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 ORIGINAL PAPERS

Influence of Temperatures and Humidity on the Orthoptera (Insecta: Orthoptera) Associations of Dobrogea, Romania

Laura Mariana POPA

"Ovidius" University of Constanta, Faculty of Psychology and Educational Sciences, Constanta, Romania

Corresponding author e-mail: lauramariana.popa@365.univ-ovidius.ro

Abstract

Due to its climatic peculiarities, Dobrogea is an area suitable for the development of particular orthopteran populations. Abiotic factors influence the Orthoptera, limiting the number of generations and the abundance. Longitude, latitude and altitude determine the geographical spread of the species, but the main abiotic factors that influence orthopteran populations are the temperature and humidity. Although most species have wide tolerance limits on humidity and temperature variations, these factors directly influence affect the way they feed and reproduce.

Keywords: Orthoptera, diversity, ecology, humidity, temperature

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Introduction

Continental Dobrogea is a plateau with altitudes ranging between 100 and 476 m, which obviously rise above the western and northern plains, the Danube Delta, the Razelm Complex, as well as the Black Sea, passing south into the Deliorman Plateau. [20]The Dobrogea plateau, between the Danube (west and north), the Black Sea (east) and the border with Bulgaria (south) is a Danubian-Pontic unit. Dobrogea is generally characterized by the existence of two well-individualized climatic units: sea coast unit and the continental unit located over a distance of 50 km from the coast. A distinct feature of the climate in Dobrogea is the priority frequency of the drought phenomenon, which is formed against the background of the lowest amounts of atmospheric precipitation in Romania. The Black Sea determines the formation of a distinct regional unit: the coastal area, the continental shelf and the Romanian Black Sea coast [20].

A distinct feature of the climate in Dobrogea is the frequency of the drought phenomenon, formed against the background of the lowest amounts of atmospheric precipitation on the Romanian territory. The average annual air temperatures oscillate within limited the highest values, above 11° C, being recorded in the coastal strip, on a narrower surface in Central Dobrogea and wider in South Dobrogea and in the Danube Delta. [1] The monthly average values of the maximum daily air temperatures recorded in clear and cloudy skies increase from the sea shore to the western extremity of Dobrogea during the warm period of the year (April-October) and have an inverse distribution in the

winter months. On days with overcast skies, the phenomenon of decreasing maximum daily temperatures towards the coastal area, under the influence of the cold waters of the Black Sea is most evident between April and June.

The distribution of Orthoptera is directly influenced by the distribution of vegetation. The vegetation of Dobrogea consists of complexes of different phytocenoses and depends on the type of soil, altitude and latitude and the nature of the component species, so that different microclimates can be created within the same area.

The annual isotherms decrease, in value, as the distance from the coast increases and the altitude of the relief.

Material and methods

The material was collected by sweeping the vegetation with an entomological net on a transect with a length of 200 metersand about 2 m wide. The standard vegetation sweeping procedure is a 180˚ reciprocating arc [2,3]. Calibration of transects in order to obtain accurate estimates of population intensity was performed using the MER (marking - release - recapture) method according to the recommendations in the literature. The catches were made for a period of six months per year (April - October) between 2010-2020.

The orthoptera specimen identification was made according to external morphology and genitalia using the identification keys by [15,16,18]. For the study of the orthopteran communities from Dobrogea we chose 18 collection points - 6 collection points in Tulcea county (Măcin, Babadag, Tulcea, Caraorman, Sulina, Enisala) and 12 collection points in Constanţa county (Hagieni, Mangalia, Eforie Nord - Techirghiol, Agigea, Fântâniţa-Murfatlar, Valul lui Traian, Constanţa, Mamaia, Cernavoda, Cheile Dobrogei, Histria).[26]

The influence of temperature and humidity

Temperature is a factor that influences orthoptera either in a stimulating or limiting sense. Each species has a minimum temperature at which it is active and a maximum temperature, between these being the tolerance limit. [25] Regarding the influence of temperature on orthoptera in Dobrogea, we found that during the study years the values were similar from year to year. (see Figure 1)

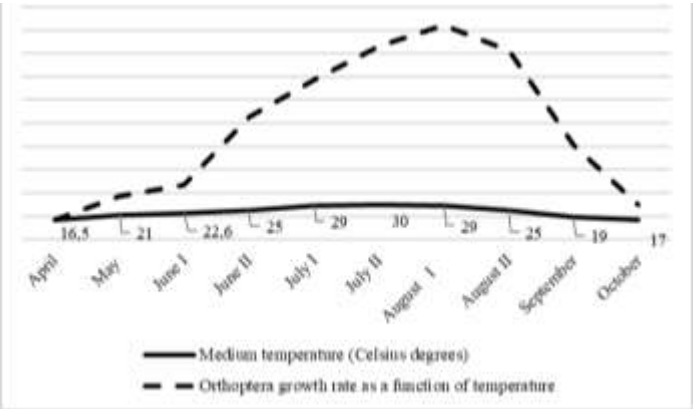

Fig. 1 The influence of temperature on the growth rate of Orthoptera

In April - May the number of orthoptera is small. At an average temperature of about 19º C the larvae begin to hatch in late April and May. There are very few species with tight temperature tolerance limits. Vegetation is abundant [5]but variations may be due to precipitation. In the Histria, the high wind speed is the factor that limits the development of orthoptera in the spring. In June there is a progressive increase in the number of orthoptera at an average temperature of 24º C. Abundant vegetation correlated with increasing temperature favors the development of orthoptera; even on very hot days. The still high humidity of the air and soil positively influences the abundance of orthoptera in June. Even in the sandy areas of Caraorman, Agigea are conditions that ensure greater vegetation.[10] Variations can be given by precipitation or wind speed. (see Figure 1)

In July, the number of orthoptera increases slightly. The average value of orthoptera is similar to the average value of June in most collection points. This is explained by the increase in temperature that causes the phenomenon of drought. The sandy soil from Agigea does not retain water, so the biomass of vegetation decreases and delays the increase in the number of orthoptera. Areas close to a water source (Histria, Sulina) are protected from the effect of drought. At an average temperature of 30 º C in arid areas with anthropogenic activity such as Cernavoda or Mamaia, the numerical abundance of orthoptera decreases. During this period, the abundance of orthoptera with wide tolerance limits to high temperatures increases. (see Figure 1)

Between September and October the trend of the number of orthoptera is decreasing. Many species lay their eggs taking advantage of the larger vegetation mass this season. As the temperature drops (especially during the night) in October, the numerical abundance of orthoptera decreases. The vegetation shows a revival with the decrease of the average temperature and the increase of the atmospheric humidity which helps orthoptera to lay eggs with a higher rate of resistance over the cold season.

Poikilothermic animals have a biological cycle influenced by temperature: the larvae of some orthoptera hatch in April - May (*Dociostaurus brevicollis, Decticus albifrons*), and some larvae or adults that overwinter appear earlier in March - April (*Acrotylus insubricus*, *Tetrix subulata*). (see Figure 2)

Stenotherm orthoptera such as *Oedipoda germanica* or *Acrotylus longipes* grow within tight temperature limits, while euriterms such as *Tettigonia viridissima* or *Chorthippus parallelus* can live within much wider limits.

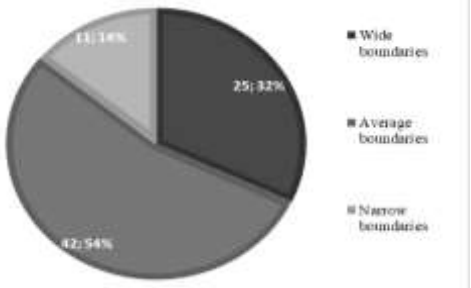

Fig. 2 The proportion of the number of orthopteran species according to the degree of tolerance to temperature variation

At low temperatures, adult death occurs by freezing water in there body. The optimum average temperature for most orthopteran species is around 25^0 C. At values between 18-21^0 C only a few species appear. In areas near the Black Sea, resistant species are *Decticus albifrons, Platycleis affinis, Calliptamus barbarus, Chorthippus loratus*. In the area of the continental steppe, the species of orthoptera have a faster development than those in the coastal area.

Temperature also influences behavior during the day. Strong xerothermic species (*Decticus albifrons*) are active throughout the day, while mesothermic species are more active in the morning and evening (*Isophya rectipennis*). However, there are also xerophilous species such as *Acrotylus longipes* that can withstand very high temperatures, above 50^0 C at ground level. At very high temperatures they do not feed and prefer to stay on the plants. When they reach the ground, they protect the limbs they lift alternately from the ground. At the opposite pole are species of the genus *Tetrix sp*. which can withstand very low temperatures of -20^0 C. [14] The temperature strongly influences the growth and development of *C. italicus*. At temperatures ranging from 23 to 35 °C, the development time was negatively linearly related to temperature ($P < 0.01$). Temperature and nutrition interact to affect key life history traits: size at maturity, development rate, reproduction and survival.[8]

The relative humidity of the air influences the growth and development of orthoptera. The optimal values of relative humidity characteristic of orthoptera are between 40-80%. Depending on the degree of humidity, we can divide orthoptera as follows: euribiont orthoptera (living within wide humidity limits) such as *Tettigonia viridissima, Chorthippus brunneus* and stenobionts (preferring closer limits) such as *Arachnocephalus vestitus*. From the point of view of the degree of humidity in the preferred habitat, orthopterans are classified into: xerophilous, meso-xerophilous, mesophilic, hyro-mesophilic and hygrophilous. (see Table No. 1)

Table 1) Orthoptera preferences identified based on humidity

Nr. crt.	*Specia*	*higrofil*	*higro-mezofil*	*mezofil*	*mezo-xerofil*	*xerofil*
1.	*Tylopsis lilifolia*	-	-	-	+	+
2.	*Phaneroptera nana*	-	-	+	+	+
3.	*Phaneroptera spinosa*	-	-	-	+	+
4.	*Leptophyes albovittata*	-	+	+	+	+
5.	*Isophya dobrogensis*	-	-	-	+	-
6.	*Isophya hospodar*	-	-	-	+	-
7.	*Isophya rectipennis*	-	-	-	+	-
8.	*Isophya modesta*	-	-	-	+	-
9.	*Poecilimon brunneri*	-	-	-	+	+
10.	*Saga gracilis*	-	-	-	+	+
11.	*Saga pedo*	-	-	-	+	+
12.	*Conocephalus fuscus*	+	+	+	+	+
13.	*Conocephalus dorsalis*	+	+	-	-	-

14.	*Conocephalus hastatus*	-	-	-	+	+
15.	*Ruspolia nitidula*	+	+	+	+	+
16.	*Tettigonia viridissima*	+	+	+	+	+
17.	*Tettigonia caudata*	+	+	+	+	+
18.	*Gampsocleis schelkovnikovae*	+	+	+	-	-
19.	*Gampsocleis glabra*	-	+	+	+	+
20.	*Decticus verrucivorus*	-	+	+	+	+
21.	*Decticus albifrons*	-	-	-	+	+
22.	*Zeuneriana amplipennis*	+	+	+	-	-
23.	*Platycleis affinis*	-	-	-	+	+
24.	*Platycleis intermedia*	-	-	-	+	+
25.	*Platycleis veyseli*	-	-	+	+	+
26.	*Pholidoptera griseoaptera*	-	-	+	+	+
27.	*Pholidoptera fallax*	-	-	+	+	+
28.	*Bucephaloptera bucephala*	-	-	-	+	+
29.	*Rhacocleis germanica*	-	-	+	+	+
30.	*Bradyporus dasypus*	-	-	-	+	+
31.	*Ephippiger ephippiger*	-	-	+	+	+
32.	*Gryllus campestris*	-	+	+	+	+
33.	*Melanogryllus desertus*	-	+	+	+	+
34.	*Modicogryllus frontalis*	-	+	+	+	+
35.	*Modicogryllus truncatus*	-	-	+	+	+
36.	*Modicogryllus burdigalensis*	-	-	+	+	+
37.	*Pteronemobius heydenii*	+	+	-	-	-
38.	*Oecanthus pellucens*	-	+	+	+	+
39.	*Arachnocephalus vestitus*	-	-	-	+	+
40.	*Gryllotalpa gryllotalpa*	+	+	+	+	+
41.	*Gryllotalpa unispina*	-	-	-	+	+
42.	*Xya variegata*	+	+	+	+	+
43.	*Xya pfaendleri*	+	+	-	-	+
44.	*Tetrix ceperoi*	+	+	-	+	+
45.	*Tetrix subulata*	+	+	+	+	+
46.	*Tetrix bolivari*	+	+	-	+	+
47.	*Tetrix tenuicornis*	+	+	+	+	+
48.	*Asiotmethis limbatus motasi*	-	-	-	+	+
49.	*Pezotettix giornae*	-	+	+	+	+
50.	*Paracaloptenus caloptenoides*	-	-	+	+	+
51.	*Calliptamus italicus*	-	-	+	+	+
52.	*Calliptamus barbarus*	-	-	-	+	+
53.	*Acrida ungarica*	-	-	-	+	+
54.	*Oedaleus decorus*	-	-	-	+	+

55.	*Oedipoda caerulescens*	-	-	-	+	+
56.	*Oedipoda germanica*	-	-	-	-	+
57.	*Sphingonotus caerulans*	-	-	-	+	+
58.	*Acrotylus insubricus*	-	-	-	-	+
59.	*Acrotylus longipes*	-	-	-	-	+
60.	*Aiolopus thalassinus*	+	+	+	-	-
61.	*Epacromius coerulipes*	+	+	-	-	-
62.	*Paracinema tricolor bisignata*	+	-	-	-	-
63.	*Mecostethus parapleurus*	+	+	-	-	-
64.	*Stethophyma grossum*	+	-	-	-	-
65.	*Dociostaurus brevicollis*	-	-	-	+	+
66.	*Stenobothrus lineatus*	-	+	+	+	+
67.	*Omocestus rufipes*	-	+	+	+	+
68.	*Omocestus petraeus*	-	-	-	+	+
69.	*Omocestus minutus*	-	-	-	+	+
70.	*Gomphocerippus rufus*	-	+	+	+	+
71.	*Chorthippus brunneus*	-	-	+	+	+
72.	*Chorthippus mollis*	-	-	+	+	+
73.	*Chorthippus oschei*	-	-	-	+	+
74.	*Chorthippus loratus*	-	-	-	+	+
75.	*Chorthippus dichrous*	+	-	-	+	-
76.	*Chorthippus parallelus*	+	+	+	+	+
77.	*Euchorthippus pulvinatus*	-	-	-	+	+
78.	*Euchorthippus declivus*	-	-	+	+	+

In Dobrogea, the meso-xerophilous species predominate (34%), followed by the xerophilous (28%), the mesophilic (27%) and the hyro-mesophilic (14%). Hygrophilous species represent only 10% of the total species of orthoptera in Dobrogea.[12]

Conclusions

(1) The characteristics of the Orthoptera species in the studied areas reveal a great ecological plasticity: Orthoptera preferences encountered depending on the humidity of the environment reveal a predominance of xerophilous elements (*Oedipoda germanica, Acrotylus longipes longipes, Acrotylus insubricus or Dociostaurus maroccanus*), while most others *Ruspolia nitidula, Euchorthippus declivus, Chorthippus* sp.) have wider preferences, being species that are found in most locations. These are hygrophilous elements, hyro-mesophilic elements, mesophilic elements and meso-xerophilic elements and xerophilous elements.

(2) Temperature is a stimulating or limiting factor for orthoptera and directly influences their number of generations. Being poikilothermic animals, they depend decisively on air temperature. Most of them lay eggs in the fall, but there are species of

orthoptera that winter in the nymph or adult stage: among the Ensifers - *Gryllus campestris*, species of the genus *Tetrix* and *Acrotylus insubricus*.

(3) From the point of view of humidity, we have identified both Euribiont species that manifest themselves as normal metabolically within wide humidity limits (40 - 80%), resisting just as well in the dry periods of a year and in periods of prolonged drought. (*Decticus verrucivorus, Tettigonia viridissima*), as well as stenobionts (*Ephippiger ephippiger, Oecanthus* sp.) that live in closer limits. In turn, stenobionte species can be divided into hygrophilous species (*Tetrix bolivari, Chorthippus paralelus*, etc.), mesophilic species (*Tettigonia viridissima, Decticus verrucivorus, Gryllus campestris*, etc.) and xerophilous species (*Decticus albifrons, Oedipoda caerulescens*, etc.). While the species *Oedipoda germanica, Acrotylus longipes, Acrotylus insubricus* have clear preferences for habitat type, most other species have broad preferences *Tettigonia caudata*, or *Chorthippus parallelus* being even species that can be found in all 5 categories - meshyophilous, higrophilous elements , meso-xerophilous and xerophilous.

(4) The populations of orthoptera that characterize the Dobrogea plateau by their presence, are in a state of dynamic equilibrium that allows the existence of an impressive populations - over 50% of the total species in Romania. This diversity of species can be interpreted as an indicator of a "*healthy*" natural environment. And yet the presence or absence of orthopteran species in a certain type of habitat indicates the sometimes dramatic change in habitats in the investigated area, most often through anthropogenic intervention. The types of habitats thus created bring with them, through the new conditions they offer, a specific fauna, in these cases appearing, in fact, the elements of intergradation of the preferences of different species.

References

[1] BAVARU A., GODEANU S, "Biodiversitatea și ocrotirea naturii", Ed. Academiei Române, București 2007

[2] BELLMAN, H. & LUQUET, G. -. *Guide des Sauterelles, Grillons et Criquets d Europe Occidentale*, (358 pp., Delachaux et Niesle, Paris, Franţa, 1995).

[3] CHOPARD, L. - 1951. *Faune de France, Orthopteroides*, 68-316, Lechevalier, Paris, Franţa.

[4] CLISSOLD FIONA J, STEPHEN J. SIMPSON. *Temperature, food quality and life history traits of herbivorous insect Current Opinion in Insect Science* Volume 11, October 2015, Pages 63-70

[5] DEFAUT, B. - 2001. *Actualisation taxonomique et nomenclaturale du Synopsis des Orthopteres de France*, 6 pp., Paris.

[6] DONIȚĂ, N., 1969: „*Vegetaţia Dobrogei ca fenomen geografic*", Stud. Geogr. Dobr., Bucureşti

[7] DONIȚĂ, N., POPESCU, A., PĂUCĂ-COMĂNESCU, M., MIHĂILESCU, S. & BIRIŞ, I. A. - 2005. *Habitatele din România*, 498 pp., Ed. Tehnică Silvică, Bucureşti.

[8] FONDERFLICK J, et all *The impact of grazing management on Orthoptera abundance varies over the season in Mediterranean steppe-like grassland* Acta Oecologica Volume 60, October 2014, Pages 7-16

[9] GODEANU S- sub redacția "Determinatorul ilustrat al faunei Romaniei", Volumul III, Mediul terestru, ed. Vasile Goldiș university press, Arad 2010

[10] IORGU, I. Ş. & PĂIŞ, L. M., 2006 -The diversity of the Orthoptera species (Insecta: Orthoptera) from Agigea Reservation of marine dunes, Lucrările Conferinţei Naţionale

Biodiversitate şi impact antropic în Marea Neagră şi în ecosistemele litorale ale Mării Negre, Universitatea „Al. I. Cuza" Iaşi, 135-142
[11] IORGU, I. Ş., PISICĂ, E. I. & PĂIŞ, L. M., 2008 - The Orthoptera associations (Insecta: Orthoptera) from Letea Sand Bank and Sulina (Danube Delta Biosphere Reservation, Romania), Brukenthal Acta Museii III.3: 111-122
[12] IORGU, I., PISICĂ, E., PĂIŞ, L., LUPU, G. & IUŞAN, C. - 2008. Checklist of Romanian Orthoptera (Insecta: Orthoptera) and their distribution by ecoregions. Travaux du Museum d'Histoire Naturelle "Gr. Antipa", LI: 119-135
[13] IVAN D., 1992 – "Vegetaţia României". Ed. Tehnică agricolă. Bucureşti.
[14] JIN-LONG RENA, XIONG-BINGTUB – 2016. *Influence of temperature on the development, reproduction, and life table of Calliptamus italicus* (L.) (Orthoptera: Acridoidea)
[15] KIS, B. - 1963. *Ortopterele din Dobrogea*, Studia Universitatis Babeş-Bolyai, Serias Biologia, 2: 83-103.
[16] KIS, B. - 1967. Ord. Orthoptera in L'entomofaune des forets du sud de la Dobroudja, Travaux du Museum d'Histoire Naturelle "Gr. Antipa", 7: 107-113.
[17] LUPU, G. - 2007. Carnivorous and omnivorous species of Orthoptera order recorded in the Danube Delta Biosphere Reserve, Scientific Annals Of The Danube Delta Institute, Tulcea – Romania, 13: 55-58
[18] LACHENICHTA M.W., S. CLUSELLA-TRULLASBL. BOARDMANA C .LE ROUXAJ. S. TERBLANCHEA *Effects of acclimation temperature on thermal tolerance, locomotion performance and respiratory metabolism in Acheta domesticus L. (Orthoptera: Gryllidae) Journal of Insect Physiology* Volume 56, Issue 7, July 2010, Pages 822-830
[19] MAES, D., GHESQUIERE, A., LOGIE, M. & BONTE, D. - 2006. Habitat Use and Mobility of Two Threatened Coastal Dune Insects: Implications for Conservation, Journal of Insect Conservation, 10 (2), pp. 105-115
[20] MIHAILESCU F., PALTINEANU CR.,SECELEANU I., 2000 – Dobrogea, conditii pedoclimatice, consumul şi necesarul apei de irigaţie ale principalelor culturi agricole. Ed. Ex Ponto, Constanţa
[21] PĂIŞ, L. M. & IORGU, I. Ş. - 2009. Synecological data on the Orthoptera (Insecta: Orthoptera) in some areas from Dobrudja (Romania). Lucrările Simpozionului Entomofagii şi rolul lor în păstrarea echilibrului natural, Universitatea „Al. I. Cuza" Iaşi, 213-222
[22] PISICĂ, E. I. & IORGU, I. Ş., 2006 - Preliminary data concerning the Orthoptera (Insecta) fauna from North Dobrogea (Romania), Travaux du Museum d'Histoire Naturelle "Grigore Antipa", XLIX: 119-128
[23] PISICĂ, E. I. & PETRESCU, A. - 2005. Contribuţii la cunoaşterea faunei de ortoptere şi dictioptere (Insecta: Orthoptera şi Dictyoptera) din România, Muzeul Olteniei Craiova. Oltenia. Studii şi Comunicări. Ştiinţele Naturii, 21: 73-80.
[24] PÂRVU C. 2001 – "Ecologie generală". Ed. Tehnică, Bucureşti
[25] VADKERTI, E. & SZOVÉNYI, G. - 2005. Habitat preference of four protected bush-cricket species (Orthoptera, Phaneropteridae, Isophya) in South Hungary, Biologia, Bratislava, 60 (5): 545-549
[26] VĂDINEANU A., OLTEAN M., GÂŞTESCU P., VÎJDEA V., COLDEA GH., MUNTEAN I., MANOLELI D., DONIŢĂ N. 1992 –" Conceptul de ecoregionare ecologică şi diferenţeierea ecoregiunilor din România. Mediul înconjurător", III, 4: 3-6.
[27] http://osf2x.orthoptera.org/osf2.2/OSF2X2Frameset.htm;
[28] http://140.247.119.145/OS_Homepage/ - The Orthopterists Society