FIGHTING BACK AT BITING FLIES

At the Knipling-Bushland U.S. Livestock Insects Research Laboratory

If there's ever been such a thing as good news about biting flies, blood-sucking ticks, and flesh-eating maggots, much of it would have come from ARS researchers in Kerrville, Texas.

Scientists there have helped livestock producers get good control of these livestock pests and reduce the amount of pesticides in use.

This month marks the 50th anniversary of ARS' Knipling-Bushland U.S. Livestock Insects Research Laboratory.

Over the past half century, Kerrville researchers have produced an arsenal of treatments to protect livestock from biting pests, benefiting farmers in the United States and around the world.

Counted among their successes are improvements to the widely used pest-control eartags for livestock, sustained-release pills called boluses for long-term control of dung-breeding flies, ways to squelch outbreaks of cattle fever ticks, vaccines to control cattle grubs and mange mites, and improved controls against ticks that spread human diseases such as Lyme disease and ehrlichiosis. The latter is a recently recognized rickettsial disease with symptoms resembling those of Rocky Mountain spotted fever.

Even before the lab was built in 1946, ARS entomologist Edward F. Knipling laid the scientific cornerstones of livestock pest control with his pioneering method to control screwworms, a plague that had decimated the southwestern U.S. cattle industry and also posed a human health threat.

Knipling hit on the idea of using irradiation to sterilize male screwworm flies, then loosing the sterilized males to mate—uselessly—with the wild female screwworm flies.

Later described as the world's first peaceful use of atomic power, Knipling's theory—and its artful execution by entomologist Raymond C. Bushland and other Kerrville researchers—was successful beyond almost everyone's expectations.

Screwworms were wiped out in tests conducted in 1955 on the island of Curaçao, off the coast of Venezuela. Shortly after that, similar programs eliminated screwworms from Florida by 1957 and across the southwestern United States in 1962.

In 1995, the sterile male technique was estimated to benefit U.S. producers in excess of $489 million annually, excluding labor costs. "Without a doubt, the screwworm eradication program is the most

In the early 1950's, entomologist Raymond Bushland (top) and technician Don Hopkins make one of their first attempts to sterilize screwworm pupae by irradiation.

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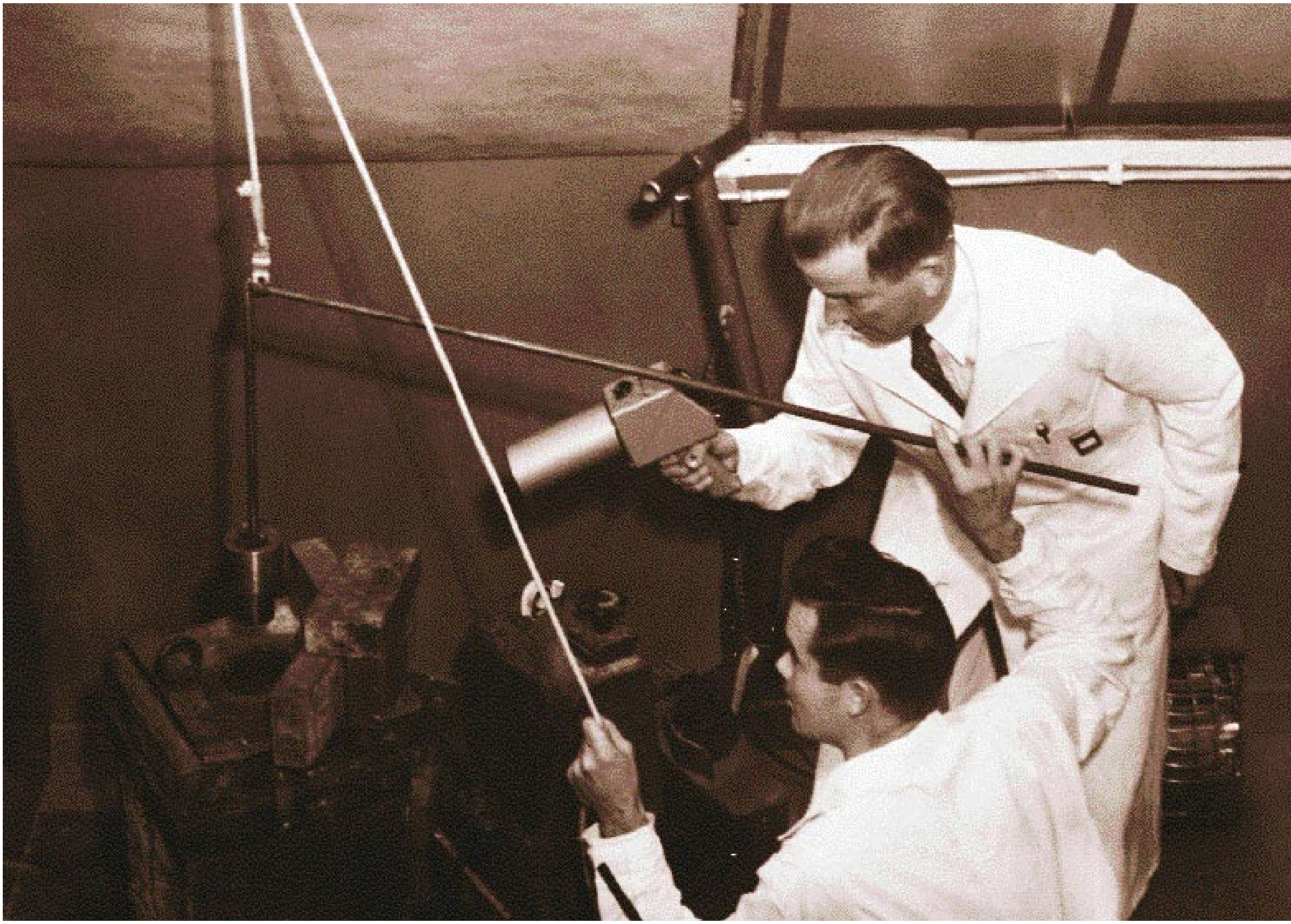

important one ever carried out in the livestock industry," says former Texas governor Dolph Briscoe, Jr., of Uvalde, Texas.

The Kerrville lab that today bears the pioneering scientists' names was built in 1946 and formally dedicated in January 1947. It was formed as a consolidation of three smaller laboratories—at Menard, Uvalde, and Dallas, Texas. Its first director was E. W. Laake, and Bushland was the assistant director.

"It was a nice, sunny day in January after we had experienced a terrible, cold spell that had lasted since December 26, 1946," recalls retired ARS scientist Owen Hugh Graham of Mission, Texas. He conducted control studies on the stable fly and horn fly at the newly opened Kerrville facility.

Quelling Cattle Fever Ticks

Today the lab conducts studies to control ectoparasites of livestock, says lab director Sidney E. Kunz.

There are two research units—a Biting Fly and Cattle Grub Research Unit under Kunz' direction and a Tick Research Unit led by John E. George. The Tick Research Unit also includes two researchers and one technician located at a facility in Mission. Their research supports cattle fever tick eradication efforts in Texas by USDA's Animal and Plant Health Inspection Service (APHIS).

As nearly 1.5 million cattle per year enter the United States from Mexico, they are routinely dipped in an organophosphate pesticide known as coumaphos.

"It's our primary means of defense against the cattle fever ticks that once nearly ruined the southern cattle industry," says George.

The cattle fever tick and the southern cattle tick were eradicated from the United States in 1946. But these ticks are still a problem for Texas ranchers because they are abundant in Mexico, including the border areas adjacent to south Texas.

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Hair loss and skin damage caused by an extensive infestation of mange mites, *Psoroptes ovis.* (K7268-14)

Additionally, the widespread occurrence in Mexico of southern cattle ticks that are resistant to coumaphos and other pesticides further complicates efforts to keep the tick out of the United States.

The main defense against the possibility of reintroducing cattle fever ticks and cattle fever into the United States is a series of dipping vats placed at the United States-Mexico border and in the quarantine zone in south Texas. APHIS administers the tick eradication program, and ARS researchers provide research support. [See "Ticked Off!" and "Cattle Take a Dip at the U.S. Border," *Agricultural Research*, April 1994, pp. 4-9.]

"We have to be increasingly vigilant in our efforts to prevent the cattle fever ticks from being reintroduced to the United States," says George.

The tick research team, using molecular genetic techniques, is looking for ways to detect pesticide-resistant ticks while testing new acaricides and devising ways to control ticks on white-tailed deer and other game animals that serve as alternative hosts for ticks.

Dipping cattle in coumaphos is currently the only treatment, in addition to hand-inspection conducted by APHIS agents at border crossings and in the quarantine zone. The dip in the vats must be replaced every 2 years, or less—depending on the number of cattle dipped. This produces large amounts of waste material, and disposing of that waste can be a problem.

Bacterial organisms that may occur in the dipping vats as oxygen is depleted gradually convert coumaphos into potasan, a compound highly toxic to cattle. To forestall this process, ARS microbiologists Jeffrey S. Karns in the Soil Microbial Systems Laboratory and Daniel R.

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Entomologists Elmer Ahrens (left) and Ronald Davey compare a sample of biofiltered coumaphos dip (left vial) with untreated solution. (K7262-9)

Shelton in the Environmental Chemistry Laboratory in Beltsville, Maryland, found that the breakdown of coumaphos could be prevented by making the vat contents more acidic.

Their solution was to add triple superphosphate fertilizer, which lowers the acidity (pH) level of the water and vat materials to under 5.5, a level that inhibits growth of the bacteria, thereby preventing degradation of coumaphos.

But acidic or not, after thousands of cattle have swum through a vat, hair and manure accumulate, and the fouled vat fluid must be removed and safely disposed of. About 100,000 gallons of spent vat fluid are generated annually in the 42 dipping vats of APHIS' Tick Eradication Program. The 1,500- to 2,000-parts-per-million (ppm) concentration of coumaphos remaining in the vat fluid presents a disposal problem.

To solve this problem, ARS microbiologists Walter W. Mulbry and Karns devised a way of cleaning the contents of dipping vats.

They designed a big tank with a pumping system to constantly recirculate the fluid through plastic filter mats. Their biofilter tank is 17 feet high by 10 feet in diameter and acts like a large aerator.

In principle, it operates the same as a trickling filter used in sewage treatment facilities, says Karns.

Armed with the aeration equipment and fertilizer and the contents of a 4,000-gallon dipping vat used in field trials, ARS researchers working at Mission have found that the level of coumaphos can be lowered by the work of beneficial bacteria to 10 ppm within about 2 weeks. Their goal is to reduce the total level of coumaphos to just 1 part per million—or less—in the spent vat material.

"There may be something nutritionally lacking in the vat material that the coumaphos-degrading bacteria need to finish the job. If we can isolate exactly what it is, we could add a waste product containing that specific nutrient," says Karns.

In spite of occasional problems with using coumaphos in dipping vats, it has been a worthy chemical for fighting a host of pests. It was one of the first organophosphates used effectively against cattle grubs.

Since the early days of the lab, Kerrville researchers have helped chemical companies test compounds. Their work has led to wide acceptance by the pesticide industry of organophosphates, the first alternative chemicals used in place of DDT. Many of these organophosphates developed from ARS-industry cooperation are still on the market today.

In the mid-1970's, technology developed by ARS and researchers at Kansas and Oklahoma State Universities gave cattle producers eartags that slowly released an insecticide. The first eartags held organophosphates that were effective against horn flies for 6 to 10 weeks. Then came pyrethroid tags that controlled the biting flies for l6 to 24 weeks.

The tags were a big hit with producers because of their convenience and effectiveness. The slow release of insecticide as delivered through the eartags reduced the amount of pesticide in the environment by 98 percent.

ARS agricultural engineer J. Allen Miller contributed to development of the tags by detailing the process of their slow release and developing design criteria to improve their efficiency.

But something happened that no one anticipated.

Because the eartags were so popular with producers and used so extensively on cattle, less-susceptible

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Insecticidal eartags work much like tick and flea collars for pets to provide long-lasting control of horn flies. (K7264-7)

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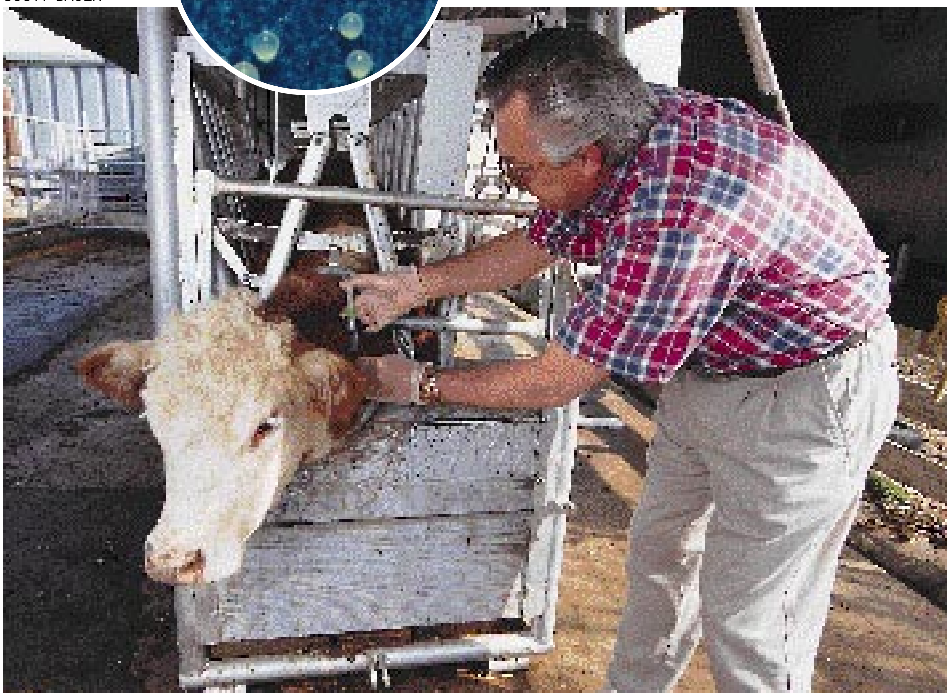

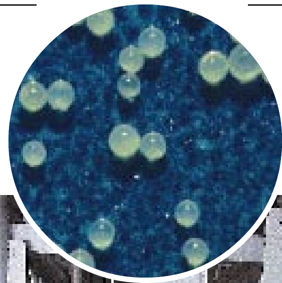

Agricultural engineer J. Allen Miller injects a suspension containing drug-releasing microspheres under the skin to control the ticks and flies that torment cattle. (K7267-6) Inset: Microscopic view of individual microspheres.

horn flies eventually became resistant to the tags' pesticides, says Kunz.

The first outcry about insect resistance came from Florida cattle producers in 1982. The Kerrville researchers responded by developing a test kit to monitor resistance in fly populations. They also recommended that if producers would periodically change from pyrethroids to organophosphates and then switch back to pyrethroids, the eartags could be retained in cattle producers' arsenal of weapons against horn flies. The pest was then costing producers about $750 million a year.

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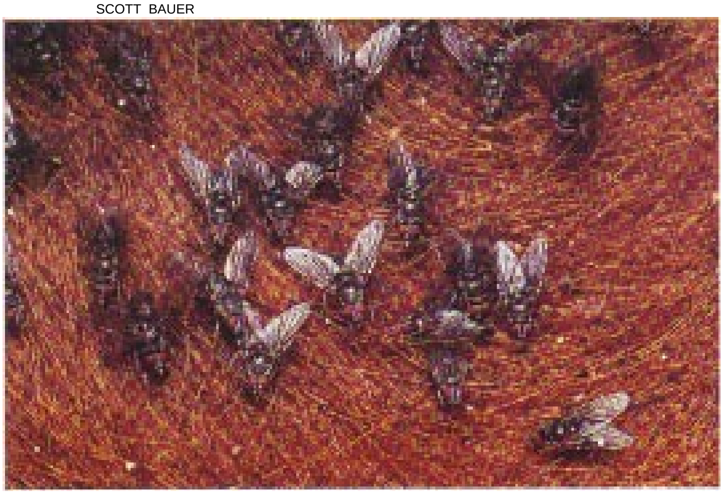

Horn flies, *Haematobia irritans.* (K7265-11)

In another improved delivery system to reduce the amount of pesticide used to control livestock pests, Miller devised a sustained-release pill called a bolus. The bolus stays in a cow's stomach, slowly delivering insect growth regulators and thwarting development of dung-breeding flies. This patented technology is the foundation of two commercial boluses being marketed today.

"This is sound technology. The drug is delivered to the manure, where the immature stages of the horn fly develop, thus preventing them from becoming adults," he says.

Miller also demonstrated that a pour-on avermectin-based insecticide can provide 35 days of horn fly control when applied to cattle during spring roundups. Another plus: The treatment also controls cattle grubs. Avermectins are relatively new compounds that work at very low doses.

In another research project that could have come straight from the pages of a futuristic novel, Miller and chemist Delbert D. Orhler have developed bioabsorbable, injectable beads containing avermectins.

These tiny microspheres—just twice the diameter of a human hair—can be injected under cattle's skin for slow release of insecticide into the bloodstream, giving up to 12 weeks of control against lone star ticks, cattle fever ticks, and horn flies.

Conventional injectable formulas control ticks for less than a week, and flies for less than 3 weeks. The pesticidal microspheres could provide an alternative to costly gathering and dipping of cattle in south Texas' quarantine zone, just across the border from Mexico.

The tick research team of entomologist J. Mathews Pound, Miller, and technician Craig A. LeMeilleur has also invented an interesting and practical way to control ticks. Their device has been dubbed the "four-poster" because its four pesticide-applying rollers resemble the corner posts of a bed.

White-tailed deer, a prime host of the tick, are lured to the four-poster with corn. When the deer poke their heads in to eat the corn, their necks rub against the rollers, and the tick-

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Slow-release insect growth regulators in the large pill (bolus) being given by animal technician Keith Shelley will prevent development of horn flies and face flies in the manure. (K7266-3)

control chemicals are applied. Since patenting in 1995, several companies have expressed interest in marketing the device.

Fending Off Grubs and Scabies

Researchers in the Biting Fly and Cattle Grub Research Unit take the same serious approach to fighting cattle grubs. These parasites damage the quality of meat and hides of infested cattle, and—if no controls were used—they could cost cattle producers about $500 million annually.

The grubs are larvae of the heel fly, which lays its eggs on the hair of a calf's leg. After the eggs hatch, the larvae burrow into the skin and make their way to the animal's esophagus. After months of parasitic feeding, the larvae tunnel to the animal's back, eat through its skin, and drop to the ground where they begin the egg-laying cycle again.

Under one of the first cooperative research and development agreements (CRADA) between ARS and industry, the Kerrville researchers discovered a source of natural immunity to the grubs and put that source to use in a genetically engineered vaccine.

The agreement between Kerrville researchers and BERLEX Biosciences, a California-based biotechnology company, resulted in a marketable vaccine within 3 years.

In a current CRADA with Mallincrodt, an Illinois-based vaccine maker, immunologist John H. Pruett and microbiologist Kevin B. Temeyer are developing a vaccine to protect cattle from scabies, a worldwide disease that can cause death in animals infested with mange mites. They've identified a protein from the mite that can be used as a vaccine to reduce mite infestation. A vaccine is needed because the only means of controlling these mites is the use of toxic pesticides.

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Immunologist John Pruett prepares chromatographic equipment for the purification of parasitic cattle grub proteins for use as possible immunogens in anti-parasite vaccines. (K7268-15)

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To obtain recombinant proteins for vaccine research, molecular biologist Kevin Temeyer and lab technician Anna Barwick clone messenger RNA isolated from ground up whole mites. (K7265-9)

For their technology transfer work, the researchers in the Biting Fly and Cattle Grub Research Unit—Kunz, Miller, John H. Pruett, Jr., Kevin P. Temeyer, Delbert D. Oehler, William F. Fisher, and Philip J. Scholl—won ARS' technology transfer award in 1992. It was followed in 1993 by the Federal Laboratory Consortium award for repellant technology transfer.—By **Linda Cooke,** ARS.

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