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Study of bio-ecology and insecticide resistance of the Codling moth, of apple *Cydia pomonella*

Abstract

The codling moth, *Cydia pomonella* (Linnaeus) (Lepidoptera: Tortricidae), is the major pest of apple cultivation in many parts of the world. The species has achieved a nearly global distribution due to its successful adaptation to different environmental conditions Although codling moth is an economically important insect pest in Greece, there is not any detailed study on its ecology and control.

The aim of the present thesis was the study of various factors that influence the effectiveness of Integrated Pest Management programs. Particularly, the insecticide resistance in various populations from mainland Greece was examined along with aspects of the species population genetics and its dispersal ability. In addition, the reliability of three phenology models was evaluated and the moth phenology was investigated in major apple growing regions of Greece. Lastly, the suitability of two artificial diets in codling moth mass rearing systems was evaluated.

Laboratory experiments revealed that «Manduca Premix-Heliothis Premix» media was more suitable for larval mass-rearing than Ivaldi-Sender, as larvae grew faster and attained higher weight at the pupal stage. None of the three phenology models examined simulated accurately the phenology of codling moth in two major apple-growing regions, i.e., Aghia, Larissa and Zagora, Magnesia. The flight curves showed the existence of four generations in Aghia and three or four in Zagora.

The resistance of codling moth populations to ten insecticides of various chemical classes was explored by the application of discriminating doses to different developmental stages of the insect. Various levels of resistance were observed in almost all the insecticides examined and with methoxyfenozide being the most efficient one. In addition, cross-resistance was observed between organophosphates pyrethroids and growth regulators. Biochemical assays revealed that the main mechanism involved in resistance in Greek populations is the elevated activity of mixed-function oxidases (MFOs). On the other hand, no *kdr* resistance or Ache mutations were found in the populations examined.

The flight capacity of both male and female moths was studied through mark-release-recapture experiments (MRR) using pheromone and kairomone-baited delta traps. In addition, the moth dispersal was examined by kinship analysis of collected larvae based on microsatellite genotyping DNA analysis. Both approaches

demonstrated a low dispersal distance for the majority of individuals (40m and 80m for MRR method and kinship analysis, respectively). Only a low percentage of individuals appear to disperse in longer distance, reaching either 80m (MRR method) or 240m (kinship analysis).

Finally the genetic variation and structure of codling moth populations from different hosts (apple, peach, and walnut) and regions of Greece and France as well as from different hosts was investigated by the application of 11 microsatellite DNA markers. Results showed that populations can be distinguished in two main groups. The first included the samples from Greece and the second those from France. The analysis also revealed that the populations from Greece were not genetically differentiated. The same was observed in populations from France. Although these results imply the occurrence of extensive gene flow, they cannot be interpreted by the insect dispersal that has been determined to be very limited. Therefore, this gene-flow could be attributed to man activities including commerce.