

OBITUARY

Moshe Kehat

1934–2001



IN MEMORIAM

Moshe Kehat, distinguished agricultural entomologist, passed away on November 15, 2001. He was born on May 4, 1934 in Tel Aviv, and attended elementary and secondary schools there. During 1952-55 he served in the army and was a member of Kibbutz Iftah in Upper Galilee, where he discovered his interest in agriculture and in developing new methods of plant protection. Moshe studied at the Faculty of Agriculture of The Hebrew University of Jerusalem, receiving his M.Sc. degree in 1960, and his Ph.D. degree in 1967 for his thesis on “Lady-birds as predators of pests of date palms in Israel”, supervised by the late Prof. H. Z. Avidov. He decided to specialize in Entomology and to focus on solving problems of pest control in agricultural crops. His research was conducted at the Department of Entomology of the Agricultural Research Organization (ARO), where he worked from 1959 until his retirement in 1999, attaining the scientist level equivalent to full Professor in 1982.

Dr. Kehat’s first major project concerned date palm pests: scale insects, moths and beetles. He founded and led the development of the integrated pest management program (IPM) in date palm plantations in Israel. Repeated applications of chemicals in palm plantations in the late 1950s interfered with the biological equilibrium and resulted in severe outbreaks of the parlatoria date scale *Parlatoria blanchardi*, which caused serious damage. In untreated plantations, however, or on uncultivated date trees, the scale never reached the economic threshold, which indicated the importance of natural enemies. Moshe and his group developed an integrated control program focusing on biocontrol of the scale. In an extensive survey in untreated plantations, five main groups of natural enemies were found: parasitoids, lady beetles, predacious beetles, green lacewings and predatory mites. The re-establishment of parasitoids and beetles in plantations from which they had been exterminated enabled a reduction in the use of broad-spectrum pesticides and resulted in a sharp decline of the parlatoria scale population.

Another extremely damaging date pest at the time was the date pit scale *Asterolecanium phoenicis*. With the aim of reducing the population, Moshe studied the scale’s phenology and distribution and conducted an extensive survey of infested date palm trees in commercial plantations, home gardens, roads and fields. Infested trees in commercial plantations were treated repeatedly with insecticides, while those at other sites were pruned and scorched with a flame-projector. The date fruits were protected mainly mechanically with dense-netting coverings. (The research on date palms was done in cooperation with the late Prof. Eliahu Swirski and other colleagues.)

In the late 1960s and early 1970s, Moshe initiated work on controlling pests of greenhouse roses, with special consideration of the Egyptian cotton leafworm *Spodoptera littoralis*. Treatment with chemical sprays was problematic, due to rapid development of resistance. Dichlorvos, applied with electric vaporizers, was an efficient insecticide and effective also against other pests, including the California red scale *Aonidiella aurantii*.

During 1970–73 Dr. Kehat was a Visiting Research Entomologist at the Waite Agricultural Research Institute of the University of Adelaide, Australia. His extensive research, with Dr. M. Wyndham, on the rutherfren bug *Nysius vinitor*, an important pest of fruits and vegetables, included studies of the biology, ecology, feeding behavior, development on different host plants and migration of the pest. After his return to Israel, Moshe concentrated his efforts mostly on moth pests in different crops, particularly cotton. His extensive experience and deep understanding of conventional control of pests with chemicals and its adverse effect on natural enemies and resulting development of resistance, prompted him to study alternative methods. The main topics of his research at first were the sexual behavior, mating and fecundity of *S. littoralis*, the cotton bollworm *Helicoverpa armigera*, and the spiny bollworm *Earias insulana*, with reference to pheromones. The identification and synthesis of the first sex pheromones of moths, particularly of *S. littoralis* in 1973 (UK) and 1974 (Japan), coincided with the wide interest in and research on sex and other pheromones and their potential in pest monitoring and control. Moshe recognized immediately the importance and potential of pheromones, as selective and nontoxic biochemicals, in IPM. From then until his last days, Moshe devoted his time, in close cooperation with Department colleagues in chemical and entomological disciplines, to basic and applied research on pheromones. He developed close contacts with pheromone research groups abroad, beginning with the TPI Institute (today the University of Greenwich) in the UK, and Japan, later with Thailand and in particular with various USDA and other teams in the USA.

The first target of the pheromone work was *S. littoralis*, one of the most damaging pests in the 1970s and 1980s in cotton and other crops, and Dr. Kehat initiated field experiments with live virgin females as baits. Basic information was obtained on male capture and enabled the study of pheromone trap design and test layout. *S. littoralis* served as a model for about 10 years and Moshe assessed various components affecting male catch: trap design, purity and composition of the pheromone blend, and the importance of its minor components. Whereas wet or sticky pheromone traps were popular abroad, Moshe's field tests indicated clearly that under Israeli conditions dry funnel traps for moths are easier to maintain and superior in performance. These tests were subsequently extended to other moth pests and today, following his work, dry funnel type traps are used for almost all moth pests in Israel. The composition of the pheromone blend of *S. littoralis* identified in the UK and Japan was not identical, nor was the field activity of the main component from different sources identical, indicating the presence of other compounds. Moshe demonstrated the importance of minor components in the pheromone of *S. littoralis* that contains a major component and one essential minor component at a relative concentration of 1%. Along with colleagues, Moshe constructed wind tunnels to evaluate the attractiveness of different pheromone blends and the impact of minor components. A key issue concerned monitoring and assessment of the actual pest population by correlation with male capture in pheromone traps. In observations of moth behavior at night under natural conditions – the most reliable technique for direct evaluation of the performance of pheromone traps – Moshe showed that the peak trap capture of *S. littoralis* males occurred when the actual female population had already declined. This is indicative of an increase in larval population, because it occurs after most females have mated.

Dr. Kehat pioneered mating disruption with sex pheromones in Israel and it is now used against several key pests in the country. Preliminary tests of the technique in 1978 were followed by advanced experiments with laminated Hercon dispensers and later by aerosol formulations. The results indicated that closely positioned pheromone sources are essential for successful disruption of *S. littoralis*.

Dr. Kehat conducted extensive research on additional cotton moth pests: *H. armigera*, *E. insulana*, and the pink bollworm *Pectinophora gossypiella*. Field observations led to the discovery of a second essential component of the *E. insulana* sex pheromone that was later identified by the TPI team in the UK. Moshe's efforts were dedicated to mating disruption experiments with these three pests, and close cooperation with the Israel Cotton Board, and the Agan, Shin Etsu and

Agrisense companies enabled extensive field tests for several years. Different formulations were studied extensively and disruption efficacy was assessed in night observations and later with mating tables, a technique with live virgin females developed by Moshe to assess mating disruption in small plots. This method enabled a large number of field tests in order to evaluate varying amounts of pheromone and density of pheromone sources on the efficacy of mating disruption. Optimization of mating disruption for the practical control of *P. gossypiella*, which became the most serious pest of cotton in the 1990s, occupied Moshe in the last years of his work.

In the 1990s Moshe began a large-scale project of monitoring and control of important moth pests in orchards and vineyards: the peach twig borer *Anarsia lineatella*, the codling moth *Cydia pomonella*, and the European vineyard moth *Lobesia botrana*; traps were developed also for other fruit pests. The effect of dispenser type, pheromone dose, field aging of dispenser, and type of trap on male capture was studied, and the findings led to the development of pheromone traps for monitoring purposes. Moshe pioneered also control of these pests by mating disruption, which became a standard procedure for the codling moth; control tests of the vineyard moth have reached the final stage before commercial use. (The research on pheromones was conducted in cooperation with many co-workers, including the late Dr. Shmuel Gothilf.)

Dr. Kehat spent two sabbaticals (1989/90 and 1993/94) with Dr. E.R. Mitchell at the USDA in Gainesville, Florida, studying pheromone traps and mating disruption of the tobacco budworm *Heliothis virescens*, the diamondback moth *Plutella xylostella*, and the beet armyworm *Spodoptera exigua*.

Moshe used his broad experience with pheromones to study and promote their use against date palm pests. He developed pheromone traps for monitoring the raisin moth *Cadra figulilella* and tried to control it by mating disruption. He studied extensively the phenology, behavior and aggregation pheromones of sap beetles, *Carpophilus* spp. After his retirement from the ARO he served as the scientific coordinator of the red palm weevil (*Rhynchophorus ferrugineus*, a destructive pest of dates) international project sponsored by The Peres Center for Peace. He promoted preventive field tests (with colleagues and growers) using traps baited with the aggregation pheromone for monitoring and mass trapping of this pest, which was a potential threat to Israeli date plantations. Moshe coordinated the cooperation among Egypt, Jordan, the Palestinian Authority and Israel and kept up with meetings and consultations at his home, and via e-mail, despite his severe illness.

Dr. Kehat participated in numerous local and international projects, including several BARD and CDR programs. He published, with co-workers, some 160 scientific articles, presentations from Congresses, and chapters in books. Moshe had widespread connections with scientists throughout the world, and his advice was highly appreciated and respected. He was an ardent supporter of IPM, and gave numerous lectures on ecologically friendly means to control pests. A serious and diligent scientist, Moshe devoted much time to public activity, serving as Head of the Department of Entomology (ARO) during 1986-1990, as Deputy Director of the Institute of Plant Protection during 1990-93, and on many scientific evaluation panels and agricultural recommendation committees. In 1982, Moshe functioned as a FAO consultant in Thailand. From 1988 to 1998 he was a valued member of the Editorial Board of *Phytoparasitica*.

The entomological community in Israel and abroad has lost a generous colleague and a first-rate scientist who combined basic knowledge with a practical approach, and provided crucial contributions to ecologically friendly pest control. The growers in Israel will miss the advice of an excellent friend and partner. It was a privilege to work with Moshe, who was highly respected and loved by his colleagues. We shall cherish his memory.

Moshe is survived by his loving wife Judith, his loyal companion since 1957, and sons Ran and Omri and their families, who comforted and encouraged him consistently during his serious illness.

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(written in cooperation with the late Eliahu Swirski)
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