1. Summary

The European cherry fruit fly, *Rhagoletis cerasi* Loew (Diptera: Tephritidae), is a highly destructive pest of sweet cherries in Europe. Up to 100% of the fruit can be infested. Methods for controlling this pest are limited in organic agriculture as well as in integrated production, as the insecticide currently used (Dimethoate) is being challenged due to problems of ecotoxicity and residues. Alternative methods for cherry fruit fly management are therefore needed. The aim of this thesis was to develop a new control strategy for *R. cerasi* using entomopathogenic fungi.

In a first step, the effects of six fungus isolates on the mortality of different life stages of *R. cerasi* were assessed in a series of laboratory experiments. All fungus isolates caused mycosis in *R. cerasi* larvae and adults. These results are the first evidence of the susceptibility of *R. cerasi* to infection with hyphomycetous fungi. Because the flies for the laboratory experiments were collected from different locations in northwestern Switzerland, susceptibility to entomopathogenic fungi can be assumed for the cherry fruit fly population in the whole region. Although all fungus isolates tested were pathogenic to adults and larvae, virulence varied considerably among fungus isolates and *R. cerasi* life stages. The effects on L_3 larvae were negligible; none of the fungus isolates induced mortality in more than 25% of the larvae. In contrast, adult flies were found to be highly susceptible to all fungus isolates (*Metarhizium anisopliae* 714, *M. anisopliae* 786, *Isaria fumosorosea* 531, *I. fumosorosea* Apopka 97 and *Beauveria bassiana* ATCC 74040) except *Isaria farinosa* 954. The high mortality of 90 to 100% induced by *B. bassiana* and *I. fumosorosea* during the pre-oviposition period led to significantly reduced oviposition. Higher conidia concentrations generally led to higher mortality. *B. bassiana* was the most effective isolate at low concentrations. Young flies showed lower mortality rates than older flies, but effects on egg eclosion rate were greatest young flies treated zero to one day after emergence. A fly-to-fly conidia transmission could not be proven after treatment of flies with a conidia suspension. Soil treatments with entomopathogenic fungi to infect emerging flies were also effective. Although the adult emergence rate was not reduced, flies emerging from treated soil showed a mortality of 42 to 83%. The oviposition rate was thus reduced by 29 to 73%, depending on the fungus isolate.

In a second step, different field application strategies were considered: soil treatments with entomopathogenic fungi to control emerging adults, the use of auto-inoculative devices for attract-and-kill strategies, and on-plant application as mycoinsecticides. Because the two American cherry fruit fly species *Rhagoletis indifferens* and *Rhagoletis cingulata* were introduced in Europe in the 1980s and because the isolates of entomopathogenic fungi selected for *R. cerasi* might show a different virulence on these species, the field experiments were accompanied by a four-year monitoring campaign for these species. The results of the campaign indicate that the population density of the American species is very low (<0.001%) in commercial sweet cherry orchards in northwestern Switzerland.

Soil treatments with biocontrol agents can only be effective if fly migration between differently treated trees is low. In order to examine the general potential of soil treatments, experiments using netting to cover the soil were conducted in two years and in two different orchards. The netting reduced fruit infestation by 91%. In addition, it was shown that the flies move only very short distances (less than 5 m) within orchards. In general, soil treatments are

considered to be a promising strategy for controlling *R. cerasi.* The efficacy of soil treatments using different formulations of entomopathogenic fungi was evaluated in semi-field trials. Soil treatments with barley grain-formulated entomopathogenic fungi had no effect on fly emergence rate. However, adult mortality was significantly increased. The oviposition rate was thus reduced by up to 90%. In conclusion, the experiments provide first evidence that control of adult *R. cerasi* is possible with soil treatments under field conditions in temperate zones. A further development of this control strategy seems worthwhile for fungus isolates tested, *B. bassiana* and *M. anisopliae*. However, the results of the one year semi-field experiments do not allow general conclusions.

Another approach to bring the flies in contact with entomopathogenic fungi is the use of auto-inoculative devices in an attract-and-kill strategy. For an effective attract-and-kill strategy, however, highly attractive traps and baits are an essential prerequisite. The attractiveness of baits was therefore evaluated using yellow sticky traps in combination with different baits in field experiments in three years and in five different orchards. Although some baits were able to double the number of captured flies, the response of the flies to the various baits was low overall. More effective baits are needed in order for their application to be economical.

On-plant application of mycoinsecticides is another method for exposing the flies to entomopathogenic fungi. Foliar applications of *B. bassiana* (product Naturalis-L) at seven day intervals significantly reduced the number of infested fruit by 60 to 70%. Flight activity monitored by yellow sticky traps was only slightly affected by treatments. Infection of flies under field conditions was shown to be possible. The results were obtained from five experiments in two years with considerably different weather conditions and in different orchards with different flight intensities of *R. cerasi*. The other treatments tested (PreFeRal®WG containing *I. fumosorosea* and extensive application regime of Naturalis-L) were less effective. In order to evaluate a possible repellent effect of formulation additives contained in the oil-based formulation of the product Naturalis-L, laboratory, semi-field and field experiments were conducted using Naturalis-L, additives of Naturalis-L and other oil products. Observations of fly behaviour in the laboratory experiments revealed that oil products had an oviposition deterring effect: flies frequently landed on treated fruit and started their typical oviposition behaviour; however, due to the slippery, oily fruit surface, the flies were not able to penetrate the skin with their ovipositors. The rate of successful oviposition was thus reduced. Under field conditions, however, rape oil products degrade too rapidly to provide good control. For the product Naturalis-L, these results suggest a dual mode of action: (1) some flies are killed due to fungus infection and (2) sub-lethally infected and weakened flies might be overtaxed by the oily film on the fruit surface and therefore unable to oviposit.

In conclusion, the application of Naturalis-L (*B. bassiana*) is a suitable and economically feasible strategy for controlling *R. cerasi*. Naturalis-L is currently registered for cherry fruit fly control in Italy and Switzerland. For good efficacy, four treatments of 0.25% Naturalis-L with 1000 l water per hectare should be applied at seven to ten day intervals beginning five to ten days after the beginning of the flight period until seven days before harvest. In extensively managed standard trees, *R. cerasi* management is still difficult, and Naturalis-L applications are not recommended due to possibly insufficient fruit coverage in the upper canopy. Further research is needed to evaluate whether soil treatments with barley grain-formulated fungi could be a viable strategy for controlling *R. cerasi* in these orchards.