of the chemical used, lot number, vat capacity, volume charged, date initially charged, replenishment data, species of animals and number of animals used. (See Annex VI).

Vats should be charged according to the VS Memorandum as follows:

1. When vat becomes too foul for use
2. When two animals per gallon of initial charge have been dipped
3. When sediment level reaches 10% (Sludge level determined with glass cylinders)
4. When vat has been charged for 120 days

The following is a check list for vat recharging:

- Check for leakage
- Read labels on pesticide
- Use safety equipment
- Always have clean water available

Vat management is most important especially in eradication programmes. It avoids killing animals, developing resistance and toxic factors.

A spray dip machine costing approximately US$17000.00 was described. Spray nozzles should be checked before use. In hand-spraying, droplet size is more important than pressure. A portable dipping vat, a Little Dipper with the use of a nurse tank, was described. Stress should be avoided before dipping. Water should be offered before and cows and calves should be separated in order to avoid losses.

It was pointed out that Pesticide Safety and Disposal was governed by Laws under the US Environment Protection Agency. Federal regulations and State regulations may differ and change from time to time. It may be difficult to keep up with them.

Land fills should be avoided to prevent deaths of animals or humans.

Regarding disposal, the best measure is not to have any left over. Containers should be rinsed three times before being destroyed and disposed of in approved land fills.

He reviewed his experience with 48 dipping vats along the US/Mexico borders which were all fenced and had warning posters and signs.

Filters were used to prevent sludge problems. If sludge was more than 10% acaricide use should be avoided. Sedimentation tanks were best used when dipping was in progress. (See Annex VII).

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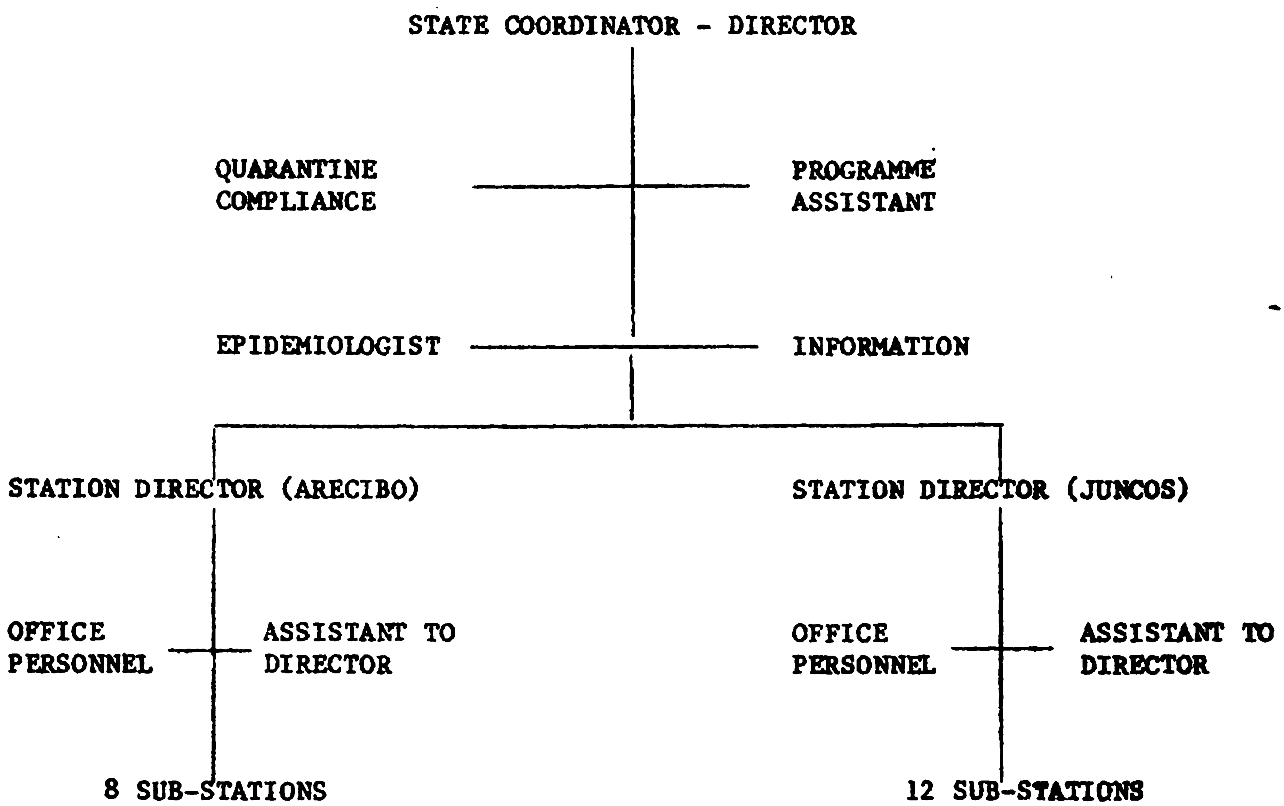
The Puerto Rico Tick Eradication Campaign was introduced by Dr. Thomas Holt, Area Veterinarian in Charge, Puerto Rico and USVI, USDA - APHIS-VS. He stated that it was a large programme with proposed costing over 11 million dollars/year and over 700 employees. Dr. Charles Suthern made the presentation on its Organisation.



Puerto Rico has been divided into 5 zones, virtually one for each year. A programme has been established to combat three tick species - B. microplus, A. variegatum and D. nitens. All livestock in an area are treated and this is no longer done by just recognising ticks on farms and quarantining.

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Tick ecology and biology studies are required because of the North vs South ecoclimates. A. variegatum is distributed in the drier South.

Industry support is obtained through the Tick Advisory Committee backed by Puerto Rican legislative.

Legal support and sufficient manpower are in place.

Administrative procedures include policies for hiring and firing, duties and responsibilities of personnel, record keeping and a training programme for employees and herd owners.

There is an orientation and training period for all inspectors, lasting several weeks. This includes public cooperation with industry and information to the public. No cost/benefit ratio is calculated in Puerto Rico but it is 1:40 in the US Mainland.

- Started with CO-RAL (Asuntol) - used in beef cattle and CIO-RID - used in dairy cattle. These presented a toxic problem especially to employees since they lowered blood cholinesterase levels.
- TAC-TIC (Amitraz) - general use except for horses.
- Atroban - synthetic pyrethroid - used for horses and sheep but very expensive.
- Stray Animal Detention Centres used.
- Previous campaign carried out in 1946-1952.
- Puerto Rico declared free in 1954.
- Estimated economic losses:
  - 50 ticks - loss of 185 L milk/year and 80 lb/head/year.

- Quarantine effected through Laws 106-60.
- Stray animal problem - animal confined - owner charged for pick-up, feed, etc. - animal auctioned if not claimed.
- Goals set for 1986 - 10,000 more herds to be tick free
- Control of hay and feed from outside quarantine areas.

The funds for the campaign are provided by the Food & Nutrition Service of USDA (PAN) - APHIS VS Legislated Funds from Puerto Rico (RC). (See Annex VIII).

Dr. Carmelo Gonzalez, Director, Arecibo, dealt with Eradication Procedures. His approach was based on the seven basic principles and how the procedures measured up to them.

1. Scientific knowledge: the Tropical Bont Tick had been found in the Centre and South of the Island. Its distribution was established by Dr. Garris in 1980. Information on Boophilus was available from files of the previous eradication campaign. Boophilus was distributed throughout the island.

2. Support of the Livestock Industry: The Amblyomma Survey Area had revealed about 2000 head. A record of 225 animals had died from Dermatophilosis. Control of Dermatophilosis was based on antibiotics plus CO-RAL applications. Nevertheless, he felt the Livestock Industry did not feel threatened and the clout of people in the affected area was limited.

   A survey in 1978 showed that B. microplus had spread throughout the North-Central part of the island. The industry had begun organizing and the politicians were responding to pressure. In 1981, Programme Management decided to divert funds to Amblyomma variegatum eradication. By this time, A. variegatum had spread to South West to Ponce and Vieques as well as original CIDRA area near Juncos.

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Under old laws, violators were exposed to small fines. Now, much harsher penalties viz. $10.00 to $100.00 are meted out. Movements of animals are controlled and are only allowed for slaughtering. He considered that legal support was very good and quarantine lines were clearly specified.

3. Infrastructure: The Campaign could only rely on Veterinary Labotatories at Ames, Plum Island and the Tick Laboratory at Mayaguez.

He noted that A. variegatum areas had been treated every two weeks for eighteen months followed by six months surveillance. He believed the areas had been free by the end of 1984. There was a seasonal build-up usually in May, but no more were seen for the rest of the year. A few months previously, a non-engorged female and two males had been discovered in Ponce. Five herds in Rojas and five in Ponce were still under treatment for A. variegatum and the remainder under surveillance.

Regarding B. microplus, a budget of 11 million dollars had been prepared for 1986. Two fronts exist - the North West and the East. Some reinfestation had taken place and it was most important to prevent this. He attributed this to animal movement through cattle dealers who move all around the island.

Inspectors visit farms for scratching ticks and issue permits if movement is allowed. Back-tag plus a yellow mark signifies permission for movement and a red cross mark signifies the opposite.

Animals requiring compulsory movement, e.g., dry cows to dairy barns, are sprayed and the animals examined before and after. Along quarantine lines, treatment stations have been established and scratching takes place with a similar system as above.

Patrols have been developed for 24 hours along quarantine lines, 7 days per week. Before this, dealers would move cattle at night or when they knew patrols were not present. The personnel wear uniforms,

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travel in identified vehicles and look for vehicles moving animals. If there is a breach of movement, the individuals are advised to return to the treatment centres. Laws are now being revised to increase fines from $100.00 to $1000.00.

Inspectors check counts of animals. The Programme Management Team meets every Tuesday in San Juan to discuss field problems, look for solutions, approve team decisions and develop programme policy.

He noted that treatment started in 1979 and up to 1983, 0.25% Coumaphos was used. After 1983 treatment was carried out with 0.025% Amitraz solution.

He advised that training was being given in Farmer Communication, Scratching Techniques, Safety Measures, Tick Identification.

Mr. Julio De Jesus, Director, Juncos Station, Eastern Zone, described his area of responsibility which comprised some 100,000 animals in 6000 herds. Some of the equipment used was from the St. Croix Campaign in 1968.

He introduced Mr. Antonio Perez whom he considered an outstanding team operator, to describe the equipment used in the programme. He made his presentation on protective clothing - yellow cabs with masks, filters, goggles, gloves - which was very important even though it was very hot in the Tropics.

The Spray Dip machine was illustrated. The pesticide was mixed in a John Bean Sprayer then passed on to the Spray Dip Machine.

A 25 gallon steel tank with Atroban was kept on hand for spraying horses and sheep. This was usually kept in a Pick-up.

Back Pack Sprayers were used for single to few animals on high mountain areas.

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He emphasised the need for highly trained personnel to avoid accidents and to obtain speed. Once trained, he had not encountered many problems in the field.

Mr. Luis Rivera, Assistant Director, Santurce, described the Radio-Communication System. Three repeaters had been installed on peaks in the North East at Yunque, Central South at La Santa and Central West at Indiera. Two stations existed in each quarantine area and each patrol vehicle on the quarantine line had a two-way radio. Each radio cost about $408.00.

Dr. Reed Rollo, Veterinary Epidemiologist, APHIS-VS, spoke on pesticide use and its effectiveness. He explained the strategy of treating hosts with pesticides at specified times, the treatment interval determined to avoid adult females from laying eggs and for specified periods for premises to have larvae and nymphs die off. He dealt with properties of pesticides, their efficacy considering subsequent infestation levels on treated animals and no new larvae produced in treatment zones. Trials involved counts of number of ticks on treated and non-treated animals and replete females producing non-viable eggs. He advised of a protective covering which developed with the moulting nymph.

Toxicity was concerned with the host, programme personnel and wild life. Chemical irritation, allergy, systemic toxicity were usual manifestations. It depended upon the formulation of the pesticide being used and method of infusion, whether breathed, drunk, absorbed and in relation to time.

Consideration had to be taken on withdrawal times for slaughter and for milk use.

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Dra. Ivonne Borras supported the presentation on pesticides. CIO-RID, organophosphate was supplied in 5 gallon cans as emulsifiable concentrate containing 14.5% of Ciodrin. One part to twenty eight parts water yielded 0.47%. Later, 1 gallon Ciodrin was used in 38 gallons of water, therefore, the 5 gallon can could be used in 190 gallons of water.

It controlled other ectoparasites as well but could not be used on Brahman cattle because of its toxicity. It was found to be lighter than water and so was not recommended for dipping vats. It creamed to the surface and increased toxicity to the first batch of cattle. It led to dyspnoea, incoordination, collapse and death. Diarrhoea and tremors were noted. Atropine Sulphate was the antidote.

Disadvantages included expense and toxicity. Employees had to be bled every month and replaced from time to time.

Residues in Milk:

	12 Hours	1 Day	3 Days	7 Days
Coumaphos	0.03	0.02	0.01	0.01
Ciodrin	0.007	0.004	0.001	-

Atroban was selected because of the toxicity of Amitraz to horses. It was also used for sheep which had not been included in the original trials. It was a synthetic pyrethroid - Permethrin presently being used at dilution 1:800 yielding 0.053% or 1 pint in 100 gallons of water. It was a broad spectrum pesticide effective against flies, lice and multi-host ticks. It was an eye irritant but this was minimal at the dilution being used. It was developed by Wellcome Research Laboratories. Its efficacy included Amblyomma and Dermacentor but was very expensive. Residues were minimal at 0.005 and were extensively metabolised. The product was stable in water for months and so was used in dipping vats.

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Dr. Reed Rollo continued with discussions on Amitraz. This had been developed since the '70's and had been used in Australia for over 12 years. The present formulation used produced an 0.025% emulsifiable concentration with xylene, 760 ml in 100 gallons of water. Effectivity included all ticks at all stages including moults. It was biodegradable, spread all over the skin when applied and had good residual action.

Regarding toxicity, Amitraz was rapidly excreted. No specific target organ was noted. CNS depression with death due to respiratory failure resulted. It is used in dogs for demodectic mange. Two chihuahuas had died. Acute toxicity is usually followed by complete recovery with sedation and bradycardia noted. LD 50 at 100 mg /kg.

There was no eye irritation in rabbits. Laboratory studies had not revealed any immunogenic, teratogenic or carcinogenic effects.

Used in field trials, with water to 15 X concentration, hair loss was reported without blood chemistry changes and all animals recovered. 11 L of 40 X concentration resulted in severe CNS depression but total recovery. Treatment at weekly intervals for 10 months at twice the recommended dose had revealed no problems. Apart from horses in which it produced Colic, it was also toxic for fish.

After 12 years' use in Australia, 3 herds had reported increased levels required for kill. Stability was good. It broke down with manure but Calcium Hydroxide will overcome.

Crystallization refers to US formulation when spraying wettable powder with 2-3 μ in size and xylene evaporated off. It was highly stable at pH 12.0 plus Calcium Hydroxide. Used against Boophilus sp., there was 94% detachment after 8 hours, 100% kill after 48 hours and 97% control after 21 days.

Results from Davis: there was 100% detachment after 6 hours. Females collected after 20 days suffered 98% reduction in index of reproduction, > 99% control or > 100% loss of egg viability plus residual effect from 7-10 days.

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There is need for definitive answers following rain or spraying wet animals.

Dr. Francisco Zayas, State Veterinarian in Charge, discussed administrative matters. Personnel would increase from 620 to 825 in the near future. He advised that there should be no system for overtime or time back. He recognized that bad habits are contagious. When problems arose in the field, one should go out and see.

Laws should be kept as simple as possible. Be forceful right from the beginning, he advocated, and lower the boom from the start. There was a need for fines to be raised e.g., $100 to $500 and $250 to $1000. Legal proceedings took time, often one year or more. Time meant money and if they caused loss of time to the farmer, they would soon comply. Compliance was best had by talking to owners and establishing good relationships.

Mistakes should be recognised and changed immediately. For example, there was no need for three people in trucks with John Bean Sprayer, especially with smaller herds. Two were sufficient.

Pesticide use invariably had problems. They were dealing with 100,000 cattle every year. There was susceptibility to Anaplasmosis and Babesiosis and Inhalation Pneumonia in horses. Administrative procedures must be set in place - if the animal was killed, then payment must be made.

Equipment should be practical. Dip Tanks were expensive. There was the problem of pesticide residues in dealing with the Environment Protection Agency. They were thinking of going back to Dips but those that were more cheaply built.

Vehicle control was important. Good inventories should be kept and checks should be made on thefts. Epidemiology studies were important especially when dealing with reinfestation, now running between 15 and 20%. Reasons, often not singular, should be found e.g., wild goats, hogs, security breakdown and cattle dealers.

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Mr. Julio Llinas, Livestock Extension Specialist, explained the importance of Information and Communications upon which the success of the programme largely depended. He reminded that it could be achieved by 7 agents taking 100% of their time or as much as 45 agents taking 50% of their time. A devoted communications and information team was invaluable. He reviewed the subject matter which had to be undertaken at farmers' meetings, well before the teams visited. This included training and demonstration for personnel, control of stray animals, spraying methods, detriment of poor facilities and construction.

He endorsed the use of all media - Radio, Television etc. He reminded that the use of all publications required previous approval and the benefit of using all personnel as informed liaison between the farmers and the Programme Director.

Each presentation was followed by a question and answer period. The experience of the speakers in Campaign Management and Practices was warmly appreciated. The arrangements for field visits were explained as the meeting ended on the second day.

Field visits from the Arecibo Station were undertaken by all visiting veterinarians. Transport left the hotel at 05:00 hours and after breakfast en route, the party was taken to see the portable swim vat (Little Dipper), where it had been installed to establish a new treatment centre. Coincidentally, the farmer's large herd adjoining, was under quarantine for Piroplasmosis and the control measures were discussed. The Campaign undertook regular pesticide applications as the only preventive therapy. Imidocarb is not cleared for use in bovines in the USA.

A large dairy operation was next visited where the spray dip machine and procedures for its operation were demonstrated. The animals on the farm were all tagged on both ears. Spraying followed milking. A continuous supply of replacement pesticide solution was in operation.

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The party then went to a model dairy demonstration farm where the Hydro Vat was being used. This was most impressive, power being supplied by a large generator. The facilities for animal control were noted. The use of a John Bean, 25 gallon spray tank from a Pick-up was demonstrated on calves as well as the use of a back pack sprayer. A visit to the Central Market followed, where a permanent dipping facility had recently been completed as part of the quarantine line's treatment centre. The dipping operation as well as scratching for ticks at this facility were demonstrated. The party returned to Arecibo for luncheon before visiting the Tick Eradication Campaign's control headquarters. Interest was shown in the Hydro Vat, Spray Dip Machines and vehicles on the premises. The return journey to Puerto Rico was completed without mishap at 5.00 pm.

The final day's session began with a presentation by Dr. Glen Garris on New Research in relation to Tick Control and Eradication Measures. He discussed the potential of the production of sterile males resulting from cross-breeding B. microplus and B. annulatus. The sterile male larvae produced have not been tested in the field as yet. It was estimated that it would take five generations to produce 100% sterility in males by this method.

The participants drew themselves into a circle and Dr. Thomas Holt, Area Veterinarian in Charge, led discussions on the situation and proposals for adoption by each country represented. It was interesting to hear reviews of the progress in Antigua, St. Kitts, Dominica and St. Lucia in respect of A. variegatum. The British Virgin Isalnds was not affected with A. variegatum but was interested in the measures to adopt against Boophilus species. The representatives from Jamaica, Trinidad & Tobago and Guyana were also interested in these measures as well as surveillance to guard against the entry of A. variegatum into their countries. Dr. Maitland, Barbados, felt that they were also in this category at the present time as specimens of A. variegatum had not been rediscovered. The Jamaican representative was concerned about the ability of the tick to burrow beneath the soil surface.

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The representative from Trinidad & To go felt that a brochure should be prepared to publicize awareness of Amblyomma variegatum, Heartwater and Dermatophilosis. The meeting gave support to the development of cost effective pesticide application trials proposed for Antigua with comparisons between Amitraz and Flumethrin.

Dr. Nisbett, St. Kitts, described the setting up of eleven (11) dipping vats on the island of 65 sq. miles. Each vat had a capacity of 2000 gallons and was made of reinforced concrete costing US$11,500 each. The vats were spaced so as to allow animals a maximum of 2 miles from each vat. The Project was supported by the British Development Division. The acaricide Ethion was being used. Topping up occurred using water meters with paddle boards and pumps for mixing. The service offered was a free one without registration. Recommendations included dipping at one to two week intervals. It was observed that farmers did not bring their cattle if no ticks were seen and some objected to sharing the dip with cattle infected with Dermatophilosis. This disease had been seen since 1977 when A. variegatum was appreciated on the island. Deer found were heavily infected with Boophilus microplus. No confirmation of Amblyomma species on this animal was made.

Dr. Wellsworth Christian explained measures which had confined the presence of A. variegatum to Bellevue Chopin, one small area of Dominica, and the efforts to eradicate it. He outlined proposals to ensure this.

Dr. Keith Scotland reviewed measures under an OAS sponsored project in St. Lucia in the Northern affected zone. Following the discovery of the tick in the South East portion of the island as well, activities were being conducted on both fronts. He explained the constraints with a voluntary programme but remarked on the success of reducing the incidence of Dermatophilosis.

At a brief closing ceremony, Dr. Alexander thanked the participants for their keen interest and their hosts for the time taken to demonstrate the

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operative procedures of their tick campaign. He indicated that the workshop would neither have been enjoyable nor successful without the excellent support provided by USDA/APHIS VS and ARS personnel.

Dr. Thomas Holt presented certificates of participation to 25 persons.

Dr. Wellsworth Christian of Dominica, seconded by Dr. K.S. Reddi from Grenada, proposed the following motion which was unanimously endorsed by spontaneous applause.

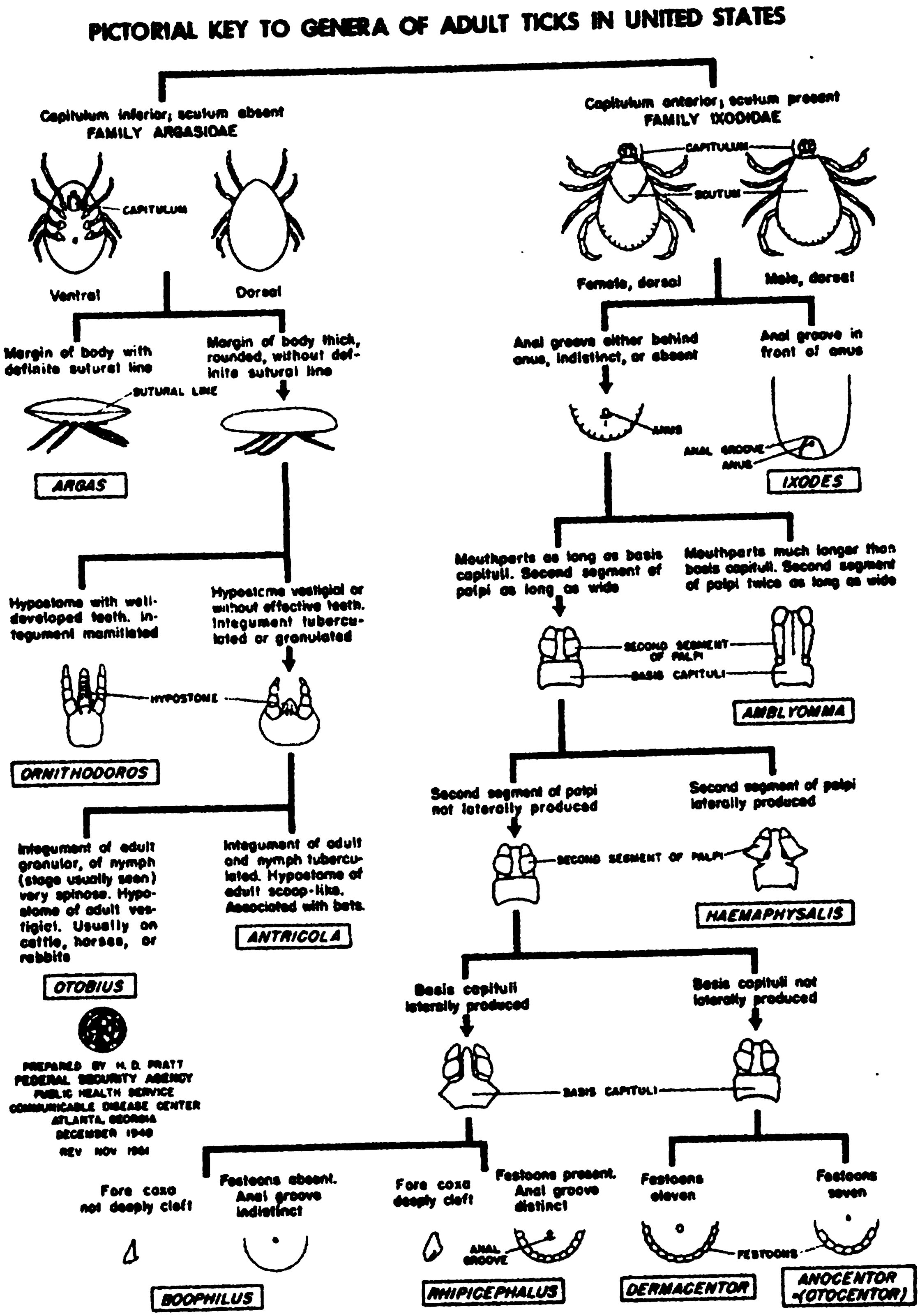
CONSIDERING

that a seminar/workshop on "Tick Eradication Measures" was held in Puerto Rico - September 3-6, 1985 sponsored by the Inter-American Institute for Cooperation on Agriculture (IICA)

that this seminar/workshop was hosted by the Commonwealth of Puerto Rico and the USDA - VS and AR Services, permitting the free exchange of information and sharing of their valuable experience

BE IT RESOLVED

that the participants wish to express their sincere gratitude to the Commonwealth of Puerto Rico and to the USDA for their full collaboration with IICA and their generous hospitality and extend to them their best wishes for complete success in their Tick Eradication Campaign.



--from Noble, E. R., and Noble, G. A., Parasitology, 4th edition, 1976, Lea and Febiger, publishers (Philadelphia), page 390. Courtesy of Federal Security Agency. Permission for photocopying granted by the publishers.

TICK BIOLOGY AND ECOLOGY

Glen I. Garris

Introduction

Ticks and tick-borne diseases are major problems limiting livestock production in most of the world. Lombardo (1975) states that 70% of the cattle in Central and South America are ranged in tick infested zones. Drummond (1981) estimates that there are about 11,300,000 cattle in the Caribbean area. Rawlins et al. (1983), from surveys in the Caribbean, found that most individuals associated with livestock production feel that ticks and tick-borne diseases are the number one problems limiting the industry. There are five species of hard ticks that are of economic importance to the livestock and pet industries in the Caribbean. These are: Boophilus microplus (Canestrini), Amblyomma variegatum (Fabricius), Amblyomma cajennense (Fabricius), Dermacentor nitens (= Anocentor nitens) Neumann, and Rhipicephalus sanguineus (Latreille). Of these, B. microplus is the most abundant, accounting for the majority of the infestations found on food animals throughout the Caribbean area.

General Life Cycles

There are four stages in the life cycle of the tick: the egg, the 6-legged larvae or seed ticks, the 8-legged nymphs, and the adults (both males and females). Transition from one stage to the next is made by one or more molts (shedding of the skin).

The life cycle of ticks can be separated into essentially two phases: the parasitic stages on a host and the nonparasitic stages that are free-living in the environment. The parasitic phase of hard ticks can be conveniently classified based on the number of hosts utilized as sources of food during the development from egg to adult. Hard ticks are often referred to as being 1-, 2-, or 3-host ticks.

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The 1-host tick spends its entire parasitic period, from young larvae to mature adults, on one animal (Fig. 1). Boophilus microplus is a 1-host tick.

The 2-host ticks attach to a host as larvae and remain on the host to complete development through to engorged nymphs which then drop from the first host to find a suitable place on the ground to molt. The unengorged adults then must find a second host to complete their development by attaching and feeding.

The 3-host tick utilizes a different host for each developmental stage. The larvae must find a host, feed, drop off, and molt in the environment; nymphs must find a second host and the adults must find a third (Fig. 2). Amblyomma variegatum (Fabricius) is a 3-host tick.

Ticks are obligatory parasites and require tissue fluids and blood for development and production of eggs. In feeding, most ticks attach to a preferred part of the host. Boophilus microplus favours the thin-skinned areas such as the escutcheon, scrotum in males and the region between the legs (Fig. 3). Dermacentor nitens prefers the ear, but in high populations attaches to other parts of the body. Other ticks, like A. variegatum, do not have a preferred feeding site on the host and may be found attached almost anywhere.

Ticks attach by cutting through the skin of the host with the digits of their chelicerae and anchoring themselves to the skin by inserting their hypostome into the wound. The speed at which the tick will feed depends on a number of factors such as skin temperature, skin thickness and mating (whether or not a female has been mated determines if, in most cases, she will continue feeding). Feeding in female ticks is usually a gradual process until the final day or so of feeding; then the body rapidly fills with blood.

Cuticle is expanded during the slow feeding process in order to make room for the large volume of blood that will eventually be taken into the tick.

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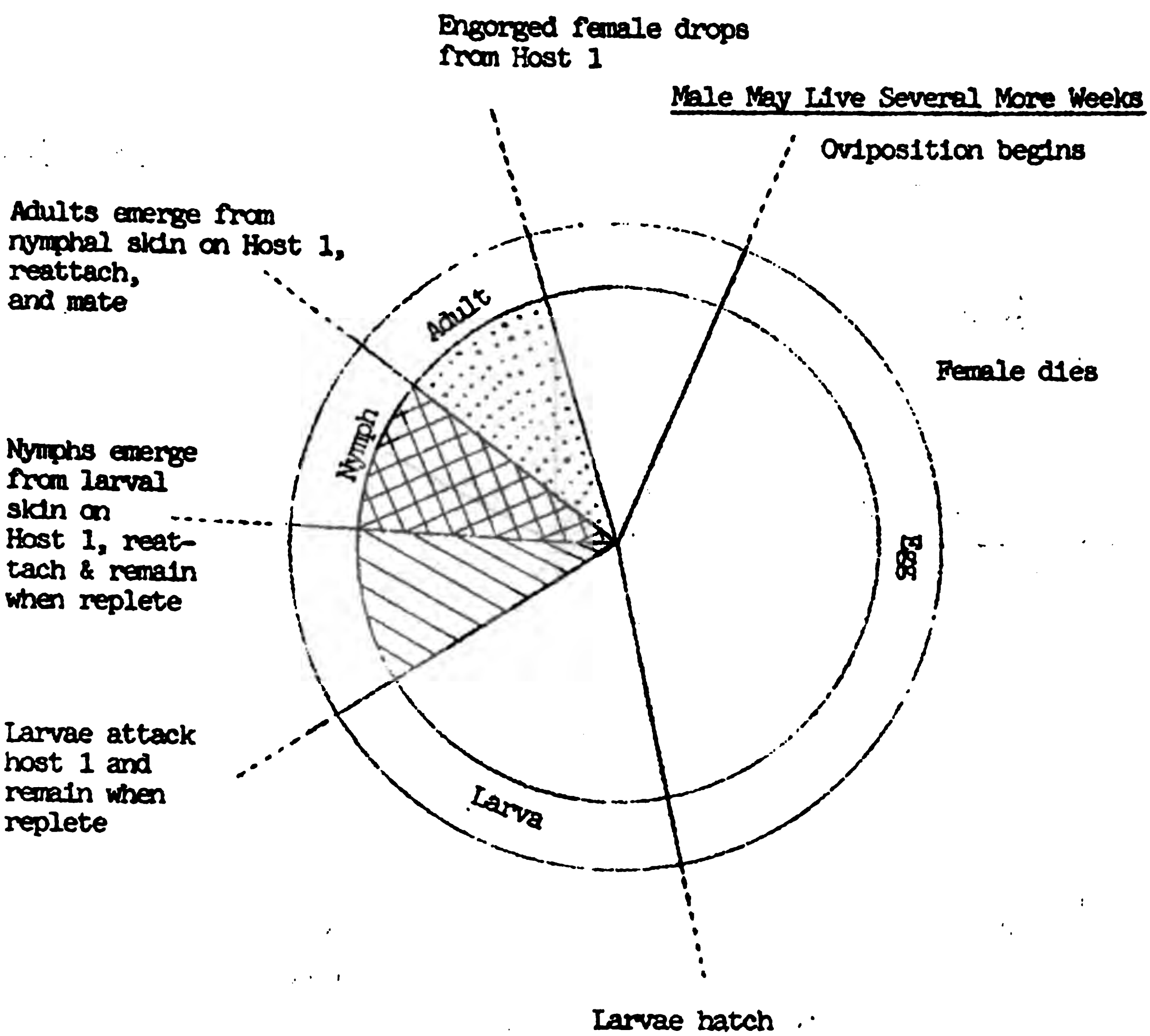

Figure 1. Schematic life cycle of a 1-host tick.

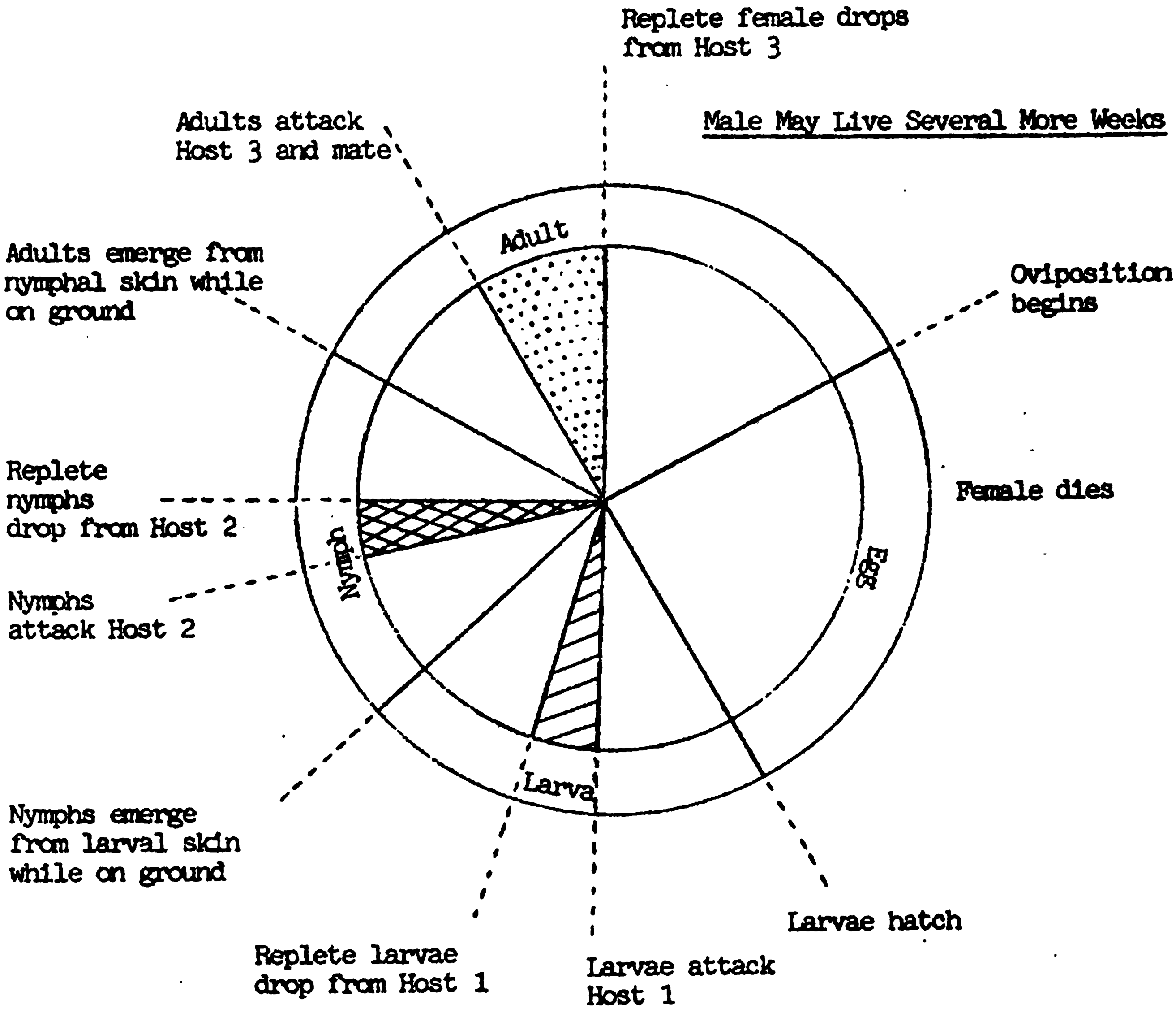

Figure 2. Schematic life cycle of a 3-host tick.

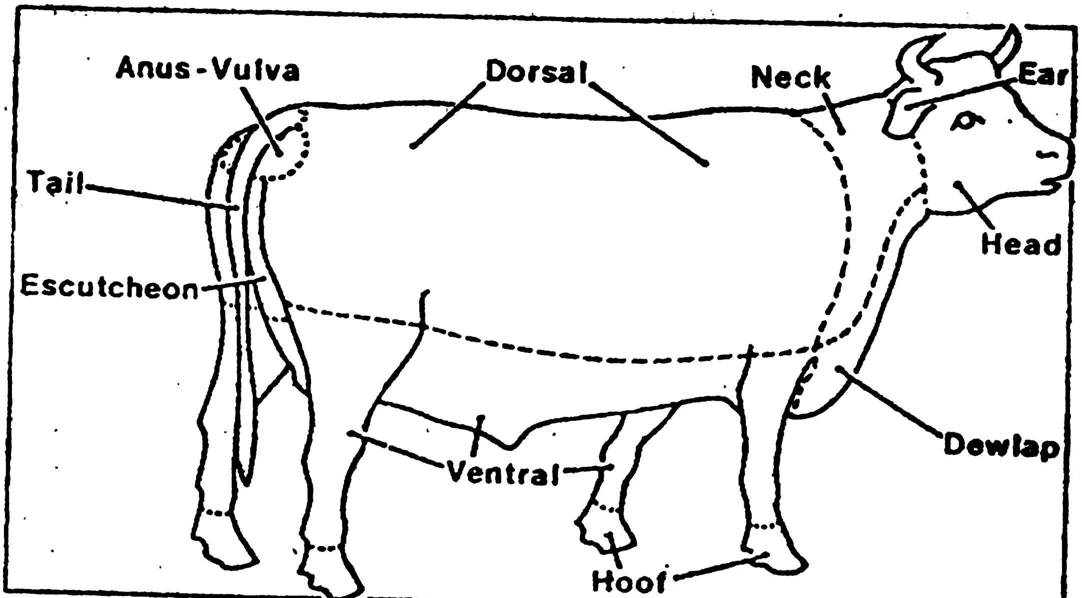

Fig. 3. Diagram showing the parts of a cow used in determining where ticks prefer to feed. For example, Boophilus microplus (Canestrini) prefer the thin-skinned areas such as the escutcheon and ventral areas while Dermacentor nitens (Neumann) will be found principally in the ears.

Hard tick larvae and nymphs usually feed for shorter periods than females. Male ticks become only slightly distended. They are intermittent feeders and may remain on the host for months during which time several small bloodmeals are taken. These bloodmeals are presumably used in the manufacture of sperm cells.

During attachment and feeding, salivary secretions from the tick are injected into the wound, apparently to aid in penetrating the hosts' skin and in preventing the clotting of blood and fluids so that they can be taken in by the tick. The salivary secretions may be very irritating to the host and may contain disease causing organisms. The depth to which the ticks' mouth parts penetrate varies considerably. The feeding process of penetrating the epidermis with the hypostome is a source of infection (i.e. dermatophilosis) and causes damage to the skin surface (an economic loss to the leather industry).

Larva: Following hatching, larvae usually remain clustered near the place of emergence; apparently a protective measure to prevent desiccation and aid survival. Most larvae do feed within a week of hatching. When they are ready to feed they are often found on vegetation and upon arrival of a suitable host, they become active and attempt to crawl onto the host animal. Larvae seem to be stimulated most strongly by CO_2 and odors, but many other factors may be involved in stimulation also. Having found a host, the larvae may attach immediately or may wander over the host's body surface in search of a preferred feeding site. The preferred feeding site may be specific or general and is dependent on the species of tick and many other factors.

Nymph: The activities and habits of nymphs are similar to those of larvae, except nymphs tend to live longer than larvae; their feeding period on a host is slightly longer also. In those species of one-host ticks that shed their skin on a host (B. microplus), molting takes place following larval engorgement and a short resting period. On the other hand, those three-host ticks that

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molt off the host may take two weeks or longer.

Adult: In those species that molt on the host (1-host), the adult female merely crawls from the nymphal skin and re-attaches at another site. The male sheds the nymphal skin, re-attaches and feeds for a short time, then seeks a mate. The mating process is completed on the animal and involves a complicated sequence of chemical and contact stimuli.

The behaviour of adults of those species that leave the host as nymphs to molt in the environment are similar to the larva and nymph that also molt off the host; however these unengorged adults may live for much longer periods of time than the immature stages without a bloodmeal.

Copulation of hard ticks usually occurs on the host; it generally precedes female engorgement and apparently influences the length of time needed to complete feeding. Female hard ticks may engorge and drop off the host within a few days of attachment or remain on the host for 30 days or longer. Apparently the females which remain attached for long periods fail to find mates. Males usually remain on the host much longer and thereby provide ready mates for virgin females. Again, the mating sequence is very complicated and is somewhat species specific.

After mating and engorgement, the female drops from the host and crawls to a protected place to lay her eggs. A waxy material is secreted on the eggs to protect them from dehydration and keep the eggs in an adherent mass. The female hard tick will engorge only once and will die shortly after she has completed the laying process.

The incubation period of the eggs for each species is different and can be quite variable in the length of time required to hatch. The incubation of the eggs may be from about two weeks to several months and is influenced by biotic and abiotic factors with temperature and other climatic factors being the most important.

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Ticks are rigidly bound by behavioural patterns; however, depending on the species involved, they have made adaptation that help insure survival. For example, 3-host ticks, unlike 1-host ticks that do not leave their host, must leave their host to shed their skin and, therefore, are subjected to higher risk of mortality in the environment than are 1-host ticks. To overcome this mortality, 3-host ticks are able to withstand long periods of time without feeding, their capacity to reproduce is enormous (with one female producing several thousands of eggs), and many have adapted to the wide range of hosts as sources of blood. In contrast, 1-host ticks have adapted themselves to molt on the host; thus, lowering the level of mortality from climate, etc. encountered off the host.

Ticks have also synchronized many of their activities with those of their host. For example, the drop off of ticks from a host is more controlled so that a majority of engorged ticks drop off the host at times during a 24-hour day that may coincide with the time when that host is at rest and, therefore, the ticks drop off in a more favorable site for tick survival. Ticks during the final phase of the feeding process rapidly engorge so that less time is spent on the host in the fully engorged state. The rapid engorgement during the final day of feeding may prevent crushing by the host itself or predation from birds.

Many species of ticks are able to survive for long periods of time without a bloodmeal. Nymphs usually live longer than larvae, and adults live longer than nymphs. Moisture is important in the longevity of ticks. The absence of adequate moisture results in death. Too much moisture also can lead to death, since it permits the growth of fungi which are often fatal.

The remaining comments will be made on the biology and ecology of the five major species of ticks of importance in the Caribbean area. I will put more emphasis on Amblyomma variegatum and Boophilus microplus than on the others.

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Amblyomma Cajennense (Fabricius):

Distribution

This species is widespread throughout Mexico and Central America and into areas in South America. It is also found on the Caribbean Islands of Trinidad & Tobago, Jamaica and Cuba.

Hosts

All stages of this host attach rapidly to man and, in certain areas, larvae and nymphs are extremely abundant and aggressive in attacking man. This species is a 3-host tick that has a wide range of hosts with adults occurring in large numbers on horses, cattle, mules, donkeys and dogs.

The seasonal abundance of this tick varies, but all stages are found throughout the year where it is well established. The life cycle is presented in Table 1. The length of time each life stage may survive in the environment has not been determined but it is probably as short as 6-8 months or as long as two years. Again the survival is dependent on many factors.

Because this tick is not widespread in the Caribbean, I will not comment further on it.

Table 1. Life cycle of Amblyomma cajennense (F.)

Development		In days	
stage	period	average	range
Egg	Incubation	--	37 - 154
Larvae	Feeding	--	3 - 7
	Premolting	--	10
Nymph	Feeding	--	3 - 13
	Premolting	--	12 - 105
Male	Feeding	--	Intermittent
Female	Feeding	--	7 - 12
	Preoviposition	6.23	3 - 20
	Oviposition	28.47	17 - 36

From: Drummond and Whetstone (1975); Strickland et al. (1976)

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<u>Amblyomma</u> <u>variegatum</u> (Fabricius):

<u>Distribution</u>

This tick is widely distributed throughout Africa, in Eastern, Central and Western areas. It is found in the Caribbean on the Island of St. Lucia, Barbados, Martinique, Dominica, Marie Galante, Guadeloupe, Antigua, St. Kitts, Nevis, St. Martin (Maarten), Anguilla, Vieques and Puerto Rico.

<u>Hosts</u>

This tick has a wide range of hosts that it will feed on; from snake to man. However, in the Caribbean the range of hosts with which this tick may come into contact is small. For example, on Puerto Rico, there are only 4 wild mammal species; the mouse, 2 rat species and the mongoose. Therefore, in Puerto Rico, and probably on all the other islands where A. variegatum occurs, with the exception of Guadeloupe and Antigua, this tick primarily feeds on domestic animals. As with other ticks that show a wide range of hosts, the immature stages of <u>A</u>. <u>variegatum</u> tend to feed more often on medium-sized hosts (goats, sheep) while the adults tend to be found more often on larger animals (horses, cattle). However, on Guadeloupe, goats are infested with large numbers of adults (74 males and females per animal, Barré, N. 1985, personal communications).

Ticks on Guadeloupe have been found feeding on birds, dogs and mongooses. On Puerto Rico this tick has not been found feeding on these animals. It is possible that on Guadeloupe the density of ticks is very high and thus, the opportunity for contact between hosts (birds, dog and mongoose, etc.) and tick is greater.

Since birds, especially the cattle egret, are hosts for this tick in Guadeloupe, it becomes important to study the spread of this tick in relation to the movements by birds. Migration of the cattle egret and possibly other

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birds in the Caribbean may explain the distribution of *A. variegatum*.

Seasonal activity of these ticks varies with the location where they are found. On Puerto Rico, larvae, nymphs and adults have been collected in every month of the year. In the Sudan in Africa, adults appear towards the end of the dry season, first males and then females; populations on hosts increase in numbers and remain high through the rainy season and decrease rapidly during the dry season, although a few specimens may be found in the dry season. Larvae and nymphs are present in the dry season.

Life Cycle

The life cycle is presented in Table 2. Under ideal laboratory conditions this tick can complete the life cycle (from egg to egg) in 142 days. However, under field conditions this period of time may be extended to more than 2 years.

In Guadeloupe, we have seen that adult ticks are alive after 14 months without a bloodmeal (Barré et al., personal communications). The immature stages of this tick have been found to survive 9 months. Additional research is continuing to determine the longevity under field conditions in Guadeloupe.

Boophilus microplus (Canestrini)

This species is found in humid hot climates of the West Indies (throughout the Caribbean), Mexico, Central and South America, Australia, Africa, the Orient and Micronesis.

Hosts

The primary hosts are cattle, but it is also found on horses, sheep, goats and deer.

On the host, this tick prefers to feed on the thin-skinned areas, such as the escutcheon, but, in high populations it will attach and feed almost anywhere on the animal.

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Table 2. Life cycle of Amblyomma variegatum in the laboratory at 26 ± 1°C, 95 ± 1% RH, and 14:10 light-dark photoperiod.

	Period	Observations	Days Mean	Days Range
Egg	Incubation	85	50.3	43-62
Larva	Prefeeding	69	3.8	1-10
	Feeding	99	8.2	6-13
	Premolting	73	17.7	15-22
Nymph	Prefeeding	45	2.4	1-5
	Feeding	48	6.3	5-10
	Premolting	36	25.6	19-28
Male	Prefeeding	23	1.7	1-7
	Feeding	60	--	50+
Female	Prefeeding	23	1.7	1-7
	Feeding	101	13.5	11-16
	Preoviposition	104	12	9-21
	Oviposition	53	35.3	17-50

(Garris, 1984)

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There are probably 6 generations of this tick per year in Puerto Rico and from 3-6 generations per year elsewhere.

The life cycle of Boophilus microplus is presented in Table 3. The survival of the free-living stages of B. microplus off the host is affected by many factors. The most important factor causing the greatest amount of mortality is climate, especially the climate in the vicinity of the tick itself (microclimate).

Certain kinds of vegetation may also influence survival in that the plant may entrap the tick and prevent it from crawling onto a passing host. Stylosanthes plants and molasses grass are examples of plants that control ticks.

The behaviour of the unengorged larvae of B. microplus may also affect their survival. Larval ticks have been known to climb up vegetation and remain there until they died from dehydration or a suitable host is encountered. Another type of larval behaviour is to form clumps, i.e. masses of larvae together. Clumping behaviour is beneficial in that it gives shelter from climate and provides high moisture levels to those inside the clump.

There are many predators that kill and eat ticks. The most efficient are ants, especially fire ants and spiders. Also, bacteria and fungi may attack replete ticks, however, these diseases are usually associated with high relative humidities.

The longevity of B. microplus larvae has been shown to be 17 weeks in areas on Puerto Rico that receive from 50-75 inches of rainfall annually. However, the longevity may be longer in higher rainfall areas and shorter in lower rainfall areas.

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Table 3. Life cycle of Boophilus microplus (canestrini)

Development		In days	
Stage	Period	average	range
Egg	Incubation	--	14-146
Larva	Engorge and Molt	--	7-12
Nymph	Engorge and Molt	--	5-17
Female	Feeding	--	5-23
	Preoviposition		2-4
	Oviposition	17	12-21

From: Davey et al. (1980), Strickland et al. (1976)

Dermacentor nitens (=Anocentor nitens) (Neumann)

Distribution

This tick is common in Mexico, Central and South America (northern South America) and the Caribbean.

The primary hosts of this tick are horses, but cattle are often infested.

These ticks prefer to feed in the nasal diverticulae first then in the ears of their host but when in high numbers can be found in the mane and tail of horses. This is a 1-host tick.

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Life Cycle

The life cycle is presented in Table 4. There is very little information available on the survival and length of time these ticks live in the environment.

Table 4. Life cycle of Dermacentor nitens (=Anocentor) nitens (Neumann)

Development		In days	
stage	period	average	range
Egg	Incubation	--	21-28
Larva	Engorge and Molt	--	8-16
Nymph	Engorge and Molt	--	7-14
Female	Feeding	--	9-23
	Preoviposition	2.8	2-4
	Oviposition	14.5	9-17

From: Drummond et al. (1969); Strickland et al. (1976).

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Rhipicephalus sanguineus (Latreille)

Distribution

I mention this tick because it is worldwide in distribution and heavily infests dogs in many parts of the Caribbean. It could be confused with other ticks.

The dog tick infests dogs almost exclusively, but in Puerto Rico it has been found on rats. In Africa, this tick is found on many other hosts; including birds, cattle, deer, goats, sheep, etc.

This tick is commonly found on the ears, along the nape of the neck, and between the toes on dogs.

The life cycle of this three host tick is presented in Table 5. It can be a relatively long life cycle.

Table 5. Life cycle of *Rhipicephalus sanguineus* (Latreille)

Development		In days	
stage	period	average	range
Egg	Incubation	--	8-67
Larva	Feeding	--	3-7
	Premolting	--	6-23
Nymph	Feeding	--	4-9
	Premolting	--	12-129
Males	Feeding	--	Intermittent
Females	Prefeeding	--	-
	Feeding	--	6-50
	Preoviposition	--	3-83
	Oviposition	--	-

From: Strickland et al. (1976).

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SELECTED TICK-BORNE DISEASES OF LIVESTOCK

R.K. Strickland

BABESIOSIS

Babesiosis is a tick-borne protozoan blood disease of domestic and wild animals. The genus Babesia is large with 71 species being listed by Levine in 1971. Some 18 of these cause disease in domestic animals - cattle, sheep, goats, horses, pigs, dogs and cats. However, this discussion will be limited primarily to four species - two affecting cattle (Babesia bovis and B. bigemina) and two species in horses (B. caballi and B. equi). In general babesiosis is characterized by fever, hemolytic anemia, hemoglobinuria, and death.

Life Cycle of Babesia

The tick inoculates the infective form of Babesia into the susceptible host when the tick feeds. Ticks of the genera Boophilus and Rhipicephalus are efficient vectors. In the new world Boophilus annulatus and B. microplus are responsible for the transmission of both Babesia bovis (=B. argentina) and B. bigemina. After inoculation into the blood stream the Babesia enter red blood cells, multiply, and cause rupture of the red blood cells. The new forms enter uninfected red blood cells and the process continues until the host either dies of severe anemia and other complications due to red blood cell destruction, or the host's immune system comes into play to protect the animal.

As with some other tick-borne diseases, the severity of the infection varies with the age of the animal. Young animals usually have mild infections and recover although they often remain carriers of the infection. Adult animals usually experience severe infections of babesiosis. Death losses can be very high. One of the important signs of babesiosis is hemoglobinuria caused by the massive destruction of red blood cells. Hemoglobinuria is not associated with anaplasmosis - a disease similar to babesiosis in some respects.

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Recovered animals remain carriers and thereby serve as reservoirs of infection for uninfected ticks. The tick is infected with babesia by the ingestion of infected red blood cells. The infective form of Babesia invades the gut epithelium of the tick and begin replicating. Later the hemocytes, malpighian tubules, muscles and ovaries are involved. In 1-host ticks such as Boophilus the ovaries become infected and infection may be passed to the next generation.

After the ovaries are infected and the female lays the eggs, multiplication of developmental forms of Babesia continue in the egg yolk. As the larva develops infective forms also enter larval tissues and when the larva begins to feed on a susceptible host, the infective forms (vermicules) enter the salivary alveoli, form schizonts which then produce small, round, or pyriform bodies similar to those found in red blood cells. These forms are infective when the tick feeds on a susceptible host. (B. bovis)

Cattle

1. Babesia bigemina

Babesia bigemina is an important parasite in cattle. It is the organism most commonly associated with the so-called Texas fever which caused tremendous economic losses in the southern United States in the late 19th and 20th centuries. Babesia bigemina was the organism that Smith and Kilbourne reported as the causative agent of Texas fever. They discovered that it was transmitted by Boophilus annulatus, the cattle fever tick. Their discovery in 1893 was especially important since it marked the first time that a protozoan parasite was proven to be transmissible to a mammalian host by an arthropod vector.

Babesia bigemina is a large organism whose pear-shaped form measures 4-5 X 2 microns. Babesia bigemina is often found in combination with other tick-borne pathogens such as Anaplasma marginale and B. bovis (=B. argentina). This combination often produces a synergistic pathogenic effect. Reportedly the

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Australian strain of B. bigemina is not highly pathogenic, whereas the African strain is highly pathogenic.

Incubation Period

- Clinical Signs

A. High fever - 160°F
B. Difficult respiration
C. Severe anemia
D. Constipation in early stages
E. Icterus
F. Hemoglobinuria
G. Drop in milk production
H. Possible abortion
I. Depression, ataxia, convulsions, mania, and coma

Mortality is highly variable. Young animals often have only mild cases whereas adult animals may suffer severe death losses. Mortality may reach 90%. The disease is more severe in hot weather.

- Postmortem lesions

A. Blood thin and watery
B. Anemia
C. Icterus
D. Enlarged, distended gall bladder
E. Degeneration of kidneys and liver
F. Hemoglobinuria
G. Splenomegaly

- Diagnosis

A. Clinical signs, postmortem lesions, and history of the animal and area involved.

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B. Demonstration of organisms in Giemsa-stained thin blood smears.

C. Animal inoculation (often splenectomized animal)

D. Serological tests

1. Complement fixation test (CF)
2. Indirect fluorescent antibody test (IFA)
3. Capillary agglutination test
4. Agar gel immunodiffusion test (AGID)

There are also other tests but not all tests are regarded as established diagnostic methods.

- Control and Eradication

A. A good dipping or spray program will stop the spread and control an outbreak of babesiosis.

B. Premunition using live field strains of Babesia. Dangerous and must be carefully controlled. Produce disease and use chemotherapy to treat infected animal under controlled conditions. An attenuated vaccine has been used in Australia.

C. Maintain low level of tick infection so as to ensure all young animals are exposed and infected at an age when they are less vulnerable. This develops areas of "enzootic stability".

D. Organized tick eradication programs to eliminate tick vectors. This is a long, costly process in endemic areas and requires a deep commitment to eradication and the active support of livestock industry.

E. Immunization - experimentally-killed vaccines have shown some promise, but no commercial vaccines available.

F. Tick resistant cattle - Australians have been attempting to develop cattle more resistant to ticks. Shows some promise.

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- Treatment

A variety of babesiacides have been used throughout the world. Unfortunately many of the drugs are toxic or have tissue residue problems.

A. Trypan blue - used since 1912 but not effective against the small Babesia (B. bovis and B. equi). Causes discoloration of flesh.

B. Quinoline derivatives - very effective against B. bigemina - less effective against B. bovis. Acaprin is in this group.

C. Diamidine derivatives - Berenil, Babesin, Ganaseg, Diapron, Imidocarb (1-3 mg/kg) and Phenamidine. None are approved in the U.S.A. for use in cattle at the present time, although they have been used in South America, Australia and Africa.

D. Acriflavins - these, both neutral and acid, are used against B. bigemina, and B. bovis.

2. Babesia bovis

This is a small Babesia whose pyriform intraerythrocytic form measures 2 X 1.5 microns. Babesia bovis is synonymous with B. argentina. The distribution for B. bovis is Central and South America, Africa, Australia, Asia and Europe. Babesia bovis is probably of more economic importance than B. bigemina. It has many similarities with B. bigemina. It is generally transmitted by the same ticks, often occurs in mixed infections with B. Bigemina and Anaplasma marginale, and the signs and pathogenicity are similar. Cattle with B. bovis infections often develop central nervous signs with less severe anemia and no hemoglobinuria. These CNS signs can be confused with rabies and other encephalitides. Babesia bovis is also transmitted transovarially (through the egg). Transmission of B. bovis and B. bigemina differ. The larval stage of Boophilus microplus transmits B. bovis, whereas B. bigemina is transmitted by the nymphal and adult stages. Generally the small babesia, such as B. bovis, are more refractory to treatment than

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their larger counterparts such as B. bigemina.

Horses

1. Babesia caballi

Babesia caballi is the large species which is found in the equine family. The intraerythrocytic pyriform bodies measure 2.15 to 4 microns in length and 2.0 microns in width.

Babesia caballi is distributed from southern Europe through Asia, the USSR, Africa, Central and South America, the Caribbean Basin and southern Florida.

The established vectors for B. caballi are Dermacentor (Anocentor) nitens, Rhipicephalus bursa, and R. sanguineus, as well as several other species of Dermacentor and Hyalomma.

The incubation period is 8 to 21 days following natural exposure. The initial rise in temperature is directly correlated with the detection of the parasites in blood smears.

- Clinical Signs

  A. Fever
  B. Depression
  C. Thirst
  D. Lacrimation
  E. Anorexia
  F. Mucous nasal discharge
  G. Swelling of eyelids
  H. Icterus
  I. Emaciation
  J. Hemoglobinuria is rare in B. caballi

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Mortality varies with age of animal - young animals have mild infections. Older animals may be severely infected.

Diagnosis, control and treatment are similar to those of bovine babesiosis.

2. Babesia equi

Babesia equi is a small organism much like B. bovis in cattle.

Babesia equi is more distributed than B. caballi. It has been reported from every inhabited continent.

The disease produced by B. equi is generally more severe than that produced by B. caballi. Treatment is also more difficult with B. equi. Like the other small Babesia, it is more refractory to treatment.

The vectors of B. equi include species in the genera Dermacentor, Hyalomma, Rhipicephalus, and possibly Boophilus.

The diagnosis, signs, lesions, treatment, control , etc. are similar to those given for B. caballi.

ANAPLASMOSIS

Anaplasmosis is an infectious disease of ruminants caused by a rickettsial organism in the genus Anaplasma. At one time it was thought to be a protozoa, then it was placed in an undetermined classification, but it is now placed in the family Anaplasmataceae in the order Rickettsiales.

Anaplasma marginale is the most important member of the genus and is responsible for producing clinical disease in cattle. Other animals infected include the water buffalo, elk, American Deer, Bison, antelope, etc. A second species, A. centrale, also occurs in cattle but this is a relatively

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nonvirulent organism which occurs in Africa but not in the United States. A third species, A. ovis, produces a mild to severe disease in sheep and goats.

Anaplasma marginale is widespread in the tropical and subtropical regions. It also extends into some temperate regions. Transmission is accomplished by a variety of ixodid ticks of the genera Boophilus, Dermacentor, Rhipicephalus, Hyalomma, Haemaphysalis, and Ixodes. Insects such as mosquitoes, horse flies and stable flies may mechanically transmit the disease as will contaminated instruments and syringe needles.

Anaplasma marginale remains viable for long periods within satisfactory tick vectors. Multi-host ticks pick up the organism by ingesting infected red blood cells. Following feeding the tick molts to the next stage and at the next feeding it passes the Anaplasma to a new host. Transovarial transmission may also occur in multi-host ticks. With 1-host ticks such as Boophilus, transovarial transmission is required to pass the infection from host to host.

The severity of anaplasmosis varies with the age of the animal. Calves usually have only mild infections with little or no mortality. In endemic areas where the disease is widespread, the young animals are infected early in life, recover from the mild infection, and usually remain carriers for the rest of their lifetime. The disease is more severe in yearling cattle but most recover.

However, in older cattle with no previous exposure to the disease, anaplasmosis can be severe with a mortality of 20-50%. The highest mortality is observed in adult cattle that are introduced into enzootic areas. Death losses are greater in hot weather. The incubation period is 20 to 40 days. The clinical disease may be as short as a day or less in the highly fatal, peracute form which is observed in the older, highly susceptible cattle. In the acute or subacute form, the clinical course may vary from several days to two weeks. Recovered animals often remain carriers for life.

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- Clinical signs:

  - Peracute form - animal may be found dead with little or no warning.

  - Acute to subacute form:

    A. High fever (104-107^{o}F)
    B. Depression
    C. Anemia
    D. Icterus
    E. Constipation - feces dark, blood-stained mucus
    F. Dehydration
    G. Drop in milk production
    H. Loss of weight
    I. Animal may succumb to hypoxia if/when moved or handled for treatment
    J. Animal may die 2-3 days after first clinical signs

  - Chronic form:

    A. Emaciation
    B. Icterus
    C. Anemia
    D. It is important to remember that hemoglobinuria does not occur in anaplasmosis. Hemoglobinuria usually occurs in babesiosis (piroplasmosis)

  - Postmortem Lesions:

    A. Blood thin and watery
    B. Icterus - pronounced
    C. Spleen enlarged and soft
    D. Liver is turgid and often mottled mahagony color
    E. Bile is thick and brownish
    F. In peracute cases - death may occur without anemia and icterus

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- Diagnosis:

  A. Clinical signs, postmortem lesions, and history of the animal and area involved

  B. Demonstration of organisms in stained blood smears

  C. Serological tests:

     1. Complement fixation test (CF)
     2. Rapid card agglutination test
     3. Capillary tube agglutination test

- Control and Eradication:

  A. Vaccination:

     1. Premunition using field strains of A. marginale and A. centrale. This can be dangerous; it requires good control. A. centrale not present in U.S.A.

     2. Laboratory attenuated A. marginale

     3. Inactivated A. marginale:

        - AnaplazR - Ft. Dodge Labs.
        - Sometimes induces isoimmunization and erythrolysis due to the bovine blood group it contains.

- Treatment:

  A. Antibiotics:

     - Tetracyclines:

       1. Chlortetracyclines
       2. Tetracycline
       3. Oxytetracycline

  B. Imidocarb:

     - Problem with residue
     - Not cleared by FDA

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THE THEILERIOSES

The theilerioses are a group of diseases caused by protozoan parasites of the genus Theileria which invade but do not destroy the red blood cells. The infective form of Theileria is introduced into the host by the feeding of certain ticks. The theileria organisms enter the lymphoid cells of the spleen, lymph nodes, and liver where asexual multiplication occurs. A stage of the parasite then enters the red blood cell where it is subsequently ingested by the tick. The "so-called" sexual stage of development occurs in the tick. Transmission is accompanied by the feeding of the nymphal or adult stages. There is no transovarial transmission. The larval tick stage may become infected by feeding on an infected animal and subsequently transmit the disease to another host when it feeds as the nymphal stage. Or, an infected nymphal tick can pick the infected form of Theileria which is then later transmitted by the adult stage.

The Theileria are related to the Babesia. Both genera are in the class Piroplasmasida and order Piroplasmorida. The order Piroplasmorida contains two families, Babesidae and Theileridae.

East Coast Fever

East Coast Fever is now considered as a complex of diseases caused by three species of Theileria, namely T. parva parva between cattle; T. parva lawrencei from buffalo to cattle; and T. mutans which was once considered non-pathogenic but is now known to cause disease. Ticks of the genus Rhipicephalus, especially R. appendiculatus, are the vectors. East Coast Fever occurs in East and Central Africa.

- Clinical signs:

A. Enlargement of lymph nodes draining site of tick infestation. Later there is lymphadenopathy.

B. Fever of 105-106°F.

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C. Congestion of mucous membranes. Sometimes anemia.

D. Inappetence, loss of condition, accelerated respiration, and laboured breathing. Froth may be present in the nostrils and is usually present at death.

The disease runs an acute course with death occurring from 4-21 days. Mortality may reach 90-100%. Recovered animals are immune.

- Postmortem lesions:

A. Carcass usually emaciated with gelatinous appearance of the subcutis and muscle fascia

B. Generalized lymphoid hyperplasia of lymph nodes, spleen and Peyer's patches

C. Lungs edematous with froth oozing from nostrils

D. Marked petechial hemorrhages on serous and mucous membranes in abdominal and thoracic cavities

- Diagnosis:

A. Characteristic signs and postmortem lesions (lymphadenopathy and pulmonary edema) along with infestation of R. appendiculatus is highly suggestive

B. Presence of Kochs Blue Bodies in lymph node biopsy

C. Presence of erythrocytic piroplasms in Giemsa-stained blood smears

D. Serological tests: Agar Gel precipitin test. Serological tests are not fully reliable

- Treatment:

No effective therapy exists for clinical East Coast Fever. Some antibiotics (tetracyclines) show promise if treatment begins before clinical signs appear. Tetracyclines at 5-15 mg/kg daily may suppress schizogony and moderate the disease.

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- Prevention:

  A. Dipping to control tick vectors - as often as twice weekly at times
  B. Quarantine
  C. Slaughter
  D. Vacation of infected premises

Corridor Disease

Corridor disease once considered as a separate disease is now considered as a form of East Coast Fever. It is caused by *T. parva lawrencei*. It occurs in African Buffalo and is transmitted to cattle and has been reported from Rhodesia, South Africa and Kenya. The primary vector is *R. appendiculatus*. Mortality of 60-80% has been reported. The erythrocytic forms are fewer than with *T. parva parva*.

Benign Bovine Theileriosis

The third form of East Coast Fever, formerly known as Benign Bovine Theileriosis is caused by *T. mutans* and generally produces no clinical conditions other than a mild fever, swelling of the lymph nodes, and some anemia. However, some strains produce disease and death. Cattle are affected and the vectors include *Rhipicephalus appendiculatus*, *R. evertsi*, and *Amblyomma variegatum*.

Apparently T. mutans is confined to Africa but similar forms have been reported from Europe, Asia, Australia, and the USA. However, these mild forms are antigenetically different from the true *T. mutans* and are now considered to be different species.

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MEDITERRANEAN FEVER

Mediterranean Fever is caused by T. annulata and occurs in Egypt, Sudan, southeastern Europe, Russia, the Middle East, India and Ceylon. Cattle are affected and the principal vectors are ticks of the genus Hyalomma, especially H. detritum, H. anatolicum, and H. asiaticum. Mortality as high as 25% has been reported but this is usually not the case since calfhood infection of the mild form usually occurs in endemic areas.

HEARTWATER

Heartwater is a rickettsial disease of ruminants which affects cattle, sheep, goats, antelope and water buffalo. The etiological agent is Cowdria ruminantium and is transmitted by ticks of the genus Amblyomma.

- Geographical Distribution:

  A. Africa - south east, west and central

  B. Reported from Guadeloupe in 1980. More recently Heartwater was reported from Marie Galante and Antigua

- Transmission:

  The etiological agent is transmitted by ticks of the genus Amblyomma. The common vectors in Africa include A. hebraeum, A. variegatum, A. pomposum and A. gemma. The Gulf Coast Tick (A. maculatum) and the Cayenne Tick (A. cajennense) are experimental vectors; both of these ticks are present in the continental United States. All the vectors are 3-host ticks. The infection is picked up by the tick from a carrier animal. The larva may pick up infection and then is capable of transmitting the disease to another animal when it feeds during the nymphal stage. Or, the nymphal stage may become infected and pass the infection to another host when it feeds as the adult stage. The infection is not passed through the egg (transovarial transmission).

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One of the vectors, Amblyomma variegatum, is present in Puerto Rico as well as at least 12 other islands in the Caribbean. This tropical or sub-tropical 3-host tick normally completes one generation per year in regions with one rainy period, and may produce two generations in regions with two rainy seasons.

In 1966 and again in 1984 A. hebraeum was introduced in the USA on Rhinoceroses imported from Africa. Both introductions were eradicated.

- Signs:

There are four clinical forms of Heartwater:

A. Peracute form - sudden death preceeded by fever and convulsions. The temperature will reach 106°F (41°C) within a few hours. This is followed by prostration, convulsions and death. This form is relatively rare.

B. Acute form - temperature up to 107°F, lack of appetite, depression, listlessness, rapid breathing. Nervous signs - chewing movements, twitching of eyelids, protrusion of tongue, and circling; often with a high-stepping gait. Nervous signs increase in severity and animal goes down in convulsions, chewing movements and muscle twitching. Galloping movements are commonly seen in down animals prior to death. Hyperesthesia and frothing at the mouth are also commonly seen. Abortion occurs in pregnant animals. Animal with acute form usually is dead within 4-5 days. Mortality is almost 99%. The acute form is the form most commonly observed in Africa.

C. Subacute form (chronic) - characterized by increased body temperature and mild incoordination with recovery or death in one or two weeks. Signs are similar but less severe than the acute form. This form is rare.

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D. Mild or subclinical form - this form is seen in wild antelopes and indigenous breeds of sheep and cattle in Africa. The animals show a transient febrile response with little or no clinical signs.

- Incubation period:

  - Sheep - 7-10 days - experimental
  - Cattle - 10-16 days - experimental
  - Field conditions - 14-28 days after animals introduced into heartwater-infected area clinical signs are observed.

- Mortality:

  - 10-90% +

- Postmortem lesions:

  A. Accumulation of straw-colored to reddish fluid in pericardial sac.
  B. Fluid in thoracic and peritoneal cavities.
  C. Edema of lungs
  D. Sub-endocardial petechical hemorrhages
  E. Sub-mucosal and sub-serosal hemorrhages
  F. Degeneration of heart muscle and liver
  G. Enlargement of lymph nodes and spleen
  H. Catarrhal or hemorrhagic abomasitis and enteritis.

- Diagnosis:

  A. Characteristic signs and lesions with infestation of Amblyomma ticks.
  B. Collect whole blood from febrile animals and send to laboratory as soon as possible. Collect live ticks from suspect cases. Also collect brain with blood vessels attached. Prepare jugular vein smears fixed in 100% methanol.

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C. Demonstration of Cowdria ruminantium colonies in endothelial cells of capillaries in brain, jugular vein or heart. Fix squashed brain smears with 100% methanol and stain with Giemsa. Look for organism in endothelial cells.

D. Inoculation of susceptible animals with blood or spleen suspension collected during febrile period. Also, collect live ticks - feed ticks on goats or sheep to induce disease. In addition grind up suspect ticks and inoculate intravenously in sheep and goats.

E. Indirect fluorescent antibody (IFA) test is available but still in developmental stage.

- Treatment:

A. Tetracycline and oxytetracycline antibiotics - recovered animals may remain carriers 40 days longer following treatment.

B. Sulfa drugs.

- Prevention:

A. Tick control program - dip animals - kill ticks - Amblyomma ticks.

B. Young calves (up to 4 weeks) and lambs resistant to disease. Young calves in endemic areas are often vaccinated with infective blood during first few weeks of life. Immunity is later stimulated by infected ticks.

C. Adult cattle highly susceptible. In endemic areas adult cattle are inoculated with infective blood or homogenates from infected nymphs of A. hebraeum. Inoculated cattle are closely monitored and treated with antibiotics at first clinical signs of disease. There is a risk involved - can be used only in enzootic areas.

DERMATOPHILOSIS

Dermatophilosis, also called cutaneous streptotricosis, is an epidermal infection caused by the aerobic actinomycete Dermatophilus congolensis. The disease is characterized by the formation of horny crusts that adhere firmly to the infected skin. Cattle, horses, goats, and sheep are affected.

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The organism, D. congolensis, grows in the keratinized layer of the skin of the infected animal. It produces a branched mycelium that divides transversely and then longitudinally to produce thick bundles of small cocci. These enlarge and mature into flagellated, ovoid zoospores. When the skin is wetted, the zoospores emerge to the surface where they are available for the transmission of infection. There is no resistant stage.

Transmission is mechanical and is accomplished by spiny plants, biting insects and ticks. The tropical bont tick, Amblyomma variegatum, is a very efficient mechanical vector of dermatophilosis.

The invasion of the living epidermal cells by D. congolensis induces an acute inflammation and rapid cornification of the infected epidermis. Alternate layers of dried exudate and cornified epidermis accumulate on the skin thereby producing the thick crusts so characteristic of the disease.

- Control:

A. Treatment for ticks and insects to prevent spread.

B. Large injections of streptomycin and procaine penicillin (20 mg streptomycin plus 20,000 units of procaine penicillin per pound of body weight).

AFRICAN SWINE FEVER

This is a viral disease of pigs with signs and lesions resembling those of hog cholera. In domestic swine transmission is chiefly by direct and indirect contact.

This disease is mentioned here only because two species of argasid ticks, Ornithodoros moubata porcinus in Africa and O. erraticus in Spain have been incriminated as reservoirs and vectors of the African Swine Fever virus.

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African Swine Fever was confined to Africa until 1957. Since then it has been introduced into the following countries:

- Portugal - 1957
- Spain - 1960
- France - 1964
- Italy - 1967
- Cuba - 1971 and 1980
- Brazil and the Dominican Republic - 1978
- Haiti - 1979

This disease is mentioned only because of the fact that it was recently established in Haiti where there is an *Ornithodoros* tick, *O. puertoricensis* which is found in Puerto Rico and other Caribbean islands. This tick *O. puertoricensis*, feeds on rats and other small animals. It is not known to feed on swine and is not known to have any role in the transmission of African Swine Fever.

African Swine Fever is now eradicated from the Dominican Republic, Haiti and Cuba. It is not known to be present in the Caribbean as of August 1985.

TICK CONTROL: CONCEPTS

Glen I. Garris

Tick Eradication Concepts

There are a variety of control programs available that may be used as a model in developing a national approach to the management of ticks and tick-borne diseases. However, as a final goal, it should be emphasized that control implies a perpetual effort and a perpetual drain on the economic resources of a country or individual. An alternative to control would be eradication.

Eradication implies that at some point in time, the management costs associated with ticks and tick-borne diseases are eliminated. The benefits associated with this approach are numerous (Bram and Gray, 1979).

Presented below are descriptions of two approaches to the management of ticks and tick-borne diseases, control and eradication. The information is presented to stimulate further discussions and to provide a basis for making decisions which would require an economic commitment. Considerably more information is needed before either approach can be recommended.

ERADICATION

Objectives:

1. To eliminate an unwanted tick species from an island.
2. To prevent the reintroduction of the eliminated tick into a given island from neighbouring islands.

Problems and Constraints

An eradication approach to the tick and tick-borne disease problems in

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a given area should be undertaken only when the following conditions are met:

1. There must be adequate scientific information on the biology, ecology and host relationships of the target tick species; on the epidemiology of the diseases transmitted by the target tick; and on the techniques necessary to eliminate the target tick.

2. There must be strong support from the livestock industry, from the legal and political area, and a long term commitment of manpower and financial resources.

3. A comprehensive animal health infrastructure with program policies that will be equally applied to all segments of the livestock industry must be available.

Failure to meet and implement all of the above has led to unsuccessful eradication efforts (Powell and Reid, 1982).

The problems listed above are not unsurmountable; they can be handled through advanced planning, hard work and adequate funding. Much of the information on the biology and ecology of a target tick may be extrapolated from research conducted elsewhere (i.e. Puerto Rico, Jamaica, Australia and South America for B. microplus). However, information on the seasonal abundance and survival off the host of a target tick in the island in question would need to be determined. Information on the epidemiology of possible diseases transmitted by the target tick on the respective island would also need to be determined.

Quarantine regulations are critical in an eradication program (Knipling, 1979). Implementation of quarantine policies must be equally applied to all segments of the livestock industry to protect against new infestations in areas declared tick free. New infestations may also bring new disease outbreaks in areas declared tick free because of a breakdown in disease enzootic stability. Enzootic stability occurs when tick populations are high enough

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to inoculate newly born calves with a disease. The calves develop an immunity and a minimal number of calves show clinical symptoms. Disease outbreaks occur when new animals are brought in that have not been exposed to a particular strain of the disease found in that area or when the tick vector in a given area is not at the optimum population for disease transmission to newly borne calves (Norval et al., 1983). Enzootic stability of a disease can be broken down by decreases or increases in the population of the tick vector. The tick population level is affected by many factors found in its natural environment (weather, season, etc.) or from control practices. Good control would decrease the population level and thus transmission of the disease to young calves would be limited, which may result in a breakdown of disease enzootic stability. Poor control may allow the tick population to fluctuate which could result in periods of disease transmission or periods of no disease transmission (Norval et al., 1983, De Vos and Potgieter, 1983).

Development of acaricide resistance in ticks is an important consideration in an eradication program. Constant monitoring of tick populations to determine presence of acaricide resistance is necessary. Research to develop new acaricides that may be used as alternatives to acaricides that are no longer effective is a necessary part of an eradication program. In a successful eradication program, resistance would not be a problem.

Strategy of Implementation

The eradication techniques developed during the B. microplus program currently in progress in Puerto Rico can be viewed as a model to the planning of a similar program elsewhere in the Caribbean. The eradication program in Puerto Rico has been flexible in its design and implementation of policies and regulations. It will be discussed in detail later in this workshop. However, below is a brief outline:

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1. The first step in an eradication program is to obtain adequate local and political support. With this support comes the necessary financial assistance needed to carry out the program.

2. Once financial and political support has been obtained, the second step is to conduct a detailed farm-to-farm survey to determine which animals and how many are infested. Once a herd has been found infested, it should be placed under quarantine. It is essential to prevent animals from this herd from being moved to uninfested areas, thus spreading the ticks.

3. Once the survey is completed and the ticks are contained through quarantine restrictions, treatment activities can begin. Treatment of potential hosts for B. microplus, including cattle, sheep, goats and horses can be done on a 14-day schedule between application of a suitable acaricide. It is extremely important that the animals be treated at a 14-day interval and that all animals be gathered each time for treatment.

4. Once treatments of infested animals are established, surveillance activities should be started again. A systematic surveillance program involving the examination of all livestock for ticks in all risk herds every 14 days to 2 months should be implemented. Risk herds are those herds adjacent to treated herds or herds that are frequently moved across infested areas - an exposed herd. This procedure will help to identify any missed herds as being infested and should prevent spread of ticks out of the quarantined area.

In Puerto Rico, there are two types of eradication teams; one is a treatment team and one is a survey team. However, these teams are flexible in that a survey team can easily become a treatment team and vice versa, depending on the needs of the program. From experience in Puerto Rico, it was best to begin treatment of animals in a

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primary focal area of the ticks. It was important then to clearly define this primary focal point and understand that outlying areas from the primary point can be considered as newly established centers of tick infestation. However, it must be well understood that to prevent new infestation of the primary focal point, animal movement must be strictly contained.

5. Animal movement into a quarantine area should only be allowed after they have been freed of ticks and then should be sprayed with a suitable acaricide, being shipped wet. In some instances, it is advisable to only allow movement of animals to slaughter.

6. A gradual incorporation of all infested herds into the eradication program is advisable, because it not only allows the local producers to become acquainted with the program but also provides an opportunity for the employees in the program to develop the skills necessary to successfully complete the job. This consolidation also reduces the overall costs of the program by placing more job responsibilities on each employee. Those conducting surveys can be used as the need arises to treat animals.

7. With B. microplus, all infested animals should be sprayed with a suitable acaricide every 14 days for at least 17 treatment periods. Two treatments before the completion of the 17-time treatment program and at 2 months after the program, all animals should be thoroughly examined for ticks. If ticks are found on the animals prior to the 17th application, treatments should be started again and should be for an additional 17 treatments; this premise should be treated as a new infestation. If no ticks are found on the animals at the end of the 17 treatments, the herd can be released from treatment only. These animals should be examined for ticks every 14-21 days at an additional 2 months and examined periodically (every 2 months) until the eradication program is complete for the island.

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8. New infestation of B. microplus from surrounding islands should be prevented by regulations which require animals shipped into the island to be tick free. Routine surveillance activities should be provided as a service by the government to protect from new infestations in the future after an eradication program is completed. Rapid detection through surveys could prevent the re-establishment of this tick in the island.

Project Components and Estimated Costs

Many of the components of an eradication program, such as regulations, treatment schedules etc., have been discussed and listed above. Equipment and other components along with estimated costs of these as applied to the eradication program in Puerto Rico will be mentioned later in this workshop.

The eradication costs of B. microplus in Puerto Rico would not be the same as in other islands in the Caribbean. However, the costs presented do provide a realistic reference and give some information of the economics involved in an eradication program.

A list of the equipment needed and the personnel required in the eradication program in Puerto Rico, along with estimated costs of each, are presented in Table 1. These estimates are based on the costs associated with 1) the number of animals under systematic acaricide treatment; 2) the number of animals under surveillance; 3) the number of surveillance and treatment crews; 4) equipment (both new and replacement parts); and 5) operation and maintenance of equipment. Costs associated with administration of the program are not included. Other costs that should be considered in an eradication program are incidental, indirect costs such as costs associated with (i) vehicle accidents, (ii) injury to animals and employees, (iii) delay (lost time) in purchases of replacement parts or pesticide supplies, (iv) employee absenteeism, and (v) lost time in processing program violators.

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An estimate of the output from a treatment and surveillance crew for one (1) year is presented in Table II.

Target Area

The target area would be the entire island but the primary focal point or starting place should be selected based on the local situation. For example, an area where good livestock producer participation is available, where facilities and animals are accessible, and where located convenient to needed supplies and equipment would be a good primary focal point. All ruminant animals in this area should be surveyed first and the eradication program originate in this location. Incorporation of infested herds should be gradual and not exceed the capacity of the program. New herds should not be added to the treatment program until resources to complete the job are made available.

CONTROL

Objectives:

1. To reduce the population of a given tick species to below a level at which economic damage occurs, i.e. losses in meat and milk production, the economic injury level.
2. To maintain the population of the subject tick below the level at which economic damage occurs.

Problems and Constraints

Of concern in a control program would be the effective utilization by the livestock industry of the available information and resources. How well the livestock industry uses the information and/or resources provided would depend on how well they are informed and on the economic benefit to be derived from their participation.

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The potential for the development of acaricide resistance in ticks is dependent upon the type of management developed and implemented in either a control program or eradication program. In an eradication program, acaricide concentrations applied to animals may be monitored to prevent application of doses that are sublethal to ticks or over the safe level for animals. In a control program, there is no direct control of the concentration levels. Abusive usage of acaricides has been shown to be directly related to the development of acaricide resistance in both kinds of programs.

A major concern in a control program is whether or not the program will be voluntary or carried out and financed by the government. Once the decision has been made, then, if the government is to be involved, it becomes necessary to decide to what degree? Will the government provide supplies, equipment, information, and acaricides for the control program or will government only provide information? This question is critical and will require cooperation from politicians, livestock producers and consumers. How far the government wishes to get involved in a control program will dictate the level of economic assistance needed by the producers to carry out that program.

Strategy of Implementation

A detailed plan for a control program before it is determined how far government will be involved is not practical. However, a control program should be cost effective. A good program must be one that is minimal in costs and not costing more than is economically feasible for the livestock operation in question. Usually these programs are based on tick resistant breeds of cattle, strategic dipping and pasture spelling, and are primarily aimed at beef cattle producers. A program to develop a tick resistant dairy animal would require many years of research and development. However, some breeds, such as the Jamaica Hope, are resistant to ticks. It would be dependent on livestock grower acceptance of the new breed and consumer acceptance of the

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products from such a breed.

Strategic application of acaricides is an important part of a control program. However, strategic application of acaricides requires prior knowledge of seasonal abundance of ticks on cattle (nonresistance breeds). The Australian experience with strategic application of acaricides for *B. microplus* control is well documented but requires an input of detailed knowledge of the seasonal abundance of ticks. Much of the information on seasonal abundance of ticks in the Caribbean is not available.

Pasture spelling for short periods of time (10-90 days) may allow for the extension of the period between acaricide applications. This extension will reduce the number of acaricide applications required to keep the tick population below the economic injury level, that level above which economic loss due to ticks occurs i.e. loss of milk and meat. Cattle could be treated with an appropriate acaricide before rotation into a pasture vacated for 60-90 days. However, this approach has not been adequately tested in the field in the Caribbean.

Project Components

The project components would depend on the program adopted. It would also depend on the level of economic assistance, producer acceptance of the program and many other factors.

Target Area

The target area would be the entire island. However, as before, it would be important to determine a primary focal area. The overall success of the program may well rest on the success in the primary focal area.

Treatment Strategy

If treatments of cattle by dip, spray race, or hand spray are to be effective for tick control, the applications must be made at certain specific

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intervals that are determined on the basis of the life cycle of the species of tick to be controlled and the residual effectiveness of the acaricide. Another factor contributing to the choice of a treatment interval is the purpose of the treatment; it might be to control only, to prevent disease transmission, or to reduce the numbers of ticks below levels that cause damage. Thus, when populations of a 1-host species, such as the cattle tick Boophilus spp., are to be reduced, the interval between treatments may be as great as 21 days or longer. This interval will provide very good control, especially if the acaricide provides a residual protection for 3-4 days or longer. However, with adults of 2- and 3-host ticks, for example, species of Rhipicephalus, Hyalomma or Amblyomma, it may be necessary to treat the cattle on a weekly schedule. If the objective is the prevention of disease transmission (for example, piroplasmosis by B. microplus), the interval may have to be shorter so that the ticks' life cycle is broken and thus preventing feeding and transmission by the stage of the tick that is normally the vector. It would depend on whether or not you want to maintain enzootic stability.

The frequency of treatment may be complicated by the appearance of resistance to acaricides in the strain of ticks under attack. Resistance will obviously make a well established acaricide and the established treatment interval less effective than it has been in the past.

It should be emphasized that if the goal of acaricide treatment of cattle is either the eradication of a species of tick or the prevention of transmission of a disease by a species of tick, a rigid treatment schedule must be enforced. If the goal is the reduction of numbers of tick to minimize or prevent damage to cattle, then the schedule can vary greatly.

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Table I. Itemized costs of personnel and equipment used in individual crews in the <u>Boophilus</u> <u>microplus</u> (Canestrini) eradication program [1/]

Basic Crew Items	Crew Type	
	Treatment	Surveillance
	No.	No.
Crew size	3	2
Leaders	1	1
Inspectors	2	1
Personnel Costs	$	$
Crew Leaders		
Salary	6,780	6,780
Fringe benefits [2/]	1,042	1,042
Bonus	240	240
Inspectors [3/]		
Salary	12,984	6,492
Fringe benefits [2/]	2,022	1,011
Bonus	480	240
Per diem		
Crew leader	1,560	1,560
Equipment costs		
Vehicles (V)	11,000	10,000
John Bean Sprayer (JB)	5,000	0
Equipment operation costs		
V depreciation (20% cost)	2,200	2,000
JB depreciation (20% cost)	1,040	0
V maintenance	500	500
JB maintenance (10% cost)	520	0
V fuel cost [4/]	1,360	1,838
JB fuel cost [5/]	636	-

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Table I continued

Safety equipment cost		
Rainsuit (6 per individual)	315	-
Coveralls (3 per man)	167	111
Boots (1 per man)	90	60
Gloves (2 pairs per individual)	36	-
Goggles (1 per individual)	36	-
Respirator (1 per individual)	75	-
Cartridges (replacement)	750	-
Filter pads (replacement)	864	-
Totals	53,288	33,673

1/ Data supplied by Dr. D. Bokma, Tick Epidemiologist, USDA, APHIS, VS, San Juan, Puerto Rico.

2/ Fringe benefits = 6.7% of salary for Social Security, 4.25% of salary for Commonwealth State Insurance Fund, $300 (U.S.) per year health benefits.

3/ Totals for salary, fringe benefits, bonus and per diem are for 2 inspectors.

4/ V fuel costs = Mileage per vehicle per year/miles per liter x $0.34 cost per liter.

5/ JB fuel costs = Liter fuel per year x $0.34 cost per liter.

6/ Two cartridges are issued per man per week and 2 filter pads are issued per man per day of spraying activity.

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Table II. Treatment and surveillance crew output for 1 year as measured by the number of animals treated per day.

Item	Amount
Gals./Treatment	1.9
Spray days/year	240
Animals treated	3,450
Animals scratched	11,683
Treatments/day	150

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ACARICIDE RESISTANCE

Glen I. Garris

Introduction

The development of resistance to chemicals is a constant problem in the control of ticks. Individual ticks may exist in populations, or arise as the result of gene change by mutations which are better able to deal with the chemical and are not killed. These survivors pass on this ability to their offspring. Although this ability usually derives from an altered biochemical process, the existence and inheritance of these processes are genetically controlled.

This special survival ability spreads through the population because the acaricide kills the susceptible individuals and the survival ability is inherited by the offspring of the survivors. When large proportions of the population are able to survive an application of the acaricide, the population is said to be resistant.

The first case of pesticide resistance was reported in 1914. Since that time the phenomenon of resistance has proliferated exponentially. As a result, it has become a critical component in the decision making process of tick control or eradication programs. A historical perspective is presented in Fig. 1.

Questions regarding actual or potential resistance arise in the course of evaluating an acaricide for its efficacy both in the field and laboratory. Failure to control ticks with an acaricide does not necessarily mean that the ticks are resistant.

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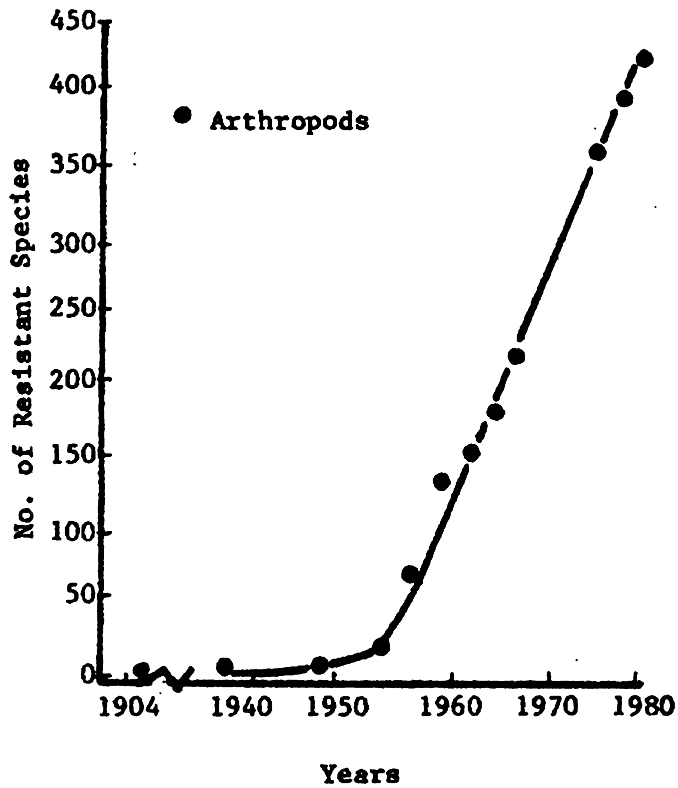

Fig. 1. Chronological increases in numbers of species of arthropods with resistance to pesticides. (Adapted from Georghiou and Mellow, 1983).

Recognition of True Resistance

Before one panics and changes the acaricide he is presently using, it is advisable to look at the following possibilities of a failure to control:

1) The build-up in tick numbers may have resulted from poor herd management and/or seasonal conditions especially favourable for tick survival. The ticks could have been mistakenly identified and the control program may not have been the correct one.

2) The failure to control may have been the result of inefficient application or incorrect acaricide concentrations used, or the acaricide could have been applied shortly before heavy rainfall, which would remove the acaricide, rendering it ineffective.

3) There could actually be a resistant population of ticks.

To determine if resistance is actually in the population, it is important to look at all other possibilities first. A detailed investigation into the method of acaricide application should be done: Did you apply the chemical to all parts of the animal? Did you use the correct concentration as directed on the label? Were there heavy rains just after applying the chemical? Was the chemical old and had it been in storage for a long time before use? Did you mix it correctly and did you mix it before taking the amount needed to set the correct concentration? Sometimes chemicals settle out in the container you purchased them in and need some mixing before use.

If you are sufficiently sure that all of the above points have been dealt with but you still see ticks that were not killed, then run a simple field test. Prepare a fresh mixture of the commercial acaricide formulation, at the label concentration, and apply it to a small group of animals that have been assessed as to the level of ticks present. This assessment can be done by

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counting the ticks on the animals in one spot or all over the animal. Be consistent, count ticks on the brisket on all animals or count the ticks in the ears, etc. Make the counts before treatment and then after treatment at 3 and 7 days. Compare the counts with the counts before treatment. If you see ticks on the treated animals, then you may have resistance! True resistance can only be determined in the laboratory following standard laboratory tests. This process is time consuming and must be carried out by trained personnel.

Methods for Determining Resistance to Acaricides

A. In Vitro Laboratory Methods

A number of methods have been developed for the estimation of susceptibility of ticks to acaricides. Laboratory techniques usually involve the use of either larval or adult ticks; however, most of the data involving resistance reports have unavoidably been obtained from larvae produced by a relatively small number of female ticks collected in the field. Practical difficulties often limit the use of larger numbers of field-collected individuals.

1. Larval and Nymphal Tests

These tests consist of two approaches: (1) immersion of the larvae in a commercial formulation of acaricide and (2) exposure of larvae or nymphs to an acaricide-impregnated surface such as filter paper (the technique developed for the FAO resistance test kit) or glass such as in a Pasteur pippette method. Although the larval bioassay system does not offer the advantage of treating larger numbers of test organisms, the methods do require incubation facilities as well as close attention to the age of the larvae, conditions of incubation, and operator techniques. Another major drawback of a larval bioassay is that the data obtained may not apply to the other stages in the life cycle.

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Although this drawback is of lesser importance in single-host ticks, where the larval bioassay has been successfully used for resistance tests and strain characterization, it is unlikely that a significant proportion of the larvae of multihost ticks will come into contact with acaricides. The validity of a larval bioassay for 3-host ticks is thus questionable.

2. Adult Tests

As in the case of larvae, there are a number of bioassay methods for adult ticks. Immersion of adults in commercial formulations of acaricides has been proposed in a number of variations. Contact with impregnated filter paper has been used to a limited extent. Total application of pesticides dissolved in an organic solvent has been recommended by the World Health Organization. The bioassay of adult ticks is certainly of obvious advantage in screening for resistance in the case of multihost parasites; however, there are a number of drawbacks to the technique. It seldom is possible to obtain sufficient adult ticks from the field for a meaningful bioassay, and those that are obtained may be in different stages of engorgement and therefore of susceptibility. The criteria of evaluation of such assays are often complex. It is difficult to assess morbidity or death in a relatively immobile engorged female tick, thus a ratio of reproductive efficiency has been suggested as an assay criterion. Such ratios are not necessarily amenable to probit analysis, and the quantal response of ability to produce one or more viable eggs is probably a better criterion.

B. Interpretation of Resistance

The presence of resistance is usually determined by comparison of the susceptibility of the strain of tick in question to that of a reference strain of the same species. Where dose-mortality relationships have been statistically analysed, the LC_{50} or LD_{50} values are used for comparison. Ticks are said to be resistant when there are great differences (by a factor of >10X) in these values.

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D. Types of Resistance

Resistance to an acaricide, or to a number of acaricides within the same chemical group, can differ significantly, and, as previously pointed out, from one strain to another of the same tick species. Characterization of any particular tick strain is therefore necessary before the status of resistance is determined.

E. Cross Resistance

Resistance to one member of a group of acaricides may result in a degree of resistance being conferred to other acaricides in the same class or in entirely different classes. This resistance across classes or in the same class is called cross resistance (Table 1).

Table 1. Cross resistance to Ixodicides by ticks.

GAMMA BHC to TOXAPHENE to GAMMA BHC
DDT to PYRETHRUM to DDT to PYRETHROIDS to DDT to PYRETHRUM
DIOXATHION to DIAZINON to QUINTIOFOS to DIAZINON to DIOXATHION
CARBARYL to ORGANOPHOSPHATES to CARBARYL
AMITRAZ to CHLORMETHIURON to CYMIAZOLE to CHLORMETHIURON to AMITRAZ

Management of Resistance

Acaricides are an important and useful tool for the control of cattle ticks; however, the continuing appearance of resistance is gradually reducing the choice of pesticides available for control of these new resistant strains. At the same time, new pesticides seem to be appearing less frequently. Added to this dilemma is the possibility that cross-resistance and multiple-resistance phenomena will eliminate large groups of chemicals (having similar modes of action or detoxification) before these can be used in the field. It is obvious that the useful life of present acaricides must be extended for as long as possible. This can be done in a number of ways, many of which involve the integration of nonpesticidal, biological, or cultural methods into tick control programs. The introduction of tick resistant cattle such as the Zebu (Bos indicus) or Zebu-European cross cattle, and the use of pasture rotation in conjunction with proper acaricide use, have been found to be the most successful strategy for management of ticks in Australia.

In other areas where several species of multihost ticks may share hosts with single-host ticks, management strategies become more complex and less easy to apply. As a result, little extension of this Australian approach has occurred in other areas. No single strategy for resistance management will succeed for any length of time and therefore a combination of strategies must be used, either together or in sequence.

Some resistance management factors are dependent on the type of animal management system used and are thus under the control of the government or livestock producer. It has been suggested that the rate of resistance build-up will be slowest if:

1. The pesticide has a short environmental life.
2. The pesticide does not have a similar mechanism of action or is not degraded by similar pathways to earlier-used pesticides.

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3. Selection is directed mainly against the least numerous stage of the pest (i.e., adults).

4. The pesticide is not applied to large areas.

5. From time to time generations are left untreated to allow for selection by factors other than pesticides.

A combination of these strategies would be ideal but are rarely attainable; however, some measures can be adopted. Use of low-persistence pesticides or formulations can be controlled through the choice of appropriate acaricides. However, the availability of a pesticide with a novel mechanism of action or degradation is not always predictable. A knowledge of the mechanism of action and degradation of the previously-used pesticide would allow for more rational choice to be made of the new pesticides. Incomplete treatment of cattle either by not treating all animals or by allowing a treatment-free period is not always practicable when dealing with control methods and disease stability and should not be done when eradication is the goal.

A further operational influence on the rate of resistance development is the dose or concentration to which the organisms are exposed. A lower dose of pesticide will slow the rate at which resistance develops. This lower dose will have little effect on the number of organisms, and ineffective control will be achieved. Use of higher doses (a dosage aimed at 99% kill of a given population) will result in a rapid rate of selection of resistant individuals; however, numbers of these resistant ticks will increase so slowly that effective control will be achieved. In a program where higher doses are used, resistant survivors may build up to economically significant levels; alternatively, it is possible that if the population is reduced to suboptimal numbers, the strain may become extinct. It is this philosophy, management by saturation, that has been successful in U.S. eradication programs.

The rate of resistance development is dependent on the frequency of selection, and a reduction in the latter would prolong the useful life of the

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acaricide. A reduced frequency of acaricide treatment of host animals is possible if a higher threshold of infestation is used or if other cultural methods of control are combined with acaricide use. This may not be possible in the case of disease vectors or multihost ticks or in an eradication program.

The use of mixtures or the alternation of pesticides of different mechanisms of action has been shown to decrease the rate at which resistance develops. Similar effects have been observed in B. microplus (Biarra strain) when chlordimeform was added to ethion in dipping vats in Australia. The use of mixtures of pesticides with different modes of action is one means of approaching the saturation management tactic without undesirable host toxicity, but also may cause cross resistance and other problems with high levels of resistance developing. Alternation of chemicals has not been reported in tick control but in many cases would not be possible where dipping is used.

At the present time a number of methods for management of tick resistance are available, and a number of other approaches to tick control show promise but lack field application data. It is also apparent that resistance is a phenomenon that is virtually inseparable from acaricide use in the long term (see Fig. 1). In the case of increasing costs for acaricides and in effectiveness and success in an eradication program, every method for postponing resistance must be developed and used.

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ANNEX VI

UNITED STATES DEPARTMENT OF AGRICULTURE
ANIMAL AND PLANT HEALTH INSPECTION SERVICE
WASHINGTON, D.C. 20250

VETERINARY SERVICES MEMORANDUM 556.5 August 6, 1975

Subject: Guidelines for Use of Spray-dip Machine for Treating Cattle

To: Area Veterinarians in Charge
Veterinary Services

I PURPOSE

Spray-dip machines have been purchased by the Animal and Plant Health Inspection Service as well as by several States. It has also been necessary on some occasions for Federal or State personnel to supervise the treatment of cattle in privately owned spray-dip machines. In recent years, the spray-dip machines have been used to treat cattle because of scabies and by owners for various ectoparasites.

This memorandum will provide guidelines and directions for operation and modification of spray-dip machines. It supersedes ANH Division Memorandum 556.5, dated May 27, 1969. It is divided into sections which should make it possible to use the pertinent sections separately whether for operation or modification.

The modifications described in this memorandum are in the interest of improved operation and greater safety to persons involved in spraying operations.

J.M. Hejl
Deputy Administrator
Veterinary Services

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NOTE: Mention of companies or products used in this publication is solely for the purpose of providing specific information and does imply recommendation or endorsement by the United States Department of Agriculture over others not mentioned.

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II ITEMS TO BE KEPT WITH THE SPRAY-DIP MACHINE

(Items 1-7 should be kept in a waterproof container)

1. Operating instructions.
2. List of permitted dips.
3. VS Memorandums on permitted dips.
4. Log Book

   A log book should be with the spray-dip machine. This book should be up to date. The book should contain a running total of the time the spray-dip machine has been operated by day and hours. Information concerning machine operating performance and maintenance shall also be entered in the book. The book should be checked each time before starting.

5. Supply of VS Form 5-56.
6. Release forms.
7. Supply of VS Form 5-56.
8. Laboratory calibrated metal measure, pint or quart.
9. Water meter (this should be calibrated periodically).
10. 30-gallon drum marked at 25-gallon level for replenishment.
11. Mask - unless issued to individual.
12. Gloves (waterproof) - unless issued to individual.
13. Protective clothing (waterproof) - unless issued to individual. (This may be either a waterproof raincoat or waterproof two piece, foul weather suit).

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III GETTING ANIMALS INTO THE SPRAY-DIP MACHINE

In order to expedite the spraying of cattle, it is desirable to have a suitable chute that is long enough (approximately 30') to hold at least six to eight animals in single file and prevent their turning around. The chute should be equipped with a sliding door or pole about 8' from the point where the cattle leave the chute and enter the spray-dip machine. A man should be kept at this gate to prevent more than one animal from entering the spray-dip machine at a time. As the animal enters the spray-dip machine from the chute, the operator closes the door and another animal is allowed into position ready to enter the spray-dip machine as soon as the operator opens the front door to discharge the treated animal.

Cattle are reluctant to enter the spray-dip machine if the front doors are closed. They enter more readily if the operator holds the front door about half-way open until the animal is well into the spray-dip machine, then flips it closed and immediately closes the back door before the animal can back out.

If the animals are released from the spray-dip machine as soon as the nozzles are turned off, they will carry out considerably more dip than if they are held about ten seconds after spraying before release.

As the operator releases the treated animal, he should immediately open the back doors so that the next animal in line could see the preceding one go out. It will generally follow with little urging.

When using the grub scrubber, a 20- or 25-foot length of 5/8" or 3/4" hose should be used. It is attached to the hose valve just above the pump.

IV LENGTH OF TIME FOR ANIMALS TO REMAIN IN SPRAY-DIP MACHINE

All cattle should remain in the spray-dip machine for ONE FULL MINUTE with the exception of calves under the age of 8 weeks. These calves should be given two 10-second sprayings with an intermediate pause.

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Cattle should receive three 20-second bursts of spray with a few seconds pause between bursts to give the animal an opportunity to breathe. If necessary, the time in the spray dip machine should be increased to assure that all of the animal's skin is wet.

The first several animals and periodically thereafter the hair of animals should be parted and close examination made to assure that the dip is reaching the skin.

V SETTING UP SPRAY-DIP MACHINE

1. Spray-dip machine should be backed into place at end of chute so that the rear doors just clear end of chute.
2. A hole should be dug under sump so that when spray-dip machine is lowered to ground it will not rest on sump.
3. Jacks should be lowered by using speed crank thereby raising spray-dip machine.
4. Remove wheels.
5. Lower spray-dip machine to ground making certain that tank is sitting absolutely level and that all jacks are solidly placed.
6. Remove draw bar.
7. Attach ramp at front of machine.

If the floor is positioned too high in the rear for the cattle to step into the spray-dip machine, a small ramp should be constructed inside the chute.

Two small chains should be used to chain the spray-dip machine to the holding chute. These are placed around the back corner jacks and then around posts of the chute.

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VI FILLING TANK

Screw the 2" plugs into the openings in the sump. The 1" plug is to be screwed into the tee at the bottom of the vertical pipe on the side of the spray-dip machine opposite the motor.

Before filling, be sure that the tank, particularly on the motor side, is free of straw, pebbles, or any other foreign material that would be picked up by the sump thereby clogging the nozzles.

THE CAPACITY OF THE TANK SHOULD BE CALIBRATED WITH A WATER METER AND MARKED AT THE 200-GALLON LEVEL AND AT 25-GALLON INCREMENTS BELOW THAT POINT.

VII LUBRICATION

1. Oil all contact points on front and back door control levers periodically.
2. Apply coating of cup grease to rollers on top of front and back doors periodically.
3. Put cup grease in tube of revolving strainer. To do this, strainer must be taken off its mounting and turned upside down.
4. Apply grease to pump packing gland periodically through zerk fittings.
5. Oil screw jacks with kerosene or distillate.

   IF OIL IS USED, THE DUST FROM THE ROAD WILL COMBINE TO FORM A PASTE AND MAKE THE JACKS DIFFICULT TO OPERATE.

Instructions for lubricating the engine are on the metal plate attached to the engine housing.

VIII BEFORE STARTING THE ENGINE

Be sure to read the instruction plate on the engine housing.

Check the oil level. Change the oil after every 50 hours of operation. Use SAE 30 in the summer and SAE 20 or 20W in the winter.

The carburetor breather should be cleaned every time the motor oil is changed, or sooner if necessary.

IX STEPS FOR STARTING ENGINE

1. Be sure that 2" main spray control valve is closed completely.
2. Open ¼" valve in ¼" pipeline running from pump to muffler of engine.
3. Close 3/4" lever handle valve in pipeline next to strainer.
4. Start engine and set throttle for full speed.

   WHEN SPRAYING, ENGINE SHOULD BE RUN CONTINUOUSLY AT FULL THROTTLE which will give an engine speed of approximately 3,000 RPM.
5. Close bottom of muffler by holding up on handle to which little metal cover is attached. Hold this handle up firmly until water is forced through muffler jet next to handle you are holding.
6. Close ¼" valve.
7. Drop handle leaving muffler open.
8. Open 3/4" valve next to strainer after which water should immediately begin to spray through small nozzle pointed at side of strainer.

THE PUMP SHOULD PICK UP ITS PRIME IN 15 TO 20 SECONDS.

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A. If Pump Will Not Prime

1. Open 3/4" hose valve just above pump.
2. Pour in a pint or two of dip which will run down into pump bowl.
3. Close valve tight and repeat priming operation.

B. If Pump Still Refuses To Prime

It is possible that there is an oil leak somewhere in the suction line or around the pump. Check to see that valves are holding, that all pipes are screwed tight, and that hose clamps in the suction line are tight. Also, check the jet casting assembly attached to the bottom of the muffler. If there is not a strong force coming from the opening at the bottom when the muffler flap is closed and the engine is running up to maximum speed, completely remove the casting assembly by:

1. Removing two cap screws which hold two parts together.
2. Swinging bottom half away by moving entire 1/4" pipe assembly a few inches.
3. Removing top half of jet casting by unscrewing it from nipple underneath muffler.

Examination will probably reveal some obstruction in the smaller chamber preventing passage of exhaust through the jet.

X AGTITATOR

After pump and engine are operating properly, check to be sure that all four holes in the agitator pipe (on floor of the tank) are open and forcing a good stream towards the centre of the tank.

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Should any of these holes become clogged, they can generally be cleaned out with a piece of wire. If necessary, pipe plugs at the end of the lines may be removed and the pipes flushed out. IT IS NECESSARY THAT THESE LINES BE KEPT OPEN AT ALL TIMES TO PROPERLY AGITATE THE DIP BATH.

XI SPRAY NOZZLES

There are 28 spray nozzles. All of the NOZZLES MUST BE KEPT OPEN AT ALL TIMES TO INSURE COMPLETE WETTING OF ANIMAL. Check nozzles every 20-30 minutes.

To inspect nozzles, with throttle at full speed, crack the main control valve slightly. This will permit a small stream of fluid to flow to each nozzle. The operator can then see if all are open. If the valve is wide open, there will be such a fog that only the top nozzles can be seen.

If any of the nozzles are clogged, remove them. They can usually be freed of any debris by tapping them on a wrench or some solid object.

XII ADDITION OF CHEMICALS

Addition of chemicals should be done only when the engine and pump are in operation so that the chemicals will become thoroughly mixed with the water. Chemicals should be slowly poured in near the agitator pipe holes.

<u>Allow a few minutes for the chemicals to become thoroughly mixed before starting the spray operation</u>.

Do not add any wetting agent, defoaming agent, detergent, or other such material to the dipping bath.

XII REPLENISHMENT OF THE DIP

NEVER ALLOW THE DIP BATH TO GO BELOW THE 7/8 STARTING LEVEL. Dip that has been premixed in the replenishment drum should be added to the vat in multiples of

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25 gallons or allowed to trickle in at a rate which will maintain level in the tank.

Each time dip is added to the vat, the top should be skimmed off to get rid of the hair and other foreign material that is floating on the surface. This is done on the side opposite the motor. If the side opposite the motor fills up and runs over, use a long-handled brush for cleaning the two screens in the vat divider.

WHEN THE DIP BATH BECOMES TOO DIRTY, DRAIN AND REFILL, or whenever the number of animals equals two times the number of gallons in the initial charge. Samples should be collected in 4-oz plastic bottles rather than collecting bath in a bucket and then pouring it into the plastic bottles. When filling the plastic bottles from the nozzle, the bottle should be held closely against the nozzle outlet.

XIV DRAINING THE SUMP AND TANK

<u>Both the dip concentrate and dipping bath are poisonous</u>. Every precaution should be taken to prevent the contamination of water supplies and the poisoning of animals, pets or people.

A. To Drain the Sump and Tank

1. Remove 2" plugs located in bottom of sump.
2. Flush and clean tank.
3. Replace 2" plugs.
4. Add about 50 gallons of water.
5. Prime pump and run a few minutes to flush and clean pipelines and nozzles.
6. Remove 2" plugs and drain.

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B. To Drain in Freezing Weather

1. Remove 2" plugs
2. Remove 1" plug from bottom of vertical pipe on right-hand side.
3. Remove ½" plug from bottom of pump bowl.
4. Leave main control valve open.

BE SURE TO LEAVE 2" MAIN VALVE OPEN TO DRAIN WHEN THE MACHINE IS NOT IN USE.

XV REVOLVING STRAINER

There is an insulated wire running from the distributor on the motor to the strainer. This wire MUST be left hanging in the centre of the strainer so that when the strainer becomes full it will ground out the motor and keep the strainer from overflowing into the tank. Be sure to check this wire occasionally to see that vibration has not caused damage to the insulation.

If the injector pipe, 1½" curved pipe above the strainer, does not flow a full stream when the motor is running at top speed:

1. Check to be sure that the pipe is down firmly in place.
2. Check to see whether debris is plugging the pipe around jet in sump.

If the trouble is elsewhere:

1. Remove 1½" pipe.
2. Disconnect union in 3/4" pipe leading to jet and remove pipe assembly.
3. Unscrew jet and remove any obstruction.

The speed of the strainer is controlled by the angle at which the stream of liquid from the fan-shaped nozzle strikes it. THE SPEED OF THE STRAINER SHOULD BE SET AT NOT LESS THAN 50 RPM OR MORE THAN 75 RPM.

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The strainer should be emptied every time the tank is refilled or sooner if necessary. It should not be allowed to become more than one-half full of debris before emptying.

A. To Remove the Strainer For Cleaning

1. Remove strainer shield, lifting it by handles.
2. Lift 1½" injector pipe off its bracket and turn to left.
3. Pull strainer away from spray-dip machine, lifting up at same time.

B. To Replace the Strainer

1. Hold bracket bearing strainer axle at an angle.
2. Strainer is then put on part way and pushed back into position until it will clear side of machine and rest on its bracket as before.
3. Replace injector pipe, checking to be sure that it rests down firmly on its hanger bracket and that it fits snugly over short section of 1¼" pipe above injector nozzle in sump.
4. Replace shield and resume operation.

If the strainer is to be emptied while the engine is running, close the 3/4" lever handle valve in the line next to the strainer. This will shut off the liquid going to the injector and the strainer nozzle. The valve should be opened as soon as the strainer is in operating position.

Occasionally, it will be necessary to add light grease to the strainer axle. To do this, simply insert about a teaspoon of grease into the 1" pipe in the center of the strainer.

XVII PUMP PACKING

Allow the packing to run loose enough so that it will continuously drip but not run in a steady stream. If the packing is too loose, air can enter around the packing and cause difficulty in priming.

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XVII SPECIAL NOTES

THE SPRAY-DIP MACHINE, AND THIS MEANS ALL PARTS, MUST BE KEPT IN GOOD REPAIR AT ALL TIMES. THE SPRAY-DIP MACHINE SHOULD BE CLEAN AND IN GOOD WORKING ORDER AND REPAIRS SHOULD BE MADE WHENEVER NEEDED. IT SHOULD BE KEPT IN CONDITION FOR USE WHENEVER NEEDED. THE SPRAY-DIP MACHINE SHOULD BE EMPTIED BEFORE IT IS TOWED AND SHOULD NOT BE TOWED AT SPEEDS IN EXCESS OF 45 MILES PER HOUR.

SAFETY REQUIREMENTS OF THE STATE IN WHICH SPRAY-DIP MACHINE IS TOWED SHOULD BE MET. THESE SHOULD INCLUDE TAIL LIGHTS, STOP LIGHTS, AND TURN SIGNALS.

THE RESPIRATOR FILTER SHOULD BE REPLACED EVERY 8 HOURS OR LESS; AND IF EXPOSED TO DIRECT SPRAY, SHOULD BE REPLACED IMMEDIATELY.

XVIII MODIFICATIONS

Spray-dip machines have been modified to meet the particular needs of the stations to which they have been assigned. Several of these modifications should be considered essential for the protection of the operator and others working around the machine and for safe towing. As the towing vehicle is not the same at every station, modifications can be made to either the towing vehicle or the spray-dip machine. If these modifications have not already been made, steps should be taken to do so.

You may wish to make additional modifications and/or additions depending upon the conditions under which the spray-dip machine is used. Such modifications and/or additions may include: (1) Painting inside of machine (using vinyl primer and epoxy enamel) to reduce corrosion, (2) reinforce points found to be weak, (3) fenders, (4) install drain cocks at water trap points to prevent freezing, (5) a walk-through foot bath to reduce mud and debris carried into the machine, (6) tabs to prevention of rotation of mixing jets, (7) water pressure gauge, (8) spirit level to assist in leveling machine, (9) stop watch and tally counter, (10) attached ramps at either or both ends, (11) a holding

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chute, (12) heavier jacks so that machine can be used without removing wheels, (13) heating system for use with lime-sulphur dips, and (14) zerk fittings.

Protection of personnel has been accomplished by modifying the spray-dip machine in such a manner as to retain the spray within the machine. The following pictures indicate the manner of modification. Rubber sheeting for use on the door and doorway may be found in a GSA Catalog. It is called -- Sheet Solid. It is 1/8" thick and 36" wide.

1. A strip of rubber 6" wide is fastened across the inside of both front and rear openings as shown in fig. 1 and fig. 2.

2. A strip of rubber 3" wide is attached to the outside edge of each of the four doors. It must be attached in a manner that will keep the rubber flap in contact with the machine when the door is closed.

3. A strip of rubber 6" wide is folded lengthwise and fastened along one edge of one door in front and rear of machine. It is attached to allow the folded portion to cover the crack between the two when they are closed. This folded rubber strip is shown in fig. 1 and fig. 5. The rubber sheeting is fastened to the machine using a metal strip for reinforcement and either stovebolts or sheet metal screws depending upon location.

4. The top of the machine is closed by the placing of three fibre glass panels over the screen guard at the front of the machine. The panels are held in place with bolts and oversized washers. The joints between the edge of the panels and the machine are caulked as shown in fig. 6. The rear portion of the top is closed by building a hinged lid which can be opened by the operator. It also has a plexiglass insert to allow the operator a view of the interior of the machine. This lid is shown in figs. 7, 8 and 9.

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5. Fig. 10 and fig. 11 show a guard rail built around the platform. Figs. 10, 11 and 12 also show a detachable ladder for use in reaching the platform.

6. Fig. 13 and fig. 14 show a ramp for the front of the machine. Fig. 13 shows point and method of attachment while fig. 14 shows the ramp in place for use.

7. Fig. 15 shows the modified spray-dip machine set up for use.

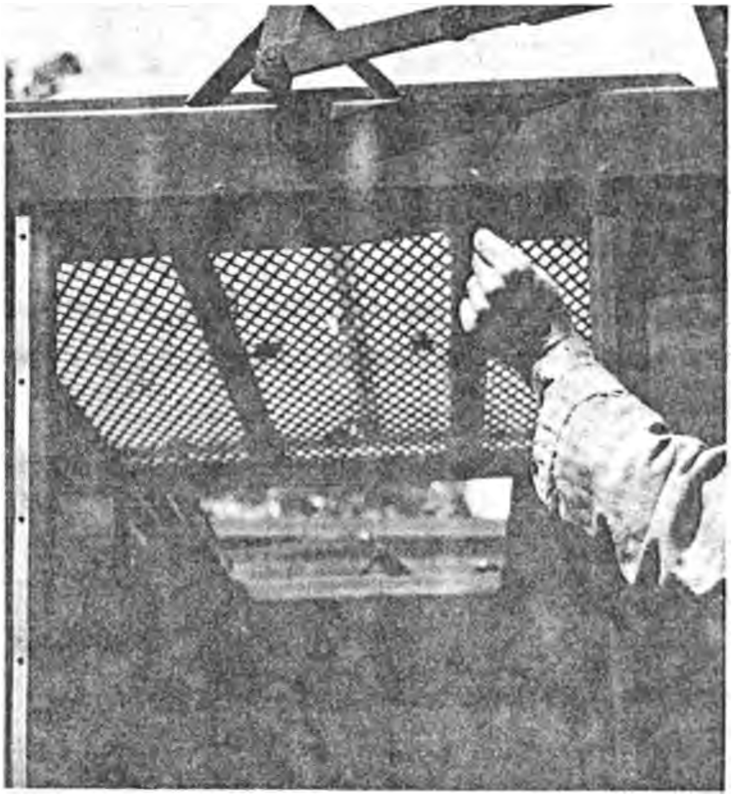


Fig. 1

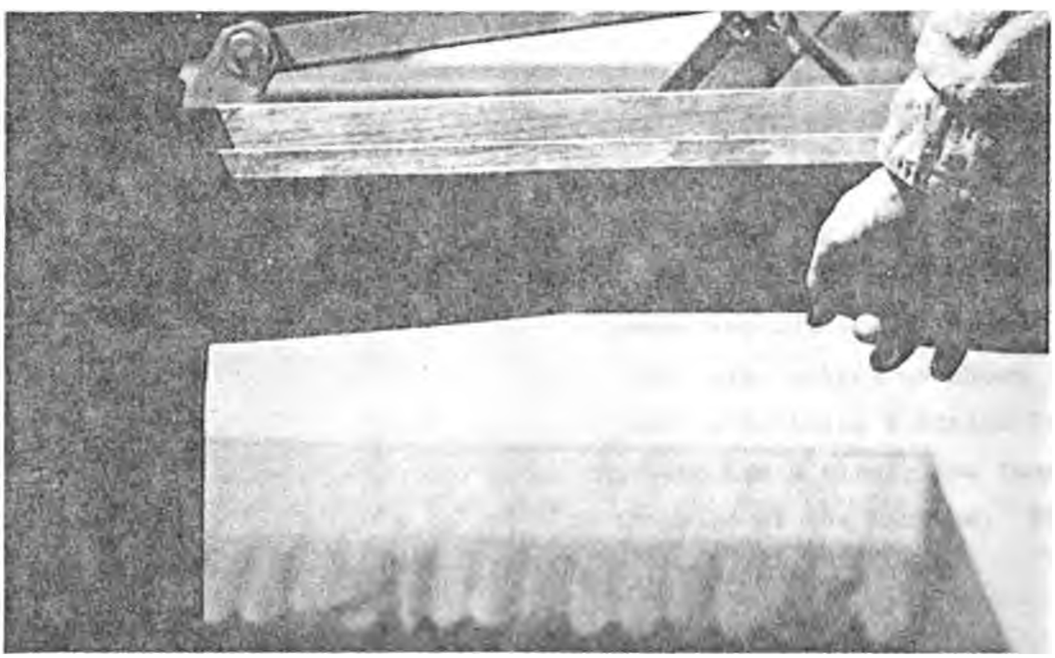


Fig. 2

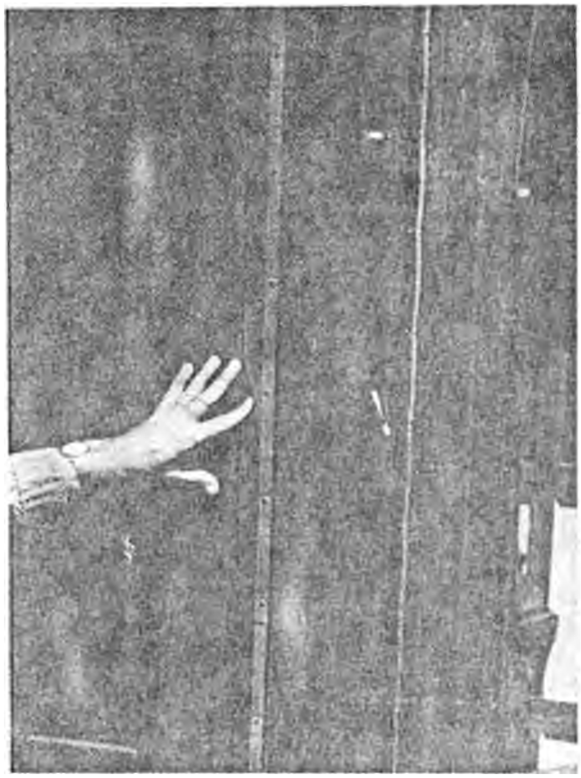


Fig. 3

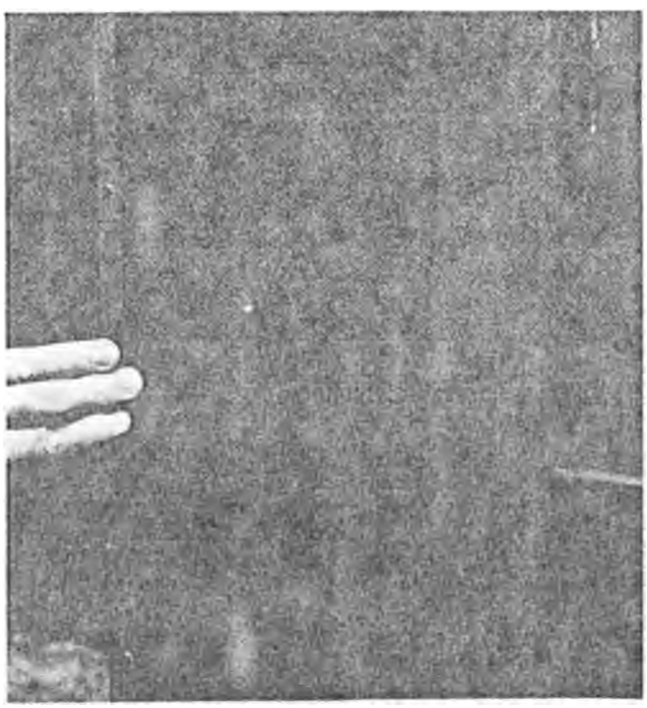


Fig. 4

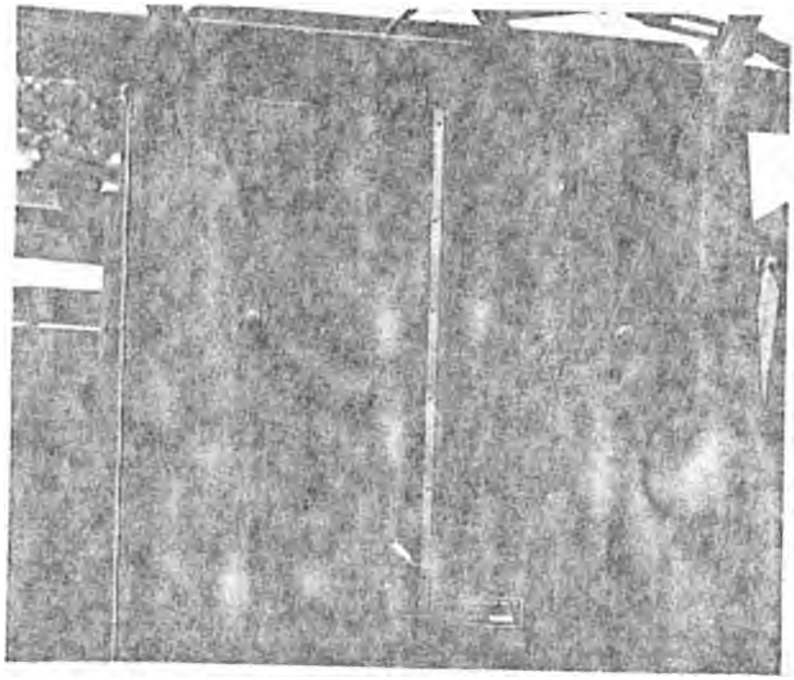


Fig. 5

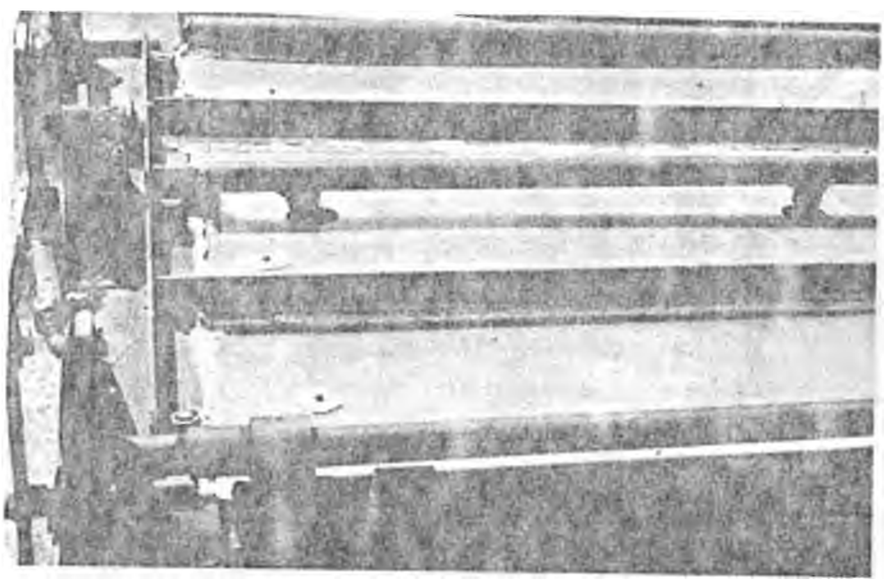


Fig. 6

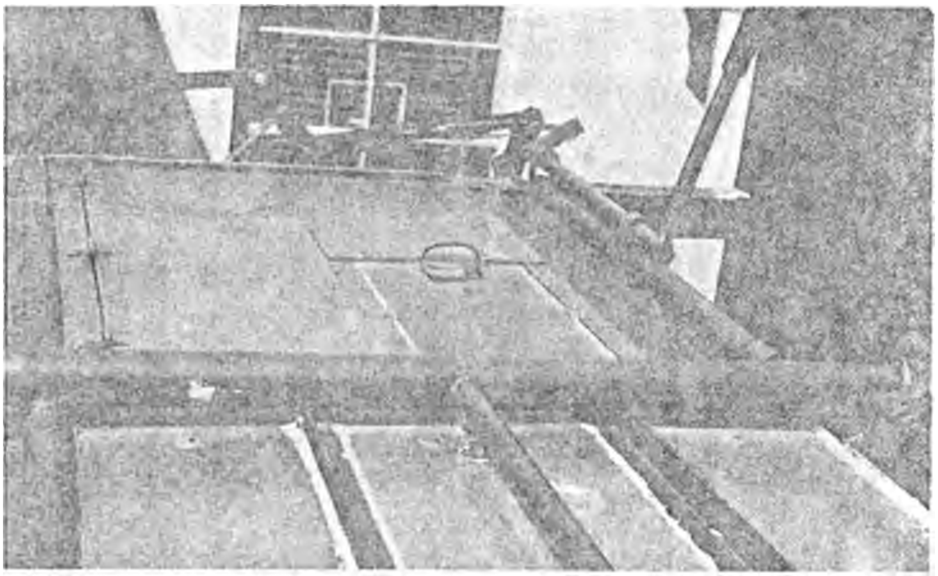


Fig. 7

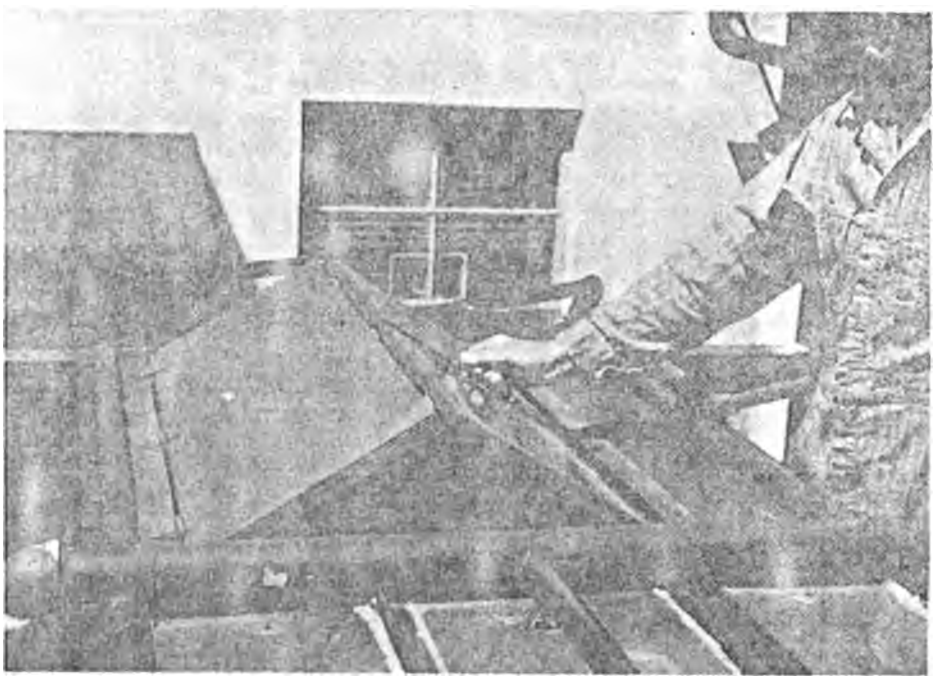


Fig. 8

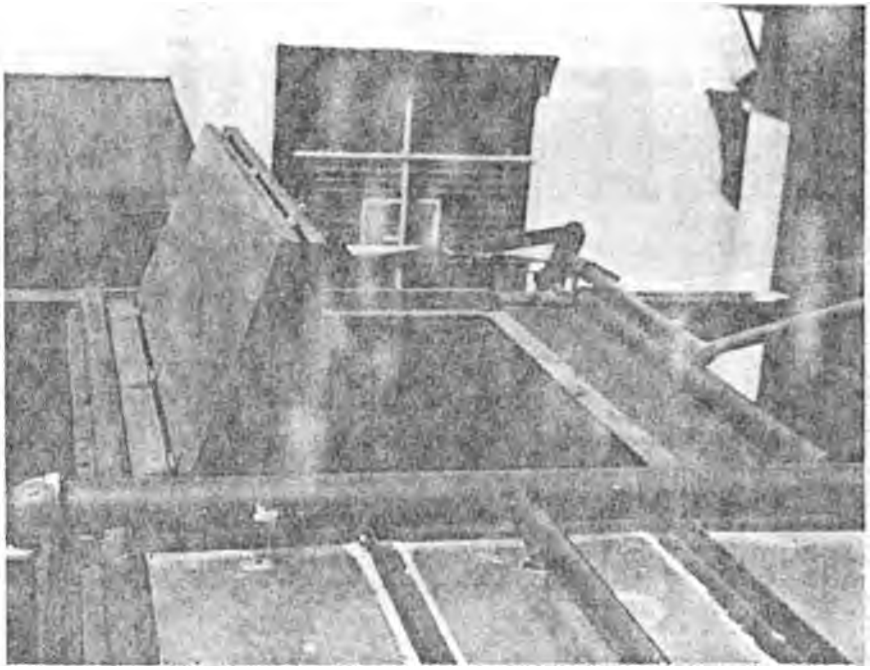


Fig. 9

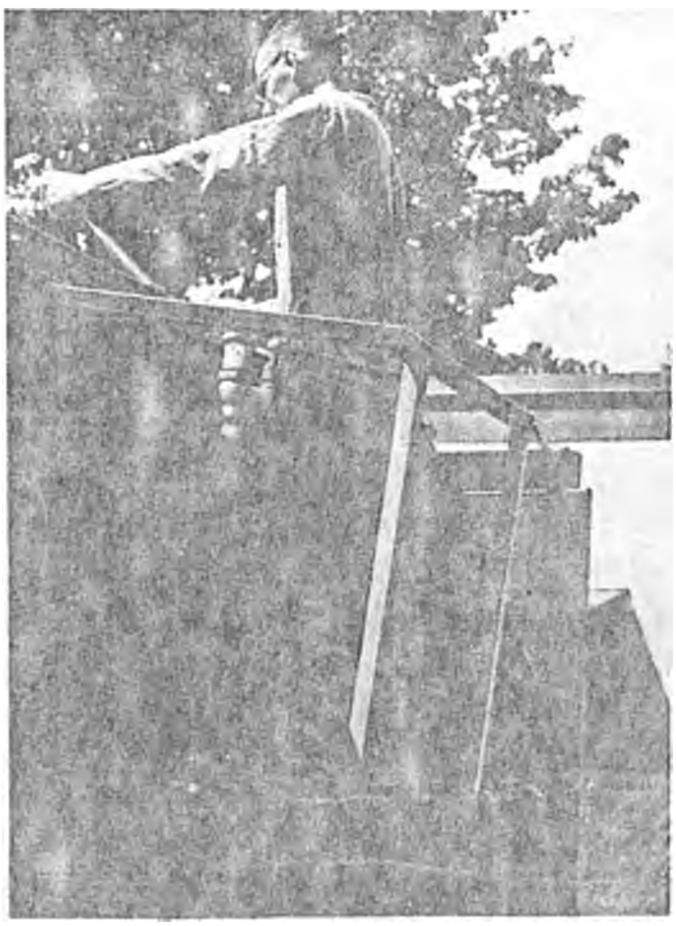


Fig. 10

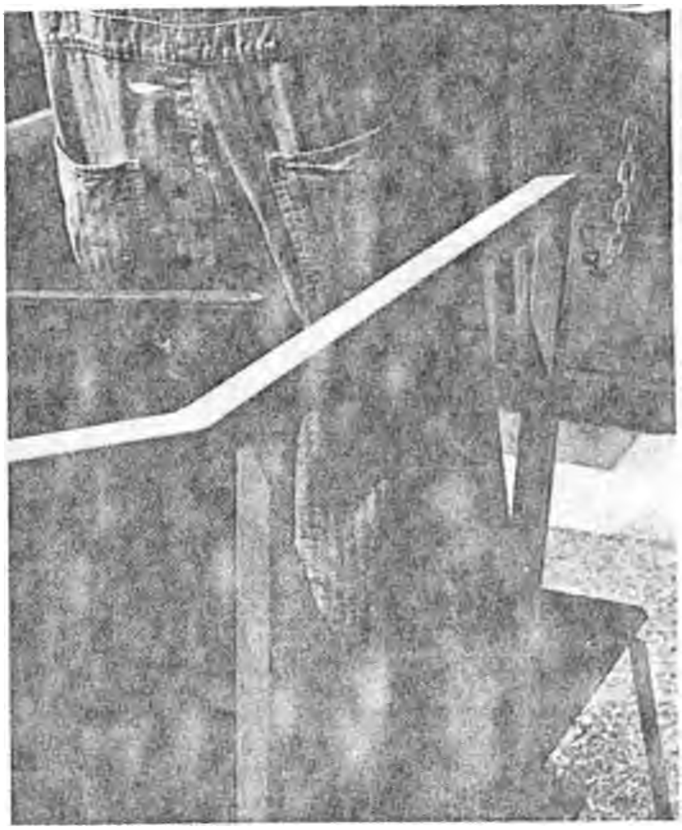


Fig. 11

Fig. 12

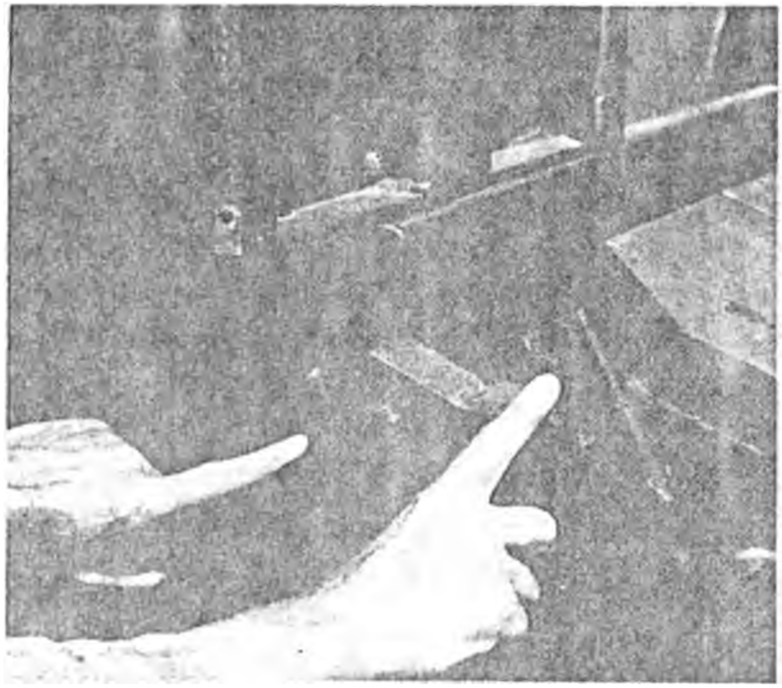


Fig. 13

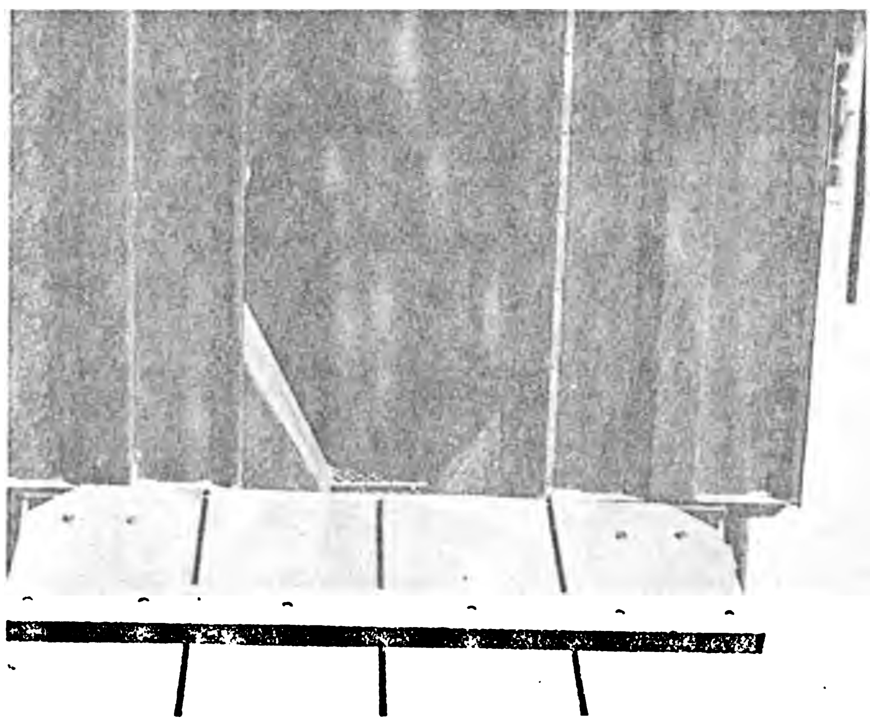
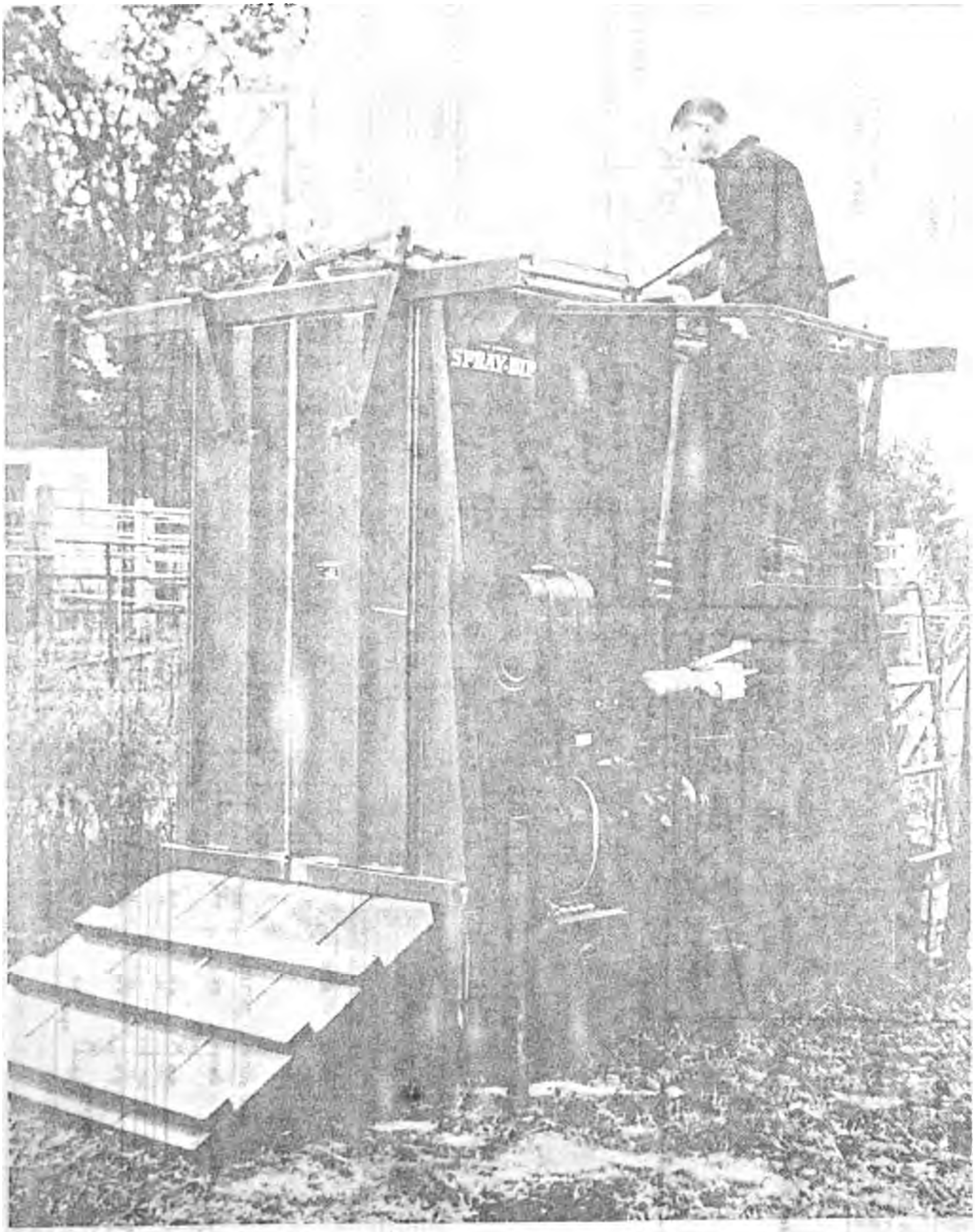
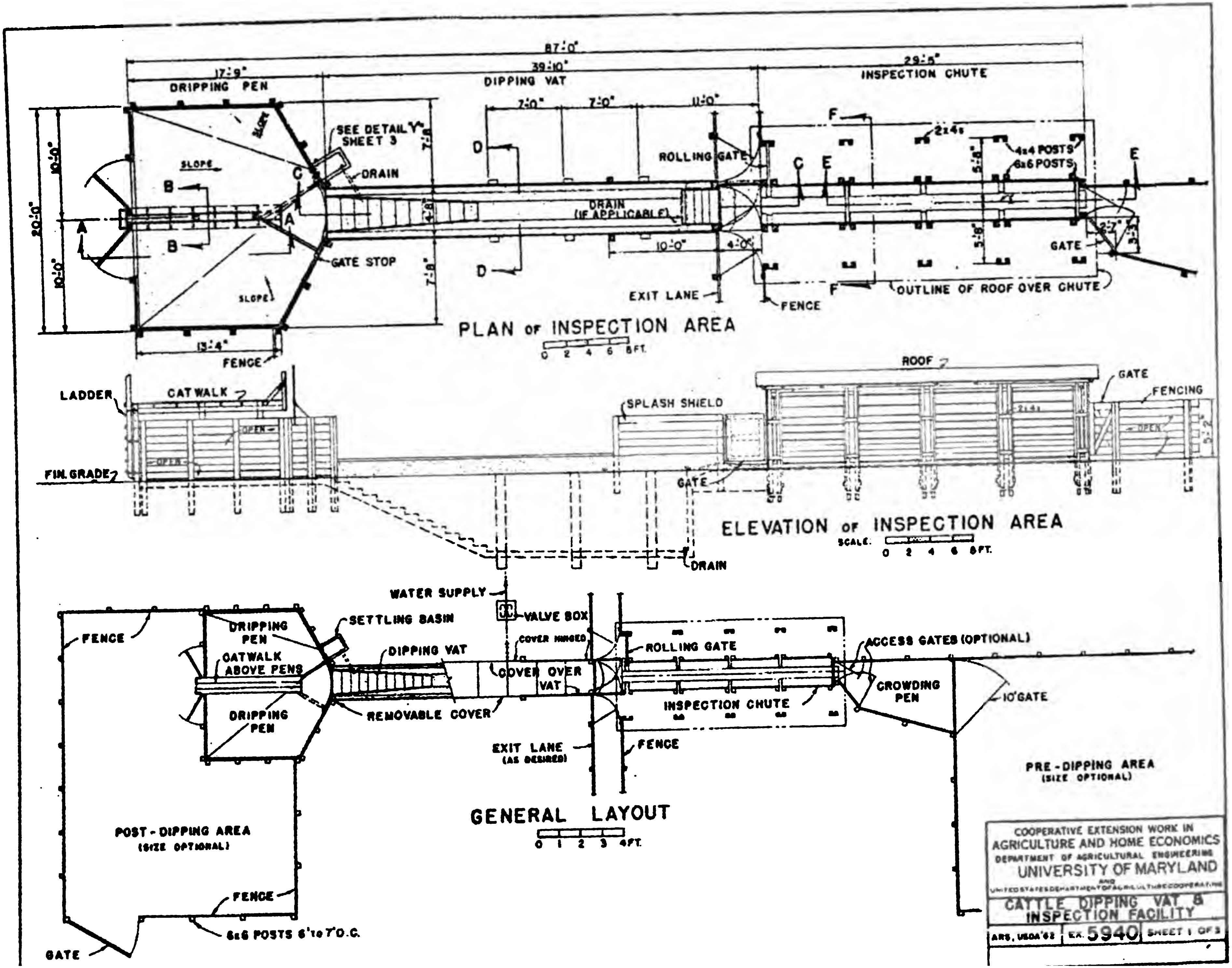
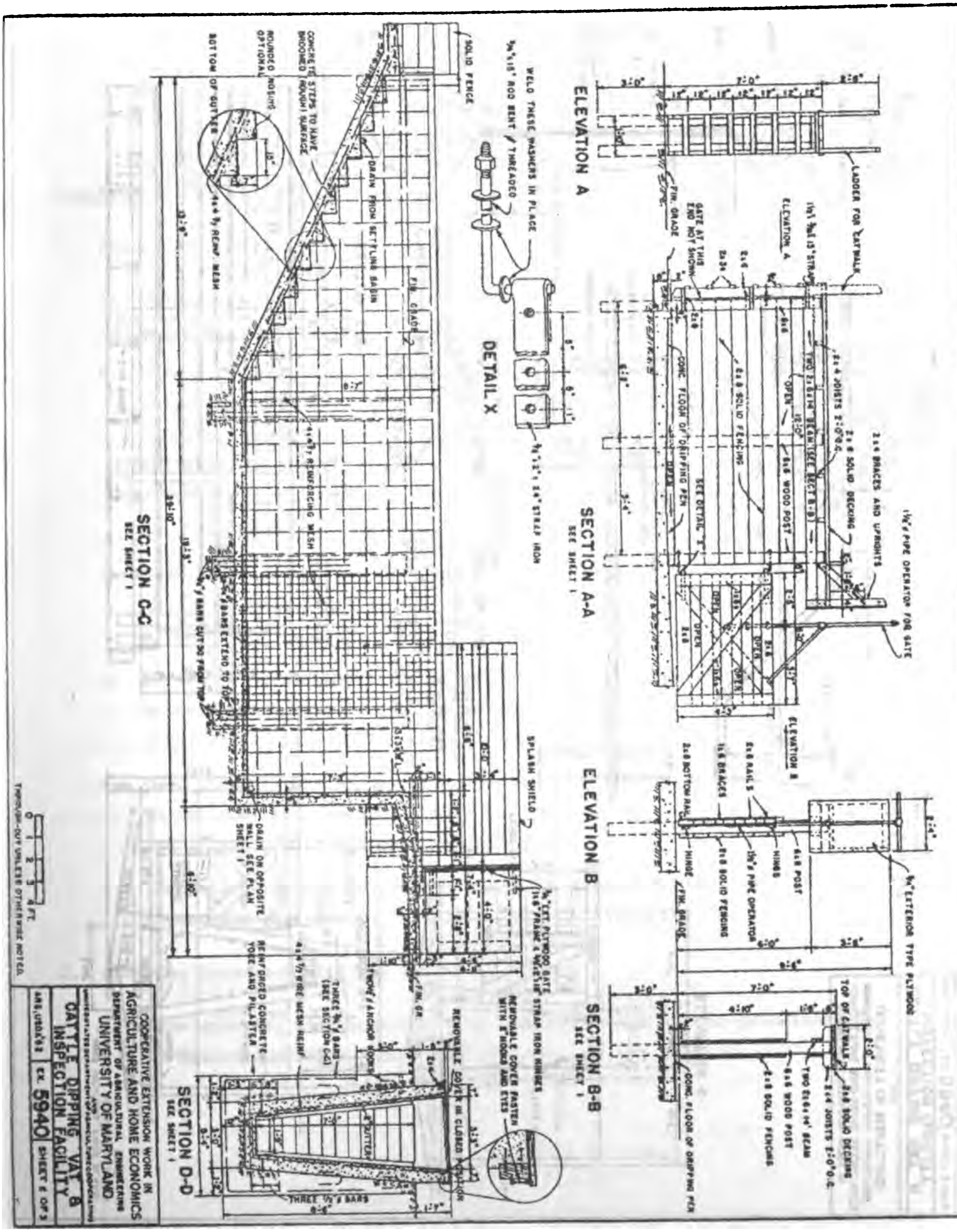
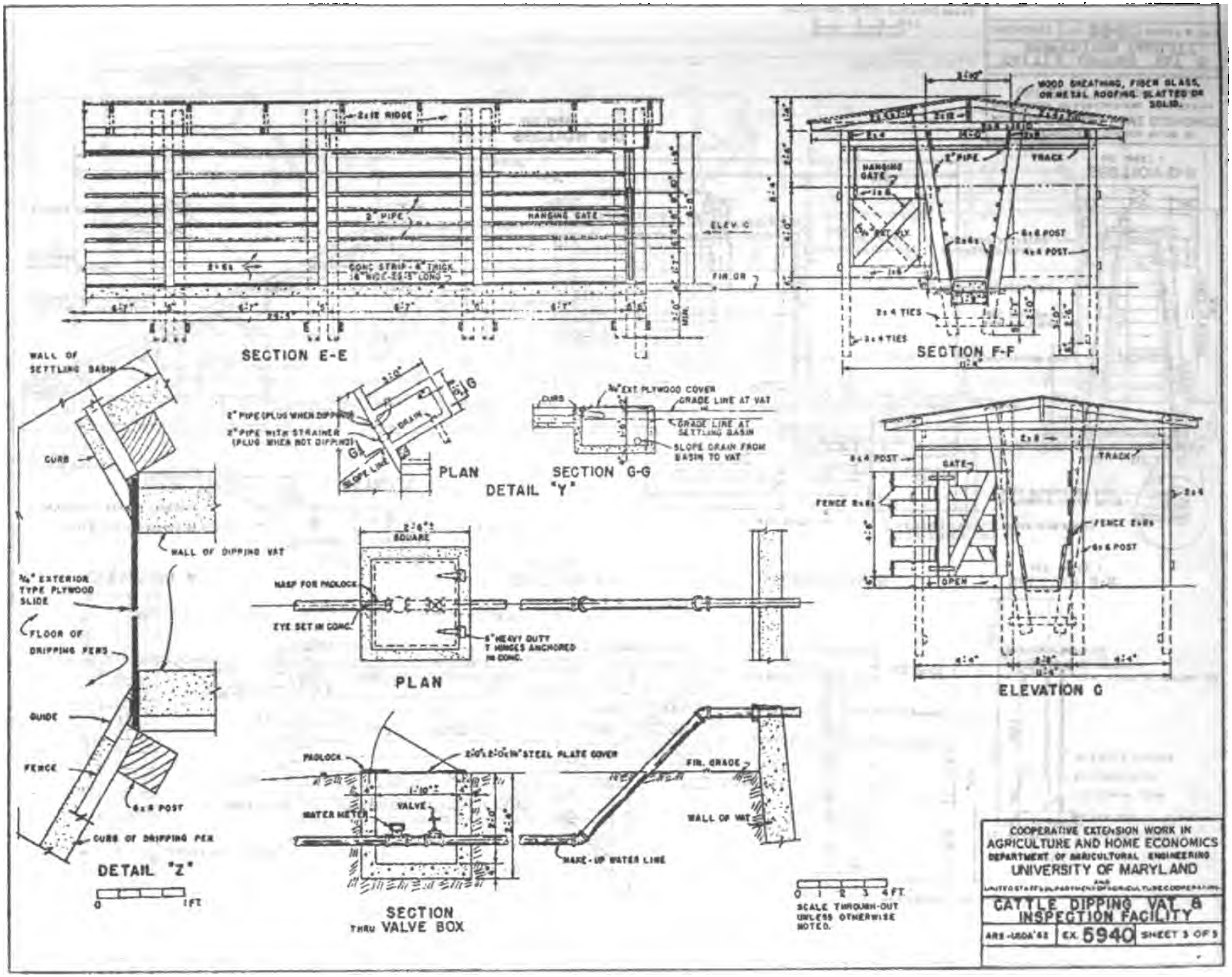


Fig. 14


SPRAY-DIP


PLAN OF INSPECTION AREA
0 2 4 6 8 FT.
87'-0"
17'-9"
DRIPPING PEN
39'-10"
DIPPING VAT
29'-5"
INSPECTION CHUTE
7'-0"
7'-0"
11'-0"
20'-0"
10'-0"
10'-0"
SLOPE
SEE DETAIL "Y" SHEET 3
DRAIN
DRAIN (IF APPLICABLE)
ROLLING GATE
2x4s
4x4 POSTS
6x6 POSTS
5'-8"
4'-8"
7'-8"
10'-0"
4'-0"
GATE STOP
GATE
EXIT LANE
FENCE
OUTLINE OF ROOF OVER CHUTE
13'-4"
ELEVATION OF INSPECTION AREA
SCALE 0 2 4 6 8 FT.
ROOF
LADDER
CATWALK
OPEN
FIN. GRADE
SPLASH SHIELD
GATE
FENCING
DRAIN
GENERAL LAYOUT
0 1 2 3 4 FT.
WATER SUPPLY
VALVE BOX
SETTLING BASIN
DRIPPING PEN
CATWALK ABOVE PENS
DIPPING VAT
COVER HINGED
COVER OVER VAT
REMOVABLE COVER
ROLLING GATE
ACCESS GATES (OPTIONAL)
CROWDING PEN
10' GATE
INSPECTION CHUTE
EXIT LANE (AS DESIRED)
FENCE
PRE-DIPPING AREA (SIZE OPTIONAL)
POST-DIPPING AREA (SIZE OPTIONAL)
6x6 POSTS 6' TO 7' O.C.
COOPERATIVE EXTENSION WORK IN AGRICULTURE AND HOME ECONOMICS
DEPARTMENT OF AGRICULTURAL ENGINEERING
UNIVERSITY OF MARYLAND
CATTLE DIPPING VAT & INSPECTION FACILITY
ARS, USDA '62
EX. 5940
SHEET 1 OF 3


ELEVATION A
LADDER FOR CATWALK
SECTION A-A
SEE SHEET I
1½"ø PIPE OPERATOR FOR GATE
2x4 BRACES AND UPRIGHTS
2x8 SOLID DECKING
2x4 JOISTS 2'-0" O.C.
2x8 SOLID FENCING
6x6 WOOD POST
CONC. FLOOR OF DRIPPING PEN
GATE AT THIS END NOT SHOWN
FIN. GRADE
OPEN
ELEVATION B
¾" EXTERIOR TYPE PLYWOOD
6x6 POST
HINGE
2x6 RAILS
1½"ø PIPE OPERATOR
1x6 BRACES
2x8 SOLID FENCING
2x8 BOTTOM RAIL
SECTION B-B
SEE SHEET I
TOP OF CATWALK
TWO 2x6x14' BEAM
6x6 WOOD POST
DETAIL X
WELD THESE WASHERS IN PLACE
SPLASH SHIELD
SOLID FENCE
DRAIN FROM SETTLING BASIN
CONCRETE STEPS TO HAVE BROOMED (ROUGH) SURFACE
ROUNDED NOSING OPTIONAL
BOTTOM OF GUTTER
REMOVABLE COVER FASTEN WITH 2" HOOKS AND EYES
REMOVABLE COVER IN CLOSED POSITION
REINFORCED CONCRETE YOKE AND PILASTER
DRAIN ON OPPOSITE WALL SEE PLAN SHEET I
SECTION C-C
SEE SHEET I
SECTION D-D
SEE SHEET I
THROUGH-OUT UNLESS OTHERWISE NOTED.
COOPERATIVE EXTENSION WORK IN
AGRICULTURE AND HOME ECONOMICS
DEPARTMENT OF AGRICULTURAL ENGINEERING
UNIVERSITY OF MARYLAND
CATTLE DIPPING VAT & INSPECTION FACILITY
EX. 5940


WOOD SHEATHING, FIBER GLASS, OR METAL ROOFING. SLATTED OR SOLID.
2x12 RIDGE
2" PIPE
HANGING GATE
CONC STRIP-6" THICK, 16" WIDE-25'-5" LONG
ELEV. C
FIN. GR.
MIN.
SECTION E-E
HANGING GATE
TRACK
6x6 POST
4x4 POST
2x4 TIES
SECTION F-F
WALL OF SETTLING BASIN
CURB
WALL OF DIPPING VAT
3/4" EXTERIOR TYPE PLYWOOD SLIDE
FLOOR OF DRIPPING PENS
GUIDE
FENCE
6x6 POST
CURB OF DRIPPING PEN
DETAIL "Z"
0
1FT
2" PIPE (PLUG WHEN DIPPING)
2" PIPE WITH STRAINER (PLUG WHEN NOT DIPPING)
DRAIN
SLOPE LINE
PLAN
DETAIL "Y"
CURB
3/4" EXT. PLYWOOD COVER
GRADE LINE AT VAT
GRADE LINE AT SETTLING BASIN
SLOPE DRAIN FROM BASIN TO VAT
SECTION G-G
SQUARE
HASP FOR PADLOCK
EYE SET IN CONC.
6" HEAVY DUTY T HINGES ANCHORED IN CONC.
PLAN
4x4 POST
GATE
TRACK
FENCE 2x8s
FENCE 2x8s
6x6 POST
OPEN
ELEVATION C
PADLOCK
STEEL PLATE COVER
VALVE
WATER METER
FIN. GRADE
WALL OF VAT
MAKE-UP WATER LINE
SECTION THRU VALVE BOX
0 1 2 3 4 FT
SCALE THROUGH-OUT UNLESS OTHERWISE NOTED.
COOPERATIVE EXTENSION WORK IN AGRICULTURE AND HOME ECONOMICS
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CATTLE DIPPING VAT & INSPECTION FACILITY
EX. 5940
SHEET 3 OF 3

PESTICIDE SAFETY - STANDARD OPERATING PROCEDURES

Bill Rodgers

Section I - Standard Field Procedures

1. Chute Spraying Livestock

   a. Chute spraying should be discontinued unless absolutely necessary to carry out the program.

   b. When it is necessary to scratch and chute spray livestock, an on site inspection should be made by the supervisor or inspector in charge of spraying operation to see if facilities furnished by the rancher are suitable for a safe and effective job. If a suitable chute is not available, then a portable chute furnished by the Department to carry out the operation in a safe and effective way should be used.

   c. When at all possible, when using portable equipment, wind direction should be taken into consideration when setting up scratching and spraying chute; wind direction and spraying chute should be parallel.

   d. During the actual spraying operation, livestock in the chute should be sprayed one side at a time to avoid spraying the inspector on the other side of the chute.

   e. Care should be taken by the inspector in charge of the spraying operation, to see that the rancher, any of his help and other inspectors are kept out of the way of the spraying solution.

   f. Inspectors engaged in chute spraying will wear the MANDATORY personal protective equipment.

2. Spraying Livestock with The Spray-Dip Machine

   a. When spraying livestock with the spray-dip machine, the guidelines in VS Memorandum 556.5 should be followed.

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b. An on premise inspection should be made by the supervisor, or inspector in charge of the spraying operation, to see that suitable facilities are available to do a safe and effective job. If suitable facilities are not available, the Department should provide a portable chute so that the operation can be carried out in a safe and effective manner.

c. The spray-dip machine operator should also charge and replenish the spray-dip machine and would be the only one required to wear the mandatory personal protective equipment.

d. When the operator needs help to charge or replenish the machine, or is relieved during the spraying operation, the helper or relief man should wear his own protective equipment. The same protective equipment should not be used by more than one inspector.

e. Care should be taken by the inspector in charge of the spraying operation to see that neither the rancher nor any of his help be exposed to the dipping solution.

f. The top doors of the spray-dip machine should always remain closed when cattle are entering machine and when the main spray valve is open.

g. Sometimes cattle will get down inside machine and must be helped out. Time should be allowed for nozzles to stop dripping dip solution before anyone enters the box. Handling wet cattle without gloves should be avoided. Anyone handling wet cattle with bare hands will wash immediately. Water trailers containing fresh water should always be available at the site of all spraying operations.

h. Supervisors should make sure that spray-dip machines are in safe working order. Top doors should be tight, front and rear openings adjusted tight enough to prevent an unnecessary amount of mist from escaping, and main spray valve not leaking.

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3. Spraying Horses (14-Day Permits or for Exposure or Movement)

   a. Horses being sprayed should be tied in such a way as to prevent injury to the animal. If horses are hand held, care should be taken to avoid spraying the holder. The owner or holder should be warned that the spray solution is poisonous.

   b. A horse put on 14-day Permit is done so as a courtesy to the owner. If the animal cannot be restrained or controlled sufficiently to spray safely, then an effective spraying job cannot be accomplished, and removal from 14-day Permit or treatment in dipping vat is recommended.

   c. Wind direction should be taken into consideration when spraying horses. Inspectors should keep the wind at their back when possible.

   d. When more than three horses will be sprayed in one place, the inspector should consider wearing rubber boots. Continuous absorption of the pesticide through contaminated leather boots is possible.

   e. Personnel should not eat, smoke or chew tobacco while spraying or handling pesticide until hands and face have been washed.

   f. Personnel should not blow through clogged nozzles, hoses, etc.

   g. Containers of Toxaphene, Del-Nav, or Co-Ral should be locked in tool box in vehicle so that they will not be broken or accessible to children.

   h. Inspectors engaged in spraying horses will be required to wear the mandatory personal protective equipment.

4. Charging and Replenishing Dipping Vats

   a. When charging or replenishing dipping vats with Co-Ral, we must remember that the powder is a concentrate that is many times more toxic than the dipping solution. Greater care must be exercised to avoid contamination.

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b. Dipping vats should be charged according to VS Memorandum 556.1.

c. Vats should be charged by emptying Co-Ral powder in the tank of a Hudson or John Bean sprayer with approximately 100 gallons of water, agitated for approximately 10 minutes and pumped into the vat.

d. When using 48 pound drums to charge dipping vats, the following procedures will reduce the hazard of handling Co-Ral concentrate:

1. Open drum and remove plastic bag containing Co-Ral Powder, carefully lay the bag on top of the spray machine tank; while holding bag closed, carefully undo wire securing open end of the bag, lower open end of bag into spraying machine tank to the water level, turn loose bag opening and gently shake out contents into spraying machine tank.

2. The four pound bags can be emptied into the spraying machine tank by gently shaking out contents while holding bag inside tank as much as possible.

3. Vat managers should always use complete bags. Two pounds more or less will not have much effect on the outcome of the strength of concentration in a dipping vat.

e. Supervisors should see that spraying machines are well maintained and ready to use when needed for charging and replenishing dipping vats.

Section II - Safety Equipment

1. The following approved personal safety equipment is furnished to each employee and should be available for use at all times.

a. A heavy metal waterproof box to store the following safety equipment.

b. Welsh respirator No. 7500-30

c. One box (6) respirator cartridges No. 7500-21

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d. One box (20) respirator filters No. 7500-23

e. Two extra filter covers No. 7500-14

f. 12" X 12" zip lock plastic bag (respirator bags)

g. One pair of clean coveralls

h. One plastic rain suit

i. Rubber boots (high top or pull over boots)

j. Rubber laboratory apron

k. One pair of heavy rubber gloves

l. Two packets of respirator detergent-sanitizer

m. One bar of hand soap

n. Name, address and phone number of nearest Poison Control Center and personal doctor

o. One pair approved pesticide safety goggles

p. A five gallon fresh water container conveniently located

Section III - Recommended Safety Procedures

1. Whether an individual needs to wear certain items of protective clothing and equipment at a particular time depends on the potential for his exposure to the pesticide. It also depends on the extent of his carelessness and his awareness of possible danger from exposure.

2. Chemical substances taken into the respiratory system ultimately reach the alveoli of the lungs. In the alveoli there is an interchange of oxygen and carbon dioxide between the blood and the lungs. The oxygen goes into the blood to supply the body with fuel and carbon dioxide is removed as waste.

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Gases and vapours that are present in the air, when spraying or handling concentrated pesticides, get taken into the lungs along with oxygen and may be absorbed by the blood. Once in the blood stream, they are deposited in the various body tissues and organs and ultimately cause a toxic action. The type of action may be chronic or acute. An acute action occurs when the concentration of the chemical is so great that some biologic system of the body is overwhelmed and can no longer perform its function. A chronic action results from exposure to lower concentrations over long time periods. Such continuous exposure may ultimately lead to disability or death. Some vapours, such as chlorinated hydrocarbons, may result in occupational cancer.

The danger of chronic poisoning is always present due to the fact that employees use pesticides on a daily basis, therefore, compliance with the recommended safety procedures could eliminate any danger of chronic poisoning.

3. It is recommended that respirators always be worn when spraying or handling pesticide concentrates as they afford the maximum protection from exposure that is practical.

4. Rubber gloves are recommended for use when spraying, handling pesticide concentrates or solutions, or anytime the hands come into contact with pesticides.

5. The approved pesticide goggles are recommended for use when pouring or mixing liquid concentrates because of the danger of accidental spilling or splashing the concentrate into the eyes.

6. Rubber laboratory aprons are recommended for use when limited spraying operations are done by employees, when pouring or mixing liquid concentrates, or cleaning or performing maintenance work on spray-dip machines and sprayers.

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7. Rubber boots are recommended for use when chute spraying, when working around dipping vats where enough splash out occurs to wet ground with pesticides, spraying horses when enough horses are sprayed in one location to wet ground with pesticide, and when pouring and mixing liquid pesticides because of the danger of accidental spilling or splashing of pesticides on boots or shoes.

8. Plastic rain suits are recommended for use when chute spraying and possibly when spraying with spray-dip machine where high winds could blow spray mists on operator.

9. Spray-dip machines and all portable sprayers should be cleaned thoroughly after each use and especially before any maintenance is done on them. Pesticide residues left on spraying equipment could be potentially dangerous to repairmen who don't know or understand the nature of the pesticide used.

10. It is recommended that employees carrying containers of Del-Nav or Toxaphene for use in charging Edge-Rite spray tanks:

    a. Use original containers and not transfer to container other than labeled container.

    b. Carry not more than 1-gallon containers unless transporting pesticide for use in charging vats, spray-dip machines or sprayers.

    c. Keep pesticide containers locked in tool box when unattended.

11. It is recommended that all pesticide containers be disposed of as follows:

    a. Fiberboard Co-ral drums should have holes punched in them and be placed in a sanitary landfill.

    b. Toxaphene gallon jugs should be rinsed a minimum of three (3) times and be broken in a sanitary landfill.

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c. Five gallon Del-nav cans or 1 gallon jugs should be rinsed a minimum of three times and have holes punched in them and be placed in a sanitary landfill.

d. Four pound Co-ral bags should be placed in a sanitary landfill, or burned on the site if in sparsely settled area, if permission is obtained from owner.

e. Empty pesticide containers should never be left lying around vats and pens and never be placed in vat disposal pits.

12. It is recommended that pesticides be stored according to VS Memorandum 556.1, Supplement No. 9:

a. Pesticides should be stored in a locked and posted place. Children and other untrained persons should not be able to get to them. The storage place should keep the pesticide dry, cool and out of direct sunlight. It should have enough insulation to keep the chemicals from freezing or overheating.

b. The storage place should be separated from housing for animals and man.

c. The fire department, or persons who would be involved in fighting fires, should be advised of the location and type of pesticides that are stored. Some pesticide formulations, when exposed to fire and water, can cause dangerous explosions or give off poisonous fumes when burning.

d. Pesticides should be stored in the original containers and away from food, animal feed or seeds. Containers should be checked often for leaks or breaks. If one is damaged the contents should be transferred to a container that has held exactly the same pesticide or placed in a clean container that is properly labeled.

e. Pesticide containers should be destroyed and disposed of immediately upon emptying.

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Section IV - Procedures for Reporting Unsafe or Unhealthful Working Conditions

1. Federal law requires that management will set up programs to protect their employees from on the job safety and health hazards:

   a. APHIS Form 250 is available, in each county office, for all employees.

   b. When a work hazard is recognised by an employee, it should be reported to the supervisor. Where the hazard is such that it is imminent danger, telephone the supervisor.

   c. The supervisor takes corrective action immediately when notified of a hazardous condition. (Corrective action should be taken at the organizational level closest to the employee's work situation).

   d. If the hazard has not been acted upon by the supervisor, the employee files APHIS Form 250, APHIS Notice of Hazard/Safety Inspection, with the designated safety and health official. Identify, in detail, the grounds for such action. The employee does not have to sign the form.

   e. The designated safety health official for your work place is Al Cagle, Regional Safety Officer, Oklahoma City, Oklahoma. Phone (405) 231-4335 FTS 736-4335.

Section V - Mandatory Safety Equipment and Procedures

1. The following safety equipment and procedures will be mandatory for the use of approved pesticides in official treatment of ticks for eradication.

2. All new employees who are to be exposed to organophosphate pesticide (Co-ral and Delnav) will have a preexposure blood sample taken, for cholinesterase level determination, before exposure.

3. All personnel exposed, even infrequently, to organophosphate compounds will have cholinesterase level determinations of no more than two (2) month intervals.

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4. Respirators: The following procedures regarding respirator maintenance and use are mandatory:

   a. Install new respirator cartridges after each 8 hours use, or more often if any odours of pesticide can be detected.

   b. When cartridges are changed, respirator face piece will be washed with respirator sanitizer and detergent, rinsed, dried, thoroughly inspected for cracks in face piece, inhalation and exhalation valves checked, and placed in a zip-lock plastic bag.

5. Respirators will be used when performing the following:

   a. The spraying of any livestock
   b. Disinfecting premises or equipment
   c. Charging or replenishing dipping vats or spraying equipment
   d. When handling any opened pesticide concentrate.

6. Goggles must be worn when performing the following:

   a. Anytime opened pesticide concentrate containers are being handled.
   b. Chute spraying any livestock
   c. Anytime employee is exposed to pesticide drift.

7. Hats, rubber or plastic rain hat or plastic hard hat, will be worn when performing:

   a. Chute spraying any livestock
   b. Anytime employee is exposed to pesticide drift.

8. Rubber boots will be worn when performing the following:

   a. Chute spraying of any livestock

   b. Performing any duty where the ground or floor becomes saturated with any dip solution or disinfectant.

   c. Pants legs will be worn outside of boot tops.

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9. Rubber aprons will be worn when performing the following:

   a. Spraying any livestock

   b. When handling opened pesticide concentrates

   c. Except when rainsuits are worn.

10. Rubber gloves will be worn when performing the following:

   a. Spraying any livestock

   b. Anytime opened pesticide concentrates are being handled

   c. When cleaning and disinfecting premises or equipment.

11. Rainsuits will be worn when performing the following:

   a. Chute spraying any livestock

   b. Anytime an employee is exposed to pesticide drift

12. An ample supply of fresh water will be available where an employee is handling any pesticide concentrate or dip solution.

13. Containers will be stored in vehicles under lock and key, except material being transported to dipping vats or spraying sites.

14. Transportation of pesticides:

   a. All personnel transporting pesticides will follow the instructions set forth in VS Memorandum 556.1, Supplement Number 9.

15. Dispose of all pesticide concentrate containers in the following manner:

   a. Glass containers will be rinsed a minimum of three (3) times and broken in a sanitary landfill.

   b. Plastic and metal containers will be rinsed a minimum of three (3) times, rendered useless by making holes in them, and placed in a sanitary landfill.

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c. Paper and fiberboard containers can be destroyed by fire in an unpopulated area, with the permission of the property owner, or rendered useless and placed in a sanitary landfill.

16. Employees will thoroughly wash all exposed skin:

a. After each spraying operation

b. After charging and replenishing spraying equipment and dipping vats

c. After every C&D operation

d. Anytime pesticides or disinfectants are handled.

17. Respirators and other safety equipment issued by VS, and other personal equipment furnished by the employee, will be inspected by the supervisor and union steward, or his representative, quarterly and the inspection documented on appropriate forms.

THE PUERTO RICAN TICK ERADICATION PROGRAM

Charles B. Suthern, D.V.M.
Gary P. Combs, D.V.M., M.P.H.

The Commonwealth of Puerto Rico is one of the easternmost islands of the Greater Antilles group of Caribbean Islands. It is approximately 100 miles long and 35 miles wide. It is bounded on the north by the Atlantic Ocean while its southern shores are washed by the Caribbean Sea. It has an area of approximately 3,400 square miles and a population of 3,500,000 people. The livestock population is estimated at 40,000 cattle herds with 600,000 head and a horse population numbering 8,000 head.

Physically, it has a central mountain chain with northern and southern coastal plains. The northern half of the Island receives more rainfall and has larger rivers than the drier southern half. The mean temperature ranges about 75 to 80 degrees the year round.

The Tick Eradication Program in Puerto Rico was established to eradicate the Tropical Cattle Fever Tick and the Bont Tick from the Island. It is a cooperative program between the Commonwealth of Puerto Rico Department of Agriculture and the U.S.D.A., A.P.H.I.S., Veterinary Services. The eradication of Boophilus microplus ticks in Puerto Rico began in 1979 after a tick free period of 20 years (1954 - 1974).

The first Tick Program in Puerto Rico began in 1936 and continued until 1941 when Puerto Rico was declared free. Surveillance continued at a low level until end of World War II when surveillance was increased. Ticks were reintroduced from St. Croix in 1950. The last ticks were collected in December, 1952 and the island was declared free in 1954. Boophilus were again recognized in January of 1978.

Taken from the Proceedings of the 88th Annual Meeting of The United States Animal Health Association, Fort Worth, Texas, 1984.

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The Amblyomma Program

In June of 1974 Amblyomma variegatum, the Tropical Bont Tick was confirmed in the Cidra-Cayey area. Surveys were made, but eradication was not started until 1981. The Tropical Bont Tick is a three host tick native of south Sahara Africa. At each stage of its development (larva, nymph and adult) this tick takes a blood meal from its host, drops to the ground and moults. It then crawls up a blade of grass and waits for a new host. This tick can harbor the agents of the rickettsial disease, Heartwater, caused by Cowdria ruminantium and dermatophilosis, a skin condition caused by Dermatophilus congolensis. It is also associated with the causative of Q Fever, Coxiella burnetti and and Tick Typhus by R. conori.

By April, 1981, 152 herds were under systematic treatment, which meant the application of Coumaphos (Coral) or Ciorid pesticide every week. This schedule was later changed to every two weeks. Trials were made with various antibiotics on livestock affected with dermatophilosis. Treatment with Coral or Ciorid and a long acting penicillin proved to be effective to control this disease. Systematic treatment was continued in the Cidra-Cayey area until March, 1983. The last Amblyomma tick was found in that area in September 1982. The area was declared Amblyomma free in July, 1984.

Amblyomma ticks were found near the municipalities of Ponce, Cabo Rojo and on the island of Vieques after they were first seen in the Cidra-Cayey area: As ticks were found, the infested premises were quarantined and put under systematic treatment. There are two premises in Ponce on which ticks still are seen. One Amblyomma male was found in Cabo Rojo and one male on the island of Vieques in 1984. At present (September 1984) only 62 premises in Puerto Rico remain under quarantine for infestation by Amblyomma variegatum.

In October 1983, an Amblyomma cajennense (Cayenne tick) was found in the Rincon area, on the western end of the island. An extensive search of the

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area was conducted and no other ticks of this species have been found. From where it originated, is still unknown.

The Boophilus Program

In January of 1978 Boophilus ticks were found in the abbatoir at Mayaguez on cattle from the San Sebastian Market. The cattle originated from a farm in Utuado. After nearly a year of survey to determine the extent of infestation, the present Tick Eradication Program was started. The island of Puerto Rico was placed under federal quarantine in 1978 as a result of reinfestation by Boophilus microplus.

Boophilus microplus, the Tropical Cattle Fever Tick, is a one host tick, which lives in tropical and sub-tropical areas of North, Central and South America, and also in Africa, Australia and tropical areas of Asia. Besides its role as vector of the agents of Babesiosis (Piroplasmosis) and Anaplasmosis, it causes anemia, weakness, loss of weight and reduction of milk production.

Puerto Rico cattle ticks develop through three stages in their life cycle. Eggs are laid by female ticks which hatch into six-legged larvae. These climb up a blade of grass and wait to contact a host animal. The larvae crawl up through the hair and take a blood meal by piercing the animals skin with its specialized mouth parts. The tick then goes through a moult on the host or drops to the ground depending on the species. Amblyomma ticks fall off and moult on the ground, while Boophilus ticks moult on the host animal. This moult produces a nymph which takes a blood meal and drops off the host if it is an Amblyomma tick, or moults in place if it is a Boophilus tick. The adult ticks mate, take a blood meal and then the female drops off to find a humid place on the ground to lay eggs. If conditions of temperature and humidity are right, the eggs will hatch quickly and the lifecycle will continue. The female Amblyomma tick will lay up to 20,000 eggs. A female Boophilus will lay up to 4,500 eggs.

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Our Tick Eradication Program is based on systematic treatment of herds for a minimum of 10 treatments (30 weeks) in order to break the reproductive cycle of the tick. The Program personnel treat all susceptible animals in the quarantine area with a suitable pesticide every three weeks. Between treatments, the livestock go out to pasture and collect more ticks which are then killed when the cattle are resprayed. Systematic treatment consists of treating every susceptible animal on a premises every three weeks without fail. The treatment cycle must not be broken. The herd owner must gather his entire herd every treatment day or the cycle will be considered broken and a new series of treatments will have to be started.

Reinfestations

Reinfestations are a major problem in this Program. Some predisposing causes in Puerto Rico are: (1) the limited area of the island where livestock can be pastured , which does not allow for vacating of pastures and (2) the high density of the livestock population. The principle cause of reinfestation is the illegal movement of cattle across the quarantine lines, from infested areas to areas under treatment. First, there is the movement of cattle by dealers and then there is the movement due to split herds. There are many dairy herds in Puerto Rico. Some of the larger herds are split into the milking line, dry cows and heifer herds. As heifers or dry cows freshen, the dairyman will want them on the line as soon as possible. If the dry cows or heifers are outside of the treatment zone, they will more than likely be ticky. (95% of cattle outside of the quarantined areas are infested). Due to the economic necessity of getting newly freshened cows onto the milking line, quarantines are violated and reinfestations occur. Since July, 1984, a 24-hour patrol of the quarantine line has been initiated and this has greatly reduced illegal movements. Puerto Rico has another movement problem. That of the movement of infested grass. In general, pastures are overpopulated and overgrazed. In times of drought food for animals becomes a problem. Herd owners

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go out along the roadsides, into vacant lots and deserted pastures, and cut grass to bring home to their livestock. This grass is often infested with ticks. It is illegal to move grass across the quarantine line. We try to stop the practice and are searching for ways to solve the problem. Livestock need the feed. Imported hay is very expensive and fumigation of this grass has proven impractical. We are investigating whether the pelletizing of hay or grass will be helpful.

There are many stray animals in Puerto Rico. Farmers with small acreage put their animals out to pasture on roadsides and in open areas. These carry ticks from vacant premises, roadsides and infested farms to herds under treatment and to herds already treated and released. The Program has constructed two detention areas for stray animals with corrals for the different species, These are located in the east and west quarantine zones. Stray animals are picked up with judicial authority, then are scratched, treated and held until claimed by the owner or auctioned off and sold for slaughter. The confiscation pens are under the control of the quarantine line patrol.

Quarantine Areas

The Puerto Rico Eradication Program has two Boophilus microplus quarantine areas, one on the eastern end of the Island with headquarters at Juncos, the other on the western end of the island with headquarters at Arecibo.

The Juncos Quarantine Station has an area of 342 square miles bounded on the east by the Atlantic Ocean. The station is divided into 4 substations: Juncos, Las Piedras, Humacao and Yabucoa. The quarantine line is 77 miles long and is manned 24 hours a day, 365 days a year. This station has been selected as the area from which expansion should proceed. The Tick Eradication Program will expand from the present area north to the Ocean, including the El Yunque National Forest and east to the Ocean. This expansion would give a north-south quarantine line which would be much shorter and more easily protected.

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By FY 1985 the quarantine area should be pushed west to a line from San Juan, and south to the Caribbean. By FY 1986 the quarantine line should have moved west to a north-south line dividing off the eastern one-third of the Island. The following year the quarantine line is projected to divide the Island in half. By FY 1989, the Program should join the quarantine line of the Arecibo station.

The Arecibo station is in the northwest corner of the Commonwealth. Its present area is about the same as that of the Juncos station. It has five sub-stations located at Isabela, Moca, Quebradillas, San Sebastian and Aguada. This quarantine zone will extend toward the south, straightening its quarantine line to a north-south direction, in order to maintain its quarantine security without draining too much the limited funds of the Program.

At present there are 1,279 herds under treatment in the Juncos station with 42, 350 animals. There is a total of 3, 501 premises in the Juncos quarantine area. At the Arecibo station there are 1,582 herds under treatment with 17,500 animals. There is a total of 4,004 premises in the Arecibo quarantine area. In FY 1984, 2,595 premises were freed of ticks in both stations and 844 premises were reinfested, leaving a net-free balance of 1,751 herds freed of Boophilus microplus.

There were 143 premises released from quarantine for Amblyomma variegatum infestation with no reinfestations.

Each of the Boophilus quarantine areas is under the direction of a Station Director who reports to the Program Director. Each of the two stations is divided into substations. Each substation is the responsibility of a supervisor. Most of the field supervisors are federal employees, some are state employees.

The field supervisors are responsible for all activity at the substations.

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They have up to 10 or 12 groups of 2 or 3 PRDA cattle tick inspectors. The groups are trained as tick inspectors who scratch animals for ticks and/or treat them with pesticides. Still other groups check animals for ticks and give movement permits if animals are free of ticks. Some work on spray dip machines, others put on ear tags to identify the animals. Each group consists of a group leader and one or two inspectors.

Around each quarantine area there exists a quarantine line which is guarded by quarantine line personnel. Personnel on the quarantine line are divided into patrols who ride the quarantine line in jeeps and cars, and treatment station personnel who operate treatment stations along the quarantine line. The treatment stations have a corral and a treatment chute where animals entering the quarantine area can be off-loaded from trucks, scratched to assure that they are tick free, sprayed preventively with an appropriate pesticide, and then reloaded. The driver then receives a permit to enter the quarantine area. If one or more of the animals is found to have ticks, the load is rejected for entry. The animals will be sprayed but denied entrance into the zone.

Puerto Rico has many hills and small dirt roads which must be travelled in order to get to the cattle farms. For this reason 4 wheel drive vehicles are used by the Program to haul the heavy equipment necessary to spray the cattle.

The cattle are treated with pesticide sprayed at 100 psi from 200 gallon high pressure spraying machines. When there are more than 50 animals in a herd of cattle, a spray dip machine is used. This is a mobile unit with a metal chamber supplied with spray jets placed in a way that pesticide can be sprayed to thoroughly wet an animal inside the chamber. An animal to be treated enters one end of the machine, the jets are turned on for 10 second blasts, then the other end opens and the animal goes out. It is economical because pesticide is recycled.

When there are many animals to be treated a hydrovat may be used. This is a portable cage which can be lowered into a pesticide solution in a stationary

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tank. Livestock are driven into the cage and lowered into the pesticide solution. It is then raised hydraulically to ground level and the livestock are let out. The hydrovat is much faster than is the spray dip machine.

There are now only 2 dipping vats in operation in Puerto Rico. A dip vat facility is under construction at the San Sebastian Livestock Market within the Arecibo quarantine zone on the western end of the Island, and others are planned. The earlier tick Program used 400 dip vats for treating livestock. Most of these have been filled in or are beyond repair.

Security and Safety

Security is an important item in the Tick Program. The Program has hundreds of thousands of dollars in pesticides, equipment and supplies. These must be kept secure from theft, vandalism and deterioration. When possible we use guard dogs for protection from theft and vandalism. They are dependable, alert and inexpensive.

The Program is very concerned for the safety of its employees. TEP employees wear protective clothing when spraying livestock. They receive more protection than is required by EPA or suggested by the manufacturer's labels. Because of their continual contact with a pesticide drenched atmosphere, employees are required to wear raingear,boots, respirator masks, goggles and gloves. The P.R. Tick Program uses the most effective and safe pesticides permitted by the EPA. In the 1936-54 program, arsenicals were used and the animals sometimes showed toxic symptoms. The EPA later prohibited use of these products. The present program started in 1979 using CoRal (Coumaphos) for beef cattle and horses. Ciorid (Crotoxyphos) was used for treatment of dairy herds. Both of these organophosphate products cause toxic reactions: reduction of the cholinesterase levels in man and animals with toxic symptoms of weakness, headaches, dizziness, incoordination, nausea, slow heart rate or an influenza-like illness. Before adequate protective measures were instituted 40% of our employees had to be shifted away from exposure to pesticide due to low cholinesterase levels. Today the Program

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uses TAKTIC (Amitraz) on all animals susceptible to ticks except horses and sheep. It uses Atroban (Permethrin) for horses, sheep and in dip vats for all species. This product is very stable in dip vats.

Atroban is used as a 0.050% solution in water and is available to the Puerto Tick Project under a 24C Registration. It can also be used as 0.5% wipe-on for application in the false nostrils of horses in the control of Dermacentor nitens, the tropical horse tick. It is of unusually low toxicity to mammalian species, has a broad pesticidal spectrum and is rapidly metabolized and eliminated so as to present little concern with potential residues in meat or milk.

Taktic is an extremely active acaricide. It has an extended residual action, being effective against all ticks at all stages of development. It acts on the metabolic processes of the tick by enzyme inhibition. This results in the stimulation of tick activity, causing it to remove its mouth parts from the animal, move itself rapidly in a disorganised manner, drop off and die. Gravid female ticks tend not to lay eggs but even eggs that are laid are not viable. Taktic is used in Puerto Rico under an EPA Section 18 Emergency Exemption.

Taktic has proved very valuable to the Program.. This product has allowed the Program to prolong the interval between treatment cycles against Boophilus ticks from 2 to 3 weeks. It is equally as effective against Amblyomma ticks. When the Program was using organophosphate products: Coral, Ciorid and Deltox, there were incidents of toxicity both in employees and livestock. Those employees working in the field were tested every two months to control their blood cholinesterase level. Any lowering of this vital blood constituent below the employee's base level was reason for his immediate removal from any contact with organophosphates.

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The Authority for the Cattle Fever Tick Program

The regulation that governs the control and eradication of Boophilus ticks is based on Puerto Rico law # 106 promulgated in 1936 and revised in 1980. It describes the structure and implementation of the Program, the duties of herd owners to the Program and establishes a quarantine for areas under treatment. Stray animals are regulated under this law, also the movement of animals, materials, feed and equipment. The law provides for inspection, treatment, surveillance and termination of quarantine of susceptible animals. It also provides penalties for violations of the provisions of the law.

Law #60 regulates in comparable manner the Program to eradicate the Tropical Bont tick, Amblyomma variegatum. Under this law, farms where Amblyomma ticks were found were placed under individual quarantine and treated.

Compliance is very good because with an average of 2,918 herds treated monthly, there were only 253 violations of these laws, prosecuted during FY 1984. This is less than 10% over the course of a year.

The Tick Eradication Program Budget

The Tick Program Budget is made up of funds from APHIS, VS, Legislated Funds from Puerto Rico (RC) and from special project funds from the Food and Nutrition Service of USDA(PAN). This last is special project money from the Block Grant which replaced food stamps in Puerto Rico.

1984 funding was as follows: There were 1.7 million dollars from APHIS, Veterinary Services, 1.25 million from legislated funds for the Puerto Rican Department of Agriculture and 8.6 million dollars from PAN funds. The total budget was 11.5 million dollars. Below is a chart showing the amount of funds budgeted for the Program since 1978.

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The full PAN funds for the 1984 budget were not approved until May 25, 1984. As a result of this late funding, vehicles, equipment and supplies, although ordered in 1984 will not arrive until FY 1985. The trucks which are badly needed will not be delivered until January 1985. In the meantime, we are using federal vehicles and some jeeps bought with PAN money. Some federal vehicles and equipment have come in from other states having excess trucks and excess cattle spraying machines. The 1985 budget will be essentially the same as 1984.

RESUME OF FINANCIAL INPUTS FROM THE BEGINNING OF THE TICK PROGRAM

	USDA APHIS VS	Other Federal	Commonwealth	
1977	$ 100,000			$ 100,000
1978	1,218,737		$ 150,000	1,368,737
1979	2,255,799	$879,854*	150,000	3,285,653
1980	1,157,762	756,101*	595,000	2,508,863
1981	1,297,461	467,128*	1,328,784	3,093,373
1982	1,674,733	3,380*	3,669,267	5,347,380
1983	2,188,733	3,100,795**	1,928,549	7,218,077
1984	1,678,006	8,694,144**	1,250,000	11,622,150

*Comprehensive Employment Act Funds

**Nutritional Assistance Plan Funds

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Fecha Devolución	Nombre del solicitante