NATIONAL ACADEMY OF SCIENCES

EDWARD F. KNIPLING
1909–2000

A Biographical Memoir by

PERRY ADKISSON AND JAMES TUMLINSON

Biographical Memoirs, VOLUME 83

PUBLISHED 2003 BY
THE NATIONAL ACADEMIES PRESS
WASHINGTON, D.C.

E. F. Knipling

EDWARD F. KNIPLING

March 20, 1909–March 17, 2000

BY PERRY ADKISSON AND JAMES TUMLINSON

EDWARD F. KNIPLING, RETIRED U.S. Department of Agriculture entomologist and administrator died on March 17, 2000, in Arlington, Virginia, at the age of 91. He was best known for developing the sterile insect technique, which was the principal technology used to eradicate the screwworm fly from North America.

Often called "Knip" by his friends and colleagues, he was born in Port Lavaca, Texas, on March 20, 1909, and grew up on his parents' small farm. His dad assigned many chores to him on the farm, one being the odious task of doctoring baby calves that had screwworms burrowing in their navels and wounds. Another was picking cotton by hand in boll-weevil-ravaged fields. From this experience young Knipling developed an interest in entomology and later said that he decided at an early age he wanted to make a greater contribution to agriculture than treating screwworm-infested calves or pulling a sack down a cotton row. Thus, after leaving the insect-laden farming area of the Texas gulf coast he decided that entomology was the logical field for him to enter.

After graduating from high school Knip enrolled at Texas A&M College (now Texas A&M University), where he was awarded bachelor and master of science degrees in entomology in 1930 and 1932, respectively. In 1947 he was awarded a Ph.D. in entomology from Iowa State University.

Knip's career with the U.S. Department of Agriculture (USDA) began in 1930 as a field aid in the former Bureau of Entomology and Plant Quarantine, where he assisted in field studies in Mexico on the pink bollworm. In 1931 he was appointed a junior entomologist to conduct research at Menard, Texas, on the biology and control of the screwworm. The screwworm is a subtropical fly that lays its eggs in the open wounds of warm-blooded animals. The flesh-eating larvae or maggots cause suffering, death, and untold economic losses in cattle, other livestock, wildlife, and even humans. In his screwworm research assignment Knipling's talents as a scientist became obvious, as did his keen intellect for looking at old problems in a new way. By 1937 he had teamed with a young colleague, R. C. Bushland, to study the mating habits of screwworm flies. Observing that male flies mated repeatedly while female flies mated only once in their lifetime, Knip believed they had found a weak link in the screwworm's life cycle that might be exploited for control. The question was: "How?" This was a question Knip pondered for several years before finding the answer.

Knip's research in Texas on screwworms was interrupted intermittently when he was assigned to conduct research on other pest problems of livestock in Illinois, Iowa, and Georgia. In 1940 he was placed in charge of research on mosquitoes of the northwestern states with headquarters in Portland, Oregon.

During World War II Knip was given the important assignment of devising better ways for controlling the arthropod vectors (flies, mosquitoes, lice, and other biting insects) of human diseases affecting our troops. He was made director of the USDA research laboratory at Orlando, Florida, where he led the development of DDT and other insecticides and repellents for use by our armed forces and allies to control the vectors of malaria, typhus, plague, and other arthropod-vectored diseases that had exacted a tremendous toll on troops in previous wars. The laboratory was successful in its mission to develop effective control measures of the disease vectors, thus preventing infection, illness, and death of thousands of service personnel across the world. The research conducted at the Orlando laboratory received national and international recognition. Many of the repellents and methods of control for the arthropod vectors of some of the most serious human diseases are still being used throughout the world today.

During this period Knip continued to think about the screwworm problem. With imagination and innovation he conceived the idea of using sterile insects for population suppression and eradication. He reasoned that if male flies could be produced in large numbers, sterilized, and released into the environment they might out-compete, on a simple probability basis, the wild fertile males in breeding with females. Because female screwworms mate only once, those that were bred with sterile males would lay infertile eggs and thus not produce any progeny. Knip reasoned that if a sufficient number of sterile males could be released into the wild population they would essentially overwhelm and breed the screwworm population into extinction. Knip was consumed by this idea and soon began developing simple mathematical models of the population dynamics of the screwworm fly. These models convinced him that the sterile insect concept should work according to laws of probability if methods could be developed for sterilizing the males and mass rearing the flies in sufficient numbers to out-compete the fertile males when released into the field.

In 1946 Knip was placed in charge of all USDA research on insects affecting livestock, man, households, and stored products and was transferred to headquarters in Washington, D.C. From this position he encouraged Bushland who was still in Texas to pursue this line of research with the screwworm fly. They maintained frequent communication to exchange ideas and discuss new research approaches to the problem.

In the January 1950 issue of *American Scientist* Professor H. J. Muller of Indiana University in Bloomington reported that fruit flies could be sterilized by exposure to X rays. This report excited Knipling and Bushland and they decided to try this procedure on screwworm flies; however, Bushland's laboratory did not have the needed equipment, and funds were not available to purchase what was needed. Not being one to give up, Bushland smuggled insects into the X-ray laboratory of an army hospital in San Antonio, where he was a friend with some of the staff members. There he was able to use their equipment on days when the unit was not busy. He tested various dosages of X rays on the adult, larval, and pupal stages of the screwworm. He discovered that screwworm flies subjected to an appropriate dosage of X rays in the pupal stage not only survived but also emerged into healthy adults that were sexually sterile. Cage studies using both sterile and normal flies in various ratios confirmed the theory that reproduction of the screwworm could be inhibited at levels consistent with the mathematical probability models.

Part of the problem was solved. There was a way to sexually sterilize the screwworm without any serious adverse affect on their health or their ability to compete with wild males in mating with females. The other parts of the problem were: "How do you mass rear large numbers of screwworm flies and how many will be needed to suppress a field population over a large area?" Bushland was given the problem of developing methods for mass rearing the insects and improving the sterilization technology, while Knipling continued working on mathematical models to answer the question of how many flies would be needed to obtain success with sterile male releases.

In 1954 Knip was given the opportunity to test his theories when the Dutch government asked the USDA for help in controlling screwworms that were decimating the goat and dairy calf populations on the island of Curacao off the coast of Venezuela. From a rearing facility in Florida 170,000 flies a week were produced, sterilized with a gamma radiation source, and transported to and released across the island. Very soon the number of wild flies in the population was reduced; after several months and about three fly generations the population was eradicated from the island, which has remained free of infestation since 1954.

This successful demonstration that the sterile insect release method could be used to eradicate insect pest populations not only excited Knipling and Bushland but also gave their work great impetus as it excited the livestock producers in screwworm-infested areas of the United States.

During the late 1950s a much larger and more difficult test of the sterile insect release technique was made. Livestock producers in Florida gained support of federal and state agencies to conduct an eradication program in their state. By 1959 the screwworm was eradicated from Florida and all of the southeastern United States.

This success led livestock producers in Texas and Oklahoma to organize and gain support for a similar program. The producers raised a substantial amount of money for the program and were assisted by two prominent Texas ranchers, President Lyndon Johnson and Governor Dolph Briscoe of Texas, in obtaining federal and state funds and technical assistance. By 1966 the screwworm was eradicated from the United States. In 1972 the program was expanded to Mexico, where eradication was achieved in 1991. The program has since moved through all of Central America and a barrier zone is now being maintained at the Panama-Colombia border.

The eradication of the screwworm from North America was truly a remarkable achievement, both technically and economically. The benefits to livestock producers throughout the eradication zone are well over $1 billion per year. The cumulative benefits over more than 50 years, including all the economic multipliers, environmental quality, and avoidance of animal and human suffering, are too large and staggering to even estimate.

The success of the sterile insect release technique for eradicating the screwworm fly was the first successful demonstration that a pest species can be eliminated from large geographical areas with appropriate technology. Furthermore, the sterile insect technique is credited as being one of the most significant peaceful applications of nuclear radiation for the benefit of mankind. This technique has since been used to eradicate and control other pests, such as the Mediterranean and other fruit flies in California, Florida, and other parts of the world. In 1988 it was also discovered that the screwworm had been accidentally introduced into Libya and soon thousands of animals were infested. The greater threat was that the screwworm fly might infest most of Africa, causing severe losses to food animals and wildlife. The sterile insect release technique was employed, and the fly was successfully eradicated from Africa.

From 1953 to 1971 Knip was director of the USDA's Entomology Research Division, where he was in charge of all arthropod research conducted by the Agricultural Research Service. During this period great advances were made in the field of entomology and pest management, attributed to his vision and leadership in developing and promoting principles and strategies for suppressing insect pests by such techniques as sterile insect releases, pheromone traps, biological control agents, and cultural practices, with a minimal use of insecticides.

During the latter part of his career Knip became convinced that it was also possible to eradicate the boll weevil, the second scourge of his youth, from the United States. He was able to gain support for his ideas within the USDA and with cotton producer groups. A large research project was mounted in the early 1960s to develop the technology needed to eradicate the weevil, or at least eliminate it as an economic pest of cotton in the United States. During the 1960s and 1970s Knipling developed a conceptual framework for an eradication program, using a variety of techniques. His concepts were field tested in Mississippi and later fine tuned in the cotton fields of Virginia and North Carolina, where the boll weevil was successfully eradicated in 1987. Following this, eradication programs were conducted throughout the southeastern United States. The program has moved westward across the Cotton Belt, with eradication efforts currently underway in the mid-south, Texas, and Oklahoma. Eradication of the boll weevil from the United States should be accomplished relatively soon. When this is done, the use of chemical pesticides on cotton, and the consequential environmental impact, will be greatly reduced.

After retirement in 1973 and until his death Knipling remained professionally active, including serving as an unpaid consultant to the USDA's Agricultural Research Service and the Animal and Plant Health Inspection Service, where he advised on pest management programs. Throughout his 28 retirement years he continued to publish extensively, and was considered a leading authority on insect population dynamics and control. In 1979 he wrote a book on the basic principles of insect population suppression. In 1992 he wrote another book on insect parasitism from new perspectives. In these and many other publications, as well as in seminars and lectures on insect pest management, Knipling constructively questioned and challenged many conventional insect control strategies that are based on small areas, farm-to-farm applications, continued heavy reliance on insecticides, and reactive treatments after pest populations reach high levels and damage occurs. He was a strong proponent of the area-wide management of pest populations by a variety of proactive technologies. His primary theme was to prevent insect pests from reaching damaging levels by using biological and other nonpesticidal suppression methods that would not adversely impact the environment and nontarget organisms—over large geographic areas.

In addition to his many professional achievements Knipling was the patriarch of a large and active family that shared many common interests and bonds. His wife of 66 years, Phoebe, was also an Iowa State University Ph.D. graduate and was an accomplished educator in the Arlington County, Virginia, public school system. Together they had 5 children, 14 grandchildren, and 9 great-grandchildren.

Knip's professional interest in entomology and nature in general greatly influenced day-to-day life and activities of the family. For example, all of their pets were named after insects, either their common or scientific names: Siamese cats Anthonomus and Culex were named after the cotton boll weevil and a type of mosquito, respectively.

Knip was an avid outdoorsman and naturalist with a strong conservation ethic. The family owned several large properties in the mountain regions of Virginia, West Virginia, and Vermont. These properties were managed for recreation and timber production. Knip was an accomplished archer, hunter, and fisherman. He almost always caught more fish than anybody else, often self-attributed to being able to "think like a fish" and outsmart them. He even carved and painted his own fishing lures, making them look like insects, of course. His favorite was a lure that looked like a cicada; he called it "Humbug" and caught lots of fish with it.

In summary, Knipling had three main themes in his life: his family, his profession, and his great reverence for nature and love of the outdoors. In his roles as a distinguished scientist and administrator Knip significantly advanced the world's knowledge of insect pest management and alleviated some of the most important insect pest problems of agriculture across the world, in an environmentally sound manner. The scientific principles and strategies he promoted and documented are sure to continue to guide new developments in insect population management well into the future.

We thank Edward B. Knipling for helpful comments and information and Susan H. Fugate of the National Agricultural Library for assistance in locating and verifying information.

SIGNIFICANT HONORS AND DISTINCTIONS

1947 Presidential Medal for Merit
1948 King's Medal for Service in the Cause of Freedom, Great Britain
1952 President, Entomological Society of America
1966 Membership, National Academy of Sciences
Rockefeller Public Service Award
1967 National Medal of Science
Honorary doctorate, North Dakota State University

1970	Membership, American Academy of Arts and Sciences
	Honorary doctorate, Clemson University
1971	President's Award for Distinguished Federal Service
1975	Honorary doctorate, University of Florida
1986	Agricultural Research Service Science Hall of Fame
1991	FAO Medal for Agricultural Science
1992	World Food Prize
1995	Japan Prize
1996	Honorary doctorate, Texas A&M University

SELECTED BIBLIOGRAPHY

1949

Insect control investigations of the Orlando, Fla., laboratory during World War II. Smithsonian Annual Report for 1948. Publication 3968, pp. 331-48.

1955

Possibilities of insect control or eradication through the use of sexually sterile males. *J. Econ. Entomol.* 48(4):459-62.

1957

Control of screw-worm eradication fly by atomic radiation. *Sci. Mon.* 85(4):195-202.

1959

Screw-worm eradication: Concepts and research leading to the sterile male method. Smithsonian Annual Report for 1958. Publication 4365, pp. 409-18.

Sterile-male method of population control. *Science* 130(3380):415-20.

1960

Use of insects for their own destruction. *J. Econ. Entomol.* 53(3):415-20.

Plans for a comprehensive research program on the boll weevil. Summary-Proceedings: *The Cotton Gin and Oil Mill Press* 61(2):43-44.

The eradication of the screw-worm fly. *Sci. Am.* 103(4):54-61.

1962

With L. E. LaChance. Control of populations through genetic manipulations. *Ann. Entomol. Soc. Am.* 55(5):515-20.

1963

A new era in pest control: The sterility principle. *Agric. Sci. Rev.* 1(1):2-12.

Opportunities for the development of specific methods of insect control. *Proceedings of the XVI International Congress of Zoology* 7:14-26.

1966

Some basic principles in insect population suppression. *Bull. Entomol. Soc. Am.* 12(1):7-15.

1968

With J. U. McGuire. Population models to appraise the limitations and potentialities of *Trichogramma* in managing host insect populations. TB-1387. U.S. Department of Agriculture.

Technically feasible approaches to boll weevil eradication. Summary Proceedings. 1968 Beltwide Cotton Production Mechanization Conference, pp. 14-18.

1969

Concept and value of eradication or continuous suppression of insect populations. IAEA/FAO panel meeting, sterile-male technique for eradication or control of harmful insects. Vienna, Austria, pp. 19-32.

1970

Suppression of pest Lepidoptera by releasing partially sterile males—A theoretical appraisal. *Bioscience*, April 15, pp. 495-70.

1972

Use of population models to appraise the role of larval parasites in suppressing *Heliothis* populations. Technical Bulletin 1434. U.S. Department of Agriculture.

Sterilization and other genetic techniques. In *Proceedings, Symposium of Pest Control: Strategies for the Future.* Washington, D.C.: National Academy of Sciences.

Entomology and the management of man's environment. *J. Aust. Entomol. Soc.* 2:153-67.

1979

The basic principles of insect population suppression and management. ESA Agriculture Handbook No. 512. U.S. Department of Agriculture.

1983

With E. A. Stadelbacher. The rationale for areawide management of *Heliothis* (Lepidoptera: Noctuidae) populations. *Bull. Entomol. Soc. Am.* 29(4):29-37.

1984

With R. L. Ridgeway, E. P. Lloyd, and W. H. Cross. Analysis of technology available for eradication of the boll weevil. Agricultural Handbook No. 589, pp. 409-435. U.S. Department of Agriculture.

1985

Sterile insect technique for screwworm suppression—The concept and its development. ESA Miscellaneous Publication No. 62, pp. 4-7. U.S. Department of Agriculture.

1992

Principles of insect parasitism analyzed from new perspectives: Practical implications for regulating insect populations by biological means. Agricultural Research Service Handbook No. 693. U.S. Department of Agriculture.

1998

Sterile insect and parasite augmentation techniques: Unexploited solutions for many insect problems. *Fla. Entomol.* 81(1):134-60.