Age-specific life tables of the aphelinid wasp, Aphytis diaspidis and its diaspidid hosts, Hemiberlesia lataniae and Quadraspidiotus perniciosus with special reference to the intrinsic rate of increase

The developmental times, age-specific survivorship beginning with 1-day-old offspring and age-specific fecundity for females were used to construct life tables of the cosmopolitan oligophageous ectoparasitoid, Aphytis diaspidis DeBach, and its polyphageous hosts, Hemiberlesia lataniae (Signoret) and Quadraspidiotus perniciosus (Comstock) under laboratory conditions of 19±2°C, 60±10 % rh and 10:14h L:D photoperiod. The developmental times were 46.5, 29.9, and 31.4 d for A. diaspidis, H. lataniae, and Q. perniciosus females, respectively, whereas the generation time was 66.8, 80.21, and 57.48 d, respectively. Although there are no dramatically changes in population growth parameters between both hosts, but Q. perniciosus seems to be a more suitable host for rearing A. diaspidis under commercial conditions due to its higher net (R0) and gross (GRR) reproductive rates and shorter generation (T) and generation doubling (DT) times. According to these characteristics, the parasitoid population could be multiplying faster on Q. perniciosus than H. lataniae populations. Moreover, the high survival rate of A. diaspidis during its early reproductive period contributes significantly to increase its population. Based on obtained population growth parameters, A. diaspidis is a suitable candidate for using it in augmentation biological control programs of both hosts. The rm value of A. diaspidis was exceeded that of H. lataniae and Q. perniciosus by 1.08 and 1.09 times. Based on T, the parasitoid could produce 1.16 and 1.39 generations on each generation of H. lataniae and Q. perniciosus. These results are shown to have multiple practical implementations in mass rearing traits and augmentation biological control programs.

Lebenstafeln des idiobiotischen Ektoparasitoiden Aphytis diaspidis und seiner beiden Wirte Hemiberlesia lataniae und Quadraspidiotus perniciosus wurden unter Zuhilfenahme der Entwicklungszeit, der altersspezifischen Überlebensrate sowie der Fekundität der Weibchen bei 19 ±2°C, 60 ±10 % rF und 10h:14h L:D konstruiert. Obwohl die beiden Wirtsarten keine dramatischen Unterschiede in den Populationswachstumsparametern (intrinsische (rm) und finite (?) Zuwachsraten) aufweisen, scheint Q. perniciosus günstiger für die Zucht von A. diaspidis zu sein, da sie eine höhere Netto- (R0) und Bruttoproduktionsrate (GRR) sowie eine jüngere Generationsdauer (T) hat. Entsprechend kann sich der Parasitoid in Q. perniciosus-Populationen rascher vermehren als in H. lataniae-Populationen. Die hohe Überlebensrate von A. diaspidis in der frühen Reproduktionsphase und die kurze Generationsdauer tragen signifikant zum Populationswachstum bei und lassen die intrinsische Zuwachsraten (rm) ihrer Wirte um das 1,08-fache (H. lataniae) bzw. 1,09-
Host age preference and host searching efficiency of Encarsia citrina Craw. (Hymenoptera: Aphelinidae) a parasitoid of Euonymus scale, Unaspis euonymi Comstock (Hemiptera: Diaspididae) in Austria

Encarsia citrina Craw. is considered as a promising parasitoid to be used as a bio-agent against the cosmopolitan diaspidid insect, Unaspis euonymi (Comstock). Laboratory studies were carried out to determine 1) the ovipositional preference of E. citrina for host's age by exposing it to 5-20 day-old scales 2) effect of temperature (17.5, 20, 25, and 28\(^\circ\)C) and parasitoid's density (1, 2, 3, 4, and 5 females/30 hosts) on host searching efficiency of E. citrina. E. citrina significantly preferred 10 day-old scales with the highest emergence rate. Temperature had significant effect on the searching efficiency of E. citrina over the range of 17.5–28\(^\circ\)C. The highest rate of search was obtained at 20\(^\circ\)C. Although increasing parasitoid density at 20\(^\circ\)C reduced progeny production in E. citrina due to the increase of mutual interference, it was able to distribute its eggs among the hosts more regularly. The highest values of killing (k-value) were also obtained at 20\(^\circ\)C and the ratio of 4 parasitoid females/30 hosts. The shortest and longest handling time (Th) was measured at 20 and 17.5\(^\circ\)C, respectively. Accordingly, 20\(^\circ\)C is suitable condition to Encarsia reproductive and activity. E. citrina seems to be a good candidate to control U. euonymi from late spring to early summer as well as during autumn in Austria, where the temperature is frequently around 20\(^\circ\)C. Therefore, parasitoid releases within this period on the early 2nd instar (10 days old) with a ratio of 1 parasitoid: 7.5 hosts have to be considered in the future biocontrol program of U. euonymi.

Functional responses of Encarsia perniciosi and Encarsia citrina to Quadraspidiotus perniciosus in response to temperature

Prior to the field release of natural enemies in bio-control programs, it is essential to evaluate their efficiency under laboratory conditions. One informative method is the functional response of natural enemy to host density. Moreover, temperature is an important factor that affects the efficiency of bio-control agent. First, we examined the effect of densities of the diaspidid host, Quadraspidiotus perniciosus (Comstock) on functional response types of the aphelinid parasitoids, Encarsia perniciosi (Tower) and Encarsia citrina Craw. Secondly, we examined the temperature-dependent functional response for the E. perniciosi. Three constant temperatures (15, 20, and 25\(^\circ\)C) and five host densities (10, 15, 20, 25 and 30 scales) were used. At each temperature, 10 to 30 1st
instars were exposed to a female E. perniciosi for a 24 h. In the first experiment, the decelerating rate of decrease in the parasitism rate of E. perniciosi indicated a type II response, whereas the absence of significant dependence on host density by E. citrina indicated a type I response. In the second experiment, E. perniciosi exhibited type II response (inverse-density dependent parasitism rate) at all temperatures. Therefore, releasing the E. perniciosi early in the beginning of growing season on low host populations can provide more control. The attack rate of E. perniciosi increased with increasing temperatures from 15 to 25°C, whereas the handling time decreased. 25°C seems to be the most suitable condition for Encarsia activity and reproduction. This implies that E. perniciosi is well adapted to relatively moderate temperature, which allows its implementation as a bio-control agent of Q. pernicosus during the growing season even in countries of higher latitudes.

4-

Biological control of scale insects using insect parasitoids: Efficiency of certain parasitoids as bio-agents against some scale insects

Known for a long time to applied biologists for importance of parasitoids in regulating the population densities of scale insects. The author has spent ore than five years researching biological control, visiting and studying the efficiency of certain parasitoids for controlling San Jose scale and lataniae scale. The author during his study has been visited Austria throughout study grant for two years â€as an original habitat for the new invasive pest to Egyptian farmlands, SJS, without its specific natural enemiesâ€ to compare the role of native parasitoids with the local parasitoids. The author discuss therotical approaches and specific experiments in pest control. The monograph it has assemled will interest investigators in basic and applied studies of the diaspид parasitoids as key regulating factors in biocontrol. After a general introduction to the importance of diaspидids species and their parasitoids, the book contains the different components of the population ecology, host-host stage preference, reproductive strategy, searching for a host, pupal cold storage, mass production and release experiments of parasitoids

5-

Foraging Behavior of the Coccinellid Nephus includens (Coleoptera: Coccinellidae) in Response to Aphis gossypii (Hemiptera: Aphididae) With Particular Emphasis on Larval Parasitism

This study assessed the effect of parasitism of Nephus includens (Col.: Coccinellidae) larvae by Homalotylus flaminius (Hym.: Encyrtidae) on the predation rates of the predator on the cotton aphid, Aphis gossypii Glover (Hem.: Aphididae) by deriving functional responses for second and fourth-instar predators at prey densities ranging from 10 to 80 aphids per arena. The relationship between the functional and numerical responses of adult females of N. includens also was determined for prey densities ranging from 10 to 140 aphids per arena. Predation rates of unparasitized and parasitized second-instar N. includens were both iby a type II functional response model with parameters as follows: unparasitized (a=0.0768 hours_1 and Th=0.975 h) and parasitized (a=0.0787 hours_1 and Th =0.8823 hours). Predation rates of unparasitized and parasitized fourth-instar N. includens were iby type III and II models, respectively, with the following parameters: unparasitized (b = 0.1702 hours_1 and Th= 0.2369 hours) and parasitized (a=...
0.038 \ h_1 \text{ and } \ Th = 0.539 \ h). The unparasitized fourth-instar was the most voracious stage, having the highest attack rate and lowest handling time. Considering these attributes, it would seem to be the most effective stage of this predator against A. gossypii. Adult female lady beetles (N. includens) showed a type III functional response and their numerical response increase to prey density was curvilinearly related to prey density, with the highest number of eggs being produced at highest prey densities. The maximum saturation level for both predation and egg production for adult females occurred at a prey density of 120 aphids. Thus, a ratio 1:120 (predator:prey) should be used when releasing this species for augmentative biological control. Release of either fourth-instar or adult stage N. includens should be minimized the potentially negative effect of parasitism by H. flaminius on early developmental stages, and hence increase its efficiency in biocontrol programs.

6-

**Are synthetic pheromone captures predicative of parasitoid densities as a kairomonal attracted tool?**

Abundance of White Peach scale (WPS), Pseudaulacaspis pentagona (Targioni-Tozzetti) and San José scale (SJS), Diaspidiotus perniciosus (Comstock) (Hemiptera: Diaspididae) adult males and their attracted parasitoids were monitored using pheromone and sticky tape traps in an orchard of Budapest, Hungary, during 2010. In this study, we tried answer on the question raised whether synthetic commercial pheromones of WSP or SJS could work as a kairomonal stimulant and positively attract higher numbers of the specialized parasitoids. Although pheromone traps attracted a wide range of parasitoid species, most of them were accidentally. However, the parasitoid Thomsonisca amathus (Walker) (Hymenoptera: Encyrtidae) and the parasitoid Encarsia perniciosi (Tower) (Hymenoptera: Aphelinidae) significantly respond to the sex pheromones of WPS and SJS, respectively, suggesting that they may play an important role in host location.

7-

**A geographical study on Pseudaulacaspis pentagona and its parasitoids in Hungarian highway margins using pheromone traps and molecular markers**

A study has been conducted to monitor geographical spread of the white peach scale Pseudaulacaspis pentagona (Targioni Tozzetti) (Hemiptera: Diaspididae) (WPS) and its parasitoid populations in 32 stops of the Hungarian highways (M0, M1, M3, M5 and M7) using pheromone traps during 2009 and 2010. In addition to the data collected in the current study, previous data were used to investigate the population trend of this pest from 2007 to 2010. The number of males recorded in traps placed on highways was much lower than in the sites close to urban areas (M0). Our data support results of previous studies which suggest the spreading of white peach scale by vehicles (ace)transport vectora). The significant decrease in the WPS male catches from 2007 to 2010 might indicate the lowering of the population levels of this pest in the area of the study. Eight hymenopterous parasitoid species were captured in pheromone traps. Coccophagus sp. was the predominate species in pheromone traps of WPS in M7, how-ever they may be associated with another coccid species. The identity of scale males and some parasitoids was proved by molecular markers.
Functional Response of the Aphelinid Parasitoid, Aphytis diaspidis: Effect of Host Scale Species, Diaspidiotus perniciosus and Hemiberlesia lataniae

Aphytis diaspidis Howard is an idiobiont parasitoid of the invasive (Diaspidiotus perniciosus Comstock) and usual (Hemiberlesia lataniae Signoret) hosts. The objectives were to study the effect of host scale species on functional response of A. diaspidis and to answer on the question raised whether the killing efficiency of this parasitoid against the invasive host will differ from that of usual host. The parasitoid showed no host species preference with a type II response when offered both hosts at densities of 10–50 insects per patch. The proportion of hosts parasitized exhibited the same characteristic curve for the parasitoid on both hosts: a wave form that appeared to be a composite of a decelerating (type II) response at low host density and an accelerating and a decelerating (type III) response at medium to high densities. I assume that egg limitation, and/or host feeding rather than parasitism may have induced the modified type II response. The number of host parasitized within a 48 h increased with host density with a maximum of 18.3 and 18.6 adults of D. perniciosus and H. lataniae, respectively. However, the proportion of host parasitized significantly decreased with host density. This implies that the wasp seems to be more affective in low host populations. This result has to be considered in rapid population control. Estimated handling times for parasitoid were 0.98 and 1.258 h and attack rates were 0.016 and 0.02 h−1 on H. lataniae and D. perniciosus, respectively. Theoretically, the maximum number of hosts that could be parasitized by a single female within 48 h was 38.16 and 48.97 of D. perniciosus and H. lataniae, respectively. The longer time in handling D. perniciosus by a parasitoid showed that the host has lower quality than the usual host, H. lataniae. The functional response results have to be considered in both mass rearing quality testing and biocontrol programs.

Effect of Prey Stages of the Two-Spotted Mite Tetranychus urticae on Functional Response of the Coccinellid Predator Stethorus gilvifrons

The effect of prey stages of the two-spotted spider mite Tetranychus urticae on the functional response of the coccinellid predator Stethorus gilvifrons was studied at 25±1°C, 6510±1% rh, and 16:8 h (L:D photoperiod). The functional response of S. gilvifrons female, to increasing prey stage density from
10−100 preys per patch, was of the curvilinear shape depicting Roger’s type II response with the highest consumption rate of larval prey stage. Results of the maximum likelihood analyses confirmed this type. By plotting a type II functional response model and polynomial logistic regression model to the numbers and proportions of consumed stages of T. urticae, respectively, the resulting regression lines fitted the data well. However, a composite waving form that appeared to be a decelerating (type II) response at low to medium prey densities and an accelerating (type III) response at high prey densities. We assume that the small size of experimental arena or predator feeding behaviour at low and high prey densities may have induced the modified type II response. A sensitivity analysis of the functional response model shows the crucial effect of prey stages on predation rates by S. gilvifrons. Theoretically, based on the lowest handling time for S. gilvifrons on larval stage of T. urticae, the maximum numbers of mites that could consume by a single female of S. gilvifrons within 24 h period were 77.42 larvae. These results improve our understanding of the interaction among S. gilvifrons and T. urticae stages and provide insights into the control of T. urticae.

10-

**Parasitism Interacts with Mutual Interference to Limit Foraging Efficiency in Larvae of Nephus includens (Coleoptera: Coccinellidae)**

Predator parasitism can modify predator-prey interactions through long-term (numerical) and short-term (functional response) impacts. However, mutual interference is another density-dependent factor that may affect predator foraging efficiency in the presence or absence of parasitism. This study examined the effects of parasitism of the invader Nephus includens (Kirsch) (Coleoptera: Coccinellidae) by Homalotylus flaminius Dalman (Hymenoptera: Encyrtidae), predator density, and prey density on the searching efficiency using the cotton aphid, Aphis gossypii Glover (Hemiptera: Aphididae) as alternate prey. Mutual interference reduced foraging efficiency by 47% in parasitized fourth-instar larvae compared to 44% in those unparasitized. Increasing predator density decreased searching efficiency more markedly in parasitized than in unparasitized larvae. The combined effects of parasitism and mutual interference reduced searching efficiency by 91%. Conversely, prey consumption by parasitized fourth-instar increased with increasing prey density, thus interference values declined from 0.98 to 0.82, indicating that the negative effect of parasitism on predator foraging diminished with increasing prey availability. Thus, these results support the inference of the “enemy release” hypothesis, that invading predators may be more successful and have higher impacts on prey when they escape from parasitism. In the context of augmentation of N. includens in Egypt, releases of predator life stages immune to parasitism, by H. flaminius, (e.g., pupae or adults) in a suitable predator-prey ratio, especially early season, should minimize the detrimental effects of parasitism and intraspecific interference on foraging behavior, thus
increasing predator ability to build up its population on alternative prey (aphid) and to attack later occurring target prey (mealybugs).