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Article

The study of katydid (Tettigoniidea) state in Mongolia

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Abstract
We carefully filtered all the studies on the classification of Tettigonoidea distributed in Mongolia, since 1960s and combined with our research results. As a result we found that 42 species (17 subspecies), 3 subtribes, 6 tribes, 16 genera, 2 subspecies belonging to 1 superfamily, were recorded in Mongolia. As a result of field research, 392 samples were collected from 140 points of 116 sums in 18 provinces of Mongolia. Deracantha onos Pallas, 1772 (Common bull katydid) has been determined to be Mongolia's most widespread katydid species. As a result of our field research conducted in 2013-2022, 82 out of 43 research points in 31 districts of 12 provinces were found. It was determined and consolidated. Based on this distribution map, using the Maxent-Geographic distribution model, it was calculated that the Common bull katydid is spread over an area of 881,730 km2. It is estimated that the average annual temperature will increase by 2.2 degrees and precipitation by 14.5 percent in 2050. In the year 2080, the Maxent model predicts that the distribution of the will increase slightly from the current average annual temperature of 4.0 degrees, and precipitation will increase by 25.8 percent.

Keywords: Katydid, species, distribution, maxent model

Introduction

Our country is developing and implementing the "National Biodiversity Program" as the world recognizes that the habitat of biological species is changing and diminishing. One of the objectives of this program is the registration of biological species [1]. Global ecological problems, including climate change, are becoming one of humanity's most pressing problems. Currently, the negative effects caused by human activities around the world, combined with the effects of climate change, may disrupt important ecological functions and cause irreversible changes in the normal functioning of ecosystems [2]. If the average global temperature increase exceeds 1.5-2.5 ºC, 20-30% of plant and animal species known to date will be at risk of extinction and will bring significant changes. In Mongolia, climate change is happening very intensively compared to the world average. According to the trend of deviation of the average annual air temperature and total precipitation from the long-term average (1961-1990), the average annual air temperature in Mongolia has warmed by 2.25 ºC between 1940 and 2017, while the total precipitation has decreased by 15% [3].

The World-Wide Fund for Nature's "Living Planet 2020" report notes that the populations of mammals, birds, amphibians, reptiles, and fish surveyed by the Living World Index declined by an average of 68% (62-73) between 1970 and 2016. Along with these, we do not know how many species of arthropods have silently disappeared, but studies have shown that the total biomass of flying insects on the European continent has decreased by 76-82% in 27 years, threatening the balance of the ecosystem [4].

Orthoptera, a group of insects distributed in our country, has a great impact on bio-geocenosis, environment, and agriculture. Humans have long been interested in insects and recorded them in scriptures, using them for food and medicine,

and has been fighting against insects that harming pastures, hay, and crops [5]. Many orthopterans are associated with large scale destruction of crops, rangeland and pastures. Plangia graminea (Serville) (Orthoptera: Tettigoniidae) is considered a minor sporadic pest in vineyards of the Western Cape Province, South Africa, and was the focus of this study. In the past few seasons (since 2012) P. graminea appeared to have caused a substantial amount of damage
leading to great concern among the wine farmers of the Western Cape Province [6]. In Africa and Southeast Asia, there is a tradition of drying and using chickpeas as a valuable source of protein [7].

Tettigoniidea, which belongs to the subfamily of long tentacles (Ensifera) of straight-winged insects distributed on our planet, compared to the locusts (Acrididea), which belongs to the subfamily of short tentacles (Caelifera), in terms of agricultural importance, distribution density, pastures, effects on hay and grain yields and other research activities have been relatively little studied.
Therefore, in today's time when the ecosystem and biological diversity are changing due to the effects of climate change, there is an urgent need to determine the species composition, study their biology and ecology, and prognosing the distribution status.

Methods and materials

We collected katydid from the steppe. We collected samples by method at permanent agricultural observation sites and pasture condition “stop points” established by the Meteorological and Environmental Research Agency. The results of the research on the distribution of katydid carried out by the Mongolian-Soviet and Mongolian-German joint biological expeditions in 1961-1967 were determined using the computer program Google Earth Pro [8-13]. The institute used academic reports of field research conducted in 2013-2022 [14].
Katydid distribution map was created using “Mongolian National Atlas” 2009 shapefile, geographic information ARCGIS-10.8, umerical processing using Microsoft Excel programs.

The average air temperature and precipitation norms for 1991-2020 (recommended by the World Meteorological Organization) for 128 weather stations covering Mongolia were used in the calculation [15].
The Maxent-Geographic distribution model was used to calculate the distribution change of Deracantha onos Pallas, 1772 used The following information was used in the model input. These include: Biological information or data on the distribution points of common bullfrog (Excel file with *.CSV extension), Environmental information or maps of air temperature, precipitation, soil, vegetation and natural zones and belts prepared on ArcGIS [16].

Results

In carrying out the research work to determine the composition of katydid species distributed in Mongolia, all printed materials about katydid created in Mongolia since the 1960s were carefully filtered and combined with the results of our research. As a result of our research, we compiled and summarized the distribution of 42 species (17 subspecies) of 16 genus of 3 family in Mongolia. As part of the work to register, assess the state of, and prevent shortages of straight-winged insects distributed in Mongolia, the field research work that was carried out covering all the provinces and regions of our country in 2013-2022 was carried out at the "Permanent Agricultural Climate Observation Area of the State Hydrometeorological Network" and "grassland condition monitoring area (parking point)" (figure 1).

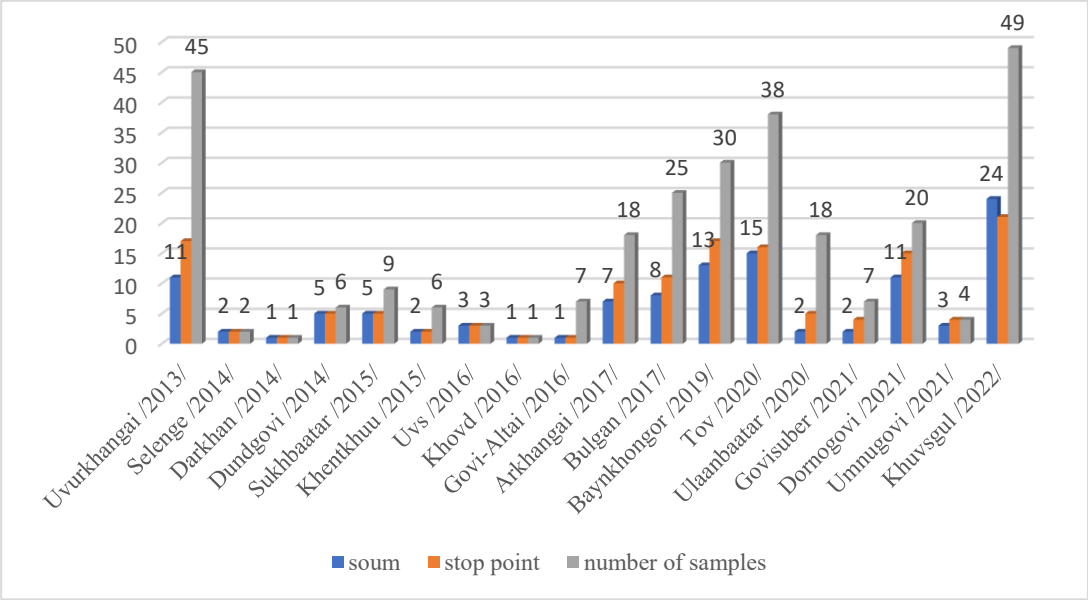

Figure 1. Results of field research /2013-2022/

As a result of field research, 392 samples were collected from 140 points of 116 soums in 18 provinces of Mongolia.

Figure 2. *Deracantha onos* Pallas, 1772

As a result of our field research, we used the maxent model to predict the distribution and impact of future climate change, which is the most distributed species in Mongolian soums, fields and the most collected katydid was the common bull katydid (*Deracantha onos* Pallas, 1772) (Figure 2).

This common bull katydid (*Deracantha onos* Pallas, 1772) is native to the steppes of the South-Pacific region and is distributed mainly in steppe zones. It belongs to the genus *Deracantha* Fischer von Waldheim of Central-Asia's steppe Orthoptera.Morphology: Compared to other species, the 10th dorsal-ventral denticle of the male has a distinct outwardly protruding denticle. The lateral edge of the female genitalia is straight or has a small convex surface. Body length: male 42-53 mm, female 35-55 mm, length of the dorsal spine: male 14.2-15.1 mm, female 14.5-17.8 m

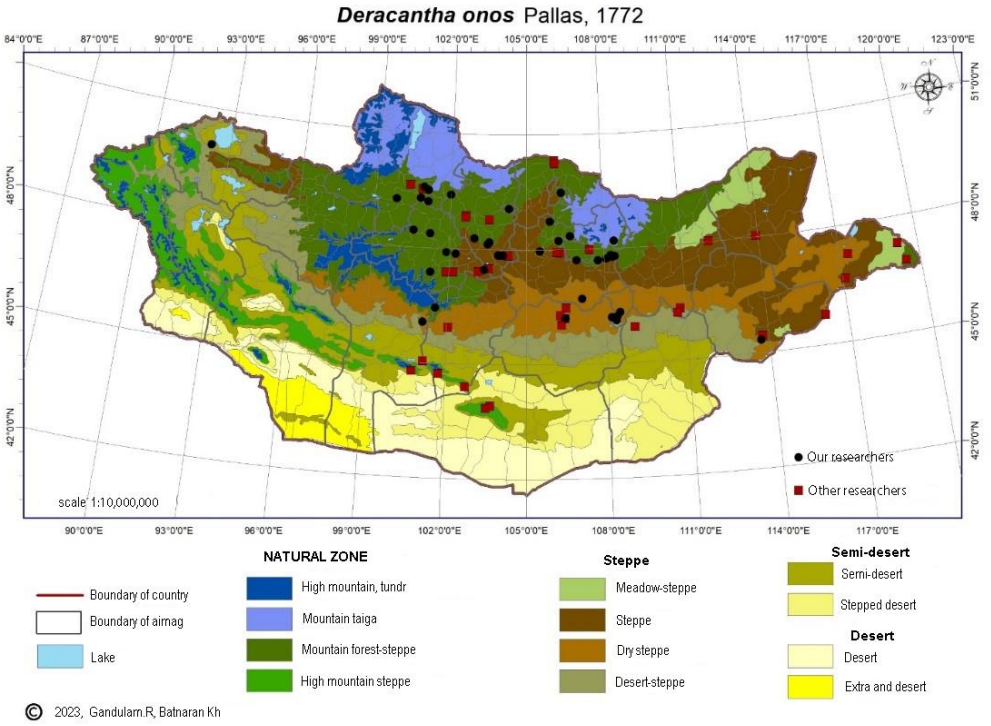

Figure 3. Distribution of *Deracantha onos* Pallas, 1772 years (1961-2022)

As you can see from the figure, the katydid is mostly distributed in the fields and forest areas of the central part of Mongolia, and in terms of physical geography.It has been determined that it is distributed in the Gobi-Altai Mountains, Khangai, Khenti Mountains and Eastern Mongolia.

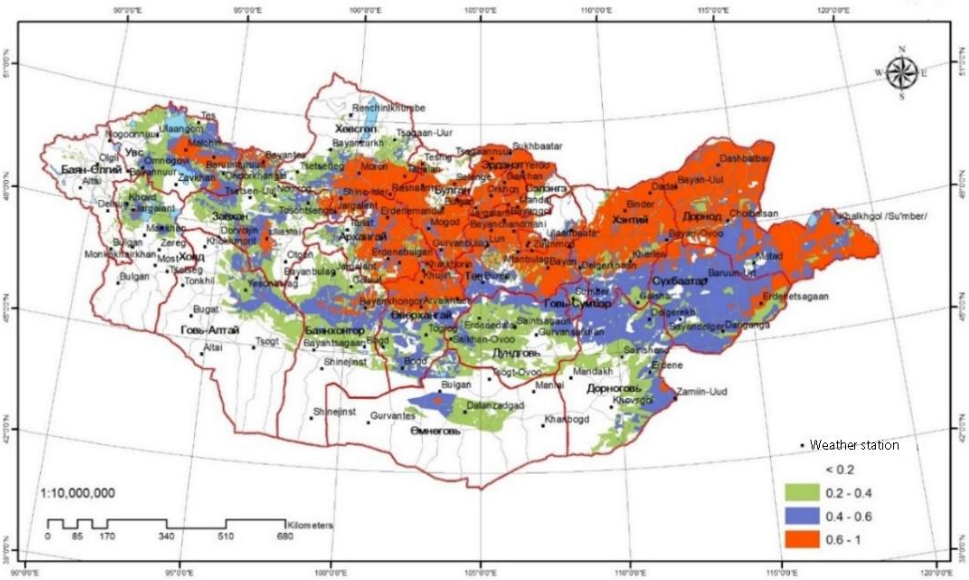

Figure 4. Distribution map of *Deracantha onos* Pallas, 1772 katydid calculated by Maxent model

The distribution calculated by the Maxent model in detail (Figure 3) shows that out of the 126 regions (meteorological stations) selected, the area with high distribution in 44 regions is 332,267 km^2, medium distribution in 21 regions is 288,143 km^2, low distribution in 24 regions is 261,320 km^2, and land with no distribution in 38 regions. size is 680658 km^2. The model estimated that *Deracantha onos* Pallas, 1772 rivers have a total distribution of 881,730 km^2

Table 1.

Distribution size of katydid, (km^2)

№	Category	multi-year average	Hadley		ECHAM	
			2050 year	2080 year	2050 year	2080 year
1	< 0.2	680,658	677922	670820	685427	626057
2	0.2-0.4	261,320	269584	272925	264927	328712
3	0.4-0.6	288,143	273664	263022	268042	276097
4	0.6 <	332,267	341236	355630	343956	331409
Total distribution		881,730	884,484	891,577	876,925	936,218

According to the table of results calculated by Maxent model, *Deracantha onos* Pallas, 1772 katydid currently has a total of 881730 km^2 or 88.2 million ha, which is spread over 78.75 percent of the total territory of our country. According to the prognoses in the distribution of katydid, the total land area will expand by 275.4 ha in 2050 and 984.7 ha in 2080 in the Hadley model, and 480.5 ha in 2050 and 5448.8 ha in 2080 in the ECHAM model. In the ECHAM model, the size of non-dispersed areas will expand by 476.9 ha in 2050, and will decrease in 2 models in other periods, and the area with low distribution will expand by 360.7-6739.2 ha in 2 models, the size of medium spread areas will decrease by 1204.6-2512.1 ha in 2 models, the size of high spread areas will expand by 896.9-2336.3 ha in 2 models, but in ECHAM model it will decrease by 85.8 ha in 2080 (table 1).

Discussion

The study of Gobi's straight-winged birds in Mongolia was done quite well between 1970 and 1980 within the framework of the joint Mongolian-Russian expedition, and there are one species of cockroach, 4 species of mantis, 110 species of grasshoppers, and 11 species of katydid, which is more than 60% of the total number of recorded straight-winged in our country. The share of native species in this region reaches almost 30 percent, which is due to the creation of biological diversity adapted to terrestrial island-specific ecosystems that are abundant in the Gobi-desert region of Mongolia. Detailed studies of katydid in forests, steppes and other natural areas have not been carried out so far. Mongolian-German joint expeditions such as Mongolian-Russian, Mongolian-Czechoslovakian and Mongolian-Czechoslovakian expeditions were intensively conducted from 1960 to 1980. As a result, K. Günter, A. Cheyhan, and L. Chogsomjav created many works on the distribution and taxonomy of katydids [8-13]. Further research is very insufficient and almost not done. However, between 2013 and 2022, we organized a field study to determine the composition and distribution of straight-winged insect species in Mongolia.

As a result of the research work, 25349 grasshopper samples were collected from 924 stations for monitoring the condition of pastures and 326 soums of 21 provinces of our country, and 392 katydid samples from 140 points of 116 soums of 18 provinces were collected and analyzed. As a result of the research, it was determined that 12 species of 9 genus of 1 family are prevalent, and by compiling the results of field research, works related to katydid, and press reviews, 42 species of 16 genus and 17 subspecies of 1 family were recorded, and it is major research on straight-winged insects in recent years. In the 21st century, the world is undergoing climate change, and biodiversity continues to change. Mongolia is developing and implementing national programs related to climate change. Part of this is the National Programs to Combat Desertification and Biodiversity. Within the framework of this work, we are conducting a study of straight-winged insects distributed in our country, including long-tentacled straight-winged insects.

A study of the status of the distribution of the katydid has been completed to estimate how the distribution range of the katydid will change in the medium and long term due to the influence of climate change. In 2014, researchers Kh. Batnaran and T. Turbat completed a study on the short, medium and long-term distribution of the A*ngaracris barabensis* Pallas, 1773, which is the most widespread in the steppe region of our country and there is a result of the research work, it is estimated that in the near term, the distribution of Baraben's tarshana will decrease by 10.3% from the current level in 2035, in the medium term, it will increase by 8.3% in the level of 2065, and in the long term, in the level of 2100, it will expand its distribution range by 26.4% from the current level [18]. Our research is the first work done on

katydids, and it is estimated that the distribution of katydids will decrease by 0.55% in the medium term at the level of 2050 and expand by 6.18% at the level of 2080 in the long term. It is estimated that the range of distribution will expand [16,17].

Climate change and global warming have emerged as pressing challenges of our time, with far-reaching consequences for the environment, societies, and economies worldwide [19]. Scientists have calculated that the average global air temperature will increase by 1.1-6.5 ºC by the end of this century [20]. According to our Maxent model, the average annual temperature in Mongolia will increase by 2.2 degrees and precipitation by 14.5% in 2050, and by the end of this century, in 2080, the average annual temperature will increase by 4.0 degrees and precipitation by 25.8%, which is close to the estimates of the above scientists.

Conclusion

In conclusion 1 superfamily, 1 family, 3 subfamily, 6 tribes, 16 genus, 2 subgenus, 42 species (17 subspecies) have been identified and included in the taxonomy in Mongolia. When calculating the distribution of 1772 katydid *Deracantha onos* Pallas, by the "Maxent-Geographic Distribution" model, it is spread over 88.2 million hectares, which is 78.75% of the total territory of our country. *Deracantha onos* Pallas, 1772, when the average annual temperature in our country reaches 2.2 degrees in 2050 and precipitation increases by 14.5%, the range of distribution will decrease by 0.55%, in 2080, the average annual temperature will be 4.0 degrees, precipitation will increase by 25.8%, and the distribution range will increase by 6.18%.

Conflict of Interests:

The authors declare no conflict of interests.

Author's Contribution:

All members participated in the field research activities under the leadership of doctor (ScD) B.Kh. Based on this work, the initial draft of the manuscript was prepared by G.R and reviewed and revised with the participation of T.G. The final version of the manuscript was then prepared, and all members unanimously agreed to approve and endorse it.

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