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Claims of potential expansion and future climatic scenarios for *Orius* species (Hemiptera: Anthocoridae) throughout Iran

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ABSTRACT

Orius Wolff 1811 occurs throughout Oriental, Ethiopian, Palaearctic, and Neotropical regions and feed on a wide range of insect pests. This study investigated habitat suitability for 15 species of Orius under current and future climates throughout Iran using a Maxent modeling approach, combining presence-only field data with climate derived variables. To produce the models, samples were collected from 310 localities where the Orius was found. The accuracy and performance of distribution models were also evaluated by the area under receiver operating characteristic curve and jackknife analysis. In the Maxent model, the climatic and elevation were the major bases for the current models. In modeling future distribution, the elevation was excluded. Precipitation of the wettest period was significantly important within the model. The potential distribution of the Orius species under variable climates exceeded the current distribution in some areas of Iran, notably the northwestern and northeastern regions. Under future scenarios, the climatically suitable areas for Orius species globally were projected to expand.

Keywords: Bioclimatic variables, Distribution modeling, Maxent, Niche modeling, *Orius*, Species composition

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INTRODUCTION

Orius Wolff 1811, known as minute pirate bugs (Heteroptera; Cimicomorpha), contains about 70 described species which are distributed throughout a wide range of ecological habitats in Oriental, Ethiopian, Palaearctic, and Neotropical regions [21, 24].

The members of this genus have attracted the attention of entomologists as effective polyphagous predators of important agricultural pests in various agro-ecosystems worldwide [23, 40]. Some species, such as *Orius laevigatus* Fieber, 1860 and *Orius albidipennis* Reuter, 1884, are commercially produced and extensively used in biological control programs in both greenhouses and naturally occurring crops throughout the world [42, 23]. Any new information on the ecological and biological aspects of these predators, including distribution modeling in their current natural habitats and the impact of global warming on their future distribution, can help scientists to design better biological control programs which will consequently result in their more effective usage in pest control programs.

Ecological niche modeling is an effective method for predicting species ranges. It uses local information on the presence of organisms combined with local climatic data to generate models for identifying potential habitats and to assess the likely impact of potential future climate change on species distribution inhabiting the same or similar environmental space [34, 20]. Such methods have been used in Lepidoptera, Diptera, Coleoptera and, to a lesser extent, in Hemiptera to generate both current range and future predictions based on models of global climate change [4].

Maximum entropy implemented in the program MaxEnt [33] is a method prevalently used in distribution prediction modeling. It takes a limited dataset of presence localities [7] and climatic variables from the widely used Worldclim database [19] and fits a statistical distribution to those points to describe and predict a fundamental ecological niche. Additionally, projecting these models onto the future climate dataset represents climatic change scenarios. This allows us to examine the potential effects of global climate change on the predicted future distribution of *Orius*.

For this study, we selected Iran because of its many different climate regions. Iran can be divided into at least four different climate zones, so this area seemed suitable for ecological niche modeling studies. Despite numerous records [e.g. 31, 28, 25, 8, 9, 18] showing the wide distribution of the *Orius* species no information is available on the predicted distribution of the genus in different climates of the country.

Our objectives were to: (1) predict suitable habitats for current and future distribution of *Orius* species in different climates of Iran; and (2) identify the impact of environmental factors, especially global warming, on *Orius's* habitat distribution in order to understand the interaction between environmental factors and the success of conservation biological control.

MATERIALS AND METHODS

Species data

Approximately 8,000 *Orius* specimens were collected from 126 localities covering different climates of Iran [14] using nets, aspirators, and white sample trays during 2010–2012. A dataset compiled from a variety of taxonomic and faunal studies [26, 27, 28, 25, 8, 9, 11, 18] and the records of the species deposited in the Hayk Mirzayans Insect Museum (HMIM) (Iranian Research Institute of Plant Protection) were added to the final dataset. We then georeferenced each locality, assigned coordinates of latitude and longitude and estimated possible error using original publications by GPS, which led to 310 unique localities (unique latitude–longitude combinations) (Appendix A). These points were mapped for the presence of *Orius* species using ArcMap (Version 9.3) (Fig.1).

The species were identified by examining the morphology of the male genital organ according to the keys of [30, 15, 12, 8].

Ecological Niche Modeling

We modeled the potential distribution of *Orius* species throughout Iran in both current and potential future environments using the maximum entropy method of ecological niche modeling (MaxEnt ver. 3.3.3e).

We used the WorldClim dataset [19, 41] comprising nineteen temperature and precipitation variables and altitude interpolated across Iran at up to 30 second (1 km^2) resolution (Table 1). In order to estimate the effect of global climate change on the potential distribution of *Orius* species, the same variables were used to characterize the potential future climate in 2050 based on Global Climate Models (GCMs), CSIRO-Mk3.0 [16] with the A1B scenarios (IPCC, 2000).

A randomly selected 75% of the data were used for model training, and the remaining data (25%) were used for model testing. The software settings were the same as those followed by [35]. Statistical significance tests were also applied using Maxent and related GIS software, ArcMap version 9.3.

The resulting model was evaluated with the area under the receiver operating characteristic (ROC) curve [17, 33]. The area under the curve (AUC) statistic as a threshold-independent measure of the performance of a model with a range from 0.5 to 1.0 was used to indicate model prediction occurrences and perfect predictions, respectively [3, 33]. Jackknife analysis was used to estimate the contribution of each variable based on the performance of the model [32]. ArcGIS 9.3 was used to process and visualize the final map.

RESULTS

A total of 15 *Orius* species from 48% of Iran's climates were identified (Table 2). Of these species, *O. niger* and *O. albidipennis* were found in 91% and 82% of the climatic regions, respectively, while *O. perpunctatus*, *O. maxidentex* and *O. majusculus* were limited to only a few climatic regions (Tables 2 and 3; Fig. 1).

The results from the MaxEnt ecological niche modeling predicted the current distribution of the species in the genus (Fig. 2a). Within its putative current range, portions of northeastern and northwestern Iran were predicted to be suitable habitats for the genus. In other portions of the genus's known range, occurrences were correctly predicted in the north, parts of the northwest and southwest and small parts of northeastern Iran (Fig. 2a).

The results of the global climate change models including CSIRO-Mk3.0 emission scenarios for the potential distribution of *Orius* species for the year 2050 are illustrated in Figure 2b. As the figure shows, the model predicted a future replacement from the northeast and the northwest and an expansion of the genus distribution towards southern Iran in the future.

Main Variables in the Species' Distribution Models

The most important explanatory variable was 'Precipitation of the Wettest Period (Bio13)', with 'Precipitation of Wettest Quarter (Bio16)' and 'Annual Precipitation (Bio12)' collectively contributing 15.2% to the model output (Fig. 3). The response curves for 'Precipitation of Wettest Period' and 'Precipitation of Wettest Quarter' showed that areas with a precipitation range of 50 – 300 mm during the wettest period and 150-800 mm during the wettest quarter had the highest predicted suitability. 'Annual Precipitation' with a range of 200-1400 mm also led to a higher probability of presence after those variables mentioned above. The AUC value for training data was 0.959 (mean [SD] 0.005), indicating a high level of accuracy for the Maxent predictions.

DISCUSSION

Species composition and climate data

Among 15 *Orius* species, *O. niger*, *O. albidipennis*, and *O. laevigatus* were the species most frequently found in different climates of Iran with some overlap of geographic range in Iran's plateau.

Our results indicated that *O. niger* comprised about 91% of all *Orius* species collected. In this survey, *O. niger* was present in all regional climates except arid, cold winter, and warm summer (Table 3). The presence of *O. niger* detected by the present study is consistent with similar trends found by [5] and [36]. *O. niger* has adapted to a wide range of habitat and temperature conditions and is widely distributed throughout the Palearctic region [30, 5]. This fact supports the notion that this species dominates in different climate regions.

In this study, *O. albidipennis* was present in 82% of the climatic regions (Table 3) and was widely distributed in central and southern Iran. The presence of the desert-adapted *O. albidipennis* was found in the present survey to be considerably high in the arid to semi-arid regions, especially in central, south, and southwestern Iran. This finding is in accordance with other reports of *O. albidipennis* distribution [13]. *O. albidipennis* is native to the Mediterranean Basin and East Africa [37]. This distribution pattern in locations with diverse climates implies that this species is highly adaptable to a range of arid to hyper-arid climates [30, 36].

Orius laevigatus was observed in semi-arid to semi-humid climates, suggesting that it is tolerant of a wide range of climatic conditions (Table 3). Our results show that *O. laevigatus* preferred habitats with cool to mild winters and warm to very warm summers (Table 3), a finding consistent with results of [1] and [38]. [38] also pointed out that this biocontrol agent is frequently found in warm localities, including southern European habitats with mild winters. This species has also been recorded in the Black Sea, Mediterranean, Atlantic Britain coasts, and the Canary Islands [13]. This study implied that these biocontrol agents could be considered as good candidates for introduction into new localities for pest control.

Current Distribution and Climate Scenarios

The most common strategy for estimating the actual or potential geographic distribution of a species is to characterize the environmental conditions that are suitable for the species, and then to identify where suitable environments are distributed in space [29]. The models generated using 19 climatic variables indicated ranges for

Orius that are consistent with the known extent of taxon´s distribution (Fig. 2a). The north, parts of the northwest, southwest, and small parts of the northeast of Iran were predicted as suitable habitats for *Orius*. A detailed evaluation of the bioclimatic variables indicated that these regions have higher annual precipitation than neighboring areas, and thus they could be considered as promising areas for further biocontrol programs and the introduction of these natural enemies. According to the rate of contribution of climatic variables (Fig. 3), annual precipitation and two other variables (e.g. bio 13 and bio 16) were the most important factors for defining the current distribution model of the *Orius* species. The general structure of the Iranian agriculture sector, consisting predominantly of smallholder farming systems, provides the species its food and pollen needs. Small farms are separated by wild marginal plants which make semi-natural ecosystems around the main crops that are very rich sources of wild flowers and good refuges for these natural enemies [2, 6, 39, 40].

Some regions with no records of *Orius* species presence were also predicted to have suitable climate conditions, including the northeast and northwestern Iran which is dominated by a semiarid-cool-warm (SA-C-W) climate composition. These areas may have been predicted as a result of imperfections in the predictions of our models; or to a lack of records for *Orius* at locations because of insufficient samples. However, these regions may truly be suitable, and other climatic or biotic factors may be limiting the dispersal of the *Orius* species to those areas.

According to future scenarios for 2050, northern and southwestern Iran is predicted to remain suitable habitats for the *Orius* species. Additionally, a large portion of suitable environmental space is predicted to become available in southern Iran under the models of potential global climate change (Fig. 2b) which are dominated by an arid-mild winter- very warm summer (A-M-VW) climate composition. This was a somewhat unexpected result, as southern Iran, which is dominated by an A-M-VW climate, is too dry, having low annual precipitation (below 200 mm falling almost entirely in winter). The A-M-VW climate has high relative humidity (60% to 80%), suggesting that *Orius* species may inhabit southern regions of Iran by 2050 [10]. In these future scenarios, suitable areas start disappearing from the northeast and the northwest. In fact, based on our analysis, these areas seem not to be climate-suitable because of climatic changes. Climate change is evident from the increase in global average temperatures, changes in rainfall patterns, and the occurrence of extreme climatic events [22]. Some regions were projected to be climatically unsuitable as a consequence of global warming, such as temperature stress in the eastern region of Iran.

In conclusion, this research raises the issue of the impacts of climate change, which can be useful in expanding *Orius* distributions towards the southern and western parts of Iran, but also altering the location of the genus *Orius* as proposed over the next years.

Appendix A. locality Lat/Long for *Orius* species presence records

Sprcies	X	Y
Orius albidipennis	52.58694444	29.61166667
Orius albidipennis	52.43888889	29.96972222
Orius albidipennis	52.57361111	28.61333333
Orius albidipennis	52	29.96666667
Orius albidipennis	52.65222222	29.2725
Orius albidipennis	52.72166667	29.1975
Orius albidipennis	52.69416667	29.57583333
Orius albidipennis	52.14833333	29.67138889
Orius albidipennis	52.43333333	30.2
Orius albidipennis	52.68083333	29.98944444
Orius albidipennis	54.32777778	29.19888889
Orius albidipennis	53.03205556	28.48494444
Orius albidipennis	53.23027778	29.26055556
Orius albidipennis	52.65694444	29.41861111
Orius albidipennis	52.72361111	29.77416667
Orius albidipennis	52.43888889	29.96972222
Orius albidipennis	52.52583889	29.63608056
Orius albidipennis	52.68083333	29.98944444
Orius albidipennis	53.20194444	28.96888889
Orius albidipennis	54.32777778	29.19888889
Orius albidipennis	51.98315556	30.26028611
Orius albidipennis	52.59014167	30.07322778
Orius albidipennis	52.52583889	29.63608056
Orius albidipennis	53.20194444	28.96888889

Orius albidipennis	51.69	29.205
Orius albidipennis	53.32083333	29.50111111
Orius albidipennis	53.20194444	28.96888889
Orius albidipennis	53.20194444	28.96888889
Orius albidipennis	53.20194444	28.96888889
Orius albidipennis	53.20194444	28.96888889
Orius albidipennis	51.98315556	30.26028611
Orius albidipennis	52.47083333	29.77138889
Orius albidipennis	52.47083333	29.82138889
Orius albidipennis	53.32083333	29.50111111
Orius albidipennis	50.45212222	33.91476111
Orius albidipennis	56.26777778	27.18027778
Orius albidipennis	57.18694444	27.44666667
Orius albidipennis	59.53666667	36.32305556
Orius albidipennis	51.58485556	35.79991944
Orius albidipennis	52.61333333	29.58472222
Orius albidipennis	57.08416667	30.29388889
Orius albidipennis	61.50111111	31.02861111
Orius albidipennis	50.86444444	32.32555556
Orius albidipennis	48.51583333	34.79611111
Orius albidipennis	54.43611111	36.83944444
Orius albidipennis	52.42166667	29.74777778
Orius albidipennis	52.68083333	29.98944444
Orius albidipennis	49.45694444	36.85944444
Orius albidipennis	56.28083333	27.31611111
Orius albidipennis	56.36277778	27.2425
Orius albidipennis	57.18694444	27.44666667
Orius albidipennis	52.57361111	28.61333333
Orius albidipennis	53.03205556	28.48494444
Orius albidipennis	53.27555556	28.34463889
Orius albidipennis	53.20194444	28.96888889
Orius albidipennis	53.21916667	28.96888889
Orius albidipennis	51.69	29.205
Orius albidipennis	53.23027778	29.26055556
Orius albidipennis	52.68083333	29.98944444
Orius albidipennis	52.75583333	29.81777778
Orius albidipennis	52.69416667	29.57583333
Orius albidipennis	52.66583333	29.74888889
Orius albidipennis	52.42166667	29.74777778
Orius albidipennis	52.47083333	29.77138889
Orius albidipennis	52.53916667	29.62916667
Orius albidipennis	52.48	29.71305556
Orius albidipennis	51.65416667	29.61555556
Orius albidipennis	52.61333333	29.58472222
Orius albidipennis	52.52776111	29.5754
Orius albidipennis	52.57853333	29.56165
Orius albidipennis	52.76388889	29.84361111
Orius albidipennis	52.58694444	29.72833333
Orius albidipennis	54.1875	31.7425
Orius albidipennis	54.16833333	31.7375
Orius albidipennis	54.38194444	31.85833333
Orius albidipennis	54.16583333	31.73138889
Orius albidipennis	54.43083333	31.57277778
Orius albidipennis	51.07972222	30.99138889
Orius albidipennis	50.90527778	35.80083333
Orius albidipennis	53.05111111	36.56222222
Orius albidipennis	52.35666667	36.47027778
Orius albidipennis	49.45972222	37.47611111
Orius albidipennis	49.58638889	37.26888889
Orius albidipennis	54.98444444	36.48305556
Orius albidipennis	54.95111111	36.42805556
Orius albidipennis	59.44472222	36.33666667
Orius albidipennis	59.53666667	36.32305556
Orius albidipennis	59.53833333	36.31816667
Orius albidipennis	59.53944444	36.31638889
Orius albidipennis	54.98888889	36.46583333

Orius albidipennis	58.32888889	36.10305556
Orius albidipennis	57.08416667	30.29388889
Orius albidipennis	51.67138889	32.65972222
Orius bulgaconeus	45.08458333	37.58166667
Orius bulgaconeus	45.13472222	37.28888889
Orius bulgaconeus	52.35666667	36.47027778
Orius horvathi	52.42166667	29.74777778
Orius horvathi	52.58694444	29.61166667
Orius horvathi	51.98333333	29.66111111
Orius horvathi	52.64805556	29.10166667
Orius horvathi	52.57361111	28.61333333
Orius horvathi	52	29.96666667
Orius horvathi	52.43333333	30.2
Orius horvathi	52.81583333	29.34888889
Orius horvathi	52.53888889	29.60361111
Orius horvathi	52.55	28.95
Orius horvathi	52.61916667	29.07472222
Orius horvathi	52.68083333	29.98944444
Orius horvthi	49.945	36.89444444
Orius horvthi	48.52583333	37.61166667
Orius horvthi	48.33611111	37.68666667
Orius horvthi	48.60916667	37.56083333
Orius horvthi	48.71833333	37.38861111
Orius horvathi	51.07972222	30.99138889
Orius horvathi	52.48777778	29.63472222
Orius horvathi	54.3583333	30.0388889
Orius horvathi	59.47333333	36.51666667
Orius horvathi	52.75583333	29.81777778
Orius horvathi	52.59111111	29.71916667
Orius horvathi	52.68083333	29.98944444
Orius horvathi	52.64805556	29.10166667
Orius horvathi	52.53916667	29.62916667
Orius horvathi	51.98315556	30.26028611
Orius horvathi	52.47083333	29.77138889
Orius horvathi	59.02638889	35.66388889
Orius laticollis	52.58694444	29.61166667
Orius laticollis	51.98333333	29.66111111
Orius laticollis	52.69416667	29.57583333
Orius laticollis	52.81583333	29.34888889
Orius laticollis	52.68083333	29.98944444
Orius laticollis	54.32777778	29.19888889
Orius laticollis	52.53888889	29.60361111
Orius laticollis	52.58694444	29.61166667
Orius laticollis	52.81583333	29.34888889
Orius laticollis	52.59111111	29.71916667
Orius laticollis	49.32194444	37.31166667
Orius laticollis	51.98333333	29.66111111
Orius laticollis	52.69416667	29.57583333
Orius laticollis	52.81583333	29.34888889
Orius laticollis	52.68083333	29.98944444
Orius laticollis	54.32777778	29.19888889
Orius laticollis	52.53888889	29.60361111
Orius laticollis discolor	52.61138889	31.82555556
Orius laevigatus	51.98333333	29.66111111
Orius laevigatus	52.57361111	28.61333333
Orius laevigatus	52.31666667	28.58333333
Orius laevigatus	52.65222222	29.2725
Orius laevigatus	52.57083333	28.84388889
Orius laevigatus	52.72166667	29.1975
Orius laevigatus	52.66583333	29.74888889
Orius laevigatus	52.55	28.95
Orius laevigatus	52.61916667	29.07472222
Orius laevigatus	52.66583333	29.74888889
Orius laevigatus	51.98333333	29.66111111
Orius laevigatus	52.57361111	28.61333333
Orius laevigatus	52.42166667	29.74777778

Orius laevigatus	52.68083333	29.98944444
Orius laevigatus	56.28055556	27.31555556
Orius laevigatus	56.35777778	27.21138889
Orius laevigatus	52.97138889	28.58083333
Orius laevigatus	52.57361111	28.61333333
Orius laevigatus	53.21027778	36.64055556
Orius laevigatus	52.35666667	36.47027778
Orius laevigatus	49.44416667	37.44833333
Orius laevigatus	49.58638889	37.26888889
Orius laevigatus	49.66194444	37.39416667
Orius laevigatus	47.85916667	39.46666667
Orius majusculus	49.58638889	37.26888889
Orius maxidentex	56.28055556	27.31555556
Orius maxidentex	56.35777778	27.21194444
Orius maxidentex	56.35694444	27.21527778
Orius minutus	44.96361111	38.52805556
Orius minutus	49.58444444	37.26805556
Orius minutus	52.42166667	29.74777778
Orius minutus	52.68083333	29.98944444
Orius minutus	48.52583333	37.61166667
Orius minutus	49.31916667	37.31166667
Orius niger	46.7	37.91666667
Orius niger	46.73333333	37.93333333
Orius niger	61.31508333	29.12808333
Orius niger	47.09538889	38.36497222
Orius niger	52.77916667	29.24638889
Orius niger	52.58694444	29.61166667
Orius niger	52.43888889	29.96972222
Orius niger	51.98333333	29.66111111
Orius niger	52.57361111	28.61333333
Orius niger	52.65222222	29.2725
Orius niger	52.57083333	28.84388889
Orius niger	52.69416667	29.57583333
Orius niger	52.72166667	29.1975
Orius niger	52.14833333	29.67138889
Orius niger	52.43333333	30.2
Orius niger	52.81583333	29.34888889
Orius niger	52.68083333	29.98944444
Orius niger	54.32777778	29.19888889
Orius niger	52.66583333	29.74888889
Orius niger	53.03205556	28.48494444
Orius niger	51.98315556	30.26028611
Orius niger	52.53888889	29.60361111
Orius niger	52.54888889	29.53027778
Orius niger	59.47333333	36.51666667
Orius niger	59.15472222	36.47888889
Orius niger	59.02638889	35.66388889
Orius niger	52.72361111	29.77416667
Orius niger	52.72361111	29.77416667
Orius niger	51.65416667	29.61555556
Orius niger	52.445	30.20916667
Orius niger	51.65416667	29.61555556
Orius niger	53.32083333	29.50111111
Orius niger	52.52583889	29.63608056
Orius niger	52.75583333	29.81777778
Orius niger	51.98315556	30.26028611
Orius niger	52.52583889	29.63608056
Orius niger	51.98315556	30.26028611
Orius niger	53.20194444	28.96888889
Orius niger	53.20194444	28.96888889
Orius niger	53.20194444	28.96888889
Orius niger	53.20194444	28.96888889
Orius niger	53.20194444	28.96888889
Orius niger	51.98315556	30.26028611
Orius niger	52.47083333	29.77138889
Orius niger	52.68083333	29.98944444

Orius niger	53.32083333	29.50111111
Orius niger	52.42166667	29.74777778
Orius niger	52.68083333	29.98944444
Orius niger	48.52583333	37.61166667
Orius niger	49.68666667	36.81194444
Orius niger	49.945	36.89444444
Orius niger	49.45694444	36.85944444
Orius niger	49.51861111	36.62944444
Orius niger	49.42027778	36.73277778
Orius niger	48.9925	37.15972222
Orius niger	49.50166667	36.89305556
Orius niger	49.52916667	36.87666667
Orius niger	49.40805556	36.805
Orius niger	49.87277778	37.43333333
Orius niger	48.52583333	37.61166667
Orius niger	53.23027778	29.26055556
Orius niger	52.53916667	29.62916667
Orius niger	52.48	29.71305556
Orius niger	52.42166667	29.74777778
Orius niger	52.58694444	29.72833333
Orius niger	57.18694444	27.44666667
Orius niger	54.1875	31.7425
Orius niger	54.38138889	31.85833333
Orius niger	54.43083333	31.57277778
Orius niger	54.43777778	31.55638889
Orius niger	51.07972222	30.99138889
Orius niger	49.98583333	36.2575
Orius niger	51.06694444	28.93444444
Orius niger	53.21027778	36.64055556
Orius niger	53.05111111	36.56222222
Orius niger	52.35666667	36.47027778
Orius niger	49.45916667	37.43138889
Orius niger	49.44416667	37.44805556
Orius niger	49.46305556	37.4725
Orius niger	49.46138889	37.475
Orius niger	49.58638889	37.26888889
Orius niger	47.85916667	39.46666667
Orius niger	44.96361111	38.52805556
Orius niger	44.965	38.52888889
Orius niger	45.13472222	37.28888889
Orius niger	44.40611111	38.47611111
Orius niger	44.40777778	38.47694444
Orius niger	45.08458333	37.58166667
Orius niger	45.08405556	37.58411111
Orius niger	54.98444444	36.48305556
Orius niger	54.95111111	36.42805556
Orius niger	59.53833333	36.31816667
Orius niger	59.53944444	36.31638889
Orius niger	59.53972222	36.31638889
Orius niger	59.53694444	36.32
Orius niger	59.44416667	36.33477778
Orius niger	59.69222222	36.25416667
Orius niger	59.53666667	36.32305556
Orius niger	58.32888889	36.10305556
Orius niger	50.32138889	33.24194444
Orius niger	58.36527778	29.10638889
Orius niger	52.17055556	30.34166667
Orius pallidicornis	54.95111111	36.42805556
Orius Pallidicornis	53.03205556	28.48494444
Orius Pallidicornis	53.20194444	28.96888889
Orius perpunctatus	52.75583333	29.81777778
Orius retamae	52.42166667	29.74777778
Orius retamae	52.68083333	29.98944444
Orius retamae	52.57361111	28.61333333
Orius retamae	52.97138889	28.58083333
Orius retamae	53.27555556	28.34444444

Orius retamae	52.69416667	29.57583333
Orius retamae	54.1875	31.7425
Orius retamae	54.43083333	31.57277778
Orius retamae	51.07972222	30.99138889
Orius retamae	54.95111111	36.42805556
Orius retamae	52.62916667	28.45077778
Orius vicinus	45.08458333	37.58166667
Orius vicinus	49.94444444	37.265
Orius vicinus	59.44416667	36.33472222
Orius vicinus	51.56666667	35.3
Orius vicinus	45.0725	37.55527778
Orius vicinus	51.38333333	35.81666667
Orius vicinus	52.43333333	30.2
Orius vicinus	52.81583333	29.34888889
Orius vicinus	54.32777778	29.19888889
Orius vicinus	52.53888889	29.60361111
Orius vicinus	59.02638889	35.66388889
Orius vicinus	52.58694444	29.61166667
Orius vicinus	54.32777778	29.19888889
Orius vicinus	52.59014167	30.07322778
Orius vicinus	52.59111111	29.71916667
Orius vicinus	52.42166667	29.74777778
Orius vicinus	52.68083333	29.98944444
Orius vicinus	51.28333333	36.43333333
Orius vicinus	49.58638889	37.26888889
Orius sp.	45.13472222	37.28888889
Orius sp.	44.96166667	38.52861111
Orius sp.	57.18694444	27.44666667

Fig.1. Location map of *Orius* species in 23 climates of Iran

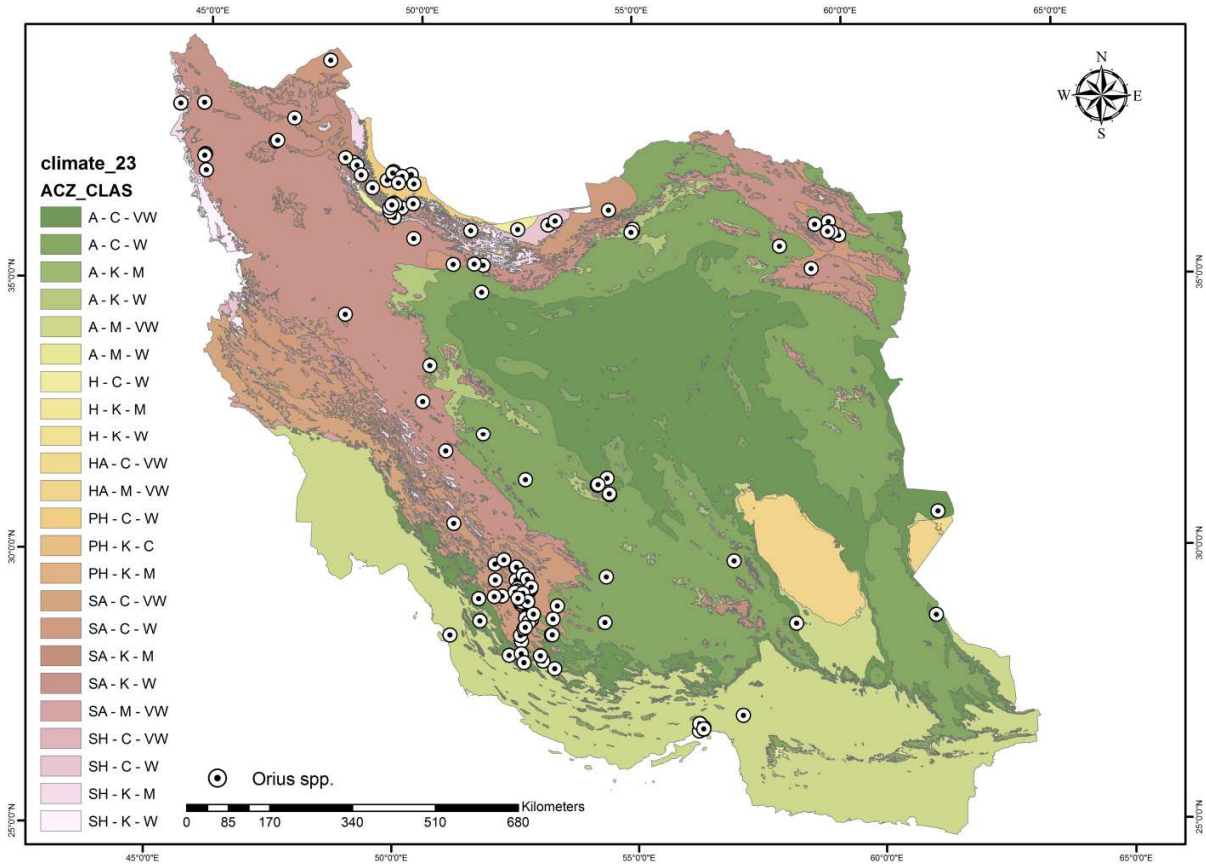

Fig. 2a. Current suitability of *Orius* species areas

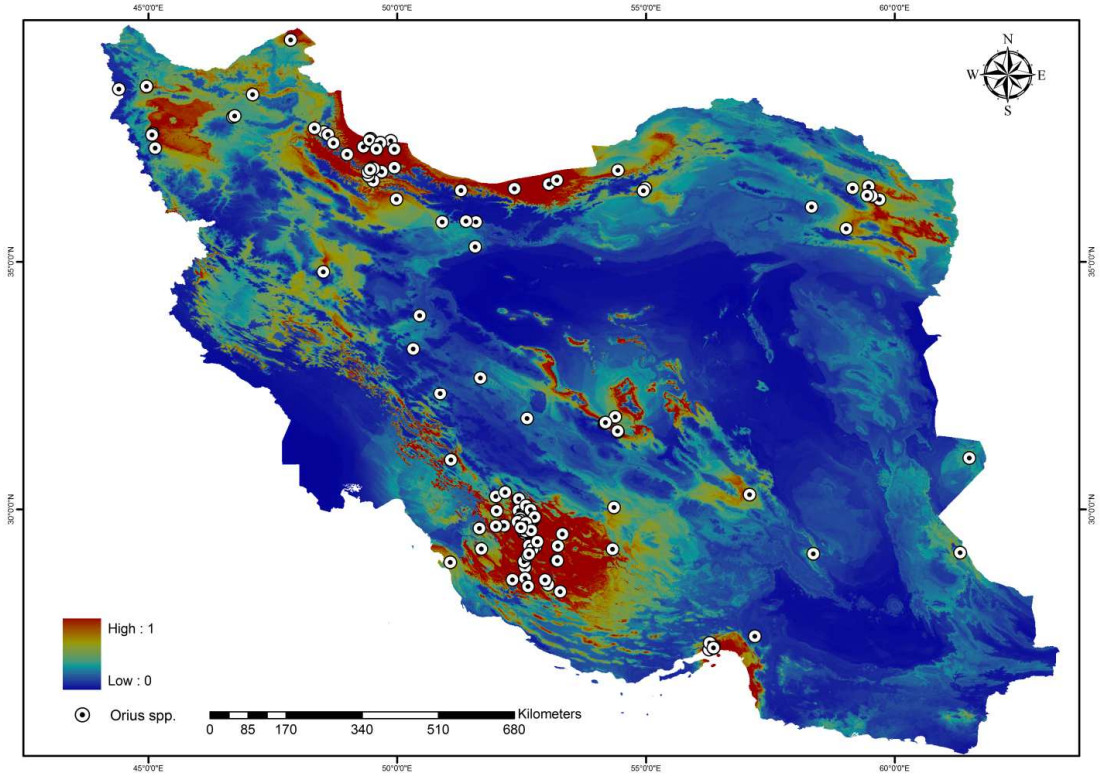

Fig. 2b. Future suitability of *Orius* species areas

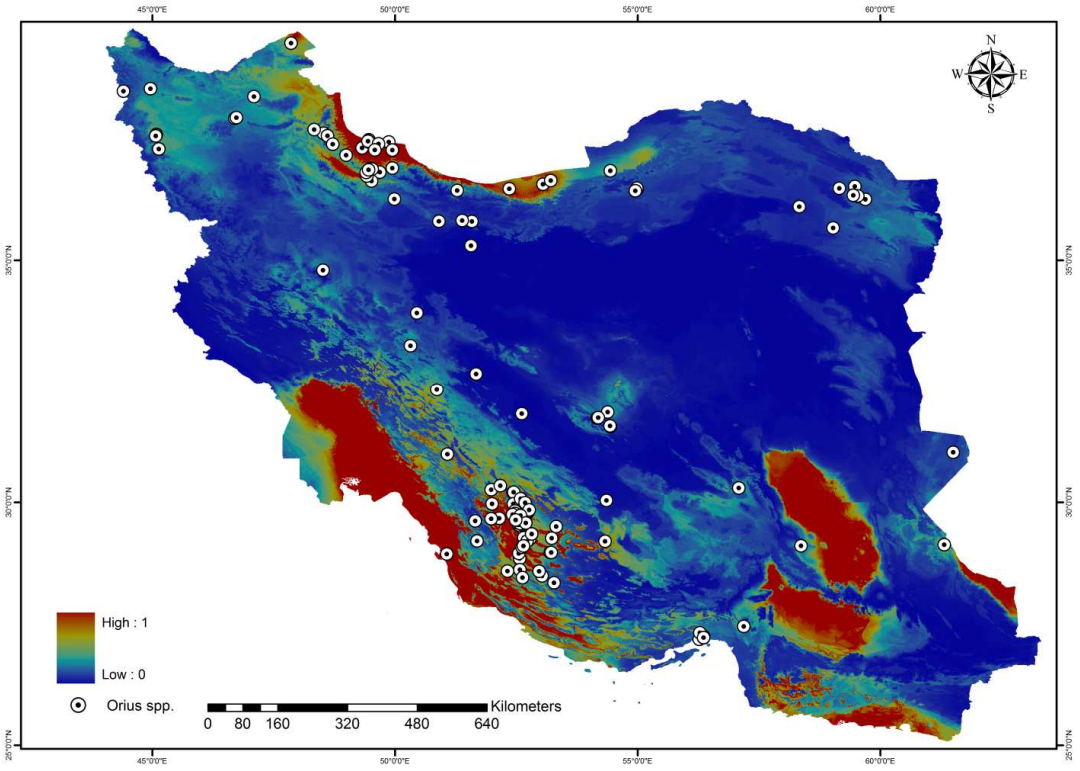

Table 1. Selected environmental variables in Maxent model for *Orius* species in Iran

Bioclimatic variables
bio1 (Annual mean temperature)
bio2 (Mean diurnal range)
bio3 (Isothermality)
bio4 (Temperature seasonality)
bio5 (Max temperature of warmest period)
bio6 (Min temperature of coldest period)
bio7 (Temperature annual range)
bio8 (Mean temperature of wettest quarter)
bio9 (Mean temperature of driest quarter)
bio10 (Mean temperature of warmest quarter)
bio11 (Mean temperature of coldest quarter)
bio12 (Annual precipitation)
bio13 (Precipitation of wettest period)
bio14 (Precipitation of driest period)
bio15 (Precipitation seasonality)
bio16 (Precipitation of wettest quarter)
bio17 (Precipitation of driest quarter)
bio18 (Precipitation of Warmest quarter)
bio19 (Precipitation of coldest quarter)
alt (Altitude)

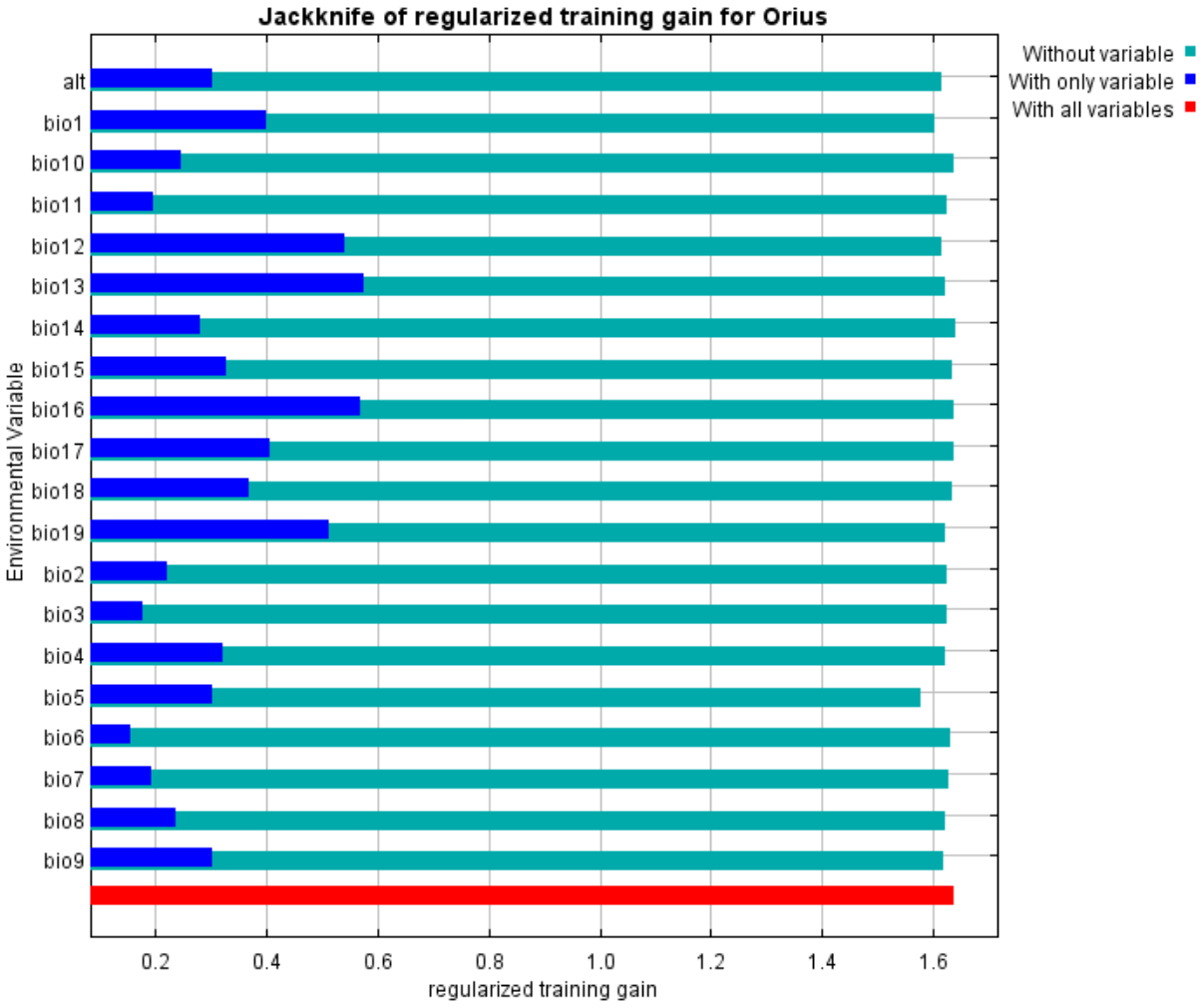

Fig. 3. Jackknife of the regularized training gain (Maxent model): without variable (light blue), with only variable (blue), with all variables (red)

Table 2. Collection localities of *Orius* species and their percent distribution in 23 climates of Iran

Species	Climates	Percentage of species
Orius niger	A-C-VW/ A-C-W/ A-M-VW/ H-C-W/ PH-C-W/ SA-C-W/ SA-K-M/ SA-K-W/ SH-C-W/ SH-K-W	91%
Orius albidipennis	A-C-VW/ A-C-W/ A-K-W/ A-M-VW/ H-C-W/ PH-C-W/ SA-C-W/ SA-K-W/ SH-C-W	82%
Orius laevigatus	A-C-VW/ A-C-W/ A-M-VW/ H-C-W/ PH-C-W/ SA-C-W/ SH-C-W	64%
Orius horvathi	A-C-VW/ A-C-W/ SA-C-W/ SA-K-M/ SA-K-W/ SH-K-W	55%
Orius vicinus	A-C-VW/ A-C-W/ PH-C-W/ SA-C-W/ SA-K-W/ SH-C-W	55%
Orius laticollis	A-C-W/ PH-C-W/ SA-C-W	28%
Orius pallidicornis	A-C-W/ A-M-VW	19%
Orius perpunctatus	SA-C-W	10%
Orius minutus	PH-C-W/ SA-C-W/ SA-K-M/ SA-K-W	37%
Orius retamae	A-C-VW/ A-C-W/ A-M-VW	28%
Orius bulgaconus	H-C-W/ SA-K-W	19%
Orius maxidentex	A-M-VW	10%
Orius majusculus	PH-C-W	10%
Orius sp.	SA-K-W	10%
Orius sp.	A-M-VW	

Table 3. Description of the 23 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
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

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REFERENCES

[1] C Alauzet; D Daragnon; JC Malausa. *Entomophaga*, **1994**, 39, 33-40.
[2] R Albajes; B Lumbierres; X Pons. *Biological Control*, **2010**, 59, 30–36.
[3] MB Araujo; RG Pearson; W Thuiller; M Erhard. *Global Change Biology*, **2005,** 11, 1504-1513.
[4] NR Andrew; SJ Hill; M Binns; MH Bahar; EV Ridley; MP Jung; M Khusro. *Peer Journal*, **2013,** 1, e11.
[5] V Baniameri; E Soleiman-Nejadian; J Mohaghegh. *Applied Entomology and Zoology*, **2005**, 40, 545–550.
[6] F Bianchi; CJH Booij; T Tscharntke. Proceedings of the Royal Society B: Biological Sciences, **2006**; pp. 1715–1727.
[7] J Elith; CH Graham; RP Anderson; M Dudı´k; S Ferrier and et al. *Ecography*, **2006**, 29, 129–151.

[8] D Erfan; H Ostovan. *Journal of Agricultural Sciences*, **2005**, 11, 81–95.
[9] SH Falamarzi; GH Asadi; R Hosseini. *Acta Entomologica Musei Nationalis Pragae*, **2009**, 49, 33-42.
[10] FAO (www.fao.org/ag/AGP/AGPC/doc/counprof/Iran/Iran.htm)
[11] M Farzaneh; H Ostovan; M Haghani. , Proceeding of 19th Iranian Plant Protection Congress, Iranian Research Institute of Plant Protection, Tehran **, 2010**; pp. 144.
[12] F Ferragut; JE Gonzalez Zamora. *Boletion de Sanidad Vegetal Plagas*, **1994**, 20, 89-101.
[13] LJ Ford. PhD thesis, University of Connecticut (Storrs, CT, **1979**)
[14] A Ghaffari; V Ghaemi; E De Pauw. Proceedings of the 8th Iranian Crop Science Congress, The University of Gilan, Rasht, Iran, **2004**.
[15] MSK Ghauri. *Journal of Natural History*, **1972**, 6, 409–421.
[16] HB Gordon; LD Rotstayn; JL McGregor; MR Dix; EA Kowalczyk and et al. The CSIRO Mk3 Climate System Model, CSIRO Atmospheric Research Technical Paper No. 60, CSIRO Atmospheric Research, Aspendale, **2002**.
[17] CH Graham; RJ Hijmans. *Global Ecology and Biogeography*, **2006**, 15, 578-587.
[18] M Hasanzadeh Awal; M Modarres Awal. *Munis Entomology and Zoology*, **2010**, 5, 658-660.
[19] RJ Hijmans; SE Cameron; JL Parra; PG Jones; A Jarvis. *International Journal of Climatology*, **2005**, 25, 1965-1978.
[20] RJ Hijmans; CH Graham. *Global Change Biology*, **2006**, 12, 1–10.
[21] DR Horton. In Encyclopedia of Entomology. Volume 3. Springer, Berlin, Heidelberg. IPCC, **2008;** pp**.** 2402-2412.
[22] V Karuppaiah; GK Sujayanad. *World Journal of Agricultural Sciences*, **2012**, 8, 240-246.
[23] JD Lattin. *Annual Review of Entomology*, **1999**, 44, 207–231.
[24] TM Lewis; JD Lattin. Proceedings of the Entomological Society of Washington, **2010**; 69-80.
[25] RE Linnavuori; R Hosseini. Heteroptera of Guilan with Remarks on Species of the Adjacent Areas. Part 1. Guilan University Publication, Rasht**; 2000**.
[26] M Modarres Awal. List of agricultural pests and their natural enemies in Iran. Revised ed., University Mashhad. **1997**; 147-429.
[27] H Ostovan. *Journal of the Agricultural Sciences*, **1998**, 4, 5–10.
[28] H Ostovan; J Niakan. Iran. *Journal of Agricultural Sciences*, **2000**, 20, 5–14.
[29] RG Pearson. Species' distribution modeling for conservation educators and practitioners. Lessons in Conservation (LinC) Developing the capacity to sustain the earth's diversity, 2007; 54.
[30] J Péricart. Hémiptères Anthocoridae, Cimicidae, Microphysidae de l'Ouest- Paléarctique. Faune de l'Europe et du bassin Méditerranéen. Volume VII. Fédération Française des Sociétés de Sciences Naturelles, Paris, France; **1972**, Volume VII.
[31] J Péricart. In Catalogue of the Heteroptera of the Palaearctic Region, Ponsen and Looijen, Wageningen, Netherlands; **1996**, pp. 108–140.
[32] AT Peterson; KC Cohoon. *Ecological Modelling*, **1999**, 117, 159-64.
[33] SJ Phillips; RP Anderson; RE Schapire. *Ecological Modelling*, **2006**, 190, 231–259.
[34] R Pyron; F Burbrink; T Guiher. *PLoS ONE*, **2008**, 3, e2931.
[35] GD Rubio; LE Acosta. *Journal of Insect Science*, **2011**, 11.
[36] T Schuldiner-Harpaz; M Coll. *PLoS ONE*, **2013**, 8(6), e66622.
[37] IS Sobhi; AA Sarhan; AA Shoukry; GA El-Kady; NS Mandour; SR Reitz. *Biological Control*, **2010**, 55, 753-765.
[38] MG Tommasini. *Bulletin of Insectology*, **2004**, 57, 65-72.
[39] T Tscharntke; R Bommarco; Y Clough; TO Crist; D Kleijn; TA Rand; JM Tylianakis; SV Nouhuys; S Vidal. *Biological Control*, **2007**, 43, 294–309.
[40] A Veres; F Toth; J Kiss; K Fetykó; S Orosz; C Lavigne; S Otto; D Bohan. . *Agriculture, Ecosystems and Environment*, **2012**, 162, 45– 51.
[41] Worldclim (www.worldclim.org/bioclim.htm)
[42] T Yasunaga. *Applied Entomology and Zoology*, **1997**, 32, 355–364.