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ARTICLE

Climate Change and Its Impact on Brown Bear Distribution in Iran

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ABSTRACT

Climate change is one of the threats in the recent century, affecting biodiversity directly and indirectly. Modeling the patterns of species distribution is one of useful tools for predicting the impacts of climate change on endangered species. Brown bear (Ursus arctos) plays an important role as a focal species in mountainous ecosystems. This study was aims to investigate the effects of future climate changes on the distribution of this species using an ensemble modeling method in R-software. For this purpose five algorithms including MAXENT, RF, MARS, GAM, GLM and BRT were used to predict the distribution of the species in the present climatic conditions as well as in the 2050s and 2070s. The results showed that temperature and precipitation were two main factors in the distribution of brown bears in Iran. Investigating the distribution of the brown bear in the future showed that suitability of its habitat will decrease in the western and central parts and increase in the northern parts. So a shift toward higher altitude will be expected for brown bear in the future. Therefore, in this condition it is imperative to upgrade the extent of protected areas for better conservation of brown bear.

1. Introduction

The consequences of the rapid changes in the global climate are still uncertain [1,2]. Since one of the most effective factors on distribution of the species is climate [3,8,35], species respond quickly to climate change [2]. Consequently, changing distribution patterns of species and/or reduction in species diversity can be expected [2,6].

In the recent years, prediction of species response to climate change has attracted much attention from scientists [4,7,8]. Predicting potential future risks play an important role in decision-making and can be used as a powerful tool to prevent the negative effects of climate change on species [4,7]. Although little evidence has been provided so far about the recent extinctions due

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to climate change, many studies have suggested habitat destruction as the major threat to global biodiversity and can be exacerbated by climate change in the upcoming few decades [4]. Nowadays, the application of species distribution models (SDMs) has been a growing increase in numerous studies in ecology, conservation biology and biogeography [9-11]. Among the various applications of the SDMs, habitat suitability of species along with the identification of factors affecting their distribution can be mentioned [11,12]. Moreover, SDMs can be used for prediction of changes in species future distribution under climate change [13,14] which plays an important role in the awareness of managers in order to better planning for the conservation of rare and endangered species [11].

There are various techniques for modeling the species distribution such as maximum entropy (Maxent) [12], artificial neural networks (ANNs) [15], multivariate adaptive regression splines (MARS) [16], random forest (RF) [17], generalized boosting model (GBM) [18], the generalized linear model (GLM) [19] and support vector machines (SVMs) [20]. However, they are considerably different in summarizing the relationships between response and the predictive variables and the projection either at the time of transferring the species distribution into different temporal or spatial contexts [21]. One of the newest SDMs techniques is the platform sdm in R. in which different implementations of the SDMs are integrated in a framework to eliminate the constraints of other methods [21].

Brown bear as a widespread species is small and often isolated populations in the Middle East countries such as Turkey, Iraq and Iran [22-24]. Brown bears live in Iran in the west of the country through the central Zagros Mountains, the Caucasus mountains in the north-west of the country, the Hyrcanian forests on the northern slopes of the Alborz mountains [25]. In recent years, the historical range of this species has declined and they are at risk of local extinction in Iran due to some reasons such as unplanned hunting and habitat loss [4,5].

Numerous studies have been carried out on brown bears that often focused on phylogeographic lineage [24], habitat suitability and connectivity [27], population genetic diversity and ecological isolation [26]. However, little is known about exact distribution and effect of climate change on the distribution of brown bear in Iran.

The aim of the present study was to determine the habitat suitability of brown bear in the present and predicting the distribution of this species in the future under the climate change in order to better planning for conservation of endangered brown bear.

2. Methods and Materials

2.1 Data Collection for Species Occurrence

The occurrence data of species were collected in three ways: 1) direct observation of species by authors, documented and georeferenced observations by personnel of the department of environment (DOE) of Iran and randomly located camera traps, 2) indirect signs of species such as fur, footprints and documented human reports of damages by brown bear and 3) data obtained from literatures [28]. All observations, documents and signs were recorded by GPS. A total of 216 records were used for modelling after removing invalid data with high uncertainty (Figure 1).

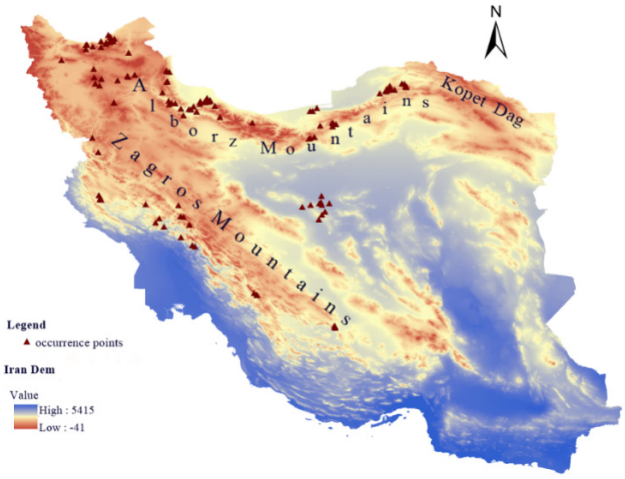


Figure 1. Recorded presence data of brown bears in Iran

2.2 Environmental Data and Effect of Climate Change on Species Distribution

Climatic data layers for HadGEM2-AO model two climate change scenarios: optimistic (2050) and pessimistic (2070) under two future emissions pathways (RCP 2.6 and RCP 8.5) were used to demonstrate the effect of climate change on the distribution of brown bears and predict their future potential distribution [29,30].

The above mentioned emissions pathways (RCP 2.6 and RCP 8.5) are described as levels of radiative forcing in different climate change conditions (between the preindustrial era and 2100) which are the quantity of energy entering the atmosphere and the reflected back [11,31]. To compare current and future conditions, 19 bio-climate variables which were maps with a resolution of 30 second (~1 km^2) and containing world climatic information were taken from the WorldClim database [32]. Then, from the 19 bio-climate maps, Iran's climate maps were extracted in the ArcGIS 10.3 software based on the Dem (Digital

Elevation Model) maps of study area to enhance the accuracy of outputs [33]. A principal component analysis was used in ArcGIS 10.3 to calculate the correlation between layers. In this way, layers with a correlation less than 0.7 were selected to avoid collinearity (auto-correlation) among variables [14,34]. Regarding the habitat and ecological needs of brown bear, finally, 7 climatic layers were selected as bio-climate variables that included annual mean temperature (Bio1), temperature seasonality (Bio4), min temperature of coldest month (Bio6), temperature annual range (Bio7), annual precipitation (Bio12), precipitation of wettest month (Bio13), precipitation of driest month (Bio15).

The total climatically suitable habitats for brown bears in different climate scenarios (present and future) were calculated by ArcGIS 10.3. Finally, in order to show any shift in the distribution of the species under climate change, the suitable range size of species in the present and future conditions were compared.

2.3 Ensemble Distribution Modeling

Species distribution modeling was fitted using SDM package in R [21]. R as an open source environment and high-level programming language widely used for numerous purpose such as graphical visualization, statistical analysis, mathematical computing, spatial analysis and modelling [21,35]. In addition to above mentioned capabilities, developing specialized and new techniques and tools through user-created packages, make R very powerful and distinguishable among other software [21].

SDMTools is a computerized platform in R which is suitable for processing the output of a set of species distribution models [21,35]. SDM includes solving a wide range of ambiguities, imperfections and shortcomings in other methods [21]. Because under different conditions, a method can be chosen as the superior model which is not universally applicable to other species, therefore, one of the possible solutions is the use of Ensemble modeling [21,36] which is suitable for dealing with mistakes and uncertainties between models [37]. In the present study sdm package in R were applied using several algorithms including MAXENT, GLM, MARS, BRT, RF, GAM for Ensemble distribution modeling under different climate scenarios as described by Naimi and Araujo, (2016) [21]and finally, the performance of the models were cross validated.

2.4 Data Analysis

Background data (e.g. pseudo-absence points) are required for all of the used models, hence a randomly drawn sample of 10,000 background points from Iran (extent of study area) was generated excepting occurrence point [14,38] by dismo package in R environment (v. 3.4.3). All available data were randomly divided into two different categories before modeling: 75% of occurrence points as training data and the remaining 25% of data set as test data were used to model cross-validation [39]. One of the most important methods in the sdm package which used for analysis in this study is weight method. The weight method makes an optimal modeling by averaging the quantitative models used to predict the distribution of species. Weighting was based on the area under the curve (AUC) and true skills statistic (TSS). AUC (a threshold-independent measure) and TSS statistics were used for estimate accuracy in the models performance. The AUC curve obtained from the Receiving Operator Characteristic (ROC) curve which is an effective indicator of threshold and prevalence for model performance evaluation [5,14,36,40]. In a model that lacks the ability to detect and predict, the AUC is 0.5 and a very high predictive and detectable model will have an AUC equal or close to 1 [5,41]. Also the TSS statistic is a good measure to predict accuracy of presence-only models which avoids reliance on prevalence or size of validation set [42]. A range from 0 to 1 is considered for TSS. In this way the performance of model was considered good in which values were higher than 0.6 [42].

3. Results

3.1 SDMs for Brown Bear

A total of 200 presence points of brown bears were obtained in this study. Based on the results the highland areas of Zagros and Alborz mountains were the most suitable habitats for brown bears (Figure 1).

The success rates of all algorithms used in the modeling were 100%. So the results are fully acceptable. Accuracy estimates of models using TSS and AUC statistics are given in Table 1. The TSS in all models was higher than the threshold level (i.e. 0.5), indicating high accuracy of modeling. Given the results the values of the AUC were higher than 0.7 which states the high accuracy of modeling.

Table 1. TSS and AUC statistics obtained for accuracy of modeling in different algorithms.

methods	Current	RCP 2.6(2050)	RCP 2.6(2070)	RCP 8.5(2050)	RCP 8.5(2070)
	AUC / TSS	AUC / TSS	AUC / TSS	AUC / TSS	AUC / TSS
GLM	0.84 / 0.58	0.85 / 0.56	0.85 / 0.59	0.86 / 0.6	0.87 / 0.63

methods	Current	RCP 2.6(2050)	RCP 2.6(2070)	RCP 8.5(2050)	RCP 8.5(2070)
	AUC / TSS	AUC / TSS	AUC / TSS	AUC / TSS	AUC / TSS
RF	0.89 / 0.65	0.92 / 0.75	0.92 / 0.72	0.91 / 0.7	0.93 / 0.75
BRT	0.84 /0.61	0.85 / 0.62	0.85 / 0.59	0.85 / 0.62	0.85 / 0.6
MARS	0.79 / 0.59	0.81 / 0.56	0.82 / 0.56	0.84 / 0.57	0.82 / 0.56
MAXENT	0.84 / 0.54	0.88 / 0.64	0.87 / 0.6	0.86 / 0.58	0.89 / 0.66
GAM	0.84 / 0.57	0.88 / 0.63	0.86 / 0.61	0.84 / 0.6	0.87 / 0.63

3.2 Variable Importance

CV testing suggested that the RF model performed reasonably well, with average AUC scores of 0.91 and TSS scores of 0.7. Brown bear species in current climate condition and under the optimistic scenario (2050) will primarily affect by temperature variables more than other variables. Annual mean temperature and temperature seasonality were two main variables affecting the distribution of this species under RCP 2.6 in 2050. Other climatic factors affecting the distribution of brown bear in the current climate condition was annual precipitation. Under the optimistic scenario for the year 2070, the most important factors affecting the distribution of brown bear were annual precipitation and precipitation of the driest month, besides the annual mean temperature. In addition, for the years 2050 and 2070, under the pessimistic scenario, annual precipitation and also precipitation of driest month and annual mean temperature were identified as the main factors affecting the distribution of brown bear. In contrast, the min temperature of coldest month had the least effect on the distribution of this species in Iran (Figure 2).

3.3 Comparison of Different Models

The results of comparison the distribution modeling of brown bear under different climate change scenarios are presented in Figure 3. Based on the results of six modeling methods, it is obvious that some models showed a wider suitable area than the other models. As an instant, in all scenarios most and least suitable habitat of brown bear were observed in prediction maps made by maxent and MRS models, respectively.

3.4 Ensemble modeling and prediction of climate change on the distribution of brown bear

Ensemble modeling was implemented to achieve a more precise model (Figure 4). Based on the results, three categories of habitats are determined for brown bear: habitats without any changes in suitability (areas that are suitable both in the current and in the future), habitats which lost their suitability (areas that are suitable in the current but will lose their suitability in the future) and habitats which will be suitable (areas that are not suitable in the present but will be suitable in the future).

Area shifts of the species distribution under different

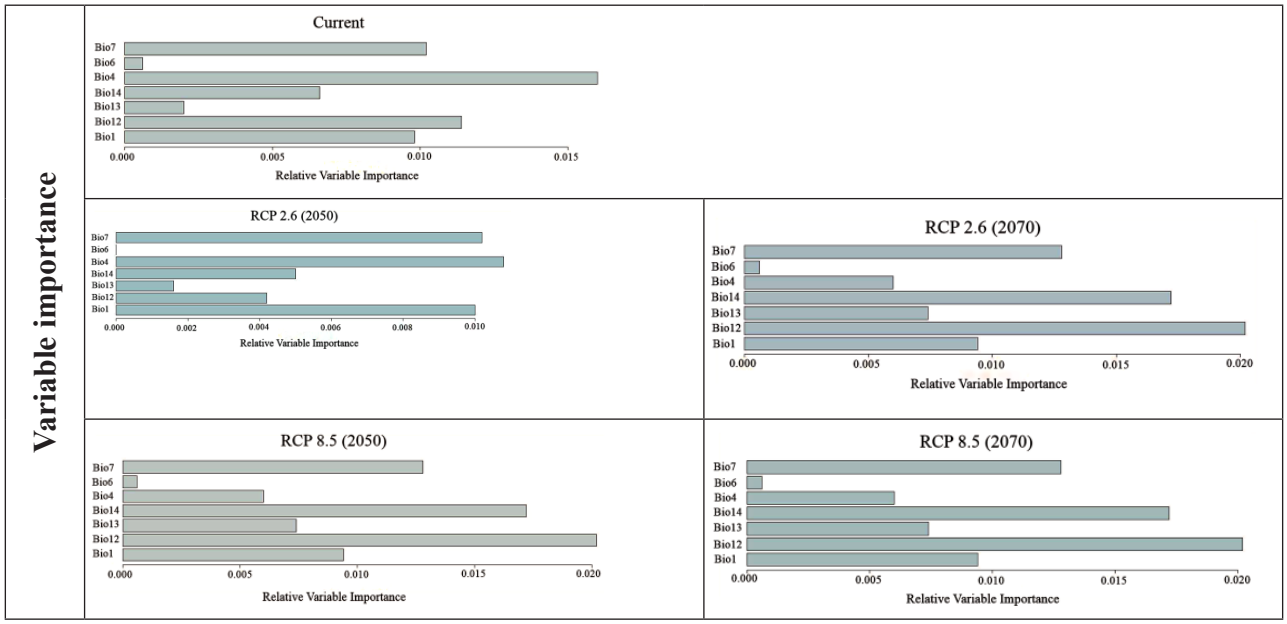
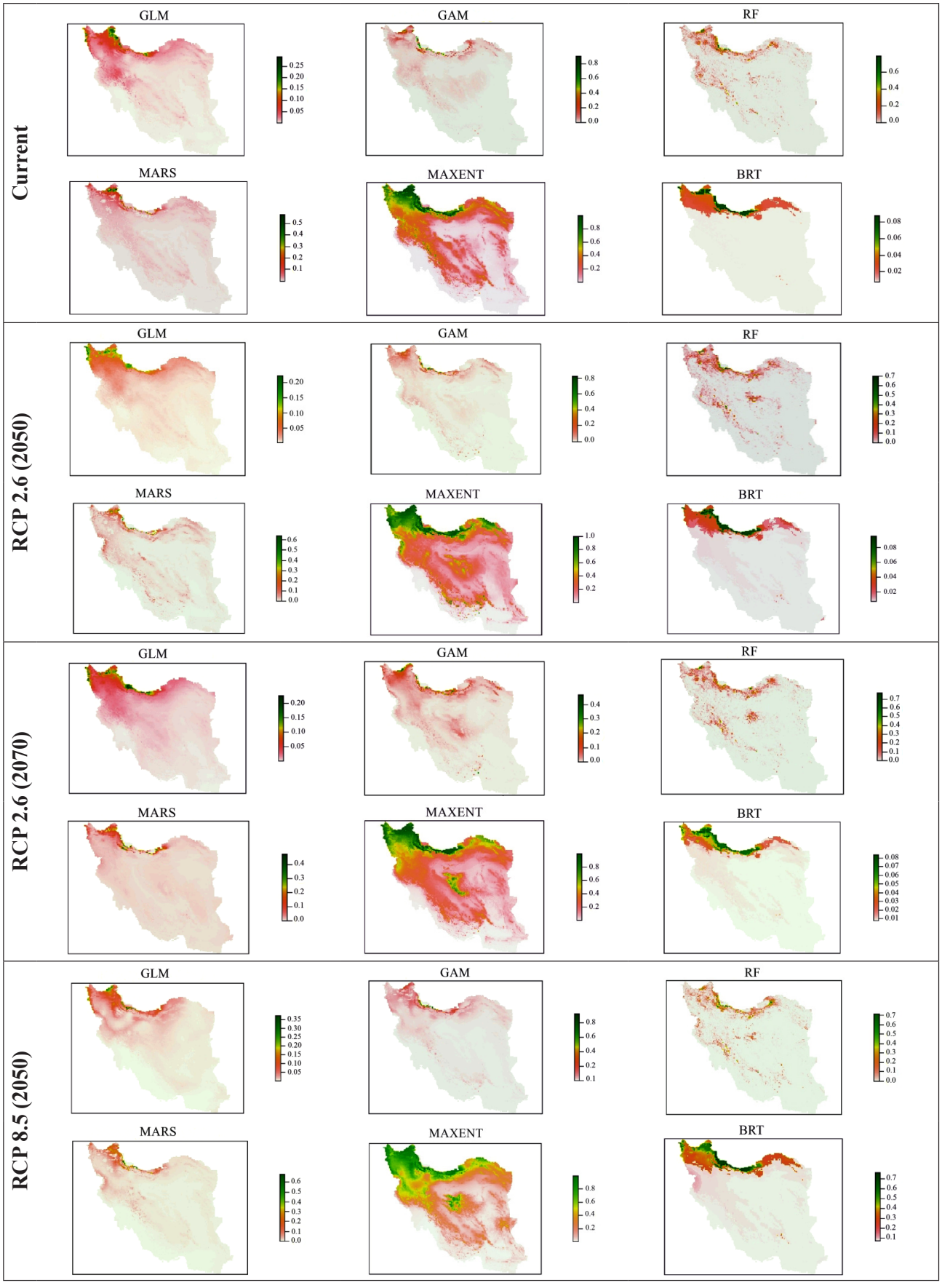


Figure 2. Importance of bioclimatic variables on the spatial distribution of brown bears in current climate condition and different climate change scenarios


Current
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GLM
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RF
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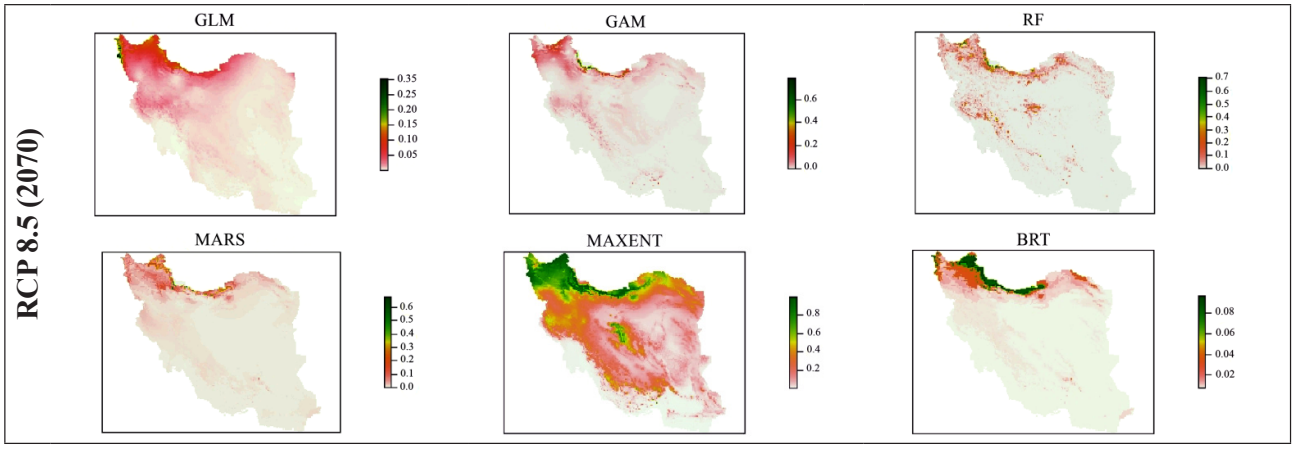

Figure 3. Comparison of predicted species distribution models in different climatic scenarios, using different algorithms

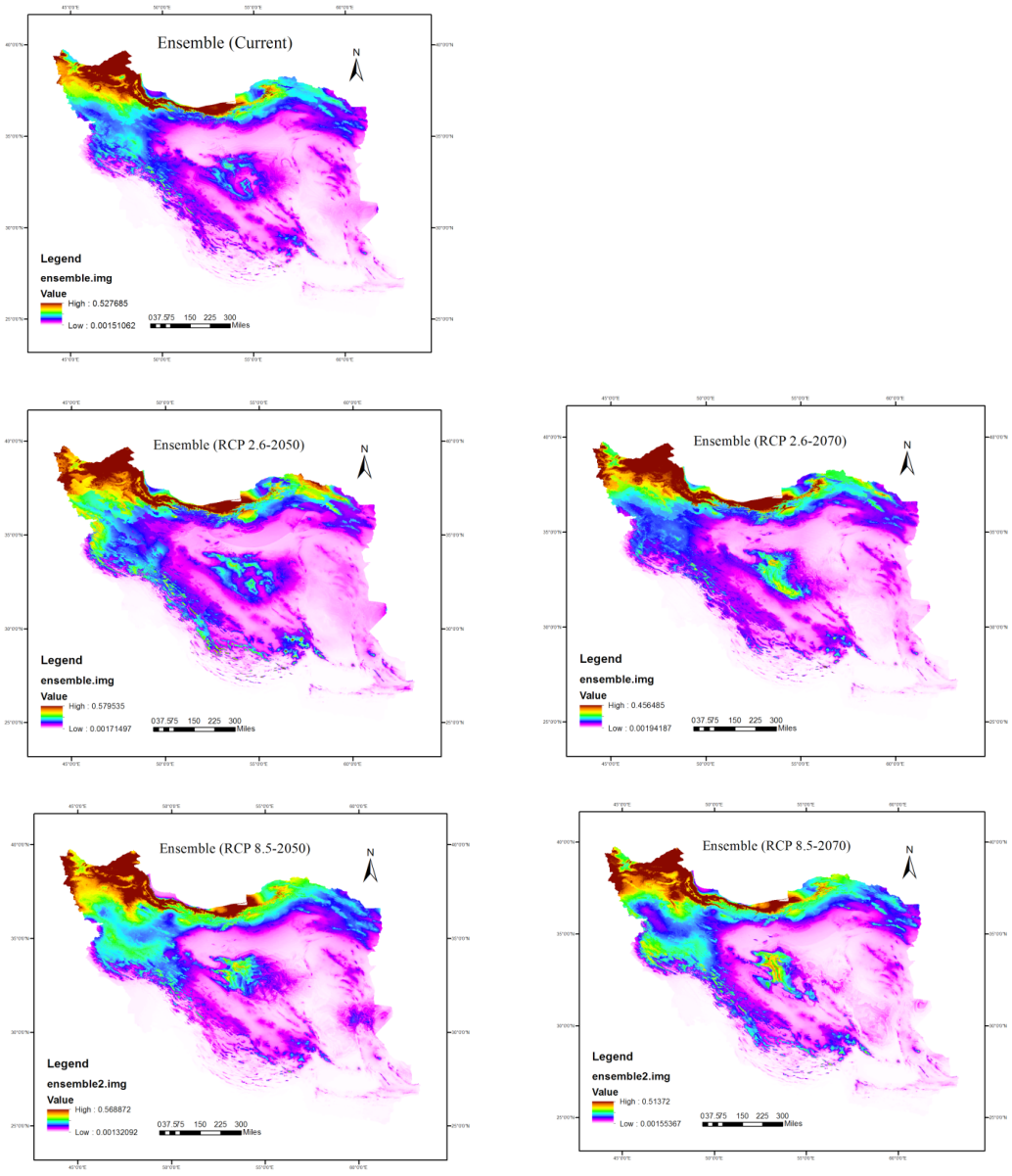

Figure 4. Ensemble modeling of brown bear under different climate change scenarios

climate changes scenarios are given in Table 2. The results demonstrated that under the optimistic scenarios for the 2050 and 2070, the distribution of this species in areas with moderate climatic suitability will be increased 24709 and 7661 km^2, respectively. However in 2050 and 2070, around 22,745 km^2 and 27,661 km^2, will be added to unsuitable areas of brown bear distribution respectively. Under the pessimistic scenario for the 2050 and 2070 the distribution of species in both moderate and suitable climates will be decreased especially in the southwestern part of the country. So that approximately 24305 km^2 and 30322 km^2 will be added to unsuitable areas in 2050 and 2070 respectively.

Prediction maps of brown bear distribution showed that in an optimistic scenario in 2050, suitable habitats of brown bear in Zagros Mountains will lose their suitability compared to current distribution. Consequently, they will have little habitat suitability for brown bear, and this trend is on the rise by 2070 so that only in the northern part of Iran as well as Alborz and Caucasus Mountains will have suitable climates.

According to the prediction maps, reduction in habitat suitability of brown bear were mostly related to western parts of Iran which are the main habitats of brown bear in the Zagros Mountains as well as in central parts of Iran. On the other hand, the climatic suitability of brown bear were increased under both optimistic and pessimistic scenarios in some of northwestern parts of Iran including northern part of West-Azarbaijan, East-Azarbaijan and Ardebil, and northern parts of the Zanjan province, and also northern parts of Iran including Gilan, Mazandaran provinces, and some parts of Golestan and North-Khorasan province, which indicated that the habitat of brown bear affected by climate change will be shifted towards the northern parts of the country.

Table 2. Comparison of distribution area of the species under different scenarios.

	suitable areas / KM^2	Moderate suitable areas / KM^2	Unsuitable areas / KM^2
Current	1478946	623108	144040
RCP 2.6 - 2050	1390156	647817	208121
RCP 2.6 - 2070	1449828	630769	165497
RCP 8.5 - 2050	1506291	571458	168345
RCP 8.5 - 2070	1472959	598773	174362

4. Discussion

Understanding the factors affecting the wildlife activities (for example climate change) plays an important role in the conservation of endangered species [43]. The results of six prediction models showed that despite the high accuracy of models used in the present study, the results obtained from six prediction models were comparable. So that the suitable habitat predicted in maxent models were wider than other models. In consistent with our results Kafash et al., (2019) [8] observed approximately different results in predictions made by four modeling methods. They suggested that results of GLM and Maxent were most liberal and conservative, respectively. So we agree with Naimi and Araujo, (2016) [21] who suggested that ensemble distribution modeling used in this study can eliminate these ambiguities, imperfections and shortcomings in other methods.

Results of the present study showed that temperature and precipitation were two main factors affecting the distribution of brown bear in Iran; on the other hand, the min temperature of coldest month had the least effect on the distribution of brown bear in Iran. These results were similar to the results of Farashi *et al.,* (2018) [44] who suggested that changes in temperature and precipitation are the most important factors which threaten mammals as other studies demonstrated [45,46]. According to the results suitable habitat of brown bear will be decreased under the climate changes which are in line with the results of Segan *et al.,* (2016) [47] who suggested that increasing the average temperature and reducing precipitation will be major factors in the habitat loss and fragmentation in the future. Also the results are consistent with the findings of Ye *et al.,* (2018) [42] and Dar et al., 2021 [48] who showed that the threatened mammals will be affected by future climate changes and will lose much of their suitable habitats. This seems to be the same trend for many mountainous species as climate change and global warming are predicted to have a more prominent effect on mountainous species [49] which stimulate species to migrate to higher altitudes of the mountains and to become isolated [49] and consequently would have promoted species extinctions through direct effects on key life-history traits of animals [31,19] and/or decrease in resource availability [52].

Bojarska and Selva, (2012) [53] suggested that climate conditions especially temperature and snow conditions can affect the feeding ecology of brown bears. It is determined that plants are considered as the most portion of brown bear diet [53]. Since climate change can alter the plant distribution and phenology so it may lead to changes in food availability and foraging behavior of brown bear and will cause competition [31,54,55]. It is noticeable that plants can shift their geographic ranges as a response to

climatic change [56]. So new patterns of plant occupancy/abundance can affect on animals which rely on plant availability for both food and shelter [31,36,57-59]. However it cannot be ignored that it is possible for brown bears to cope with this food challenge due to climate change as they have a wide food niche [60].

Since brown bear is a hibernator species and adapted to seasonal climates, so climate change can also affect breeding of brown bear [50]. During the hibernation period, female brown bears give birth [61], as a consequence they face a trade-off between reproductions and overwinter survival [62]. According to the Humphries *et al.,* (2002) [50] during warm winters in which energetic costs of torpor is increasing it can be expected that energy demands of hibernating mammals increase. As a result, these animals will face to lake of suitable amount of energy for reproduction [62]. So brown bears must increase energy uptake during the growing season especially by feeding plant food to increase body fat before den entry and subsequently to compensate for loss of reproductive potential [61]. Therefore, winter temperature and net primary productivity can directly affect the reproductive rate of brown bear and consequently the population dynamics of the species during the warming period as suggested by Albrecht *et al.,* (2017) [62].

The results showed that in both optimistic and pessimistic conditions suitable habitats of brown bear in the Zagros Mountain as well as central parts of Iran will almost lose their climate suitability for brown bear. On the other hand, the level of climate suitability of the brown bear habitat will increase in both optimistic and pessimistic scenarios in northern parts of Iran such as several parts of the Alborz, Caucasus as well as Kopet Dagh Mountains. So a migration will be expected for brown bear toward the mentioned climatically suitable habitat. Similarly, Chen *et al.,* (2011) [62] found that one of the factors affecting the species range shift is temperature and with increasing level of warming the rates of latitudinal and elevational shifts will increase. In response to rapid climate changes, however, some mammals will be unable to move their ranges quick enough to track shifts in habitats with suitable climates and most of them may not be able to keep pace with climate change [63].

In a study on effects of climate change on predictable food resource and shelter alterations of endangered brown bear, Penteriani *et al.,* (2019) [31] suggested that an increase in human-bear conflicts and bear mortality rates can be expected during range shifts of brown bear individuals from mountainous areas towards more humanized ones. Moreover, we agree with Penteriani *et al.,* (2019) [31] who pointed out more negative effects on brown bear including a) reduction of food resources leads to limited fat storage before hibernation; b) increasing conflicts with cattle farmers by an increase in tendency to a more carnivorous diet; c) increasing road kill during larger displacements between seasons to find main food resources; and d) increasing intraspecific competition with other species which have similar diet. So an appropriate management measures are quite vital to successful mitigation of such conflicts and avoid local extinction of species in the future decades.

5. Conclusions

The present study was the first step in predicting the brown bear distribution under future climate change in Iran. The results showed that temperature and precipitation reduction as the most effective factors in 2050 and 2070 would decrease the distribution range of brown bear and a shift toward higher latitudes will be expected. Hence, it is expected that the effectiveness of current existed protected areas for conservation of brown bear and their feeding resources/habitats will be reduced to protect this species in the future. Therefore, in this condition it is vital to communicate and train target groups for conservation measures including politicians, decision makers, general public, local communities, protected area officials and conservation officers and upgrade the extent of protected areas along with constant monitoring of endangered species, affected by climate change as suggested by Velásquez-Tibatá et al., (2013) [64]. It is recommended that protecting brown bear habitats along with protecting their food resources, minimizing stressor human activities and creating reserve protected areas can be much more effective to their conservation.

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EDITORIAL

Perspectives Concerning SARS-CoV-2 Transmission for the Application of the Livestock Breeding

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Viral transmission between animals and humans has been defined as Zoonosis and zooanthroponosis. The vaccine has been claimed to be the best tool to prevent viral epidemics. However, as learned from SARS-CoV-2, vaccines cannot be the true answer to prevent viral infection for everyone. Some vaccinated persons are still reported to get infected. Viral mutation has been principally postulated to explain immune evasion. Questionable, why the mutated viral strain does not evade the immunity of everyone who has been vaccinated? Mutated viral strains cause various symptoms, non-symptomatic to morbidity and mortality, in different individuals with more or less the same ratio as the original SARS-CoV-2. Approximately, 25-35% of the SARS-CoV-2 detected individuals are asymptomatic, while 15-20% developed severity and about 2-5% have critical symptoms [1,2]. Logically, the viral mutation could keep mutating in any part of its genome. The new variant might maintain infectivity in the same person and might develop to infect another person who once has not been susceptible to the original strain. Thus, the dynamics of viral infection could change from time to time. This requires a better explanation to lead us in the right direction to prevent the emergent virus either now or in the future.

A virus is an obligated intracellular agent therefore it requires entering the susceptible host cell for replication. This is unlike most bacteria which are extracellular organisms and can proliferate regardless of entering into any cell of the infected host. Actually, the virus needs susceptible cellular molecule(s) to play a role as its receptor and co-receptor for attachment and penetration. Each virus uses its receptor-binding domain (RBD)

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to bind a different cellular molecule for this process. For example, SARS-CoV-2 has been known to use angiotensin-converting enzyme 2 (ACE-2) as its receptor and transmembrane protease serine2 (TMPRSS2), and furin as its co-receptors. Many studies found that the cellular molecules of individuals are polymorphism including ACE-2, TMPRSS2, and furin. The association of these cellular molecule variants and the severity of SARS-CoV-2 infection has been suggested in many studies [3-5]. In other words, individuals must have a susceptible variant for viral attachment and penetration. Individuals who were reported to be positive with the viral genome do not mean that they are truly infected. They could be just exposed (invaded), not infected. SARS-CoV-2 has the ability to persist outside the cell for a week in a suitable condition which becomes its advantage for finding a susceptible host for easier transmission than other viruses.

On the other hand, like any foreign substance, a viral agent that is exposed to individuals could induce adaptive immunity to prevent and eradicate the virus. The major immune cells are helper T (Th) cell, cytotoxic T (Tc) cell, and B cell which plays a role to synthesize antibodies. The adaptive immunity could respond to the invading viruses regardless of whether the viruses cause infection or not. To make a story short, the induction of the compatible Th and Tc is dependent on the existence of the major histocompatibility complex (MHC) alleles of the individuals [6,7]. To produce effective adaptive immunity, individuals require compatible MHC alleles to induce the associated Th and Tc cell clones. Subsequently, Th cell clones play the essential role to promote the activated Tc and B cell to be the memory Tc and B cell for effective and long-lasting immunity. Individuals who have incompatible MHC alleles cannot generate the susceptible Th and/or Tc cell clones. Tc is a key to eliminating the viral infected cell while antibody plays a role to neutralize the viral agent for preventing its entry into a target cell. To produce the memory B cell clones that are absolutely specific to the virus's RBD, the compatible Th must be activated. The memory B cell clones can be differentiated to be an antibody-secreting B cell to produce IgG and IgA which are the effective isotype of antibody to prevent the future invading virus [8,9]. Without compatible Th, the individuals can produce only IgM which usually is less effective and disappear sooner. This later group of individuals cannot produce immunity to prevent themselves from the future invading virus [8,9]. This explains why some individuals cannot prevent viral infection although they have been vaccinated. In addition, the vaccinated individuals who have been detected to be reactive to the SARS-CoV-2 might not be truly infected but invaded. It should find a suitable clinical practice to differentiate and handle the situation.

Many viruses, including SARS-CoV-2, do not cause any pathogenesis directly to the host. It is the host immune cells that timeously produce various kinds of cytokines for responding to foreign substances that invade a body regardless of whether they are pathogens or not. The side-effect of pro-inflammatory cytokines subsequently becomes the cause of illness to the host. In the virally infected hosts, the generation of the viral progeny induces unlimited amounts of pro-inflammatory cytokines, so-called cytokine storms, to cause severe pathogenesis [10,11]. In the viral invaded host, on the other hand, the pro-inflammatory cytokines can also be produced but in a limited amount because of no production of the viral progeny but can still cause possible mild symptoms.

Accordingly, as shown in Table 1, it could be proposed

Table 1. Classification of the population based on the existences of susceptible variant(s) of receptor/co-receptor of the particular virus and the compatible MHC alleles

Population group	Susceptible variant(s) of Receptor/co-receptor	Compatible MHCs alleles	Appearances
1	+	+	cause infection and likely to show severe symptoms, however adaptive immunity should be able clear the viral agent within 1-2 weeks
2	+	-	cause infection without any compatible and effective immunity. High potential to cause mortality. Note: to avoid false positive effectivity of the candidate drug, the study should be processed with only this group, not others.
3	-	+	No infection (no viral replication), could be either non or mild symptomatic can produce the entire adaptive immunity against the invaded virus Note: these individuals could be a good source of passive immunity for group 2.
4	-	-	No infection (no viral replication), could be either non or mild symptomatic can produce IgM antiviral antibody, but no memory B and T cells

to classify individuals into four groups based on their genetics of the cellular variants for the susceptibility to the viral infection and the compatible MHC alleles to produce the viral immunity.

Since mammal livestock have similar properties of cellular functions and immune systems as humans, based on this perspective, selective breeding cannot be applied in humans but could be done with mammal livestock. Mammal livestock breeders should have the characteristics as in the population group 3 and their MHC alleles should be heterozygous to generate more compatible MHC alleles for interaction to more varieties of the antigenic epitopes of the emergent viruses. This can bring sustainability to the mammal livestock industry worldwide. In addition, it might be a good way to prevent viral zoonosis. It should be noted that the characteristics of the breeders in group 4 should be avoided since they could be the source of the viral reservoir. This issue could be discussed at another opportunity.

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ARTICLE

Growth Assessment in Camel (*Camelus dromedarius*): A Meta-Analysis Study

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ABSTRACT

In domestic animals, the body weight is the ultimate result of growth which forms the basis of meat production. Sex, nutrition, breed and health are the main factors which influence the growth rate in animals. Heredity which is the major factor affecting the prenatal growth either directly through the genotype of the fetus or indirectly through the genotype of the dam. The prenatal growth patterns and development of the camel fetus is just like the fetus of cattle, however, the meat output from the breeding she-camels is limited often due to longer gestation periods, longer milk feeding periods, lower calving rates under traditional management system. A lot of variation regarding camelid daily growth rate exists that varies widely between breeds, within breeds and regions. There is a significant effect of pre-weaning and post-weaning growth rates on the final body weights in camelids. Management system, the available milk quantity, husbandry practices and vegetative conditions are the main factors that affect the pre and post weaning growth rates of camel calves. However, it is partially dependent on the availability of browsing species throughout the whole year. In this specific study, an effort has been drawn to look into the literature data for camel growth assessment.

1. Introduction

Exploding population has challenged the available food resources; exploration of new resource eras is need of hour to combat the situation. The camel has extreme importance in this regard as it supplements the food chain by providing valuable products like meat and milk. Camel is the key source of subsistence and income for the pastoral community in many areas of the world. The dromedary camel is a best source of meat and milk especially for the areas where production performance of other domestic animals is adversely affected by the harsh climatic conditions [1].

The unique physiological characteristics of camel enable him to tolerate extreme temperatures, radiations, feed and water scarcity and rough topography [2]. Camel has no

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competition with any domestic specie regarding feed and performance due to its specific attributes; they can browse that feed material which is beyond the approach of other livestock species [3]. Even can browse prickly plants, salty and thorny bushes because of having special mouth structure. In the absence of quality forages, camel can utilize poor quality forages with much more efficiency as it can retain fiber in its fore stomach for as long as 70 hours. In contrast with other ruminants, when it is fed with low protein forage it has the capacity and efficiency of reutilizing the urea for microbial protein synthesis [4]. Due to these attributes; camel is considered as the animal with unfathomed potential to meet the future dietary and medical needs of human beings [5].

Mainly there are two types of camels, 1- Single humped (*Camelus dromedarius*) or Arabian and 2-Double humped (*Camelus bactrianus*) or Bactrian. There are 35 million camels in the world while Pakistan ranks 8th with 1.1 million camels [6,7]. One humped camel is 95% of total camel population while Sudan and Somalia contribute 50% of the world's dromedary population. About 70% dromedary population of Asia is present in India and Pakistan. More than 40% of Pakistani camel population is available in Balochistan, 30% in Sindh, 22% in Punjab and 7% in Khyber Pakhtun Khwa province [8].

In arid areas camels constitute the most important source of meat [9]. Mostly they are raised under traditional management systems as pastoralists are moving always in search of food and water over large areas for their camels [10]. Camel is an indigenous genetic resource; it needs to be managed and preserved properly. It plays an indispensable role in the pastoral ecology [11]. Different studies highlight its unique characteristics especially under stress environment [4,5;9,10]. To meet the rapidly growing demands of exceeding population, the strategic idea is to minimize the dependence on external food supply. There is need to recognize the place of camel in farm animals and to get increased output from indigenous natural resources that have not been exploited yet [12-14].

Objective of Study

This paper will illuminate the importance of camel and focus growth at different stages like birth weight, daily weight gain (growth rate) and live weights in dromedary camels.

Methodology of Study

The main methodology of approach was a desk review of literature on camel growth, regarding birth weight, growth rate and live weight.

2. Birth Weight

Various factors like sex of calves, nutrition of dam, breed of sire and dam and health influence the birth weight in camels [15,16]. Among all these, major factor is heredity which affects the prenatal growth either directly through the genotype of the fetus or indirectly through the dam. The prenatal growth patterns and development of the camel fetus is just like the fetus of cattle. The meat output from the breeding she-camels is limited often due to longer gestation periods (13 months) and the she-camel often bears single calf and rarely a twin. The ambulation time of new born camelid is very short and the calf walks within short periods (hours) after birth but remains very close to its mother until maturity as long as five years of age [15]. The range for birth weights in dromedary calves was reported between 27 and 39 kg and it is comparable than that of tropical cattle breeds. [16] reported the average birth weight of dromedary camel as 35 kg and it varies between breeds, regions and even in animals within the breed. The reported birth weights were to be, 26-28 kg in Somali and Tunisian camel calves [17-20] and 39 kg in Indian dromedary calves [21] and there is a minimum influence of sex on birth weight in dromedaries [19]. Weaning weights are very important factor in the growth rate of camels, after weaning the calves were fattened and achieved the highest weight gains at higher protein and energy regimes [25]. The birth weight and growth rate of Pakistani camel calves are summarized in Table 1.

Table 1. Birth weight and growth rate (kg) in Pakistani camel calves

Source	Camel calves	Birth Weight	Daily weight Gain
[22]	♂ calves	-	1.4
	♀ calves	-	0.95
[23]	♂ calves	-	1.5
	♀ calves	-	1.0
[24]	BLPRI Institute calves	-	0.75
	Private farmer's calves	-	0.82
[25]	♂ calves (IMS)	42	0.67
	♀ calves (IMS)	40	0.65
	♂ calves (IMS, fed with 18% CP)	42	0.95
	♀ calves (IMS, fed with 22% CP)	40	1.0
	♂ calves (SIMS)	42	0.42
	♀ calves (SIMS)	40	0.38
	♂ calves (EMS)	38	0.54
	♀ calves (EMS)	32	0.46

BLPRI: Barani Livestock Production Research Institute Kheri Murat; IMS: Intensive Management System; SIMS: Semi-intensive Management System; EMS: Extensive Management System

Figure 1. Marecha camel calves at CBRS

3. Growth Rate

[18] reported 580 gm daily growth rate between birth to 90 days age. Reported growth rate was to be 733 gm/d from birth to 180 days in Indian dromedary camels [26]. These reported values are slightly lower than that of commonly reported rates of cattle but it is really known that camels are normally raised under extensive system of management where their dependence is on rangeland grazing rather than a feedlot. There is limited work on dromedary camel's nutrition that demonstrates a significant relationship between daily intake of concentrates and daily gain. [27] reported a daily growth rate of 260 gm/d in camels fed only on mangroves and 550 gm/d in camels fed on high dietary protein and energy diet. Reported daily weight gain was 400 gm/d and 720 gm/d in Bikaneri camels between 0-1-year age and 7-8-year age, respectively [28].

Dry and wet season have a definite impact on growth rates, in Kenya the calves under traditional management system gained 222 gm/d up to 6 months age in dry season and 655 gm/d in wet season [17]. The intrinsic ability of growth is mainly governed by genetics but supplemented with proper management and nutrition [15-17]. Average daily growth rates of camel calves were reported to range between 0.72-0.86 kg affected by high ambient temperature and restricted milk feeding that can slow this rate [29]. In Kenya, the weight gain in calves was 0.41 kg/d in males and 0.38 kg/d in females while weight gain after the sexual maturity was 0.12 kg/d in males and 0.06 kg/d in females. Moreover, after reaching the adult weights, no change in weight gain was observed [30]. [31] reported that average birth weight and live weight gain of dromedary calf was 35 kg and 0.5 kg/d, respectively.

[32] reported that Sudanese camels raised and managed under semi-intensive and traditional systems did not differ significantly regarding their birth weights. These calves were studied for 18 months of growth, and the mean daily weight gain (gm) under semi-intensive management system (535±9.83) differed significantly from the traditional system (317±5.46), respectively. In Pakistani camel the range for average daily weight gain has been reported by many workers as 0.5-1.5 kg. [22] and [23] reported average daily weight gain as 1.4 kg in male, 0.95 kg in female; 1.5 kg in male, 1 kg in female camel calves, respectively in Pakistan. [24] studied the growth pattern in camel calves. Fourteen camel calves were used in that study. Among them 5 calves belonged to Barani Livestock Production and Research Institute (BLPRI), Kherimurat District Attock, Pakistan and 9 from private farmers. Trial lasted for 6 months and observations were taken at age of 7 days. Calves started nibbling at the age of 4 weeks while all calves suckled their dam's milk *ad lib*. The study demonstrated daily growth rate of 0.75 and 0.82 kg in institute (BLPRI) calves and in private farmer's calves, respectively.

Average daily weight gain was found to be 0.74 kg during 90 days in Saudi camel calves when they were fed 75% concentrate and 25% hay [33]. [34] studied the feedlot performance of dromedary camel fed different dietary regimes and reported average daily gain and dry matter intake as 0.81, 4.53; 0.59, 3.99 and 0.67, 4.42 kg with Kenana pellets, cotton seed cake and ground nut cake-based diets, respectively. [35] studied the effect of management systems on growth performance of Indian dromedary camel calves reared under organized farm conditions and reported average growth rate as significantly higher in intensive system of management (611 gm/d) than semi-intensive system of management (319 gm/d).

In recent studies, [36] compared the intensive management system (IMS) with semi-intensive management system (SIMS) regarding growth rate of Marecha camel calves and found higher growth rate about 674 g/d in male calves of 11-12 months age reared under IMS and 419 g/d in SIMS. In another study, in Marecha camel calves of 11-12 months age reported values were 397 g/d in SIMS and 539 g/d in extensive management system (EMS) [37]. [38] compared the growth performance and hair mineral status of Marecha calves of 11-12 months age in different management systems and found a significant increase in the average daily gain of male and female calves being higher in intensive management system than semi-intensive management system. [39] compared growth rate of weaned growing camel calves of almost 1-year age reared under open grazing/browsing and stall-fed system and found average daily weight gain (DWG) as 480 and 520 gm/d ($P<0.05$), respectively under open grazing and stall-fed system while feed conversion index (quantity of fodder/kg of gain) was found to be 14.42 in stall-fed animals.

The values of daily weight gain (gm) and feed conversion index (gm/kg average daily intake) of male and female weaned dromedary calves around 1-year age were found to be 670, 97.1; 650, 101.5 and 540, 154.3; 440, 125.7 reared under intensive and extensive feeding systems, respectively [40].

4. Live Weight

Various estimates of liveweights in camels have been reported. Age, feeding conditions, sex and general health are the main factors that have obvious effect on the weight of the camel [15-17;23-26,36] and they attain maturity rather slowly than other animals by reaching a liveweight of 650 kg for about 7-8 years of age. In early life (first 2-4 years) there is no marked difference of sex on liveweight in camels and at older ages males get heavier than those of females while [41] reported that mature male calves were heavier than female calves by 38%. Mature male camels (448 kg) were heavier than those of she-camels (414 kg) in the study of [16]. Camel liveweights are also affected by breed and type. Light and heavy breeds weigh about 450-550 kg and 660 kg at maturity and in good condition [42,43]. [44] reported liveweights in camels of different countries as Somalian deserted camels with lightest liveweights (350-400 kg) and Indian camels with the highest liveweights (660 kg). The range of mature weights of Australian camels was to be 514-645 kg in males and 470-510 kg in females. Iranian camels were ranged from 340-430 kg in mature weights at age of 5 years [45]. Various reports are there with a lot of variation regarding camel weights within the same region. Turkish camels ranged between 439-489 kg [46]. Liveweights are significantly affected by body condition and nutritional history. In well finished (fattened in feedlot) deserted Saudi mature camels ranged between 359-512 kg with an average weight of 475 kg [47]. However, reports are present for higher body weights in camels. Castrated male camels (Somali×Turkana) show a range of 530-800 kg liveweights as reported by [48]. [49] reported that the average adult body weight was highest in the Bikaneri breed as 617.33±17.02 and 577.83±9.79 kg in males and females, respectively while the adult Bikaneri animals were found to be heaviest than Jaisalmeri animals which were lightest.

5. Conclusions

The camel is no more considered as "Ship of the desert" now; which rather has been changed to a food security animal in the climate change context with a role as sustainable livestock specie in the desert ecology. It is the chief source of meat and milk for the pastorals and people of marginal areas who have not any mode of production regarding other livestock species and mainly rely on camel for their subsistence. Camels are very productive in terms of meat production and are well recognized nowadays due to its productive abilities and therapeutic worth. This paper highlights the growth patterns and production potential of camel generally; thus, will pave a way for further investigations in camel science proving it a sustained food animal.

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ARTICLE

Road Kills of *Bufotes viridis* (Laurenti, 1768): A Case Study from Konya Province of Turkey

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ABSTRACT

The present study reports vehicle collisions of *Bufotes viridis* (The green toad) in Konya province from Turkey. Our study was performed in more than fifty localities on Yunak-Akşehir highway (D-695). The records were taken in a short time; it is important and remarkable to come across a large number of dead individuals of an amphibian species in a short time. Among all recorded mortalities (n= 246), the highest value belonged to subadults (45% of the cases), followed by juveniles (35% of the cases). The lowest rate among the carcasses was belonged to the adult individuals (20% of the cases). There can be many factors that cause the road kills: These factors are grouped according to the literature under the headings of "direct causes", "indirect causes" and "potential causes" for the road kills. In this study, we evaluated the effects of some factors for *Bufotes viridis*. In general, all terrestrial and semi-aquatic amphibian species, which populations are located the roadsides, suffer from road kills. Because of this situation, there is a need for both further studies and habitat restorations for amphibians.

1. Introduction

There has been a significant decrease in amphibian populations worldwide over the past decade [1,2]. Although some reasons have been suggested for this situation, there are important arguments indicating that anthropogenic activities are the main reason for the decline of amphibian populations [3]. Road mortality is one of the most important human activities that cause the decline of amphibian populations [4]. Traffic has negative effects on amphibian populations and it is possible to divide the negative effects into two: One of them is direct and it means killing individuals. Another one is indirect and it represents fragmenting a population's habitat [5-7]. In both situations, amphibian populations can be severely affected by the adverse effects of road mortality [8].

In the scope of direct effects, it is possible to encounter the mass dead of amphibians as well as to coincide the dead of amphibians individually in road kills related to amphibians. Mass mortalities of amphibians often occur where roads cut across annual migration routes between

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hibernation and breeding habitats [9,10]. The most important reason of mass deaths of amphibian is fragmented habitats. Habitat fragmentation and habitat loss, which are considered as the indirect effects of road kills amphibians, are important threats to amphibian populations [11].

The direct and indirect factors have been known and researched for a long time. Apart from these factors, some researchers have also grouped "potential threats" under several categories [12]. The most noteworthy of these groupings is belonged to Collins and Storfer (2003) and Waldman and Tocher (1998). According to Collins and Storfer (2003), there may be six factors in a group for the decline of a species: Global change, including UV-radiation and climate change, contaminants, alien species, emerging infectious diseases over-exploitation, land use change, and over-exploitation [13]. On the other hands, Waldman and Tocher (1998) reported nine factors in a group: UV-B radiation, habitat disappearance or destruction, fragmentation, pesticides and fertilizers, climate change, genetic causes, diseases, acid rain, and demographic causes [14]. In some cases, a combination of several factors leads to the extinction of a species [15].

The direct and indirect factors with "potential threats" show that amphibians are one of the groups most in danger of extinction and there are many studies in the world [1-4,8,16-26]. However, there are only few studies about the road kills amphibians in Turkey [27-29].

Bufotes viridis (Laurenti, 1768) is one of the amphibian species which is highly vulnerable to road kills. The species lives in the woods, bushes, Mediterranean vegetation, meadows, parks, and gardens. It is present in modified habitats, including the center of large urban areas [30]. Although *Bufotes viridis* has been classified as LC (Least Concern) in the IUCN Red List since 2013 and population trend is stable, some researches on the declining population of the species have begun to be recorded [31]. This situation may adversely affect the population trend of the species in the long-term.

The aims of this study take attention the dense road kills of *Bufotes viridis* in the D-695 highway located between Yunak and Akşehir districts of Konya province in Turkey and contribute to the studies on the road kills of *Bufotes viridis*.

2. Material and Methods

This study was carried out in more than fifty localities on Yunak-Akşehir highway (D-695), which was located in the Central Anatolian Region of Turkey (Figure 1). We observed a large number of dead individuals of *Bufotes viridis* on the way in the summer of 2020. Therefore, this way was chosen to study road kills of the species.

The field study was performed in June which is the activity periods of amphibians. The field survey was performed at night and required only 1 hour (between 8.30 p.m. and 9.30 p.m.) on June 13, 2020. In Konya province, the mean annual precipitation over the last 91 years (1929-2020) was 25.7 mm and the mean annual temperature was 20.1 °C according to climate data provided by 8th. Konya Meteorology Regional Directorate of Turkey.

The size of the D-695 highway between Yunak-Akşehir districts of Konya province was approximately 60 km. The observers began to notice the carcasses of the species at the 50th kilometer of the highway. In other words, the observations were performed on the Yunak-Akşehir highway in an area of approximately 10 km. The highway has two-lane roads and the maximum speed limit outside settlement areas are 90 km/h. The carcasses were observed by the driver and a passenger when driving a car at slow speed (≤ 40 km/h) as reported in the literature [32]. After the first carcass was noticed, the car was stopped and two observers who walked along the part of D-695 each side, looked for carcasses. Meanwhile, the observers noticed puddles on both sides of the road. The date, temperature, and geographic coordinates were recorded using a GPS server (GARMIN eTrex 20x). We identified the individuals based on the morphological characteristics of the species. Finally, we took the photographs of all carcasses by Nikon-Coolpix P500) to record the valuable data of the species, which were exposed to the car crash.

3. Results and Discussion

The study performed with the beginning of the three-month period (June-August) during which the average temperature increases (22 °C) and the average precipitation decreases (13 mm) in Konya province. The June is an important month for this study because of be activity periods of amphibians. In parallel with this situation, some studies which on road kills of The green toad were performed in activity periods in the literature [31,33-35].

Figure 1. The map showing the highway (D-695) of the observed individuals exposed to road kills on Yunak-Akşehir in Konya province of Turkey

We detected more than 200 mortality cases of *Bufotes*

viridis only an hour on D-695 highway and recorded both numerically and visually. The photos of individuals, which exposed to road kill, were given in Figures 2 and 3. The reason why the dead individuals of The green toad were found intensively in a short time may be that *Bufotes viridis* is one of the few amphibian lives in city centers or tremendously urbanized areas in some cities [36-38]. According to study of Telenchev et al. (2016), individuals of *Bufotes viridis* can die due to crashing vehicles coming towards them at low speed while high speed on highways can be dangerous for some amphibian species.

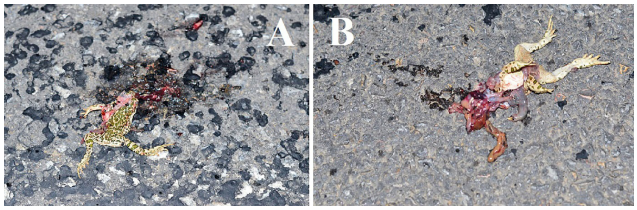

Figure 2. A general view of carcasses of a male (A) and a female (B) *Bufotes viridis* found on Yunak-Akşehir highway

Bufotes viridis is perfectly tolerant of reservoirs that have been designed by humans [38,39]. However, the dozens of carcasses of *Bufotes viridis* were seen nearly every kilometer on the highway in Konya province. The individuals of *Bufotes viridis* hibernate at high temperatures during their life cycle [40]. This situation may be causing it to expend a great energy during the hibernation period. For this reason, when the individuals of The green toad wake up from hibernation, their bodies may be more bulky than some other amphibian species. As a result, high temperatures for hibernation may be a reason why individuals of *Bufotes viridis* are intensely exposed to road kills [35].

The green toad is a more thermophilic species than some other amphibian species, preferring to breed in warmer and even temporary water bodies [33], although *Bufotes viridis* tolerates dry, sandy or stony habitats in the terrestrial areas [41]. Considering the month when the observations in this study and the puddles located on the sides of the road; it can be thought that individuals were returned from mass migration. Individuals of The green toad need to cross roads for the continuity of their migration. As a result of these situations, the individuals of the species may have exposed to a high rate of road kills while they returned from mass migration.

One of the important data obtained within the scope of this study is that the most deceased individuals (45% of the cases) of the species which was exposed to road kills were subadults. The second most dead individuals were juveniles (35% of the cases). Adult individuals were the least exposed to road kills (20% of the cases). On the other hand, Valkanova et al. (2009) reported that the adult specimens of *Epidalea viridis* have a significant predominance of the road for road kills, compared with the subadults and juveniles in Plovdiv, Bulgaria. According to study of Valkanova et al. (2009) this situation may be due to the larger size of adult individuals of The green toad. The large size of adult individuals may limit their mobility in front of the approaching vehicle [42]. In both cases, the road kills may become a threat for the future of *Bufotes viridis* populations.

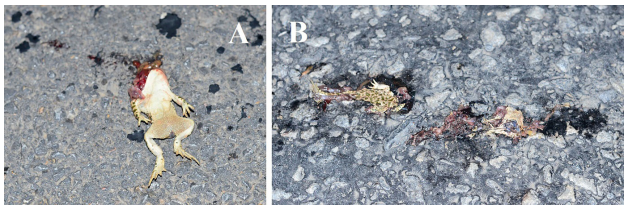

Figure 3. A general view of The green toad carcasses belonged to an adult female (A) and a subadult (B) individuals found on Yunak-Akşehir highway

As could be clearly seen, the direct factors (killing individuals), the indirect factors (fragmenting a population's habitat) and the potential factors [land use change according to Collins and Storfer (2003) and the habitat disappearance or destruction, fragmentation according to Waldman and Tocher (1998)] play a role together in the road kills of the individuals of *Bufotes viridis*.

Some important projects are performed in the world to minimize road kills of amphibians. One of the most successful examples is amphibious tunnels in this regard. The first amphibian tunnels were built in Zürich, Switzerland in 1969. Afterwards, it was recorded that road kills in amphibians decreased [12]. In Turkey, more precautions should be taken regarding road kills of amphibians to protect amphibian populations.

4. Conclusions

This study was conducted on 13th June 2020 and all observations were performed in the limited time (only an hour) on 10 kilometers of Yunak-Akşehir highway. It is remarkable that so many dead individuals were observed in a limited time and a limited area. On roads such as the highway mentioned in this study, where individuals of the *Bufotes viridis* are exposed to road kills, precautions such as closure of the road to traffic during the hours (between 8 p.m. and 6 a.m.) when the toads go out on the highway for migration will prevent the decrease of these toads. The new studies which will perform over a longer period and on a wider part of the road may point that the current numbers of the dead individuals are increasing. In

the present study, we observed that individuals belonged to *Bufotes viridis* suffered high rates of road kills on a single road. Exposure of individuals of The green toad to high amounts of road kills on other highways may pose a serious problem for the future of the species in the long period.

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ARTICLE

Call Census, Habitat Suitability Modeling, and Local Communities' Perceptions for the Conservation of a Globally Threatened Avian Flagship Species

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ABSTRACT

The Western tragopan (Tragopan melanocephalus) is recorded in the IUCN Red List of 2017 as a vulnerable bird species in Pakistan. This study provides valuable information for the conservation of Western tragopan, which is a globally threatened avian flagship species in Pakistan. This study was conducted to investigate and resolve the conservation challenges surrounding the species in two major habitat zones - Salkhala Game Reserve and Machiara National Park. The study was implemented in May-June 2020 for population density using call count data. Also, questionnaire was used for local residents' perceptions and habitat suitability modeling map was generated using the MaxEnt model based on previously recorded occurrence points as well as recorded in the survey. A total of 26 western Tragopans were identified by call count during the sampling period. Moreover, about 77.3% cited Western Tragopan they more likely to hunt while the remaining 22.6% locals recorded other pheasant. About 45.3% of this hunting for fun but only 22% for economic values and only 3% of people consider hunting as a part of their culture. Results of modeling habitat suitability of the Western tragopan showed that the species suitable habitats are small and patchy in Pakistan. We found that the Normalized Difference Vegetation Index (NDVI) with 40.6 percent contribution was the most important variable in shaping the species distribution. Our model identified some new suitable patches which can be the target of future field monitoring for finding new populations of the species and future conservation planning.

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1. Introduction

The planet is currently experiencing a sixth mass extinction [1] due to climate change, over-exploitation, environmental variation, natural disasters, and habitat destruction [2]. In light of this global extinction crisis and the continuing increase in the number of globally threatened species [3], prioritizing conservation action and funding is arguably more important than ever [4]. The process of urbanization exerts drastic changes in natural landscapes, with the complexity of urbanized zones driven by human activities that are based on social, cultural, and political drivers [5]. Such activities have had large adverse impacts on key bird species. For example, many pheasants hold a central position in the food webs of their native ecosystems, but are facing extinction due to human exploitation and habitat loss [6]. Their colorful plumages and charismatic breeding displays have made them prominent figures in traditional folklore and conservation campaigns, as well as cultural icons appreciated by native people and the mainstream public [7]. In particular, the Western tragopan (*Tragopan Melanocephalus*) subsequently referred to as 'Tragopan', an endemic and extremely elusive pheasant of the Western Himalayas, has been greatly affected by human influences, resulting in its IUCN Red List Vulnerable status (2017).

In Pakistan, the tragopan is distributed in and around Palas Valley and adjacent areas of Kohistan, Kaghan valley in the Khyber Pakhtunkhwa Province, Machiara National Park, Salkhala Wildlife Sanctuary, Pir Chinasi, and Pir Hasimari in Azad Jammu and Kashmir state of Pakistan [8-10]. The species is a brilliantly plumaged, ground-dwelling bird that shows high sexual dimorphism though no clear demarcation between juvenile females and males [11,12]. Adult females have black patches and central white streaks on their feathers while adult males have numerous white spots, each spot bordered with black and deep crimson patches on the sides and back of the neck [12]. Males also possess a naked throat (lappets) used to attract females during the breeding season [13]. Males are larger in size (body length 65-75 cm; weight 1.9 kg to 2.3 kg) than females (body length 60 - 65 cm; 1 kg to 1.7 kg) [12]. They live in broadleaf and coniferous forests with thick undergrowth and bamboo at elevations of 2,400-3,600 m [14]. The species is adapted to mountain having a dense shrub layer which indicated as the function of high disturbance and hunting rates [9]. Tragopans prefer to stay in places with no human disturbance and are confined to extremely steep terrain [7]. They move down in elevation during the winter season to lower valleys due to snowfall, which reduces the food resources available to them. They then return to higher elevations during the summer season [9].

The specie's vulnerable status is attributed to its small and sparsely distributed declining population with increasingly fragmented habitat and continuing forest loss throughout its range [15] (IUCN 2014). Current estimates suggest a global population of approximately 5,000 individuals [16], which is thought to be roughly equivalent to 3,300 mature individuals [16,17]. However, this number may be smaller than previously thought, which may warrant moving the species to endangered status [15]. Throughout its range, the tragopan is termed 'the King of Birds' among local communities. It is commonly regarded as an important flagship species for the fragile mountainous forest ecosystems where it occurs [18,19] but faces numerous conservation challenges with areas of its range being data deficient, such as the Salkhala Game reserve and Machiara National Park of Pakistan.

People of Azad Jammu and Kashmir state of Pakistan depend on ~90% of the surrounding forests for their livelihood [20]. This is reflected by the concessions granted to local farmers for unrestricted grazing of livestock, including within protected areas [21]. Together with the common local practice of maximizing livestock numbers for reasons of honor and prestige instead of quality, overgrazing of alpine pastures and the surrounding forests result in widespread suppression of forest regeneration. In a country where only ~5.1% of its total territory is forest (Food and Agriculture Organization, 2019) and significant demands are being made on this natural resource, this is further stressed by illegal logging [18]. Furthermore, illegal hunting and weak law enforcement add to the major regional conservation issues. Poaching of tragopan is done using different techniques and traditional pitfall traps were found to be used [22].

In the rural areas of developing countries, such as the Himalayan forests in Pakistan, land use is boosted to improve the production of agriculture materials [23]. The Himalayan Forest is the most destroyed among the globe's [24], due largely to degradation from sedentary livestock overgrazing, nomadic activities, legal as well as illegal tree cutting and tree harvesting [25]. More than 96% of agriculture growth in Pakistan are causing deforestation [25]. On the other hand, cattle incasement and pasture creation as it is a best source of income are also the main reason of deforestation in the Himalayan Forest [26]. Also, these forests are assumed to be the most vulnerable and fragile to climate changes [27] and many species, especially birds have threats due to fragmentation and degradation of forest [28,29].

For this study, we sought to obtain data points for call counts based on suggestions from local residents who have been working for years in the observed areas, but also

used the occurrence points for a habitat suitability model reported in previous studies (cite the studies). Specifically, we aimed to: (1) determined the number of birds using a standard method call count census recommended by [17], and also to compare the present counting with studies previously recorded for the same species at both study areas owing to evaluate if the population is increasing or decreasing, and (2) interview the local community to determine perceptions, and current knowledge base surrounding the species. Finally, we (3) aimed to find a habitat suitability model for this iconic species in order to know the future challenge for this bird.

2. Materials and Methods

Study area

The study was conducted in two major zones (see Figure 1). The Salkhala Game Reserve (SGR) and Machiara National Park (MNP). SGR (8.1 km^2, 34.33° N and 73.50° E) and its surrounding area are situated 80 km to the north-east of Muzaffarabad city, the capital of Azad Jammu and Kashmir, Pakistan. The area borders the Line of Control (LOC) with India on three sides whereas the river Nelum along with human settlements confines the north-western side of the reserve. SGR falls under the IUCN's protected area Category IV (Habitat/Species Management Area) with an altitudinal range between 1,320-3,150 m [8]. The area has a mean annual rainfall of 1257 mm with March and April being the wettest months, and heavy snowfall during the winter months [30].

Machiara National Park which is located in the Himalayan mountains of Azad Jammu and Kashmir Pakistan. This national park is located on the northeast of Islamabad with total distance of 165 km MNP (34310 N, 73770 E). The mean annual temperature range is 13.6-27.3 °C with four distinct seasons, for example winter is considered from December to February, spring from March to April, summer of the area is assumed to start from May and ending in August while the autumn season is beginning in the September and reach up to November [31]. The rainfall such as mean annual is recorded nearly 1526.7 mm and average days per year recorded for rain is about 84.5; November is assumed the driest month with 35.4 mm and July is considered the wettest month with 327.6 mm and this might be due to monsoon that is starting from July to August. MNP is the home of one of the world's most attractive hotspots for biodiversity within Himalayan mountains [32].

Forests in the study area are dominated by conifers, with broad-leaved associates, shrubs and a rich the undergrowth of herbs and grasses. Conifer tree species include west Himalayan fir (*Abies pindrow*), west Himalayan spruce (*Picea smithiana*), Himalayan cedar (*Cedrus deodara*), blue pine (*Pinus wallichiana*), Himalayan yew (*Taxus wallichiana*), brown oak (*Quercus semecarpifolia*), Himalayan maple (*Acer caesium*), walnut (*Juglans regia*), Himalayan birch (*Betula utilis*) and idian horse chestnut (*Aesculus indica*) while some Important animal species living within the study area include the common leopard *Panthera pardus,* snow leopard *Panthera uncia*, leopard cat *Prionailurus bengalensis*, Himalayan black and brown bear *Ursus thibetanus*, Asiatic jackal *Canis aureus*, red fox *Vulpes vulpes*, yellow-throated marten *Martes flavigula* and golden eagle *Aquila chrysaetos*. Himalayan temperate forests have some Endemic birds including western tragopan, cheer pheasant *Catreus wallichii* and Kashmir flycatcher *Ficedula subrubra*, although recent surveys have failed to locate cheer Pheasant or Kashmir flycatcher [18,31].

Data collection

A reconnaissance survey was conducted in May-June 2020 to identify potential habitat of the study species. Information surrounding tragopan occurrence was gathered from park employees and review literature [18,33] based on which study plots were selected in the potential habitat of species. Study sites were selected based on researcher accessibility to the area. The two major zones, SGR and MNP were further divided into survey plots shown in Table 1.

SGR was divided into six plots, each with a single point based on the presence of the bird confirmed by a departmental survey specialist and given the fact that total area of the reserve is about 5.5 km^2. Two survey teams were selected, each with a lead observer and an assistant. MNP on the other hand cover 135 km square and the divided into ten recommended plots again with single points based on previously recorded hotspot for the bird [33] and on local people information as they are familiar with many species traditionally as well as culturally. Average size of each plot was about 5x5 km^2 and the field work was carried out with three survey teams and each plot was surveyed nearly two times a week for one-month Table 1.

Due to resources limitation, we used call count census to record the number of tragopan number at each point, which is a well-known method used in previous literature following the method [34,35]. Himalayan pheasants are best surveyed in May to June when they are breeding and tend to be most vocal [18] and the reason we followed the suggested time period to study the species. Call counts were conducted in a radius of 300 m from the center of each plot to confirm the presence of the species and the numbers using call count method. Single points were then selected from each plot and then monitored once at

dawn, starting at 04h00 [34,36]. Once calling started, surveys continued for 30 minutes; no surveys continued after 05h20, method used by [37]. Finally, for MaxEnt model, we used the occurrence points reported in literature [10,35].

Questionnaire survey

Residents occupying heavily forested parts of the study area where Tragopan were likely to be present were interviewed. We interviewed both adult men and women (>18-years-old). Consent of the interviewee was sought during the survey and we recorded majority of respondents were men, potentially influenced by cultural barriers and/or restrictions that made women unlikely to interact with strangers, including the researchers.

To collect information on respondents from the area, we designed a semi structured questionnaire with the following sections: (1) Socioeconomic and demographic characteristics (history of education, livestock owned, land ownership, sources of Income, and economic losses), (2) experiences of Tragopan such as breeding season, trend of population, forest type and grazing area former used, and (3) attitudes toward bird conservation (i.e., asking whether respondents wanted tragopan to be hunt or not). A total of n=6 village was grouped into two major regions: SGR and MNP. Stratified random sampling was used to ensure that a representative number of households were interviewed. Villages were categorized based on three variables: previous records of birds, amount of forested area, and elevation. In each village, more than twenty individuals were interviewed depending on the area's accessibility and presence of occupants.

Hunting Western tragopan is illegal under the rule of Pakistan Wildlife Act. We asked common questions in order to evaluate the attitudes of locals towards tragopan. Thus, questions surrounding killing of the species were indirectly linked to other questions which could encompass the tragopan such as 1) which one bird people liked to hunt, 2) What kind of lethal technique they used, 3) Why they liked to hunt, and 4) What is the preferred time people hunt for the bird?

Environmental variables

To generate a habitat suitability model for Tragopan in Pakistan we used climatic, topography, and vegetation Normalized Difference Vegetation Index (NDVI) variables [38,39]. Climatic layers were downloaded from Wordclim (https://www.worldclim.org/) at 1 km^2 spatial resolution [39]. For including topography in MaxEnt model we considered topographic heterogeneity and slope. These variables were created using the Raster [40] based on the Shuttle Radar Topography Mission (SRTM) elevation model [41]. We performed a Pearson correlation test to identify highly correlated variables ($r > 0.75$) and found that all variables had low correlations ($r < 0.75$).

Data analysis

First, we calculated the mean call counts of Tragopan from all plots of both zones, SGR and MNP. We also compared call counts of Tragopan with the previous surveys that had done for both zones [10,35,36].

Any questionnaires with incomplete information (n =16) were removed for accurate analysis. Once we collected samples, a chi-square test was used to evaluate associations between variables. For example, "Bird Status" was recorded as either increasing or decreasing as a dependent variable with "Place" serving as the independent variable. During the analysis of the data from the attitudes, we used the type of bird people liked to hunt as a dependent variable and the remaining questions such as time they preferred and reason why people hunt the bird kept as independent variables. All statistical data were analyzed using dedicated software (SPSS, Version 25 Chicago, IL, USA) with statistical significance set at .05 [42].

MaxEnt modeling of the western tragopan

Species distribution models (SDMs) use species presence data and environmental variables and predict distribution of species in space and time [43,44]. SDMs are useful in predicting distribution of ecologically unknown avian species [45,46] and identifying high priority areas for their conservation [47]. In the present research we used Bioclimatic data downloaded from the Worldclim website [39] (WorldClim 2021), and the one remote sensing variable NDVI were downloaded from Copernicus and Nasa Earth Observations websites (Copernicus 2021; NEO 2021). All the variables were downloaded and set up with same resolutions such as 30 arcsec. We used MaxEnt 3.4.1 [44] to model habitat suitability of the Western tragopan (*Tragopan melanocephalus*) in Pakistan. MaxEnt was run with a maximum of 1000 iterations, a convergence threshold of 0.00001 and 10,000 background points [44] MaxEnt model performance was assessed using the area (AUC) under the receiver operating curve (ROC) [48]. We used the cross-validation approach and distribution records were randomly split into 10 folds containing equal number of occurrences, and training models were created by eliminating each fold in turn [49].

3. Results

Call counts of Tragopan

We recorded a total of (n=26) Tragopan calls during the sampling periods in SGR and MNP Table 1. In SGR, a total of n=12 call counts with a (mean= 2.00 and SD=1.673) were found while in MNP, a total of n=14 bird call counts were recorded with the (mean=1.40 and SD=0.516). Within plots of both zones, plot five

alone in SGR was recorded with the highest call counts (5 call counts) from the rest of the plots in both zones. Additionally, the Wilcoxon value for SGR was (Z= 0.447 Vs P value=0.655) and for MNP was (Z=0.000 Vs P value=1.00) which revealed that there was no significant change in the population of the bird in MNP while there was a slight decrease in population of SGR with the mean decreasing from 2.17 to 2. For habitat use, Tragopan were observed more (n= 14) in the broad mixed coniferous broadleaf forest than in pure conifer forests and the first month of May was recorded as a favorable season for calling in the study area. Tragopan began calling as early as 0415 hrs. and gradually increased, with a peak at 0500-0514 hrs and they stopped calling by 0530 hrs.

Local community threats to W. Tragopan

In response of the general perception and attitude toward Tragopan in both study sites, we recorded (n= 150) around both zone SGR and MNP. Mainly 54% of respondents cited decreasing the number of species in both major zones. The Chi-square detected a strong significant association among both places for decreasing population (see Table A1; Chi-square = 20.478, P=.000). In order to know about the breeding season, we recorded a total of 48.6% observation with April-May is the breading season of this bird in the area while 22% cited July to August, 7.3% other, and finally not known with 22%. For breeding season information, place remained significant (see Table A2; Chi-square test= 23.392, P=.000).

For timber collection, more than 59% of people cited a mixed coniferous broadleaf forest as a better source for temper and medicinal plant collection and only 40% were recorded for others. The significant association between the status of the bird and forest type used by the local community was recorded as significant (Chi-square test =13.607, P= .001) but a weak association was found for people using the forest in a different place (see Table A3; Chi-square test=8.247, P= .004). For livestock grazing, the majority (57%) of people liked to graze in the dense forest while only 42% cited open pasture. Nearly, all respondents were recorded with one or two dogs for livestock guarding in both the study sites.

Moreover, about 77.3% of respondents like to hunt Tragopan while the remaining 22.6% hunted other pheasant in the study area. The local people cited 45.3% of this hunting for fun, 22% for economic purposes while only 3% of people consider hunting as a part of their culture. Nevertheless, we recorded 29% of respondents as being unfamiliar with hunting. A weak significant effect was found between both zones and reason people hunt the bird (see Table A4; Chi-square test =9.60, P= .022). To know about suitable hunting times of the bird, people cited 68% in April-June, June to August 45% and other 6% while 29% recorded they do not know the exact time people like to hunt W. tragopan. Logistic regression shows weak significant relation between choice of bird people like to hunt in the area and suitable time hunting (B=.453, Standard Error=.331, Wald=1.873, Exp B= 1.573, P=.171) but strongly significant for the reason they hunt among both zones Table A5.

Habitat suitability model and variable importance

Based on AUC metric the habitat suitability model generated in this study for the Western tragopan performed well, mean AUC = 0.99. Results of modeling habitat suitability of the Tragopan showed that the species suitable habitats are small and patchy in Pakistan. Based on MaxEnt model 3729 km^2 suitable habitat identified for the species in the country. We found that NDVI with 40.6 percent contribution was the most important variable in shaping the species distribution followed by slope with 33.5% contribution, annual precipitation with 20.4% contribution, annual temperature with 3.4% contribution and topographic heterogeneity with 2.6% contribution (Figure 2).

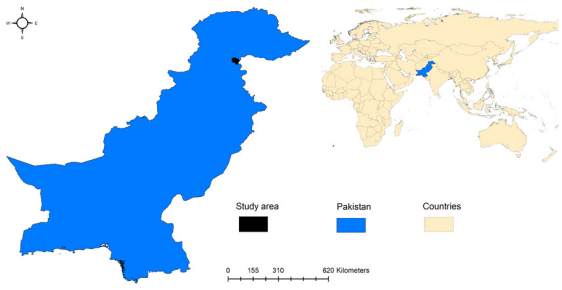

Figure 1. Location of the study area in Pakistan and global position of Pakistan among the other countries. Map was generated using QGIS 3.4.1 (https ://www.qgis.org).

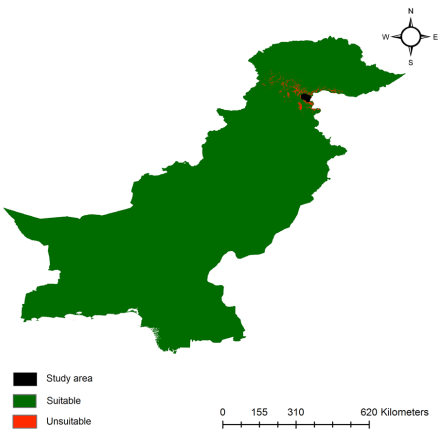

Figure 2. Habitat suitability model of the Western tragopan (*Tragopan melanocephalus*) in Pakistan. Map was generated using QGIS 3.4.1 (https ://www.qgis.org).

Table 1. Providing information of sites in each zone, habitat types and distance cover in the present study for counting bird during survey period.

S. No	Sites	Altitudes (m)	No. of calling	Survey in km²	Habitat	Previously recorded No. of call
Zone one (SGR)			Current study		Broadleaf-conifer Forest	Awan and Buner, 2014 [18]
Plots 1	Outside reserve	2,821	0	0.5	-	1
Plot 2	Outside reserve	2,875	2	1	-	3
Plot 3	Inside reserve	3,158	1	0.5	-	2
Plot 4	Inside reserve	2,651	2	1	-	1
Plot 5	Outside reserve	3,166	5	1	-	4
Plot 6	Outside reserve	3,105	2	1	-	2
Total	-	-	**12**	**5**	-	**13**
Zone two (MNP)					Broadleaf forest	Shabbir et al. 2018
Plot 1	Raveri	2819	2	0.5	-	2
Plot 2	Mali	3169	1	0.3	-	2
Plot 3	Kuthiali	3072	2	0.5	-	1
Plot 4	Moryan	2522	1	0.4	-	1
Plot 5	Charyal	2812	1	0.3	-	1
Plot 6	Roshan wala nullah	2911	2	1	-	1
Plot 7	Kuldaper	3328	1	0.5	-	2
Plot 8	Chita Kushkar	2993	1	0.5	-	2
Plot 9	Sehr	3134	2	1.3	-	1
Plot 10	Daper	3295	1	0.6	-	1
Total	-	-	**14**	**5.9**	-	**14**

4. Discussion

The Tragopan is listed as a vulnerable species in Pakistan as per IUCN Red List (2017). This species is located mainly in and around Machiara National Park and Salkhala game reserve [9]. The results of the present study are comparable with the findings of other studies conducted in Pakistan which indicate that this species has sustained its population in Machiara National Park [10]. We recorded a lower population using a call count census in the Salkhala game reserve compared to previous research [9]. Nevertheless, the plot five alone in Salkhala was a hotspot for this bird, containing a higher number of calls from the rest of the plots in both zones. The reason of high number of bird calls at this plot is due to higher altitude than other plots. Studies have demonstrated that the relative abundance of pheasants were always higher at high altitude [37]. Overall, our finding shows no too much deviation from the finding of other researchers who carried out studies from both zones in Pakistan [33,35]. However, call count is a traditional method and therefore, we suggest using advance techniques and equipment in order to report the exact number population density, relative abundance and distribution of this globally threaten species from Pakistan. Moreover, our finding suggested that Tragopan prefers a habitat on higher elevation within broad-leaved and conifer forests which is similar to the finding of researchers from the Great Himalayan National Park, India [37].

Majority of local people admitted that the species have higher threats in SGR and numerous decreases in its population has been reported over the past decades. This might be the reason of unsustainable harvest. For example, the community involved in illegal cutting the forest including fine shrubby vegetation that is used by pheasants for shelter and breeding (unpublished, office data). Also, high pressure of human activities in the area including recreational purposes as well as war and terror in the region. For example, SGR is in close touch with Indian boarder and military operations is quite common from both sides of the boarders. Local people are economically weak and local searching forest for wild vegetables for immediate consumption or to dry for winter use, including *Dryopteris, Mentha*, *Phytolacca,*

Polygonum, *Rumex, Plantago*, Angelica and *Dipsacus* [36]. Collection of morel mushrooms Morchella sp. is common and widespread in the mountains of northern Pakistan and due to their high financial value for food and medicinal values as a treatment for pneumonia. Thus, local people concentrate on forest that serve as a major economical reserve for them. Meanwhile, in a country where only around 5.1% of its total territory is forest (Food and Agriculture Organization, 2019) and significant demands are being made on this natural resource, worsened by illegal logging by logging companies [36], legal as well as illegal tree cutting and tree harvesting [25] that make the Himalayan Forest are the most destroyed among the globe's [24]. Nevertheless, more than 96% of agriculture growth are involved in diminishing forest [25] and that is why the Himalayan is the most vulnerable and fragile to climate changes [27]. On the other hand, our report suggests that majority of respondents keep dogs to protect the livestock from the regional carnivore's attack present in the area. For example, from the finding of [31] who suggested that dog can play a significant role in protection of livestock from a predator. However, dog can disturb the presence of birds including the tragopan using scent for active hunting [8].

Hunting is one of the major threats to the pheasants in the study area and this could be due to no proper protection strategy and lack of proper wildlife protection staff in the area to mitigate hunting and other threats to the birds**.** Community responses suggest that the majority of people engage in hunting for fun rather than economic purposes and the study revealed that hunting pressure is particularly high for Galliformes in the Salkhala reserve [8], with hunting for food, skins, or recreation conducted by local and non-local professional (trophy-hunting) and non- professional hunters alike. This could be the reason we recorded a lesser number of tragopans at SGR as compared to MNP. On the contrary, illegal hunting typically results in population depletion and in the worst cases may lead to the loss of species [50] and to loss of revenue due to reduced opportunities for wildlife tourism.

Results of habitat suitability modeling revealed that the Western tragopan has small and fragmented habitats in Pakistan. Our MaxEnt model estimated 3729 km^2 suitable habitat for the species. Comparing this with results of previous study on this species which identified 1294 km^2 suitable habitat for the species [51] showing that the species distribution and ecology are poorly understood in the country and highlights the importance of SDMs in studying ecologically unknown species. Habitats which were identified with high suitability are ideal targets for selecting new protected areas or redesigning current protected area networks for conservation of avian diversity in the country. We found that NDVI is the most influential factor in predicting the species suitable habitat highlighting the importance of vegetation cover for species long term survival. NDVI was identified as the most effective environmental variable in predicting suitable habitats of forest dweller birds by other researchers [47]. Our model identified some new suitable patches which can be target of future filed monitoring for finding new populations of the species. Since agricultural development and human disturbance can negatively influence the species, we recommend prohibition of land use change and human disturbance in highly suitable habitats [51,52]. Climate change, which is an important challenge for biodiversity conservation [53] was identified as a threat for the species causing range shift to higher elevation habitats [54]. In this regard ensuring the species habitat connectivity can be critical for long term survival of the species under climate change.

5. Conclusions

In the light of this global extinction crisis and the continuing increase in the number of globally threatened species [1], prioritizing conservation action and funding it is arguably more important than ever. The Tragopan *melanocephalus* is an endemic and extremely elusive pheasant of the W. Himalayas. The Tragopan bird is higher at MNP in the most suitable place to have mix coniferous broad-leaved forest. However, the community is dependent on the forest where the income source is always timber and other plants. The population status was recorded to have decreased mostly due to the local community response. Respondents reported that most people liked to hunt Tragopan more than other birds and primarily hunted for non-economic purposes, such as leisure. Thus, the birds face immense challenges for its population sustainability in the Azad Jammu and the Kashmir state of Pakistan due to rapid human influence and forest change scenarios. Therefore, the present study recommends strong monitoring of the bird and proper staff for surveying of the bird. The government should educate the department's employers for such conspicuous birds. We also recommend some further studies in the region for this bird particularly the genetic basis conservation which is still elusive in order to evaluate the genetic diversity for the species.

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Author Contributions

A.A. and I.Z conceived the study, participated in its design and coordination, A. A gave a critical view of manuscript writing and performed screening, A K, analyzed the data statistically. M Y performed habitat suitability model and participated in writing associated parts in the manuscript. M N K conducted the field work as well as performed in writing associated part of the manuscript. All authors contributed to the writing and reviewing the manuscript.

Conflict of Interest

The authors declare no competing interests.

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Appendix

Table A1. Population Trend (dependent variable) of the Tragopaneither increasing or decreasing among the places. The place remained independent variables.

Population Trend	Place		Total	Chi-square/Pearson value	P value
	SGR	MNP			
Increasing	18	11	29	20.478	.000*
Decreasing	59	22	81		
Not know	12	28	40		
Total	89	61	150		

Table A2. The breeding season information among the different places. Breeding season, a dependent with the place which is an independent variable for the model.

Breeding season	Place		Total	Chi-square/Pearson	P value
	SGR	MNP			
April to June	51	22	73	31.796	.000*
June to August	6	27	33		
Other	10	1	11		
Not known	22	11	33		
Total	89	61	150		

Table A3. Showing the relation between forest types people used in both Zones.

Types of Forest Used	Place		Total	Chi-square/Pearson	P value
	SGR	MNP			
Mixed coniferous forest	63	26	89	31.796	.000*
Other	29	32	61		
Total	92	58	150		

Table A4. The reason, (dependent variable) people like to hunt the bird for different purposes, the independent variable, place for chi-square value.

Reason People Hunt the Bird	Place		Total	Chi-square/Pearson	P value
	SGR	MNP			
Fun	43	25	68	9.650	.022
Economic Purpose	25	8	33		
Tradition	2	3	5		
Not known	19	25	44		
Total	89	61	150		

Table A5. The binary logistic regression model with dependent variable bird people like to hunt with two independent variables such as Time and Reason.

Variables	B	S.E.	Wald	Df	Sig.	Exp. (B)/Odd ratioLower	95%C.I.for EXP(B)	
							Upper	
Reason	-1.280	.336	14.550	1	.000	.278	.144	.537
Time	.453	.331	1.873	1	.171	1.573	.822	3.009
Constant	-1.344	.499	7.261	1	.007	.261		

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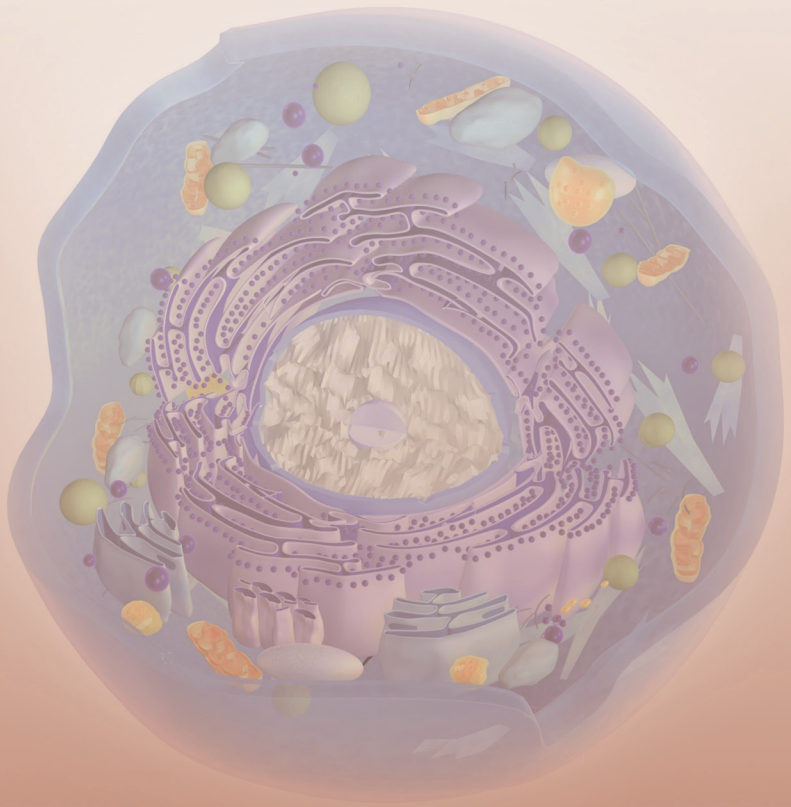

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