Alinteri J. of Agr. Sci. (2018) 33(2): 215-220
e-ISSN: 2587-2249
info@alinteridergisi.com

http://dergipark.gov.tr/alinterizbd
http://www.alinteridergisi.com/
DOI: 10.28955/alinterizbd.449574

Alinteri Journal of Agriculture Sciences

RESEARCH ARTICLE

Feeding Preferences of the Rearing of *Thanasimus formicarius* (L.) (Coleoptera, Cleridae)

Nazlı Koçoğlu[1], Gonca Ece Özcan[2*]

[1] *Kastamonu University, Institute of Science, Sustainable Agriculture and Natural Resources Program, Kastamonu/Turkey*
[2] *Kastamonu University, Faculty of Forestry, Kastamonu/Turkey*

ARTICLE INFO

Article History:

Received: 31.07.2018
Accepted: 18.09.2018

Keywords:

Biological control
Predator beetle
prey interactions
bark beetle

Anahtar Kelimeler:

Biyolojik control
predatör böcek
av etkileşimi
kabuk böceği

ABSTRACT

Predators have an efficient role on the control of bark beetle (Coleoptera: Curculionidae, Scolytinae) in the biological control. The most common and effective natural enemies of the bark beetle is clerid beetle. Since those natural enemies also feed from the individuals in the different development period of the scolytidae, it is effective for increasing the predation rate of the predator beetle. Besides that, the interaction and preferences between predator beetle-prey have potential importance for the efficacy of control programs. The aim of this study is to determine the feeding preferences of *Thanasimus formicarius* (L.) (Coleoptera, Cleridae) adults which feed from *Ips sexdentatus* (Boerner) (Coleoptera: Curculionidae, Scolytinae) adults and larva, quantitatively.. It is determined that the predator beetle consumed the given adult prey and its larva, respectively by the weight of 0-50.79% to 21.43-72.92% and by the feeding customs, 0-66.57% to 50-100% in a one-day period. The differences between the averages of the weights of its adult prey and its larva which the predator consumed is statistically significant and it is determined that predator beetle preferenced for the larva of the prey more than the adults. It is observed that the predations of *T. formicarius* adults is important on the different development periods of the species *I. sexdentatus*. As the pressure of the predator with accurate timing decrease the invasion rate, it will also decrease the amount of trees to be harmed.

Thanasimus formicarius (L.) (Coleoptera, Cleridae)'un Üretilmesinde (Rearing) Beslenme Tercihi

ÖZ

Predatörler, biyolojik mücadelede özellikle kabuk böceklerinin (Coleoptera: Curculionidae, Scolytinae), kontrolünde etkili bir role sahiptirler. Kabuk böceklerinin en yaygın ve etkili doğal düşmanları clerid böceklerdir. Bu doğal düşmalar kabuk böceklerinin farklı gelişim dönemlerindeki bireyleriyle de beslenebildiklerinden avcı böceğin predasyon oranının artması yönünde etkilidir. Bunun yanında avcı böcek - av etkileşimleri ve tercihleri biyolojik control programlarının etkinliğinde potansiyel öneme sahiptir. Bu çalışmanın amacı sabit sıcaklık ve nem koşullarında *Ips sexdentatus* (Boerner) (Coleoptera: Curculionidae, Scolytinae) ergin ve larvaları ile beslenen *Thanasimus formicarius* (L.) (Coleoptera, Cleridae) erginlerinin beslenme tercihini nicel olarak tanımlayabilmektir. Avcı böceğin bir günlük sürede beslenmesi için verilen avının erginlerinin ve larvalarının ağırlıklarına göre sırasıyla %0-50,79 ile %21,43-72,92'sini adetlerine göre ise sırasıyla %0-66,57 ile %50-100'ünü tükettiği belirlenmiştir. Predatörün tükettiği avının ergin ve larvalarının ağırlıklarının ortalamaları arasındaki fark istatistiksel olarak anlamlı olup, avcı böceğin avının larvalarını erginlerine oranla daha fazla tercih ettiği belirlenmiştir. *T. formicarius* erginlerinin zararlı tür olan *I. sexdentatus*'un farklı gelişim dönemleri üzerindeki predasyonunun önemli olduğu görülmektedir. Doğru bir zamanlama ile predatörün oluşturabileceği baskı, istila oranını azaltabileceği gibi zarar görecek ağaç sayısını da azaltacaktır.

Please cite this paper as follows:

Koçaoğlu, N. and Özcan, G. E. (2018). Feeding Preferences of the Rearing of *Thanasimus formicarius* (l.) (Coleoptera, cleridae). *Alinteri Journal of Agriculture Sciences*, *33*(2): 215-220. doi: 10.28955/alinterizbd.449574

* Corresponding author
E-mail address: goncaece@kastamonu.edu.tr (G. Ece Özcan)

Introduction

The existence and increase of biological infestation influence the biodiversity of natural ecosystems and therefore the ecological integrity (Mack et al., 2000). The bark beetles are (Coleoptera: Curculionidae, Scolytinae) one of the most destructive biological factors (Anderegg et al., 2015; Marini et al., 2017) that affect the forests. The infestation of these ecosystem elements (Raffa et al., 2015) is important in terms of sustainability of the forests (Black et al., 2010) and the economic damage caused by these elements reach significant levels (Lindgren and Raffa, 2013). Although the risk of infestation is a function of the existence, population density, and the distribution of the beetles (Fettig et al., 2007), many bark beetle species are known to cause tree deaths (Fettig et al., 2007; Meddens et al., 2012; Fetting and Hilszczannski 2015). The mass outbreak of the species, which impacts the healthy trees in case of an infestation, represents significant threats to the forests (Özcan, 2017a). Many other factors, particularly climate changes, cause considerable adverseness for the forest ecosystems (Kulakowski, 2016). The probable effects of the future climate changes will trigger more severe and frequent beetle outbreaks that will affect wider areas (Morris et al., 2018). The possibility of an infestation by these invasive species increases depending on biotic and abiotic factors that enhance the proliferation potential of these species and afterwards causes adverseness for the ecosystems.

Invasive beetle populations are affected by their natural enemies which play a balancing role (Alston, 2011) and the activities of these natural elements influence the distribution and the population size of the beetle species (Gullan and Cranston 2012). Thus biological control is an important tool in fights against infestation (Pearson and Callaway, 2003). The primary objective of all control strategies is to decrease spreading rates by repressing the population of the target species and therefore protect the trees and stands from possible attacks (Fetting and Hilszczannski, 2015). The most important requisites in protection strategies and applications are the measures taken to repress infestation populations (Özcan, 2017b).

Biological control may be defined as using an organism to decrease the population density of another organism (Bale et al., 2008). Biological control by itself is not enough to control the target species (Alston, 2011). Although these applications cannot resolve the economic effects caused by the biological forest pests completely, they may lower the quantity of the target species (Gullan and Cranston 2012), therefore the biological control agents help lower the population of biological forest pests below the economic damage threshold (Alston, 2011). Parasitoids, predators, and entomopathogens are highly effective for biological control applications (Uygun et al., 2010).

Furthermore, natural enemies such as predators and parasitoids play a key role in keeping bark beetle populations at endemic levels (Fetting and Hilszczannski, 2015). Biological controls applied by utilizing predators and parasitoids support the current control strategies of reducing damages caused by bark beetles (Moeck and Safranyik 1984). A population increase of a forest pest can be repressed by increasing the existence of specialized predators and pathogens (Powers et al., 1999). Different kinds of bark beetles usually have a common natural enemy (Reeve, 2003). Members of family Clerid are the most important (Costello, 2003) and the most widespread (Moeck and Safranyik 1984) predators of forest beetles. These species may be used as biological control agents (Reeve, 2003). However, *Thanasimus formicarius* (L.) (Coleoptera, Cleridae) is also the predator of many bark beetle species (Warzee and Gregoire, 2003). Predators have an important place among many biotic factors that influence the population of bark beetle species. In this study, the difference in feeding behaviors of *T. formicarius*, which has an effect on bark beetle population, in adult and larvae forms of prey in an artificial environment is put forth and also predation rates and consumption quantities are determined.

Materials and Method

Study Area

This study is conducted at Forest Pest Control Laboratory of Kastamonu Regional Forestry Directorate. Predator beetles and adult *I. sexdentatus* are obtained from pheromone traps which are hung in the forests of Kastamonu Regional Forestry Directorate and *I. sexdentatus* larvae are collected from damaged trees.

Data Collection

The specimens in adult and larvae forms, that are collected from pheromone traps and damaged trees, are brought to the laboratory in plastic containers. In order to determine the feeding behavior, glass rearing containers with perforated covers are used; predators and preys are kept in these containers. Pieces of bark are placed in the rearing containers of the predators and preys. The prepared containers are kept under constant temperature of 21°C and humidity of 75%. The study is conducted between May 30th and July 27th. A adult *T. formicarius* in each of the 20 containers are fed *I. sexdentatus* in adult and larvae at the same time (Figure 1). The prey beetles in adult and larvae forms are subjected to high sensitivity weighing with milligram (mg) readability and at the end of 24 hours of consumption the same individuals weighed again and the weights differences are noted.

Figure 1. Adult of *T. formicarius* are fed with *I. sexdentatus* adult and larvae

Statistical Analysis

All statistical analyses are performed using SPSS® 20.0 for Windows® software. In order to apply parametric tests the data must have either minimum interval scale or show normal distribution (Özdamar, 2004). One sample Kolmogorov-Smirnov (K-S) test is used to check (P>0.05) (Table 1) the normal distribution compliance of the weight distribution of consumed *I. sexdentatus* in adult and larvae form that were given for feeding to adult *T. formicarius* kept in rearing containers in a laboratory environment with constant temperature and humidity conditions. Corresponding to this, to determine whether the average weights of consumed prey in adult and larvae form differ from each other or not, the Independent Samples t Test—one of parametric tests—is utilized.

Result and Discussion

Predator beetles have important effects on population dynamics of the bark beetles (Turchin et al., 1999) and their natural enemies have potential benefits for biological control applications (Fetting and Hilszczannski 2015). It is stated in studies conducted that 99% of biological hazards in natural ecosystems can be suppressed by their natural enemies (Uygun et al., 2010). Predators with high impact stand out as one of the most important factors in suppressing the bark beetle populations. In terms of the biological control effectiveness, it is important to know the consumption rate of biological hazards in their different development periods by the predators.

In order to feed one adult *T. formicarius*, 2-3 adult *I. sexdentatus* and 3-6 *I. sexdentatus* larvae are put in the rearing containers. At the end of 24 hours, it is determined that the predator consumed or killed by wounding 0-66.57% of the adult specimens and 50-100% of the larvae in terms of quantity. In terms of weight, 0-50.79% of mature specimens and 21.43-72.92% larvae are consumed (Figure 2).

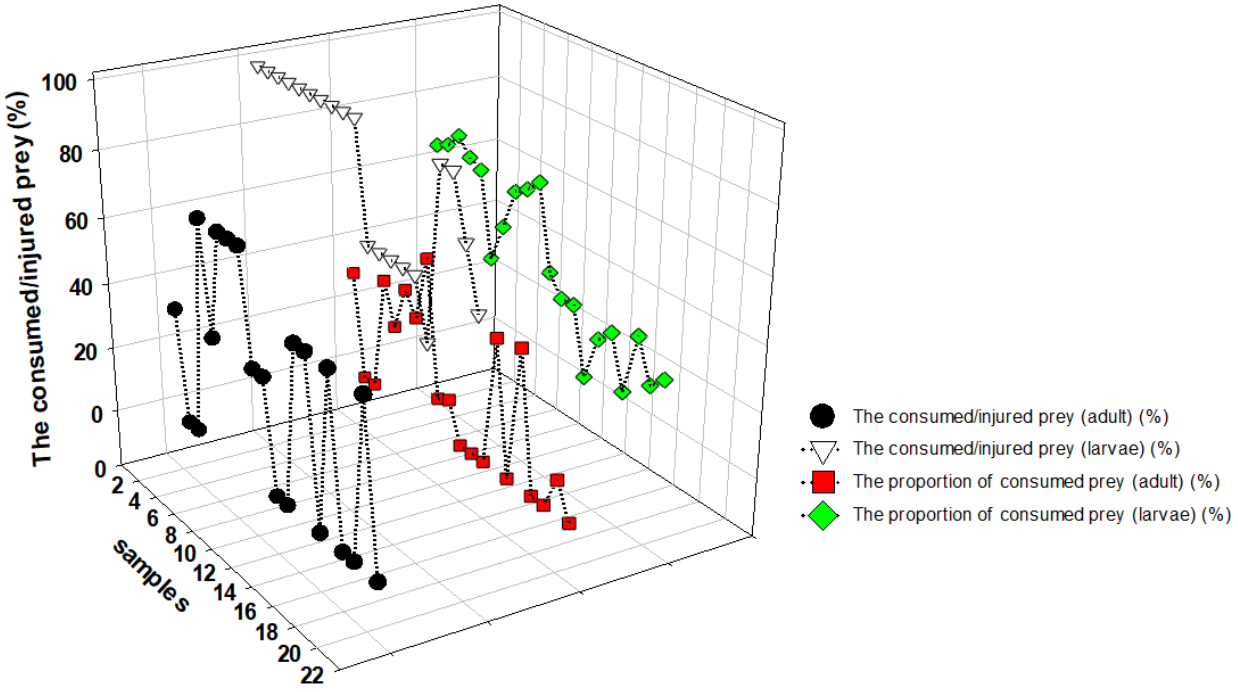

Figure 2. Consumed/wounded larvae and adult prey quantities

It is known that Cleridae feed on various bark beetle species in both mature and larva form in their galleries (Moeck and Safranyik 1984). Schroeder and Weslien (1994) indicate that this predator decreases the proliferation efficiency of

Tomicus piniperda (Linnaeus) (Coleoptera: Curculionidae: Scolytinae) by 81-92% and this rate is considerably higher than the proliferation efficiency decrease rate of other predators. The predators have higher consumption rates of the species on which they have an impact. In this study, it is clearly seen that the predator primarily preferred *I. sexdentatus* larvae.

Also in this study, a adult *T. formicarius* consumed 9.05 milligrams of adult, but 37.75 milligrams larvae (Table 1) on average in a day. The difference between the average weight of *I. sexdentatus* in adult and larvae consumed by the predator is statistically significant ($p<0.05$) (Table 2). According to this larvae are consumed 4 times more than the adult are. Furthermore, it is seen that while the predator beetle consumed 16.15% of the adult individuals on average, it consumed 49.79% of larvae on average (Table 1).

Table 1. Frequency distribution of consumed *I. sexdentatus* in adult and larvae and Komogorov-Smirnov Test of normality

	N	mgr	%	*P
		Mean±Sd.	Mean±Sd.	
Weight of Consumed Adult Individuals	20	9.05±10.415	16.15±18.04	1.141
Min.		0	0	
Max.		32	50,79	
Weight of Consumed Larvae	20	37.75±11.929	49.79±16.97	0.723
Min.		13	21.43	
Max.		54	72.92	

*P>0.05

Table 2. Independent samples t-test results comparing the weights of consumed larvae and adult individuals

	Levene's Test for Equality of Variances		t-test for Equality of Means						
								95% Confidence Interval of the Difference	
	F	Sig.	t	df	Sig. (2-tailed*)	Mean Difference	Std. Error Difference	Lower	Upper
Equal variances assumed	0.247	0.622	-8.105	38	.000	-28.700	3.541	-35.868	-21.531
Equal variances not assumed			-8.105	32.321	.000	-28.700	3.541	-35-872	-21.527

*p>0.05

During 12 feeding tests of the predator in 20 rearing containers, while all the *I. sexdentatus* larvae are either consumed or killed by wounding, there are always mature individuals of *I. sexdentatus* left alive throughout the testing. This occurrence shows that the predator primarily prefers larvae to feed on. Mature Cleridae species usually prefer to feed on other mature beetles (Costello, 2003). But this study does not show any similarities to that literature. Bark beetles are adversely affected by a high mortality rates constituted by predators (Costello, 2003).

Conclusion

In this study, which investigates the feeding preferences of a predator beetle according to calculation of the quantity and the weight of the predator's consumption rate of prey in mature and larva form in a period of 24 hours in a laboratory

environment under constant temperature and constant humidity conditions, it is found that the predator prefers larvae more. The findings of this study show that during an *I. sexdentatus* infestation, adult individuals of predator beetle *T. formicarius* may be effective on the death rates of this harmful species.

And another important consideration is that due to its predation impact on *I. sexdentatus* and other bark beetle species, the predator species can suppress the population of harmful species and therefore decrease the number of infested trees. The necessity of utilizing predator species in biological control programs are supported with these findings. Since the consumption rate of the harmful species is higher in periods prior to their maturity, it is seen that the predation of the predator can be more effective by conducting filed works.

Acknowledgment

For their support during our study we would like to acknowledge and thank Mr. Hüseyin Dinçer, Kastamonu Regional Director of Forestry at the time; Mustafa Kotil, Branch Manager of Combating Forest Pest Department; and all the personnel at Forest Pest Laboratory. This paper has been presented at the III. Turkey Forest Entomology and Pathology Symposium, May 2018.

References

Alston, D. G., 2011. General concepts of biological Control. UTAH pests fact sheet. IPM-015-11. Published by Utah State University Extension and Utah Plant Pest Diagnostic Laboratory.

Anderegg, W. R. L., Hicke, J. A., Fisher, R. A., Allen, C. D., Aukema, J., Bentz, B., Hood, S., Lichstein, J. W., Macalady, A. K., McDowell, N., Pan, Y. Raffa, K., Sala, A., Shaw, J. D., Nathan, L., Stephenson, N.L., Tague, C., and Zeppel, M., 2015.Tree mortality from drought, insects, and their interactions in a changing climate. New Phytol. 208: 674 – 683.

Black S. H., Kulakowski D., Noon, B. R., and DellaSala D., 2010. Insects and roadless forests: a scientific review of causes. Consequences and Management Alternatives. National Center for Conservation Science 33pp.

Costello, S. 2003. Clerid beetles- voracious predators" PDF. Colorado State University Department of Entomology. 1–15.

Fettig, C. J., Klepzig, K. D., Billings, R. F., Munson, A. S., Nebeker, T. E., Negrón, J. F., and Nowak, J. T., 2007. The effectiveness of vegetation management practices for prevention and control of bark beetle infestations in coniferous forests of the western and southern United States. Forest Ecology and Management 238, 24-53.

Fettig, C. J and Hilszczannski J., 2015. Management strategies for bark beetles in conifer Forests. In: Vega FE, Hofstetter RW (eds.). Bark Beetles. Biology and Ecology of Native and Invasive Species. Elsevier, Amsterdam. 555–584.

Gullan, P. J., and Cranston P. S., 2012. Böcekler: entomolojinin ana hatları. Bölüm 16. The insect an outline of entomology. Fourth Edition. Wiley-Blackwell. Çeviri Editörü: Ali Gök. XVI+564

Lingren, B. S., and Raffa, K. F., 2013. .Evolution of tree killing in bark beetles (Coleoptera: Curculionidae): trade-offs between the maddening crowds and a sticky situation. 145, 5, 471-495. https://doi.org/10.4039/tce.2013.27

Mack, R. N., Simberloff, D., Lonsdale, E. M., Evans, H., Clout, M., and Bazzaz, F. A., 2000. Biotic invasions: causes, epidemiology, global consequences and control. Ecol. Appl. 10, 3, 689–710

Marini, L., Økland, B., Jönsson, A. M., Bentz, B., Carroll, A., Forster, B., Grégoire, J. C., Hurling, R., Nageleisen, L. M., Netherer, S., Ravn, H.P., Weed, A., and Schroeder, M., 2017. Climate drivers of bark beetle outbreak dynamics in Norway spruce forests. Ecography 40: 001–010, doi: 10.1111/ecog.02769

Moeck, H. A, and Safranyik, L., 1984. Assessment of predator and parasitoid control of bark beetles. Can For Serv Inf Rep BC-X-248

Morris, J. L; Cottrell, S., Fettig, C. J., DeRose, R. J., Mattor, K. M., Carter, V. A., Clear, J., Clement, J., Hansen, W. D., Hicke, J. A., Higuera, P. E., Seddon, A. W. R., Seppä, H., Sherriff, R. L; Stednick, J. D., and Seybold, S. J., 2018. Bark beetles as agents of change in social-ecological systems. Frontiers in Ecology and the Environment. 16(S1): S34-S43. https://doi.org/10.1002/fee.1754.

Özcan, G. E., 2017a. The effect of the moisture content of scotch pines by bark beetle attacks. IV. IMCOFE / ROME, Abstract Book, 230 p.

Özcan, G. E., 2017b. Assessment of *Ips sexdentatus* population considering the capture in pheromone traps and their damages under non-epidemıc conditions. Journal of the Forestry Society of Croatia. Šumarski List. 1-2, 47-56.

Pearson, D. E., and Callaway, R.M., 2003. Indirect effects of host-specific biological control agents. TRENDS in Ecology and Evolution, 18 , 9, 456-461.

Powers, J. S., Sollins, P., Harmon, M.E., Julia A., and Jones, J.A., 1999. Plant-pest interactions in time and space: A Douglas-fir bark beetle outbreak as a case study. Landscape Ecology 14: 105–120.

Raffa, K. E, Grégoire, J. C, and Lindgren, B. S., 2015. Natural history and ecology of bark beetles. Bark Beetles Biology and Ecology of Native and Invasive Species. Elsevier. Chapter 1, 1-28pp.

Reeve, J. D., 1997. Predation and bark beetle dynamics. Oecologia, 112, 48-54

Uygun, N., Ulusoy, M. R., and Satar, S., 2010. Biological control. Türk. biyo. müc. derg.,, 1 (1): 1-14.

Warzee, N., and Grégoire, J. C., 2003. *Thanasimus formicarius* (Coleoptera, Cleridae) Why a Large Range of Prey for a Specialized Predator? Proccedings. IUFRO Kanazawa, Forest Insect Population Dynamics and Host Influences, 16–18.

Turchin, P., Taylor, A. D., and Reeve, J. D., 1999. Dynamical role of predators in population cycles of a forest insect: an experimental test. Science 285, 1068–1071.