Türk Tarım ve Doğa Bilimleri Dergisi 5(2): 146–152, 2018
https://doi.org/10.30910/turkjans.421352

TÜRK
TARIM ve DOĞA BİLİMLERİ
DERGİSİ

TURKISH
JOURNAL of AGRICULTURAL
and NATURAL SCIENCES

www.dergipark.gov.tr/turkjans

Research Article

The Distribution of *Aranciocystis muskarensis* (Neogregarinida: Ophryocystidae) in Populations of *Anisoplia segetum* Herbst (Coleoptera: Scarabaeidae) in Turkey and Its Relationship with Climatic Factors

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Received: 25.10.2017 Received in Revised: 22.03.2018 Accepted: 22.03.2018

Abstract

This study was conducted for determining the relation between climatic factors and *Aranciocystis muskarensis* (Neogregarinida: Ophryocystidae) infection in *Anisoplia segetum* (Herbst) (Coleoptera: Scarabaeidae). The samples were collected from April to July in different provinces of Turkey and 3780 *A. segetum* beetles were dissected and examined with the light microscope in 2016. Infection was detected only in Nevşehir, Konya, Aksaray and Osmaniye provinces. The highest infection rate was seen in Nevşehir with 18.53%. The correlation coefficient data indicated that the positive correlation was observed between humidity and *A. muskarensis* infection (r = 0.618, P<0.05). Multiple regressions analysis revealed that *A. muskarensis* infection formation in *A. segetum* was determined in 90.8% rate by climatic factors and the other variables (R Square = 0.908) and the most influential factor on infection was humidity (t=2.386).

Key words: *Anisoplia segetum*, *Aranciocystis muskarensis*, climatic factors, humidity, infection

Türkiye'de *Anisoplia segetum* Herbst (Coleoptera: Scarabaeidae) Popülasyonlarında *Aranciocystis muskarensis* (Neogregarinida: Ophryocystidae) Dağılımı ve İklim Faktörleri İle İlişkisi

Özet

Bu çalışma, *Anisoplia segetum* (Herbst) (Coleoptera: Scarabaeidae) da ki *Aranciocystis muskarensis* (Neogregarinida: Ophryocystidae) enfeksiyonu ile iklim koşulları arasındaki ilişkiyi belirlemek amacı ile yürütülmüştür. Örnekler, Nisan-Temmuz ayları arasında Türkiye'nin farklı illerinden toplanmış ve 2016 yılı boyunca ışık mikroskobu kullanılarak 3780 *A. segetum* bireyi disekte edilip incelenmiştir. Enfeksiyon sadece Nevşehir, Konya, Aksaray ve Osmaniye illerinde tespit edilmiştir. En yüksek enfeksiyon oranı %18,53 ile Nevşehir de görülmüştür. Yapılan analizler sonucunda korelasyon katsayısı verileri, nem ile *A. muskarensis* enfeksiyonu arasında pozitif korelasyon bulunduğunu göstermiştir (r = 0.618, P <0.05). Yapılan çoklu regresyon analizi *A. segetum* da meydana gelen *A. muskarensis* enfeksiyon oluşumunun %90,8 oranında iklim faktörleri ve diğer değişkenler (R = 0.908) tarafından belirlendiğini ve enfeksiyon üzerindeki en etkili faktörün nem olduğunu (t = 2.386) ortaya koymuştur.

Anahtar kelimeler: *Anisoplia segetum*, *Aranciocystis muskarensis*, iklim faktörleri, nem, hastalık

Introduction

Neogregarines are a pathogenic organism of several pest insects. These tiny organisms depend on their host to complete their life cycle. As a result of this relationship, neogregarines negatively affect their host fitness, fertility, and longevity (Cowley, 1989; Altizer and Oberhauser, 1999; Münster-Swendsen, 2008). Due to these properties, neogregarines can be useful in biological control strategy for the integrated management of pest insects.

Anisoplia (Coleoptera: Scarabaeidae) species are important pests of cereal crops throughout Northwest Asia and Southern Europe (Ermolenko, 1971) and in Turkey, *Anisoplia segetum* (Herbst) (Coleoptera: Scarabaeidae) is a common species that causing the significant yield losses in wheat production (Lodos, 1989; Özkan, 1996; Jameson et al., 2007). Bekircan et al. (2017) described a new neogregarine species, *Aranciocystis muskarensis* (Neogregarinida: Ophryocystidae), from the *A. segetum* in Nevşehir, Turkey. Especially last years, the importance of biological control against pest has increased with an increase in the demand for sustainable food production and restrictions on the use of chemical control agents (Sørensen et al., 2012). Therefore, the study of distribution and occurrence of *Aranciocystis muskarensis* in the different populations of *A. segetum* may offer a chance to find some new information about its effect on *A. segetum* populations as a natural repressive factor. In addition, this study attempted to determine whether there is a relationship between *Aranciocystis muskarensis* infection and climatic factors.

Materials and Methods

Study location and sample collection

In this study, adults of *A. segetum* were collected from eleven cities of six different geographical regions in Turkey where wheat production is intensively carried out (Figure. 1).

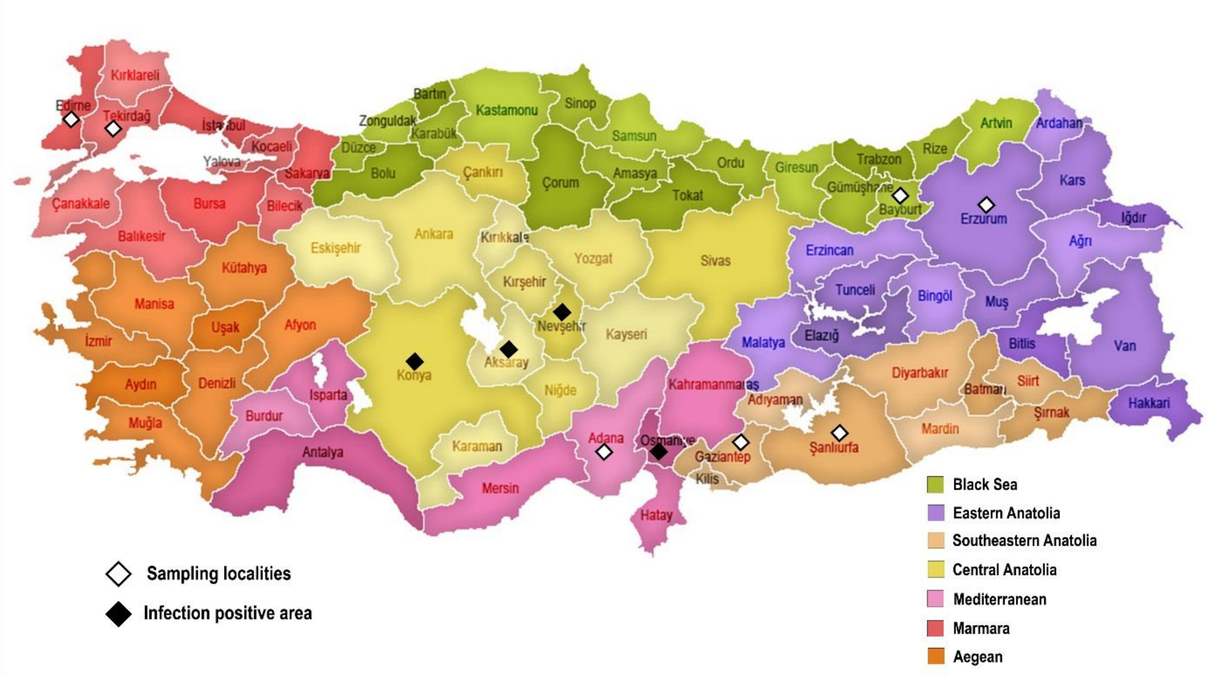

Figure 1. Prevalence *A. muskarensis* in *A, segetum* populations in Turkey.

Sample collection studies were carried out from agricultural ecosystems during the April-July period in 2016 depending on climatic conditions and insect biology. The beetles were put into plastic boxes, transported to the laboratory. The beetles were dissected in Ringer's solution and smeared on microscopic slides then observed under a binocular microscope at magnifications of 400× for detection of *A. muskarensis* oocyst structure (Bekircan et al., 2017). All dissection data (presence or absence) were recorded for using statistical analyses. In addition, the daily climatic data of working months like included temperature, humidity, and precipitation values were taken from the Directorate General of Meteorology of T.C: Ministry of Forestry and Water Affairs to determine if the climatic factors had an effect on the neogregarine infection.

Statistical analyzes

The SPSS 21. 0. 0.0 (SPSS Inc. 1989-2012) software program was used for statistical analyses. The Kolmogorov-Smirnoff test was used to evaluate the data sets (Justel et al., 1997). Correlations and multiple regression analyses were conducted to understand the relationship between neogregarine infection and climatic factors. Correlations analysis were carried according to Spearman method (Spearman, 1904).

Result and Discussion

Neogregarine infection in Anisoplia segetum populations

In the present study, a total of 33 localities from eleven provinces (Nevşehir, Konya, Aksaray, Tekirdağ, Edirne, Gaziantep, Şanlıurfa, Adana, Osmaniye, Erzurum and Bayburt) were randomly selected from six different geographical regions of Turkey for this research. Totally, 3780 *A. segetum* adult beetles were collected from the sampling locality and dissected with the purpose of determining the *Aranciocystis muskarensis* infection (Figure. 2).

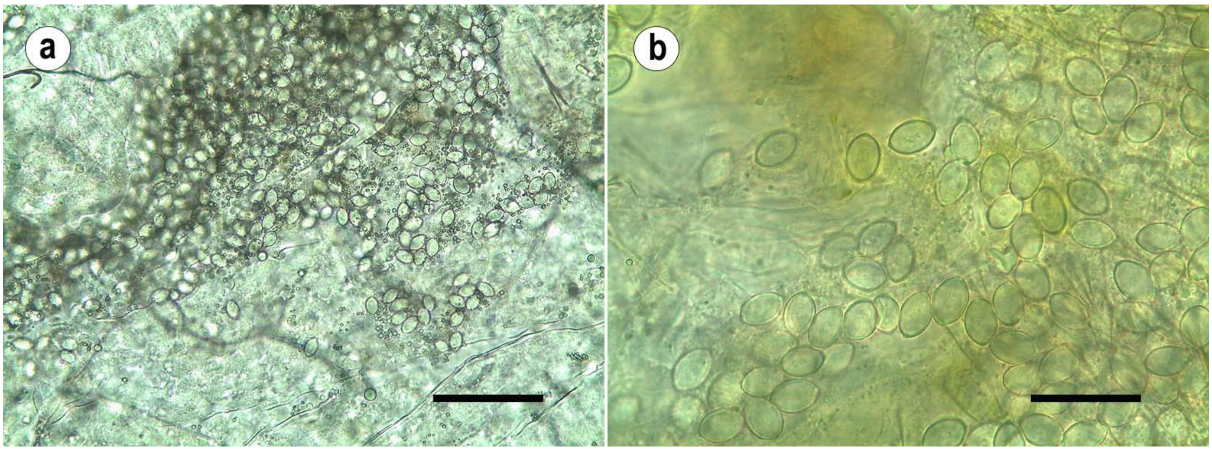

Figure 2. Oocyst structures of *Aranciocystis muskarensis* in host's hindgut at different magnifications. (a) 400X magnification (Bar: 50 µm); (b) 1000X magnification, (Bar: 20 µm).

According to this field study, the densest insect populations were found in Konya, while Bayburt was the province with the lowest insect density (Table 1). 3780 beetles were examined and, 239 of them were ascertained to be infected by *A. segetum* and the total infection rate was detected as 6.32%. Infection was detected only in Nevşehir, Konya, Aksaray and Osmaniye provinces. The highest infection rate was seen in Nevşehir with 18.53% and the lowest infection rate was seen in Aksaray with 1.87% (for the other infection rates see Table 1).

According to the result of this study; the Central Anatolia region was a most intense region for *A. muskarensis* infection in *A. segetum* populations with the 10% infection rate. In addition, June has been the month of the most intense infection rate for in this region.

Variation in climatic factors and infection incidence

Different climatic data like humidity, precipitation, mean temperature, max-min temperature were recorded and analyzed in this study for establishing the relationship between climate factors and *A. muskarensis* infection. When the provinces where the infection was positive are evaluated in terms of climatic factors the highest temperature about 38.5°C was recorded in the July in Aksaray during the year 2016. The lowest temperature of the research period was recorded in the April (-4.5°C) in Nevşehir. In addition, while the highest humidity rate was recorded in the month of April in Osmaniye with 75.6%, the lowest humidity rate was seen 32.1% in the July in Aksaray. During the year 2016, the rainiest month was June, while the driest month was July. And the highest precipitation value was recorded 94.7 mm/m^2 in Konya, again in June. When these climate data and monthly infection rates were associated, it is seen that there was a relation between humidity and *A. muskarensis* infection and the graphical representation also showed this situation (Figure 3).

Association climatic factors with A. muskarensis infection and regression model for this relation

The statistical analyses showed that there was a significant relationship between humidity, maximum temperature, minimum temperature and formation of *A. muskarensis* infection in *A. segetum* populations. The correlation coefficient data indicated that the positive correlation was observed between humidity and *A. muskarensis* infection ($r = 0.618$, $P<0.05$). On the other hand, maximum temperature and minimum temperature showed a negative correlation with *A. muskarensis* infection ($r = -0.637$, $P<0.05$; $r = -0.651$, $P<0.05$, respectively) (Table 2).

Multiple regressions analysis revealed that *A. muskarensis* infection formation in *A. segetum* was determined in 90.8% rate by climatic factors and the other variables (R Square = 0.908). However, the relationship between these independent variables was not statistically significant (Sig. = 0.132, P>0.01). The relationship between *A. muskarensis* infection and variables was formulated as F (7.3) = 4.232; P>0.01. When the effects of the variables on *A. muskarensis* infection were determined individually, the formula *A. muskarensis* infection = -42.969 + (2.919 Mean Temp. + 0.828 Humidity + 1,537 Months) – (0.973 Max Temp. + 1.079 Min Temp. + 0.080 Precipitation + 6.607 Provinces) was obtained. Furthermore, similar to the correlation analysis, it was determined that the most influential factor on *A. muskarensis* infection was humidity (t=2.386).

Table 1. *A. muskarensis* infection in *A. segetum* from the different sampling localities and months

Geographical Region	Province	Months	Number of dissected insects	Total	Number of infected insects	Infection rate	Total infection rate
CENTRAL ANATOLIA	Nevşehir	May	100	750	11	11.0%	18.53%
		June	350		82	23.4%	
		July	300		46	15.3%	
	Konya	May	78	868	5	6.41%	6.31%
		June	420		36	8.57%	
		July	370		14	3.78%	
	Aksaray	May	46	646	-	-	1.87%
		June	300		8	2.67%	
		July	300		4	1.33%	
MARMARA	Tekirdağ	April	53	120	-	-	-
		May	67		-	-	
		June	-		-	-	
	Edirne	April	35	80	-	-	-
		May	45		-	-	
		June	-		-	-	
SOUTHEASTERN ANATOLIA	Gaziantep	April	220	335	-	-	-
		May	115		-	-	
		June	-		-	-	
	Şanlıurfa	April	165	230	-	-	-
		May	65		-	-	
		June	-		-	-	
MEDITERRANEAN	Osmaniye	April	180	401	13	7.22%	8.13%
		May	156		17	10.90%	
		June	65		3	4.62%	
	Adana	April	105	205	-	-	-
		May	100		-	-	
		June	-		-	-	
EASTERN ANATOLIA	Erzurum	May	-	80	-	-	-
		June	35		-	-	
		July	45		-	-	
EASTERN BLACK SEA	Bayburt	May	-	65	-	-	-
		June	15		-	-	
		July	50		-	-	
		GENERAL TOTAL		3780			6.32%

Table 2. Spearman correlation coefficients between different variables and *Aranciocystis muskarensis* infection in *Anisoplia segetum*

	Humidity	MeanTemperature	Max Temperature	Min Temperature	Precipitation	Months	Provinces	Infection rate
Humidity	1.000							
Mean Temperature	- 0.755**	1.000						
Max Temperature	-0.851**	0.949**	1.000					
Min Temperature	-0.722**	0.963**	0.933**	1.000				
Precipitation	0.637*	- 0.560	-0.509	-0.442	1.000			
Months	-0.532	0.887**	0.740**	0.829**	-0.563	1.000		
Provinces	0.583*	-0.173	-0.400	-0.216	0.087	0.000	1.000	
Infection rate	**0.673***	-0.600	**-0.627***	**-0.651***	0.200	-0.299	0.127	1.000

**, * Correlation is significant at the 0.01 level (2-tailed) and 0.05 level (2-tailed), respectively

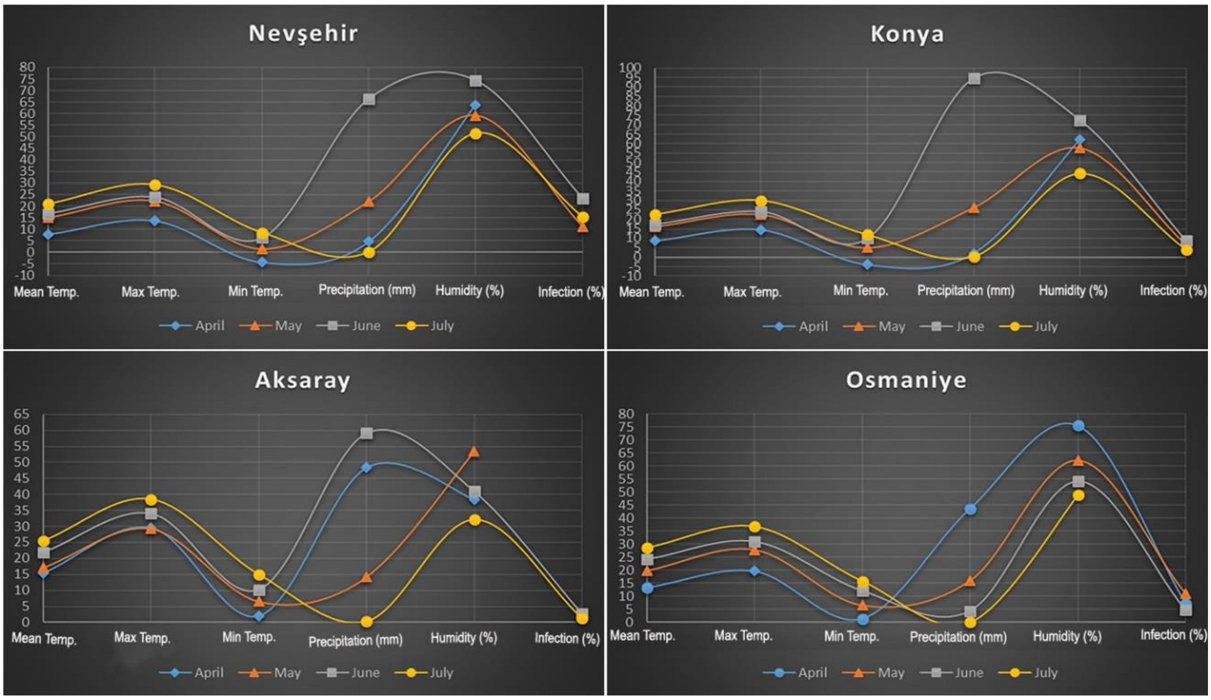

Figure 3. Relation between different climatic factors and *A. muskarensis* infection in *A. segetum* for Nevşehir, Konya, Aksaray and Osmaniye.

Conclusion

This is the first report on the distribution and occurrence of *A. muskarensis*. At the same time, this study was conducted to determine the association between climatic conditions and *A. muskarensis* infection in *A. segetum*. According to the analysis of the correlation made in this study, while significant positive correlation was determined between humidity and *A. muskarensis* infection, the significant negative correlation was observed with maximum and minimum temperature.

Weather is one of the most important factors that affects insect disease epidemics (Rahmathullah et al., 2012). Therefore, understanding of weather and climatic conditions effect on pathogenic infections is required to provide baseline information for managing the pest insects. (Selvaraj et al., 2011). However, in the literature, the number of studies that quantitatively indicate the relationship between neogregarine infections and climatic conditions is rather limited and almost nonexistent. Valin et al. (2004), determined that *Ophryocystis elektroscirrha* infection in monarch butterflies (*Danaus plexippus,* Lepidoptera: Nymphalidae), also showed slow development in hot temperature. In the same study, it was also found that the effect of *O. elektroscirrha* infection at low temperatures was less effective than that at normal temperatures. In another study conducted on monarch butterflies showed that hot temperatures caused a reduction at oocyst formation (Lindsey, 2008). All these results support the present study that both maximum and minimum temperature showed the significant negative correlation with *A. muskarensis* infection.

In the present study, there was a significant positive correlation between *A. muskarensis* infection and humidity. This result is consistent with the current literature. In many studies conducted on the Apicomplexa group, humidity was determined to be an important factor in the infections caused by pathogens from this group (Higgs and Nowell, 2000; Leinwand et al., 2005; Clopton et al., 2016). However, this study was the first attempt to determining the relation between neogregarine infection and humidity. Another difference of this study is that the data used in the present study were obtained from the natural populations and habitats of the *A. segetum*, not from the laboratory environment. In addition; for a successful management of pest insects, research on the epidemiology of the diseases should be under local conditions.

References

Altizer, S.M., Oberhauser, K.S. 1999. Effects of the protozoan parasite *Ophryocystis elektroscirrha* on the fitness of monarch butterflies (*Danaus plexippus*). J. Invertebr Pathol 74: 76-88.

Bekircan, Ç., Cüce, M., Baki, H., Tosun, O. 2017. *Aranciocystis muskarensis* n. gen., n. sp., a neogregarine pathogen of the *Anisoplia segetum* Herbst (Coleoptera: Scarabaeidae). J. Invertebr Pathol 144: 58-64.

Clopton, R.E., Steele, S.M., Clopton, D.T. 2016. Environmental persistence and infectivity of oocysts of two species of gregarines, *Blabericola migrator* and *Blabericola cubensis* (Apicomplexa: Eugregarinida: Blabericolidae), parasitizing Blaberid cockroaches (Dictyoptera: Blaberidae). J Parasitol. 102(2): 169-173.

Cowley, J. 1989. Effect of disease caused by a neogregarine protozoan (*Mattesia* sp.) on the population dynamics of a hill country sod webworm (*Eudonia sabulosella*, Pyralidae: scopariinae). J Invertebr Pathol 53: 159-163.

Ermolenko, V.M. 1971. Atlas of Insect Pests of Field Crops. Urozhai, Kiev, p. 176.

Higgs, S., Nowell, F. 2000. Population biology of *Eimeria* (Protozoa: Apicomplexa) in *Apodemus sylvaticus*: a capture/recapture study. Parasitol. 120: 355-363.

Jameson, M., Mico, E., Galante, E. 2007. Evolution and phylogeny of the scarab subtribe Anisopliina (Coleoptera: Scarabaeidae: Rutelinae: Anomalini). Syst. Entomol. 32(3): 429-449.

Justel, A., Peña, D., Zamar, R. 1997. A multivariate Kolmogorov-Smirnov test of goodness of fit. Statistics & Probability Letters 35: 251-259.

Leinmand, I., Kilpatrick, A.M., Cole, N., Jones, C.G., Daszak, P. 2005. Patterns of coccidial prevalence in lizards of Mauritius. J Parasitol. 91(5): 1103-1108.

Lindsey, E.A. 2008. Ecological determinants of Host Resistance to Parasite Infection in Monarch Butterflies. PhD thesis, Emory University of Biological and Biomedical Sciences. USA. pp 1-151.

Lodos, N. 1989. Türkiye Entomolojisi IV (Kısım I). Ege Üniversitesi Yayınları, s.250-493.

Münster-Swendsen, M., 2008. The effect of sublethal neogregarine infections in the spruce needle miner, Epinotia tedella (Lepidoptera: Tortricidae). Ecol Entomol 16: 211-219.

Özkan, M. 1996. Orta Anadolu Bölgesi Hububat Alanlarındaki Bambul Türleri (*Anisoplia* spp.) ve Bunlardan Hakim Türün Mücadeleye Esas Biyolojik Kriterleri ile Kimyasal Mücadelesi Üzerinde Araştırmalar. Proje C 1994 yılı gelişme raporu, BKA/01-E-036 (Unpublished).

Rahmathulla,V.K., Kishor Kumar, C.M., Angadi, B.S., Sivaprasad, V. 2012. Influence of weather factors on incidence and intensity of microsporidiosis in silkworm (*Bombyx mori* L.). J Entomol. 9: 266-273.

Selvaraj, S., Adiroubane, D., Ramesh, V. 2011. Population dynamics of leafhopper, *Amrasca devastans* distant in cotton and its relationship with weather parameters. J. Entomol., 8: 476-483.

Sørensen, J.G., Addison, M.F., Terblanche, J.S. 2012. Mass-rearing of insects for pest management: challenges, synergies and advances from evolutionary physiology. Crop Prot 38: 87-94.

Spearman, C. 1904. The proof and measurement of association between two things. Am J Psychol 15: 72-101.

Valin, H., Friedle, E., Altizer, S. 2004. Influence of Temperature on Susceptibility and Response of Monarch Butterflies to a Protozoan Parasite. Altizer Lab. Reports in Emory University, USA.