Diversity and abundance of parasitoids in organic apple orchards in Baden-Württemberg

Abdullah Lashkari-Bod[1] and Claus P.W. Zebitz[1]

Abstract

The diversity and abundance of parasitoids and their functional effects on their hosts in organic apple orchards located in Streuobst Plieningen and Goldener Grund in spring till autumn in the years 2011 to 2012 were investigated. In this study we found six species of parasitoids related to two different subfamilies Ichneumonidae and Braconidae. Two species of parasiotids Trichomma enecator *and* Cremastus minor *were dominant species in the region. The percentage of parasitism was low except for* Bracon gelechidae *showed 40 % rate of parasitisation. The food web was visualized to have a better understanding of functional diversity of parasitoids and their hosts in the studied regions.*

Keywords: abundance, functional diversity, food web

Introduction

Ecosystems untouched by humans and low-input agroecosystems, such as cropping systems in organic farming are considered a higher biodiversity than intensive farmed agroecosystems. Biological diversity can be quantified in different ways and diversity indices provide more information about community composition than simple species richness (Magurran 1988). Earlier studies revealed that organic farms support higher biodiversity, where diversity has been expressed as abundance and species richness (Kienzle *et al*. 1997a,b, Hole *et al*. 2005, Bengtsson *et al*. 2007), and as food-web network structure (MacFadyen *et al*. 2009).

Particularly, parasitoids and predators appear to respond favourably to undisturbed ecosystems and appear in a higher abundance in organic farming compared with integrated or conventional farming. In apple orchards, these antagonists may provide partial control of apple foliar and fruit pests (Jones *et al*. 2009, Altieri *et al*. 1986), thus, being a highly suitable study system for antagonist biodiversity and their contribution to pest control. Mainly parasitic Hymenoptera are common natural enemies in orchards, parasitizing apple key pests, including codling moth, *Cydia pomonella* L. (Lacey and Unruh 2005), various species of leafroller and leafminer moths (Cross *et al*. 1999). It was worth to assess the diversity of tortricid parasitoids in mostly extensive “Streuobst gardens” to describe the antagonistic potential of these parasitoids for later comparison with organic and IPM apple orchards.

Material and methods

Orchard study site

Larval and pupal parasitoids were collected in two Streuobst gardens located in Plieningen and on the campus of the University of Hohenheim (“Goldener Grund”). Sampling started in spring till autumn in the years 2011 to 2012 by collecting host larvae using a random observation pattern by collecting the larvae of leaf rollers on the leaf of the apple trees and using corrugated cardboard bands around the tree stems at the expected time of host pupation.

[1] Institute of Phytomedicine, University of Hohenheim, 70593 Stuttgart, Germany, parsalashkari@gmail.com, Claus.Zebitz@uni-hohenheim.de

Pest and parasitoid identification

Collected specimens were taken into the laboratory for host species determination and for further rearing until either adult emergence of the lepidopterans or emergence of parasitoids. Hosts species were determined at the fifth larval instar and parasitoid species were determined after adult emergence based on the morphological characteristics (Broad 2011, Mills and Carl 1991).

Data analysis

Biodiversity was calculated by the Shannon and Simpson index.

Results

During early May to late September in the years 2011 and 2012, in total only 24 parasitoid specimens were collected, comprising six different species of the families Ichneumonidae and Braconidae. The dominant species was *Trichomma enecator* Rossi and *Cremastus minor* Cushman, with equal abundance of eight individuals per species. *Bracon gelechidae* Ashmead and *Agathis pini* Muesbeck represented the maximum and minimum percent parasitisation, respectively. *Agathis pini* can be considered as singletons (represented as single individual) (Table 1). The collected hosts belonged to the lepidopterous families Tortricidae and Gelechiidae. The dominant host species was *Cydia pomonella* L. Shannon and Simpson diversity indices were 1.55 and 0.79, respectively (Table 1).

Discussion

In this study we estimated the abundance and composition of parasitoid species in apple orchards. Six different species were found from three different hosts in that targeted sites. *Trichomma enecator* and *C. minor* were the dominating species, parasitising *C. pomonella*. *Apantheles xanthostigma* also attacks codling moth but not as efficient as the two other parasitoid species. *Bracon gelechidae* had the highest parasitisation rate compared with the other species; however, the reason for the poor parasitisation of the other parasitoids is not clear yet. The abundance of antagonistic species in a community is not only dependent from host density or food web complexity (Woodward and Hildrew 2001; Courchamp *et al*. 2003). Other non-trophic factors such as abiotic factors, competition, or interference (Connell 1983; Schoener 1983). A probable reason for low parasitism in a community often can depend on the abundance of alternative hosts not only in an orchard but in adjacent vegetation. Furthermore, also intraguild interactions (parasitoid-parasitoid interaction) may determine species abundance (Polis and Holt 1992; Rosenheim *et al*. 1993). In this survey, the parasitoid species found mostly are generalists, using other host species as alternative or preferred resource.

For a better understanding of diversity and how it affects the stability of an ecosystem (Naeem 1998), we considered parasitoids as functional effect groups based on trophic levels as carbon and energy fluxes through ecosystem (binary structural food web) (McNaughton 1997) (figure 1). The degree of influence which species interact as host and its relevant parasitoid/s can be critical both to understand how communities function and to develop models that predict the dynamics of natural systems (Paine 1980, 1988a).

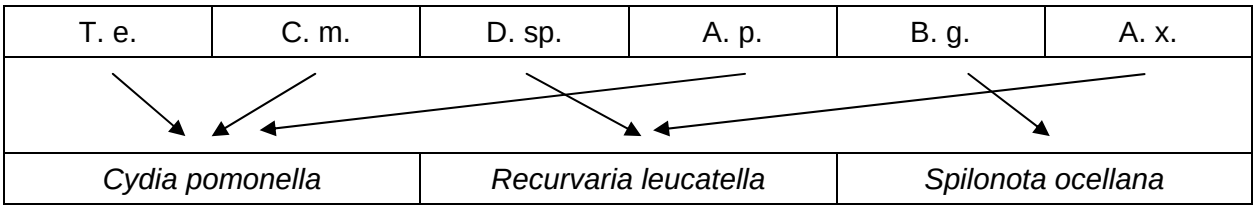

Figure1: Food web structure of host-parasitoid. Parasitoids and hosts arranged from top to down, respectively. Upper line: T. e. (*Trichomma enecator*); C. m. (*Cremastus minor*); D. sp. (*Diadegma* sp); A. p. (*Agathis pini*); B. g. (*Bracon gelechidae*); A. x. (*Apantheles xanthostigma*).

Table 1: Frequency of parasitoids reared from different pests and their parasitisation rate in apple orchards in “Streuobst Plieningen” and “Goldener Grund”.

Parasitoid	**Host species**	**Abundance (n)**	**Parasitization (%)**
Ichneumonidae			
Trichomma enecator Rossi	*C. pomonella*	8	1.22
Cremastus minor Cushman	*C. pomonella*	8	1.22
Diadegma sp.	*R. leucatella*	2	2.77
Braconidae			
Agathis pini Muesbeck	*Cydia pomonella*	1	0.15
Bracon gelechidae Ashmead	*S. ocellana*	2	40
Apantheles xanthostigma Hal.	*R. leucatella*	4	5.40
total		25	
Shannon diversity index	1.55		
Simpson diversity index	0.79		

Acknowledgment

We are most grateful of FSC (food security centre) and Fiat Panis for financial support.

References

Altieri, M. A. and L. L. Schmidt. 1986. The dynamics of colonizing arthropod communities at the interface of abandoned, organic and commercial apple orchards and adjacent woodland habitats. Agriculture, Ecosystems and Environment 16:29-43.

Bengtsson, J., J. Ahnström, and A. Weibull. 2007. The effects of organic agriculture on biodiversity and abundance: A meta-analysis. Journal of Applied Ecology 42:261-269.

Broad, G. 2011. Identification key to the subfamilies of Ichneumonidae (Hymenoptera). Department of Entomology, The Natural History Museum, London SW75BD, UK. Pp. 1-40.

Connell, J. H. 1983. On the prevalence and relative importance of interspecific competition: evidence from field experiments. American Naturalist 122, 661-696.

Courchamp, F., Chapuis, J. L., and Pascal, M. 2003. Mammal invaders on islands: impact, control and control impact. Biological Reviews 78, 347-838.

Cross, J. V., M. G. Solomon, D. Babendreier, L. Blommers, M. A. Easterbrook, C. N. Jay, G. Jenser, R. L. Jolly, U. Kuhlmann, R. Lilley, E. Olivella, S. Toepfer, and S. Vidal. 1999. Biocontrol of pests of apples and pears in northern and central Europe: 2. Parasitoids. Biocontrol Science and Technology 9:277-314.

Hole, D. G., A. J. Perkins, J. D. Wilson, I. H. Alexander, P. V. Grice, and A. D. Evans. 2005. Does organic farming benefit biodiversity? Biological Conservation 122:113-130.

Jones, V. P., T. R. Unruh, D. R. Horton, N. J. Mills, J. F. Brunner, E. H. Beers, and P. W. Shearer. 2009. Tree fruit IPM programs in the western United States: The challenges of enhancing biological control through intensive management. Pest Management Science 65:1263-1377.

Kienzle, J., C. P. W. Zebitz and S. Brass. 1997a. Floral and faunal species diversity and abundance of aphid predators in ecological apple orchards. Biological Agriculture and Horticulture 15:233-240.

Kienzle, J., C. P. W. Zebitz, S. Brass and A. Athanassov. 1997b. Abundance of different Tortricid species and their parasitoid antagonists in ecological apple orchards in southern Germany. Biological Agriculture and Horticulture 15:211-212.

Lacey, L. A., and T. R. Unruh. 2005. Biological control of codling moth (*Cydia pomonella*, Lepidoptera: Tortricidae) and its role in integrated pest management, with emphasis on entomopathogens. Vedalia 12:33-60.

MacFadyen, S., R. Gibson, A. Polaszek, R. J. Morris, P. G. Craze, R. Planqué, W. O. C. Symondson, and J. Memmott. 2009. Do differences in food web structure between organic and conventional farms affect the ecosystem service of pest control? Ecology Letters 12:229-238.

Magurran, A. E. 1988: Ecological Diversity and its Measurement. Groom Helm, London, 179 pp.

Mills, N. J. and K. P. Carl. 1991. Predators and parasitoids. In: van der Geest and L.P.S., Evenhuis H.H. (editors) Tortricid pests. Their biology, natural enemies and control. Amsterdam: Elsevier Science Publishers, pp. 235-252.

McNaughton, S. J. 1977. Diversity and stability of ecological communities: a comment on the role of empiricism in ecology. American Naturalist 111:515-525.

Naeem, S. 1998. Species redundancy and ecosystem reliability. Conservation Biology 12:39-45.

Paine. R. T. 1980. Food webs, linkage interaction strength, and community infrastructure. Journal of Animal Ecology 49:667-685.

Paine. R. T.. 1992. Food-web analysis through field measurement of per capita interaction strength. Nature 355:73-75.

Polis, G. A., and R. D. Holt. 1992. Intraguild predation: the dynamics of complex trophic interactions. Trends in Ecology and Evolution 5:151–154.

Rosenheim, J. A., L. R. Wilhoit, and C. A. Armer. 1993. Influence of intraguild predation among generalist insect predators on the suppression of an herbivore population. Oecologia 96:439–449.

Schoener, T. H. 1983. Field experiments on interspecific competition. American Naturalist 122:240-285.