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Bio geographical distribution of *Trissolcus semistriatus* Nees (Polygasteroidea: Scelionidae) an egg parasitoid of sunn pest, *Eurygaster integriceps* puton (Hemiptera: Scutelleridae) in Iran

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Abstract

Trissolcus semistriatus is an egg parasitoid showing the crucial role in plant protection as biological control agents on *Eurygaster integriceps* under different climatic conditions. The geographical distribution of *T. semistriatus* was studied using Maximum Entropy (MaxEnt) in different climatic regions of Iran. Records of 1161 specimens collected from 24 climates, altitude and climate variable data were used for modeling analysis. The results show that northwestern of Iran with climatic characteristics of mild winters, warm summers and arid regime were the most suitable areas for *T. semistriatus*, while the central, western and southeastern parts with very high temperatures were predicted to be less suitable. The habitat distribution patterns for useful species such as *T. semistriatus* can be modeled using the small number of occurrence records and environmental variables which is important in plant protection and implementation of biological control programs.

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Introduction

Wheat is one of the main agricultural crops in the world with a nutrient essential role in the food regime of the human. Sunn pest, *Eurygaster integriceps* Puton limits quantity and quality of crops in Iran and Asia (Critchely, 1998). *E. integriceps* causes 100% damages if the control measures are not taken (Kivan and Kilic, 2006). Chemical control is the main method against the pest but it has negative effects on environment, human health and natural enemies (Amir-Maafi, 2000), therefore it must be replaced by other approaches such as biological control.

One of the most important biocontrol agents are scelionid wasps as the egg parasitoids of sunn pest (Safavi, 1968). In Iran, 16 species of *Trissolcus* genus have been identified that *T. semistriatus* Nees, *T. grandis* Thomson and *T. vassilievi* Mayr are the most widespread and abundant (Abdollahi, 2004). *T. semistriatus* could be found at the altitude range of 900-2150 m throughout Iran (Radjabi and Amir-Nazari, 1989) and nearly wherever of the sunn pest presence. Obviously geographical and temporal distribution of *T. semistriatus* and its effect on the *Trissolcus* species composition vary considerably in different parts of its distribution range (Tarla and Kornosor, 2009).

Determination of insect distribution helps us to better management of pests. Therefore, the current study was carried out using the maximum entropy (MaxEnt) to know the effects of climate, the most contributing climatic variables in the distribution model and suitable habitats of this parasitoid in Iran using species distribution modeling. The objectives of this study were: (1) distribution modeling and predicting the geographic distribution of *T. semistriatus* (2) Determining climatic variables in the distribution that could be used in future ecological and biological control researches.

Material and methods

Species Data

To determine suitable habitats of *Trissolcus semistriatus*, parasitized egg masses of sunn pest were collected from 500 localities in wheat and barley fields where positive identifications had been made in 24 climates of Iran during 2012-2013. The specimens were identified based on the morphological characters of adult females according to the key presented by Masner (1980) and Kozlov (1988) using stereo zoom binocular microscope. Finally a total of 1161 *Trissolcus semistriatus* specimens including 943 specimens collected from climates of Iran, 11 specimens maintained in the Hayk Mirzayans Insect Museum and 207 records of the species distribution mentioned in valid articles were used in the species distribution modeling. Each collection site was georeferenced, and its coordinates of latitude and longitude was assigned by GPS. ArcGIS version 9.3 used to process and visualizes obtained points and the final maps (Fig. 1).

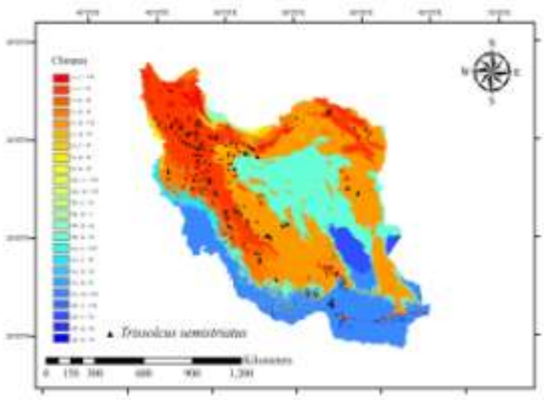

Fig. 1. Collection sites of *Trissolcus semistriatus* in 24 climates of Iran; for climate codes see Table 2.

Environmental variabales

The world Clim dataset comprising 19 climatic variables and altitude across Iran with 30 second (1~ km) spatial resolution was used to predict distribution of *T. semistriatus* (Hijmans *et al.*, 2005) (Table 1). Then, the first 8 environmental variables with maximum contributions in potential distribution model (Table 1*) including annual mean temperature (Bio-1), maximum temperature of coldest period (Bio-6), mean temperature of wettest quarter (Bio-8), mean temperature of warmest quarter (Bio-10), mean temperature of coldest quarter (Bio-11), annual precipitation (Bio-12), Precipitation of wettest quarter (Bio-16) and altitude (Alt) were used in final analysis.

Table 1. Selection environmental variables in Max-Ent model for *Trissolcus semistriatus* in Iran.

	Bioclimatic variables
Bio 1	Annual mean temperature *
Bio 2	Mean diurnal range
Bio 3	Isothermality
Bio 4	Temperature seasonality
Bio 5	Max temperature of warmest period
Bio 6	Max temperature of coldest period *
Bio 7	Temperature annual range
Bio 8	Mean temperature of wettest quarter *
Bio 9	Mean temperature of driest quarter
Bio 10	Mean temperature of warmest quarter *
Bio 11	Mean temperature of coldest quarter *
Bio 12	Annual precipitation *
Bio 13	Precipitation of wettest period
Bio 14	Precipitation of driest period
Bio 15	Precipitation seasonality
Bio 16	Precipitation of wettest quarter *
Bio 17	Precipitation of driest quarter
Bio 18	Precipitation of warmest quarter
Bio 19	Precipitation of coldest quarter
Alt	Altitude *

* Environmental variables with maximum contributions in potential distribution modeling.

Modeling

MaxEnt is a maximum entropy based on machine learning program that estimates the probability distribution for a species' occurrence based on environmental constraints (Phillips *et al.*, 2006). It requires only species presence data and environmental variables for the study area. Since its performance is better than other similar modeling methods (Elith *et al.*, 2006, Ortega-Huerta and Peterson, 2008) we modeled the potential distribution of *T. semistriatus* populations throughout Iran using the MaxEnt version 3.3.3k.

Evaluation Model

For testing of model selected 75% and 25% of the data as training and test data, respectively. Also, selected 10000 background points and logistic output format were used as pseudo absence in the entire study area, which are the continuous habitat suitability range between 0 as unsuitable and 1 as the most suitable (Phillips and Dudik, 2008). Jackknife analysis was used to estimate the contribution of each variable based on the performance of the model.

The resulting model was evaluated with the area under the receiver operating characteristic (ROC) curve (Elith *et al.*, 2006; Phillips *et al.*, 2006). The area under the curve (AUC) statistic as a threshold-independent measure of the performance of a model with a range from 0 to 1 was used to indicate model prediction occurrence and perfect predictions, Models with an AUC value higher than 0.75 are robust models (Pearce and Ferrier, 2000).

Results

The MaxEnt model predicted potentially suitable habitat for *T. semistriatus* with high success rates. According to the model, the north-west and north-central of Iran including provinces of Tehran, Alborz, Qazvin, Zanjan, Ilam, Hamedan, Lorestan, Bakhtiari, Ardebil and kohgiloyeh had a very favorable habitat and also scattered locations in the northeast, northwest and central parts of the country, including the provinces Khorasan, Semnan, West, East Azerbaijan, Kermanshah, Kurdistan, Kerman, Yazd, Iran and the West for the presence of this species are partly right (Fig. 2).

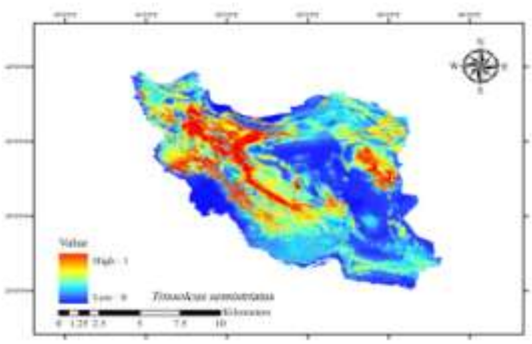

Fig. 2. Prediction of habitat suitability for *Trissolcus semistriatus* in Iran; Color from red (most suitable) to blue (less suitable) shows the suitability trends of locations.

Favorable areas for the presence and distribution of *T. semistriatus* have arid climate with mild winters and warm summers (Fig. 1 and Table 2). The humidor hyperarid localities with mild winters and very warm summers showed no suitability for the species distribution where are the climatic characteristics of central and southwest and southern parts of Iran respectively.

Table 2. Description of the 24 climates of Iran, including Moisture, winter and summer.

Climates codes	Moisture	Winter	Summer
A-C-VW	Arid	Cool	Very Warm
A-C-W	Arid	Cool	Warm
A-K-M	Arid	Cold	Mild
A-K-W	Arid	Cold	Warm
A-M-VW	Arid	Mild	Very Warm
A-M-W	Arid	Mild	Warm
H-C-W	Humid	Cool	Warm
H-K-M	Humid	Cold	Mild
H-K-W	Humid	Cold	Warm
HA-C-VW	Hyper Arid	Cool	Very Warm
HA-M-VW	Hyper Arid	Mild	Very Warm
PH-C-W	Post Humid	Cool	Warm
PH-K-C	Post Humid	Cold	Cool
PH-K-M	Post Humid	Cold	Mild
PH-K-W	Post Humid	Cold	Warm
SA-C-VW	Semi Arid	Cool	Very Warm
SA-C-W	Semi Arid	Cool	Warm
SA-K-M	Semi Arid	Cold	Mild
SA-K-W	Semi Arid	Cold	Warm
SA-M-VW	Semi Arid	Mild	Very Warm
SH-C-VW	Semi Humid	Cool	Very Warm
SH-C-W	Semi Humid	Cool	Warm
SH-K-M	Semi Humid	Cold	Mild
SH-K-W	Semi Humid	Cold	Warm

The cumulative contribution rate of the environmental variables using Jackknife test indicated mean temperature of wettest quarter, maximum temperature of coldest period and mean temperature of coldest quarter was 68% while the 5 others had only 32% contribution output in distribution prediction of the species. The marginal response curves showed the areas with maximum temperature between -10 to -5 ºC in the coldest period, mean temperature of -1 to 8 ºC and -4 to 7 ºC in the wettest and coldest quarter, respectively and altitude with 1000 m to 2000 m including the highest contribution.

The average training AUC with a standard deviation of 0.005 was 0.88 indicating high performances of the MaxEnt model for accurate prediction of the species in suitable habitats.

Discussion

This study predicts the map of potential habitat distribution for *T. semistriatus* in Iran. These new data could be applied practically in designing integrated pest management using this biocontrol agent and its introduction to new localities. *T. semistriatus* was found in the areas with a preference climatic condition ranged from mild winters to warm summers and arid regime based on the distribution prediction analyses. This corresponds with the results of studies carried out by Marton *et al.* (1970) who mostly found the parasitoids from provinces with the above mentioned climatic conditions.

The lack of species occurrence recorded in central, southwest and southern parts of Iran with hyperarid-cold-very warm climates could partly be related to the high temperatures of the localities. Central parts of Iran including salt lakes, deserts, and sand dune areas with high temperatures and windy weather (Bakhtiyari, 1998) were unsuitable habitats for the species, probably because of the impact of hot and dry weather on oviposition rate of the insect and also sex ratio bias towards male individuals (Safavi, 1968).

These parasitoids are distributed in other countries such as Syria (Trissi *et al.*, 2006), Turkey (Kocak and Kilincer, 2002) and Iraq (Wand 2011) in localities with similar climates. *T. semistriatus* is also found in Mediterranean subregions including many parts of central and western Asia (Kozlov and Kononova, 1983; El-Bouhssini *et al.*, 2004; Rajmohana, 2008; Anwar-cheema *et al.*, 2010), many regions of Europe (Popovici, 2004;Kocak, 2007) and North Africa (Laraichi, 1987).

Mean temperature of wettest quarter plays the most important role in distribution modeling of the wasp based on the marginal response curves. It means that the parasitoid prefer moderate localities for parasitization activities, the localities where are mostly found in southern parts of the Caspian Sea and western Iran. The southern and eastern parts of Iran and dry areas, as the regions with high temperatures, were poorly suitable for the species. These results are consistent with those found by Radjabi and Amir-Nazari (1989) that pointed out avoiding of *T. semistriatus* from hot and dry conditions and its distribution in moderate temperatures.

In congruence with several already published studies (Elith *et al.*, 2006; Crawford and Hoagland, 2010; Wilson *et al.*, 2011), the MaxEnt showed its high ability to produce prediction distribution models for the species under study. According to results, the significant predictions of the species distribution opened new insights into the ecology and climatic-based distribution of *T. semistriatus*.

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References

Abdollahi GH. 2004. Analytical approach to age management on sunn pest in Iran.Tehran, Iran: Agricultural Research and Education Organization, Plant Pests and Diseases Research Institute p. 1-110.

Amir-Maafi M. 2000. An investigation on the host-parasitoid system between *Trissolcus* Thomson (Hymenoptera: Scelionidae) and sunn pest eggs. PhD thesis, University of Tehran, Iran 20-45.

Anwar-cheema M, Irshad M, Murtaza M, Ghani MA. 2010. Pentatomids associated with gramineae and their natural enemies in Pakistan. Technological Bulletin Biological Control **16**, 47-67.

Bakhtiyari S. 1998. Complete Atlas of Gitashenasi. Tehran, Iran: Gitashenasi Geographic and Cartography Institute p. 1- 28.

Crawford PHC, Hoagland BW. 2010. Using species distribution models to guide conservation at the state level: the endangered American burying beetle (*Nicrophorus americanus*) in Oklahoma. Insect Conservation **14**, 511–521.

Critchely BR. 1998. Literature review of Sunn pest, *Eurygaster integriceps* Puton. (Hemiptera: Scutelleridae). Crop Protection **4**, 271-287.

El-Bouhssini M, Abdollhai M, Babi A. 2004. Sunn pest (Hemiptera: Scutelleridae) oviposition and egg parasitism in Syria. Pakistan journal of biological sciences **7**, 934-936.

Elith J, Graham CH, Anderson RP, Dudık M, Ferrier S, Guisan A, Hijmans RJ, Huettmann F, Leathwick JR, Lehmann A and *et al.* 2006. Novel methods improve prediction of species distributions from occurrence data. Journal of Ecology **29**, 129–151.

Hijmans RJ, Cameron SE, Parra JL, Jones PG, Jarvis A. 2005. Very high resolution interpolated climate surfaces for global land areas. International Journal of Climatology **25**, 1965–1978.

Kivan M, Kilic N. 2006. A comparison of the development times of *Trissolcus rufiventris* (Mayr) and *Trissolcus semistriatus* Mayr (Hymenoptera: Scelionidae) at three constant temperatures. Turkish Journal of Agriculture **30**, 383-386.

Kocak E, Kilincer N. 2002. Taxonomic studies on *Trissolcus* sp. (Hymenoptera: Scelionidae), Egg parasitoids of the sunn pest (Hemiptera: Scutelleridae: *Eurygaster* sp.), in Turkey. Turkish Journal of Zoology **27**, 301-317.

Kocak E. 2007. Egg parasitoids of sunn pest in Turkey. In: Parker BL *et al.*, Ed. Proceedings of second international conference on sunn pest; 2004 July 19–22; Aleppo. Syria.

Kozlov MA, Kononova SV. 1983. Telenominae of fauna of the USSR (Hymenoptera: Scelionidae: Telenominae). Leningrad: Nauka.

Kozlov MA. 1988. Key to the insects of the Europen part of the USSR. Part 2: Superfamily Proctotrupoidea. Leningrad: Nauka.

Laraichi M. 1987. Etude de la competition intra et interspecifique chez les parasites oophages des punaises des bles. Biologocal Control **23**, 115-120.

Marton H, Javaheri M, Radjabi GH. 1970. Sunn pest (*Eurygaster integriceps*) and its parasitoiids (*Asolcus*) in Iran. Applied Entomology and Phytopathology **28**, 56-65.

Masner L. 1980. Key to genera of Scelionidae of the Holarctic region, with descriptions of new genera and species (Hymenoptera: Proctotrupoidea). Memoirs of the Entomological Society of Canada **113**, 1-54.

Ortega-Huerta MA, Peterson AT. 2008. Modeling ecological niches and predicting geographic distributions: a test of six presence-only methods. Revista Mexicana de Biodiversidad **79**, 205-216.

Pearce J, Ferrier S. 2000. Evaluating the predictive performance of habitat models developed using logistic regression. Ecological Modeling **133**, 225–245.

Phillips SJ, Anderson RP, Schapire RE. 2006. Maximum entropy modeling of species geographic distributions. Ecological Modeling **190**, 231-259.

Phillips SJ, Dudik M. 2008. Modeling of species distributions with MaxEnt: new extensions and a comprehensive evaluation. Journal of Ecology **31**, 161–175.

Popovici O. 2004. New scelionidae species (Hymenoptera: Platygastroidea: Scelionidae) for Romania's fauna. Biological Animal **27**, 103-106.

Radjabi GH, Amir-Nazari M. 1989. Egg parasites of sunn pest in the central part of Iranian Plateau. Applied Entomology and Phytopathology **56**, 1-12.

Radjabi GH. 2007. Sunn pest management based on its outbreaks key factor analysis in Iran. Tehran, Iran: Agricultural Research and Education Organization, Plant Pests and Diseases Research Institute p. 1- 343.

Rajmohana K. 2008. A checklist of scelioninae (Platygasteridae: Hymenoptera) of India. Zoological Indian Journal **21**, 506-613.

Safavi M. 1968. Etude biologique et ecologique des hymenopteres parasites des eufs des punasies des cereals. Entomophaga **13**, 381-495.

Tarla S, Kornosor S. 2009. Reproduction and survival of overwintered and F1 generation of two egg parasitoids of sunn pest, *Eurygaster integriceps* Put. (Heteroptera: Scutelleridae). Turkish Journal of Agriculture **33**, 257–265.

Trissi AN, El-Bouhssini M, Ibrahem J, Abdollhai M, Parker BL. 2006. Effect of egg parasitoid density on the sunn pest, *Eurygaster integriceps* (Hemiptera: Scutelleridae), and its resulting impact on bread wheat grain quality. Journal of Pest Science **79**, 83-87.

Wand AKH. 2011. The level of sunn pest oophagous parasitoids (Hymenoptera: Scelionidae) in infested wheat fields of northern governorate in Iraq with an identification key of *Trissolcus* species. Bulletin of the Iraq Natural History Museum **11**, 7-15.

Wilson CD, Roberts D, Reid N. 2011. Applying species distribution modeling to identify areas of high conservation value for endangered species: A case study using *Margaritifera margaritifera* (L.). Journal of Biological Control **144**, 821–829.