Biographical Sketch (Extended)

The following biographical sketch of Edward Fred Knipling includes information on the history of the efforts of the United States Department of Agriculture (USDA), Agricultural Research Service (ARS) and Animal and Plant Health Inspection Service (APHIS) to eradicate the screwworm, a parasite of livestock and other warm-blooded animals. Because Knipling's role in this eradication program was critical to its success, extensive information on the program is included in this biographical sketch.

Edward Fred Knipling (1909-2000) was a world-famous entomologist and theorist. He advocated the use of pest specific, preventive, and environmentally-safe methods applied on an area-wide basis. His contributions include the parasitoid augmentation technique, insect control methods involving the medication of the hosts, and various models of total insect population management. Knipling was best known as the inventor of the sterile insect technique (SIT), an autocidal theory of total insect population management. The sterile insect technique (SIT) controls insect populations by releasing sexually sterile males which leads to a reduced birth rate. The *New York Times Magazine* proclaimed on January 11, 1970, that "Knipling…has been credited by some scientists as having come up with the 'the single most original thought in the 20th century.'"

Knipling contributed greatly to the development of both chemical and nonchemical methods of insect control. He found that by using detergents to form oil emulsions, the volume of oil needed for suppression of mosquitoes could be greatly reduced. He discovered that internal medication allows livestock to be protected from both internal and external insect parasites; this led to the development of highly effective systemic and feed-through insecticides now widely used in livestock and poultry production. He was the first to show, in well-controlled experiments, that insecticide-resistant populations can be developed in several generations of selection by using an insecticide to eliminate the more susceptible individuals and allowing only the more tolerant individuals to provide the progeny for each succeeding generation. Knipling was an authority on the dynamics of insect populations, and he used modeling procedures to critically analyze the suppression characteristics of various methods of control, to predict how the various methods of control would influence the population dynamics of various pests, and to evaluate how control methods might be used alone, concurrently, or sequentially for optimum results. In particular, Knipling focused on the development of biomathematical principles for applying the parasitoid augmentation technique.

Knipling, or "Knip", was born on March 20, 1909, in Port Lavaca, Texas. He was the ninth of 10 children born to Henry John Knipling and Hulda Rasch Knipling. While growing up in a German-speaking Lutheran household, Knipling worked on his father's farm from childhood through college. Knipling graduated from Port Lavaca High School at the age of 17. He studied agriculture and entomology at the Agricultural and Mechanical College of Texas (now Texas A&M University). After his graduation in

1930, he continued his studies in entomology at Iowa State College (now University), where he was awarded a master of science degree two years later. Knipling later earned his doctorate from Iowa State College in 1947.

In the summer of 1934, Edward married Phoebe Rebecca Hall, whom he met while studying at Iowa State. Phoebe Knipling was a well-established scholar who at the age of 19 earned a Bachelor of Science degree from Catawba College in 1929. By the age of 23, she had earned Master of Science and doctor of philosophy degrees in parasitology and protozoology from Iowa State. Phoebe Knipling later served as the first Science Supervisor for the Arlington, Virginia, public school system. The Kniplings had five children: Anita, Edward, Edwina, Gary, and Ronald.

Knipling spent his entire career with the United States Department of Agriculture (USDA), beginning with a temporary summer job in 1930; the United States Department of Agriculture employed him for 41 years and then provided him with collaborator status for 3 additional decades. Knipling steadily rose through the ranks and held the following three very significant positions: (1) director of the Orlando Laboratory (1942-1946) on Emergency Research to protect the United States and Allied armed forces from the disease-carrying insects that spread malaria, typhus, and plague; (2) director of the United States Department of Agriculture's nation-wide research on insects affecting livestock, man, households, and stored products from headquarters at Washington, District of Columbia (1946-1953); and (3) director of the Entomology Research Division (ERD), Agricultural Research Service (ARS), headquartered at the Beltsville Agricultural Research Center, Beltsville, Maryland (1953-1971). During the 17 years that Knipling served as the Entomology Research Division director, he gave overall direction to research on insects affecting crops such as cotton, grain, forage, fruits, vegetables, ornamentals, and other specialty crops. He was able to increase the number of research scientists investigating arthropod problems to about 450 and equip these scientists with the most advanced research instrumentation while also replacing many makeshift faculties with modern laboratories.

Working as a field aid in Tlahualilo, Mexico, he studied the pink bollworm *(Pectinophora gossypiella).* The following summer, he was appointed junior entomologist at the Dallas, Texas, laboratory of the Bureau of Entomology and Plant Quarantine (BEPQ). In Dallas, he examined the biology and control of the screwworm (*Cochliomyia hominivorax*). From 1932 to 1935 Knipling worked in Illinois and Iowa researching cattle grubs, horn flies, and the common horse bot. With respect to the common horse bot, Knipling showed that when the mouth of the horse contacts fully developed eggs glued to the horse's hair, the warmth of the horse's mouth causes the larva to immediately hatch from the egg and to enter the intestinal tract of the horse. Knipling collaborated with H. G. Wells to show that horse bots could be readily controlled by applying warm water to the horse's integument causing the larvae to hatch without risk of them entering the horse's intestinal tract.

In 1935, the United States Department of Agriculture opened a new laboratory in Valdosta, Georgia, with Ernest William Laake in charge, and Knipling and Walter E.

Dove as assistant entomologists. The laboratory's mission was to assist the livestock industry in coping with the screwworm, which had been introduced inadvertently into the southeastern United States on infested cattle shipped from the southern Great Plains to save them from the severe drought of the Dust Bowl era. The team taught the farmers to manage their livestock so that operations which produce wounds attractive to screwworms (calving, castrating, branding, and dehorning) were restricted to the winter months when screwworm populations were very sparse. Knipling sought to improve the insecticidal smears used to treat wounds of livestock. He obtained preliminary evidence that the addition of the wetting agent, Turkey Red Oil (sulfated castor oil), improved the formulation sufficiently so that a single treatment often sufficed to allow the wound to heal completely. Knipling used variously colored nail polishes to mark individual wild screwworm females which visited the wounds of tethered animals. He found that a given female would first feed on the protein-rich wound exudate and then return about 2 days later to lay a clutch of eggs (usually 100 - 400) at the edge of the wound. These eggs would hatch in about 12 hours whereupon the larvae began feeding and enlarging the wound. Knipling's observations suggested that the overwintering screwworm adult population in Georgia was very sparse.

After leaving Valdosta, Knipling spent several months in the Rio Grande Valley at Edinburg, Texas, studying the overwintering of the screwworm. His data indicated that the density of screwworm populations was no more than 100 flies per square mile, and this conclusion was later confirmed in studies by Arthur W. Lindquist. Later this finding would be significant in bolstering Knipling's confidence that sufficient screwworms could be mass reared to over-flood the wild population with sterile males.

Knipling transferred to the Menard, Texas, laboratory of the Bureau of Entomology and Plant Quarantine to continue his research. He worked at Menard from 1937 to 1940 conducting research on the screwworm. The staff at Menard included Roy C. Melvin, Henry Edward Parish, and Raymond C. Bushland (with whom he later collaborated on several crucial screwworm projects). The laboratory was charged with developing formulations, or "smears," to treat animals infested with screwworms. In order to provide the ample screwworms needed to carry out new wound treatments, Bushland developed an artificial rearing system in which female flies were induced to lay eggs on a medium of hamburger meat, blood and formaldehyde; this provided several thousand screwworms per week. The smears themselves served two functions – to kill the screwworms that infested the animal and to seal the wound to reduce the chances of re-infestation. The resulting Smear 62 could accomplish both of these tasks with a single application. Yet, Knipling realized that an effective wound treatment would never fully control the screwworm fly and would always entail high labor costs. According to Knipling, "What we needed was some preventive measure." Through careful observation of the screwworms, Knipling determined that during the first day of life as adults the flies frantically attempted to escape from the cage, on the second day they fed, and on the third and fourth days they mated. The males repeatedly attempted to mate with the females, but the females would not submit to a second mating. Knipling concluded that if a means could be found to sexually sterilize the aggressive males, sufficient numbers could be released to strongly suppress reproduction in the wild population. In this way livestock could be protected without having to treat wounds.

While at Menard, Knipling formulated an autocidal method of insect control which involved overwhelming the wild populations with genetically altered or sterile males to either suppress or eradicate the total population in an ecologically isolated region. This controversial method became known as the sterile insect technique (SIT). It had three main components:

- mathematical modeling (conceived by Knipling) that predicts the probability of sterility when an uncontrolled wild population is subjected to releases of sexually sterile insects at an initial over-flooding ratio, which assures a decline in the number of progeny produced in the target population;
- a mechanism for mass rearing the number of insects necessary to overwhelm the natural population (which was developed by Melvin and Bushland); and
- a method for sexually sterilizing the mass-reared insects (which eluded scientists until Hermann Joseph Muller's irradiation studies in 1950).

In 1940, Knipling was placed in charge of a station of the Division of Insects Affecting Man and Animals in Portland, Oregon. At this post, he investigated mosquito populations of the Pacific Northwest. Knipling and his team greatly improved larvicidal oil formulations so that they would control not only the larval stages but also the pupae. The United States then entered World War II and Knipling's work took a new direction.

In 1942, Knipling was called to lead a team of scientists in Orlando, Florida. The staff at Orlando included Raymond C. Bushland and Arthur W. Lindquist (who was also involved with screwworm research in the 1930s). The team's task was to find methods to control insect populations that transmit diseases such as typhus, malaria, and plague to the United States and Allied forces. This emergency research was undertaken jointly by the United States Department of Agriculture and the Department of Defense with supplementary funding provided by the Office of Scientific Research and Development of the National Emergency Council. The strategic plan for the research was developed in the United States Department of Agriculture's Bureau of Entomology and Plant Quarantine by Fred Corry Bishopp, Emory Clayton Cushing, and H. H. Stage.

Initially, Knipling was placed in charge of the research on human lice, vectors of typhus. Within six months, the team had developed a synergized pyrethrum louse powder designated "MYL," which controlled body lice, head lice, crab lice, fleas, bedbugs and chiggers. MYL louse powder and *dichloro-diphenyl*-trichloroethane (DDT) were used to break a typhus epidemic in Naples, Italy. This was the first time in history that a typhus epidemic was abruptly controlled by means of insecticidal treatments. Knipling was promoted to Laboratory Director in June 1942. The arousal of high morale in the staff conducting secret work was paramount. He stimulated discussion between team members by instituting technical discussions during the lunch hour each day. Moreover, on most Sunday afternoons the entire team gathered at the Knipling home to enjoy home-made ice-cream and to socialize.

In November 1942, the laboratory obtained an insecticidal preparation from the J. R. Geigy Company labeled as "Gesarol Dust Insecticide". This material was analyzed and found to contain *dichloro-diphenyl-trichloroethane* (DDT). A 10 percent *dichloro-diphenyl-trichloroethane* powder was prepared and found to control lice for many weeks. The Food and Drug Administration concluded that *dichloro-diphenyl-trichloroethane*, which is not readily absorbed through skin, was safe for use on people. In May 1943 the laboratory recommended *dichloro-diphenyl-trichloroethane* to the armed services as a louse powder and clothing impregnant. *Dichloro-diphenyl-trichloroethane* was used with astonishing effectiveness against lice in the North African war theater and widely used against mosquitoes in all theaters of the war.

Most of the effort of the Orlando laboratory was devoted to mosquitoes, and greatly improved larvicides, adulticides, repellents, and aerial application technology were developed. The "aerosol bomb" with *dichloro-diphenyl*-trichloroethane and pyrthrin was invented for use in eliminating mosquitoes from tents, rooms, buildings and aircraft. The greatest single advance in the control of insects of medical importance was the development of the residual treatment concept of mosquito and mosquito-borne disease control. The Orlando team found that pyrethrins, *dichloro-diphenyl-trichloroethane* and other toxicants applied to the interior surfaces of buildings were very effective in killing adult mosquitoes, which readily enter treated buildings. By resting on the treated surface, mosquitoes accumulate fatal doses of insecticide by the time they begin to leave the building. This stratagem not only provides relief from biting, but also largely prevents mosquitoes from carrying disease organisms from one infected person to another. Therefore such residual insecticide treatment was recommended to the armed forces, and later it became the basis of the Global Malaria Eradication Campaign.

After the war, Knipling returned to Iowa State where he earned his Ph.D. in entomology. In 1946, Emory Clayton Cushing retired from the position of Chief of Insects Affecting Man and Animals Branch and Knipling was chosen to replace him. From 1946 to 1953, Knipling directed, from headquarters at Washington, District of Columbia, the Department's nation-wide research program on insects affecting livestock, man, households, and stored products. While in this position Knipling consolidated all screwworm research at a new Livestock Insects Laboratory in Kerrville, Texas.

By the early 1950s, the screwworm had become a major concern. Knipling asked Bushland, who was assistant director of the laboratory at Kerrville, to search for chemicals which might induce sexual sterility in the screwworm. However, Bushland did not find a useful chemical sterilant. Unknown to both scientists, a method to induce sexual sterility in insects had already been devised in 1926 at the University of Texas by Hermann Joseph Muller, who was awarded the Nobel Prize in Physiology or Medicine in 1946. Muller had discovered that X-rays, when applied at sufficiently high doses, break chromosomes. Two different chromosomes with broken ends may heal together to form a chromosome with two spindle fiber attachments. Such "dicentric" chromosomes may be pulled to opposite poles of the dividing cell and prevent the cell from dividing. Broken ends of chromosomes without spindle fiber attachments are lost during cell division, and the resulting cells lack genes needed to enable the daughter cells to live.

Such lethal chromosomal changes are expressed as dominant factors and they are the most important cause of radiation-induced sexual sterility. When the sperm of an irradiated insect fertilizes the egg of a wild untreated female, the lethal chromosomal changes contributed by the sperm to the zygote prevent the embryo from developing and surviving. Consequently, most eggs bearing such dominant lethal mutations do not hatch.

In 1950, Muller published a popular article in the *American Scientist*, which Lindquist read and immediately brought to Knipling's attention. In response to a letter from Knipling, Muller expressed confidence that X-rays could be used to induce dominant lethal mutations, and hence sexual sterility, in the screwworm.

Knipling pursued research on sterility by radiation. He turned to Bushland, who had become the director of research at the Livestock Insects Laboratory in Kerrville, Texas. Using Knipling's theory and Muller's technique, Bushland completed a successful experiment. He showed that irradiated males were fully competitive with untreated males in mating with females in cages, and verified Knipling's theoretical model of suppression of screwworm reproduction by the release of irradiated males into cages containing both fertile males and females. Bushland later discovered that using gamma rays from cobalt-60 was a less expensive, but effective alternative to x-rays.

The next stage was field experimentation. In late 1951, an experiment was established on Sanibel Island in Florida by Knipling, Bushland, and Alfred H. Baumhover, an entomologist working with Bushland at Kerrville. The experiment proved that it was possible to drastically reduce the screwworm population by releasing sterilized flies. Because the island was only two miles from the mainland, however, the continuing influx of screwworms from the Florida peninsula prevented eradication. The scientists needed a more isolated area.

After the reorganization of the United States Department of Agriculture in 1953, Knipling became the director of the Entomology Research Division (ERD) of the newly created Agricultural Research Service (ARS). In this capacity, he was able to shift the focus of insect control from chemical insecticides to other methods such as biological and parasitoid. This served as a major landmark in the development of ecologically sound alternatives to the mass use of insecticides. In the same year, Knipling received a letter from Benjamin A. Bitter, a veterinarian on the island of Curaçao, Netherlands Antilles, 40 miles off the coast of Venezuela. Bitter was looking for a way to deal with the screwworm problem that had invaded the island from South America. Knipling responded with a proposal for a joint experiment between the United States and the Netherlands. Knipling clearly stipulated that the sterile insect technique (SIT) was only a theory, and could not be guaranteed to work. Bitter was interested in the cooperative effort and the team of Knipling, Bushland, Lindquist, Baumhover and Bitter spent nine months planning the experiment. About 150,000 sterile screwworm flies per week were released over Curaçao, a small island of 176 square miles; within 3 months and 4 generations of the targeted insect, the screwworm was eradicated from the island.

From the Curaçao experiment, the scientists learned how to put together a full-scale eradication program. Components of the experiment included mass rearing of screwworm flies, proper sterilization equipment and procedures, and an efficient aircraft method of dissemination. Although the Curaçao experiment had not initially been well publicized in the United States, its success soon garnered attention from agricultural officials. Most of this interest came from Florida. Knipling was initially hesitant to forge ahead, since the rearing, handling and release technology was still in a rudimentary stage of development, and such a program would require an attack on a screwworm population spread over an area of more than 50,000 square miles. Knipling argued for an additional 2 years to develop more robust technologies, and pointed out that such advances could also reduce program costs by $2 million. Governor of Florida Thomas Leroy Collins persuaded Knipling to initiate the program by asking: "Why wait 2 years to save $2 million when the losses are $10 million per year?" The Florida Legislature appropriated $3 million for the program and this was matched by the United States Congress. The Florida eradication program was given a boost when in December 1957 a very cold air mass swept through Florida and killed all screwworms southward to a line running from Tampa to Vero Beach, Florida. The United States Department of Agriculture took advantage of this situation and began releasing the sterile flies. As soon as Bushland's production increased to 14 million flies per week, sterile flies were released as far north as southern Georgia. Meanwhile, an aircraft hangar in Sebring, Florida, was rapidly converted into a giant "fly factory" and fitted with a cobalt-60 irradiator. By mid-1958, the Sebring plant began to produce 50 million sterile flies per week, and these were distributed by a fleet of 20 aircraft over the infested area. Throughout the campaign livestock owners checked all of their animals and treated all wounds with insecticide smears twice per week. The program was considered a success when no screwworms could be found in Florida after the end of June 1959.

Livestock producers in the Southwest, especially those in Texas, favorably viewed the Southeast screwworm eradication program. The challenges in Texas were much more difficult than those encountered in Florida. They included an increased area, a larger insect population, less isolation, and the guarantee that flies could easily reinfest the area from outside the program's jurisdiction. Also, a program stretching from the Gulf of Mexico to the Pacific could result in a costly stalemate. Nevertheless, the Southwest Animal Health Research Foundation raised $3 million to initiate a program, and a mass rearing facility was built at Mission, Texas. In this manner, the screwworm was largely eliminated from Texas, New Mexico, Arizona, and California. During 1966, when no screwworms could be found in the United States for a period of several months, the Secretary of Agriculture declared the screwworm to be eradicated from the United States; it was not actually until 1972 that the screwworm was officially eradicated from the United States. This followed the partnership of the Mexico – USA Screwworm Eradication Commission which launched joint operations to maintain a sterile border between the United States and Mexico to reduce the possibility of reinfestation. A large mass rearing facility was constructed at Tuxtla Gutierrez, Chiapas, and by 1984 the screwworm was eradicated to the Isthmus of Tehuantepec. Subsequently, operations were undertaken in Central America, and by 2001 the parasite has been eradicated as far south as Panama.

The sterile insect technique (SIT) helped to save billions of dollars for the livestock industries in the United States, Mexico, and Central America at an attractive cost to benefit ratio. Knipling worked hard to advance the use of the sterile insect technique to cope with other major pests. Significant research was conducted in the United States by the United States Department of Agriculture and internationally through programs of the Joint FAO/IAEA Division for Nuclear Techniques in Food and Agriculture, which Knipling and his colleagues helped establish in Vienna, Austria.

The sterile insect technique (SIT) has been used with great success against various species of tropical fruit flies. Israel developed the sterile insect technique (SIT) to suppress the Mediterranean fruit fly, *Ceratitis capitata* (Wiedemann), and thus enable it to export high quality citrus to Western Europe. Chile used the sterile insect technique (SIT) to rid the entire country of the Mediterranean fruit fly, so that by 1980 all of Chile had become a medfly-free zone. Since then Chilean fruits have entered the United States market without the need for any quarantine treatments. This has dramatically strengthened the economy of Chile. Argentina, Italy, Peru, Portugal, and other countries have initiated sterile insect technique programs that they hope will enable them to become medfly-free zones with free access to markets in southern Europe, Japan, and the United States.

Mexico has used the sterile insect technique to rid southern Mexico of the Mediterranean fruit fly. The Mexican states of Baja California, Chihuahua, and Sonora have been freed of all economically important species of fruit flies so that citrus, stone fruits, apples, and vegetables are being exported from these states without any post-harvest treatment. In other parts of Mexico, low prevalence fruit fly areas are being established by means of a systems approach. To prevent the establishment of medflies that enter the United States with smuggled fruit, sterile medfly males are being released continuously over the Los Angeles Basin in California, and over Tampa and Miami, Florida. This has obviated the need to spray these urban areas with the insecticide *malathion* to suppress outbreaks.

Japan used the sterile insect technique (SIT) to eradicate the melon fly, *Bactrocera cucurbitae* Coquillett, from Okinawa and all of Japan’s southern islands. This has opened the main markets in Japan to fruits and vegetables produced on Okinawa and the islands.

Tsetse flies, which transmit African sleeping sickness to people and livestock, are one cause of rural poverty in Sub-Saharan Africa because they prevent mixed farming. Food is produced with hoes and spades because African sleeping sickness kills draft animals. Milk cannot be produced and manure is not available to fertilize the worn-out soils. The conquest of sleeping sickness would allow the use of cattle for draft and for milk production. In 2001, the African heads of state committed their countries to a campaign to rid Africa of sleeping sickness. This undertaking is known as the “Pan African Tsetse and Trypanosomosis Eradication Campaign.” Eradication of the tsetse fly, *Glossina austeni* Newstead, and sleeping sickness from Zanzibar Island was completed in 1997 by means of the sterile insect technique (SIT). Tsetse populations had previously been eradicated by this means in small areas in Nigeria and Burkina Faso.

Research on sterilizing the codling moth, *Cydia pomonella* (L.), was initiated by M. D. Proverbs in 1955 at Summerland, British Columbia, Canada, but more than two decades lapsed before a practical program was launched against this major pest of temperate tree fruits. Since radiation affects the chromosomes of moths quite differently than those of flies, and since the large scale rearing of moths is also more difficult, the work on moths has lagged behind similar work with flies. At Knipling's behest, since 1968 sterile pink bollworm moths, *Pectinophora gossypiella* Saunders, have been released over the cotton fields in the San Joaquin Valley of California to prevent the establishment of pink bollworms that migrate annually from southern California. Knipling was personally involved in developing the use of the sterile insect technique (SIT) against the gypsy moth, but this use has been supplanted with the use of pheromones to suppress this pest – an approach also championed by Knipling.

Knipling, with the support of the National Cotton Council, was determined to eradicate the boll weevil from the United States because highly insecticide-resistant boll weevil populations had emerged. At one time, one-third of the insecticides used in the United States were distributed on cotton because of the boll weevil. It proved difficult to induce sterility in the boll weevil without greatly weakening the irradiated males. Irradiation causes damage to the midgut, and this damage prevents the boll weevil from digesting food and makes the gut vulnerable to penetration by microorganisms. The capacity of male weevils to mate falls off sharply several days after exposure. An anti-leukemia drug, busulfan, was found to induce sterility in males but not in females. This required that only treated weevils could be released and that females had to be removed by manual sorting, which proved to be impractical.

Meanwhile, Leo Dale Newsom and James Roland Brazzel, at Louisiana State University, have discovered the boll weevil enters a reproductive diapause and hibernates in trash along the edges of cotton fields. Brazzel showed that the number that survives the winter is reduced 90 percent if insecticides are applied just before diapausing weevils leave the fields. Knipling guided research which showed that if insecticide sprays were targeted to also to kill the generation-producing individuals going into diapause, then the overwintering population would be reduced by more than 99 percent. In 1978, a trial eradication testing Brazzel's idea was successfully undertaken in Virginia and North Carolina. By the end of 2004, the weevil had been eradicated in the southeastern states of Virginia, North Carolina, South Carolina, Georgia, Florida, Alabama, and in the far western states of Arizona and California. The cotton industry seems determined to achieve complete eradication of this major pest from the United States.

These sterile insect technique (SIT) programs are practical examples of the application of Knipling's theories on total insect population management. The programs involved: using field experimentation to gather baseline data on the wild population; using this baseline data to develop a model of the likely effects of a sterile insect technique (SIT) program; conducting a pilot project to assess the validity of the model and the readiness of the technology; conducting detailed planning; constructing laboratories and mass rearing facilities; developing methods of handling sterilization and aerial release; and properly using monitoring methods. This area-wide model was considered to be far more effective than the use of chemical insecticides on small populations of insect pests on a case-by-case basis. Knipling further discussed his model in his 1979 book, *The Basic Principles of Insect Population Suppression and Management* (*USDA Agriculture Handbook* 512).

Knipling considered his work on insect parasites to be as equally important as the sterile insect technique (SIT). He also believed that when combined with the sterile insect technique (SIT), the parasitoid augmentation technique could be more effective for managing insect populations than either one operating alone. Knipling’s second book, *Principles of Insect Parasitism Analyzed from New Perspectives: Practical Implications for Regulating Insect Populations by Biological Means* (*USDA Agriculture Handbook* 693), published in 1992, contains information on the use of parasites for insect control.

Knipling served as the director of the Entomology Research Division until 1971, at which time he became the science advisor to George W. Irving, Jr., Administrator of the Agricultural Research Service. Two years later, Knipling retired from the United States Department of Agriculture, having served for over 40 years. After retirement, he continued to collaborate with the Agricultural Research Service and contribute to the literature of entomology. During this period, he completed about 30 of his more than 200 publications on insects, and many more works that were not published. Knipling remained active in the field of entomology until the weeks prior to his death in March 2000.

Throughout his career, Knipling was honored with fellowships and honorary memberships from such organizations as the Entomological Society of America, the National Academy of Sciences, and the American Academy for the Advancement of Science. Knipling was also the recipient of numerous awards and honors, including several honorary doctor of science degrees. These awards include the British King’s Medal for Service in the Cause of Freedom, the Presidential Medal for Merit, the National Medal of Science, an Agricultural Research Service Science Hall of Fame induction, the World Food Prize, and the Japan Prize. In 1988, the United States Livestock Insects Laboratory in Kerrville, Texas, which was created in 1946 as the merger of the Dallas, Uvalde, and Menard laboratories, was rededicated in honor of Knipling and Bushland.

Special Collections would like to thank Waldemar Klassen for his extensive contributions to this section. Klassen worked closely with Knipling and the United States Department of Agriculture’s pest management programs throughout his career. He has served as the National Program Leader for Pest Management (ARS, USDA, 1972-1983), Director of the Beltsville Agricultural Research Center (ARS, USDA, 1983-1988), Associate Deputy Administrator for Plant Sciences and Natural Resources (ARS, USDA, 1988-1990), before moving on to positions within the Joint FAO/IAEA Division for Nuclear Techniques in Food and Agriculture in Vienna, Austria (1990-1994). Klassen currently serves as the director of the Tropical Research and Education Center at the University of Florida. Materials involving Klassen can be found within this collection in Series I, IV, and VI.