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Climatic conditions and habitats in Belső-Somogy, Külső-Somogy and Zselic as vegetation-based landscape regions III. Temperature envelopes of mesic deciduous woodlands

Éva Salamon-Albert

University of Pécs, Biological Institute, Department of Systematic and Ecological Botany
Pécsi Tudományegyetem Biológiai Intézet Növényrendszertani és Geobotanikai Tanszék,
H-7624 Pécs, Ifjúság útja 6.; e-mail: albert@gamma.ttk.pte.hu

Salamon-Albert, É.: *Climatic conditions and habitats in Belső-Somogy, Külső-Somogy and Zselic as vegetation-based landscape regions III. Temperature envelopes of mesic deciduous woodlands.*
Abstract: In our study distribution response to climatic temperature of mesic deciduous woodlands (lowland pedunculate and sessile oak-hornbeam woodlands, beech woodlands) are discussed in the relation of vegetation based landscape regions of South Transdanubia, including Belső-Somogy, Külső-Somogy and Zselic. Selected bioclimatic variables are used to characterize and compare climate envelopes of the habitats by their occurrence. Gaussian probability curves were fitted for yearly, quarterly and some short time range or variability of temperature indexes, representing annual trends, seasonality and extreme or limiting environmental factors in order to generate more biologically meaningful variables. Mesic deciduous woodlands (K) are accurately integrated into the regional habitat envelope (Á-NÉR), according to multipeaks of temperature indices. Among temperature variables, mean annual temperature and maximum one of warmest month is not relevant for habitat differentiation in any way. Mean temperature variables (BIOCLIM-6, -8, -9, -11) are resulted a moderate shifting in the realised range of habitat envelopes in case of pedunculate oak-hornbeam woodlands (K1a) especially, but not in case of sessile oak hornbeam woodlands (K2) and beech woodlands (K5). Separation of pedunculate oak-hornbeam woodlands is well represented by the range and seasonal variables (BIOCLIM-2, -4, -7). This habitat type tolerates high range of diurnal temperature, but a lower one of yearly extremities, as seasonality and annual difference. The most significant temperature effect in the existence of pedunculate oak-hornbeam woodlands is high mean diurnal range as a temperature hardiness and high mean temperature of coldest quarter as a themal limitation.

Keywords: habitat distribution modelling (HDM), climate envelope, MÉTA database, mesic deciduous woodlands, landscape ecology

Introduction

Climate elements effecting presence and distribution of semi-natural habitats by a great extent is a hot topic of current ecological research, using e.g. bioclimatic envelope models for pattern analysis and predictions (Botkin et al. 2007). Climate-vegetation relations were widely analysed under different spatial scales connected with some vegetation classification according to bioms, continents, countries and regions in Europe or in the USA (Ozenda and Borel 2000, Hossel et al. 2003, Piovesan et al 2005,

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THOMPSON et al 2005, ATTORE et al. 2007, THOMPSON et al 2008). Requirements for small-scale studies are expressed by more and more authors continually (e.g. LINDNER et al. 2010), but the conclusions derived from scientific results based on the studies have to be applied with caution.

Quantifying distributions and determining which factors influence species or habitat range limits is an ongoing challenge for ecologists nowadays (GUISAN and THUILLER 2005, COLWELL and RANGEL 2009). The studies of how objects vary in their requirements for and tolerance of environmental factors has advanced, in part due to the quantification of the ecological niche, continued the complementary concepts of the environmental and the trophic niche, serve as a basis for assessing the ecological and biogeographical similarities and differences (CHASE and LEIBOLD 2003, SOBERÓN 2007). Numerous variety of measures have been used to quantify distribution characteristics leading to construct the environmental niches and analyse their overlap (e.g. SCHOENER 1970, COLWELL and FUTUYMA 1971, MAY and ARTHUR 1972, FITZPATRICK et al. 2008; PETERSON and NAKAZAWA 2008). In recent studies differences in niches that are quantified using observed occurrences of objects can reflect an unknown conjunction of the environmental status (SOBERÓN 2007, COLWELL and RANGEL 2009).

The subset of the environmental conditions that is actually occupied by the species corresponds to the realized niche (HUTCHINSON 1957). The environmental conditions resulting the realized environmental niche are described using e.g. a set of geographically referenced variables come from widely used, systematic databases of climatic parameters (HOSSELL et al. 2003, BEAUMONT et al. 2005, HIJMANS et al. 2005, ATTORRE et al. 2007, CZÚCZ et al. 2009). However, niche characteristics and overlap is estimated through the projection of those functions derived from SDMs across a landscape by any plant species or habitat as well, evaluating range of occurrence from environmental point of view. Novel analyses, e.g. connecting distribution models with other ecological phenomena, can provide novel capacities for understanding specific and general drivers of ranges in occurrence.

In this study our aims were to analyse 1) climate envelopes of mesic deciduous woodlands by mean and extreme short-, medium- and long-term climatic temperature variables, 2) range relations as climatic niche corresponding each other and to set of seminatural habitats, 3) detecting environmental variable(s) could be the most significant for the distribution by their temperature response.

Material and method

Study area

The study area is located in Külső-Somogy, Belső-Somogy and Zselic as three vegetation based landscape regions of South Transdanubia in Hungary, defined on the basis of present zonal or dominant extrazonal or edaphic vegetation (MOLNÁR Cs. et al. 2008). Elevation varies in a moderate range from lowlands (96 m a.s.l.) to hills (300 m a.s.l.), average altitude is 161 m a.s.l. Long-term annual temperature varies between 9.8 °C and 11.3 °C, the average was 10.8 °C (SALAMON-ALBERT et al. 2011). Studied regions are at the intersection of three climatic zone: from west as the atlantic, from east as the continental and from south as the mediterranean, that can influence the climatic surface. According to the main geobotanical division of Europe, the regions are fitted in the submontaneous oak-hornbeam woodlands as mesophilous woody habitats and thermophilous oak woodlands with open steppe oak woodlands and riparian vegetation (OZENDA and BOREL 2000).

BIOCLIM variables

Monthly, quarterly and yearly averages and extremities of temperature data as BIOCLIM-1 to -11 variables were used, that were measured at regional weather stations on local scales by the Hungarian Meteorological Service (http://vissycd.glia.hu/atlasz.html, MERSICH et al. 2001) and were integrated into the WorldClim database (http://www.worldclim.org/, HIJMANS et al. 2005). Corrected recalculation of the data was carried out by the Institute of Ecology of the Hungarian Academy of Sciences (CZÚCZ et al. 2007).

Temperature variables for the analyses are BIOCLIM-1 the annual mean temperature, BIOCLIM-2 the mean diurnal temperature range, BIOCLIM-4 the annual temperature seasonality calculated as the standard deviation of monthly means × 100, BIOCLIM-5 the maximum temperature of warmest month, BIOCLIM-6 the minimum temperature of coldest month, BIOCLIM-7 the temperature of annual range, BIOCLIM-8 the mean temperature of wettest quarter, BIOCLIM-9 the mean temperature of driest quarter, and BIOCLIM-11 the mean temperature of coldest quarter. Annual data refer to monthly climate measurements from January to December, wettest quarter means data from June to August, driest quarter means data from January to March, warmest quarter means data from June to August, coldest quarter means data from December to February as the periods of three months, as ¼ of a year.

Habitats of mesic deciduous woodlands

MÉTA project (2002-2006) was a systematic habitat mapping of the Hungarian semi-natural vegetation on landscape scale integrated with spatial and geographical information (BÖLÖNI et al 2007, MOLNÁR et al 2007, HORVÁTH et al. 2008). Field data collecting were carried out at hexagon scale by high resolution (35 hectares per each) as basic units, and they were integrated into quadratic scale for landscape mapping (35 km^2 per each), both added to the MÉTA tables and databases (HORVÁTH and POLGÁR 2008). In our study mesophilous woody habitat types connected with temperature variables were assigned to finer spatial scale for 16300 hexagons of 163 MÉTA quadrats of the regions.

In total 5 MÉTA habitat types of mesophilous woodlands (K as the associated habitat group) were identified in the vegetation based regions, including K1a the lowland pedunculate oak-hornbeam woodlands, K2 the sessile oak-hornbeam woodlands, K5 the beech woodlands, K7a the acidofrequent beech woodlands and K7b the acidofrequent oak-hornbeam woodlands (MOLNÁR et al. 2008, SALAMON-ALBERT et al. 2008, 2010, 2011). In our study we focused on significant mesic woodlands as K1a (n=1792), K2 (n=2042), K5 (n=926) and associated habitat group of K (n=3848), using the binary data of occurrence for the analyses.

Sessile oak hornbeam woodlands (K2) are the most abundant in the regions as well as in Hungary. They are mostly occurred on submontane and colline exposition, but missing from lowlands, usually on deep soils, dominated by *Quercus petraea, Carpinus betulus* and/or *Fagus sylvatica*. In Belső-Somogy, this habitat type is replaced by lowland pedunculate oak-hornbeam forests, according to geographical features. It is connected to cool-humid climate suitable for mesic forests. It occurs in all type of (but mainly on solid) bedrock. In hilly regions it can rather be found on loess or loess-like sediments, but missing on sand, and occurs on clay, where it forms mosaic with lowland oak-hornbeam woodlands.

Pedunculate oak-hornbeam woodlands (K1a) are the second in abundance among mesic woodland habitat types in the regions. Shadowed and mesic forests of lowlands and hilly regions, with *Quercus robur* and *Carpinus betulus* in the tree layer. The centre of the distribution is in the western part of Transdanubia: with greatest extension in Belső-Somogy (14000 ha), and connected to this area, in Dráva-sík (6000 ha). Apart from Dráva-sík, it can be found only at the edges of Alföld, with the greatest number in Szatmár-Beregi-sík (1500 ha). It occurs on incoherent sedimentary rocks, especially on sand and clay, mainly on the humid parts of lowlands and hilly regions. On lowlands, it appears typically in high floodplains, whereas in river and stream valleys in the hilly regions of Hungary. This habitat type frequently occurs together and forms mosaic with sessile oak-hornbeam woodlands (K2).

Beech woodlands (K5) are high growing, closed mesic forests, connected to cool and humid climate with beech monodominance (*Fagus sylvatica*). The habitats occur with the greatest extension in the Északi-középhegység (45000 ha). In certain parts of Transdanubia 12500 ha, with larger extension in Zselic and Mecsek, and sporadically in Külső- and Belső-Somogy. Under less favourable abiotic environment (too dry) and/or under strong human impact the habitat is gradually reducing (e.g. Külső- and Belső-Somogy).

Habitat nomenclature is by MOLNÁR ZS. et al (2008), vegetation characterization is by BÖLÖNI et al. (2008).

Data analyses

By the set of temperature variables regional climatic envelopes are reported for semi-natural habitats (Á-NÉR), and types of mesic deciduous woodlands disposing statistically appropriate plot number (K, K1a, K2, K5). In the first step, scatterplots were constructed from the relative distribution (%) on total area covered by any semi-natural vegetation as the regional habitat envelope (Á-NÉR) and on woodland types as the habitat envelope according to temperature variables. Data originated from the associated dataset of habitat occurrence and climatic variables, were sorted for the analyses representing all of the sampling points (MÉTA hexagons). In second step, area version of Gaussian function as a nonlinear single or multipeak analysis was executed on each scatterplot, computing Levenberg-Marquardt algorithm as an iterative procedure by Origin 6.0. Area based Gaussian model describes a bell-shaped curve like a normal probability distribution function, ecologically defined as realized niche by temperature index. Temperature weighted Gaussian curves were statistically compared by a one-way analysis of variance (ANOVA). Pairwise significant differences were counted if $p<0.05$. Temperature sensitivity of a habitat by a given bioclimatic variable was interpreted as significant difference among variabilities in the temperature envelopes (e.g. K1a to Á-NÉR by BIOCLIM-2, see Table 2). Overlapping distributions without any significant difference are interpreted as a climate or habitat gradient, curve that has significant difference to any other are defined as a regional climate or habitat functional group.

Results

Climate envelope is a realized range of abiotic environmental variables that could effect pattern and distribution of habitat types potentially in geographical or natural landscape areas. Basic statistics of 9 calculated bioclimatic variables of temperature, as minimum, maximum, mean values and the range at several scales are given for the studied regions (Table 1). Referring to general temperature relations of semi-natural habitats the most relevant index is the mean annual temperature (BIOCLIM-1). It varies between 9.8 and 11.3 °C, with the range of 1.5 °C in the regions. Range of variable is differed among habitat types, with the lowest value by pedunculate oak-hornbeam woodlands (K1a) and beech woodlands (K5) opposite to sessile oak hornbeam woodlands (K2) that

Table 1: Basic statistics of temperature envelopes for semi-natural habitats (Á-NÉR), mesic deciduous woodlands (K), lowland pedunculate oak-hornbeam woodlands (K1a), sessile oak-hornbeam woodlands (K2), and beech woodlands (K5) in the landscape regions

Á-NÉR		range	min	mean	max	std
BIOCLIM-1	Mean annual temperature	1.5	9.8	10.7	11.3	0.2
BIOCLIM-2	Mean diurnal temperature range	0.7	9.0	9.4	9.7	0.2
BIOCLIM-4	Temperature seasonality of the year	50	771	796	821	12
BIOCLIM-5	Maximum temperature of warmest month	1.8	25.8	26.9	27.6	0.3
BIOCLIM-6	Minimum temperature of coldest month	1.5	-4.7	-4.0	-3.2	0.2
BIOCLIM-7	Temperature annual range	1.1	30.4	30.9	31.5	0.2
BIOCLIM-8	Mean temperature of wettest quarter	2.7	17.9	19.4	20.6	0.7
BIOCLIM-9	Mean temperature of driest quarter	1.7	1.2	2.1	2.9	0.3
BIOCLIM-11	Mean temperature of coldest quarter	1.7	-0.5	0.4	1.2	0.3

K		range	min	mean	max	std
BIOCLIM-1	Mean annual temperature	1.4	9.8	10.7	11.3	0.2
BIOCLIM-2	Mean diurnal temperature range	0.7	9.0	9.4	9.7	0.2
BIOCLIM-4	Temperature seasonality of the year	50	771	795	821	11
BIOCLIM-5	Maximum temperature of warmest month	1.8	25.8	26.8	27.6	0.3
BIOCLIM-6	Minimum temperature of coldest month	1.4	-4.7	-4.0	-3.3	0.2
BIOCLIM-7	Temperature annual range	1.1	30.4	30.8	31.5	0.2
BIOCLIM-8	Mean temperature of wettest quarter	2.6	17.9	19.3	20.5	0.7
BIOCLIM-9	Mean temperature of driest quarter	1.6	1.2	2.1	2.8	0.3
BIOCLIM-11	Mean temperature of coldest quarter	1.5	-0.4	0.4	1.1	0.3

K1a		range	min	mean	max	std
BIOCLIM-1	Mean annual temperature	1.1	10.0	10.7	11.1	0.2
BIOCLIM-2	Mean diurnal temperature range	0.6	9.1	9.5	9.7	0.1
BIOCLIM-4	Temperature seasonality of the year	39	771	786	810	9
BIOCLIM-5	Maximum temperature of warmest month	1.4	25.9	26.8	27.3	0.2
BIOCLIM-6	Minimum temperature of coldest month	1.3	-4.6	-3.9	-3.3	0.2
BIOCLIM-7	Temperature annual range	0.8	30.4	30.7	31.2	0.1
BIOCLIM-8	Mean temperature of wettest quarter	2.3	18.1	19.7	20.4	0.5
BIOCLIM-9	Mean temperature of driest quarter	1.5	1.3	2.2	2.8	0.3
BIOCLIM-11	Mean temperature of coldest quarter	1.4	-0.3	0.5	1.1	0.3

K2		range	min	mean	max	std
BIOCLIM-1	Mean annual temperature	1.4	9.8	10.6	11.3	0.3
BIOCLIM-2	Mean diurnal temperature range	0.6	9.0	9.3	9.6	0.1
BIOCLIM-4	Temperature seasonality of the year	47	774	802	821	7
BIOCLIM-5	Maximum temperature of warmest month	1.8	25.8	26.8	27.6	0.3
BIOCLIM-6	Minimum temperature of coldest month	1.1	-4.7	-4.1	-3.6	0.2
BIOCLIM-7	Temperature annual range	1.1	30.4	30.9	31.5	0.2
BIOCLIM-8	Mean temperature of wettest quarter	2.6	17.9	18.9	20.5	0.6
BIOCLIM-9	Mean temperature of driest quarter	1.3	1.2	2.0	2.5	0.2
BIOCLIM-11	Mean temperature of coldest quarter	1.2	-0.4	0.2	0.8	0.2

K5		range	min	mean	max	std
BIOCLIM-1	Mean annual temperature	1.1	10.1	10.6	11.2	0.2
BIOCLIM-2	Mean diurnal temperature range	0.5	9.1	9.3	9.6	0.1
BIOCLIM-4	Temperature seasonality of the year	43	778	800	821	6
BIOCLIM-5	Maximum temperature of warmest month	1.4	26.1	26.8	27.5	0.3
BIOCLIM-6	Minimum temperature of coldest month	0.9	-4.6	-4.1	-3.7	0.2
BIOCLIM-7	Temperature annual range	1.1	30.4	30.9	31.5	0.2
BIOCLIM-8	Mean temperature of wettest quarter	2.4	17.9	18.6	20.3	0.5
BIOCLIM-9	Mean temperature of driest quarter	1.1	1.4	2.0	2.5	0.2
BIOCLIM-11	Mean temperature of coldest quarter	1.1	-0.3	0.2	0.8	0.2

has the highest one. Bioclimatic indeces according to a mean of a short period (e.g. a day, a month or a quarter) or indicating environmental extremities could give a climate limitation for vegetation distribution. Mean diurnal temperature range (BIOCLIM-2) are quite similar among the woodland types as well as the semi-natural habitats, but the minimum, maximum and mean values significantly differs by mesic deciduous woodland types, with the highest mean in pedunculate oak-hornbeam woodlands (K1a). Temperature seasonality of the year (BIOCLIM-4) provides the best range differentiation among the habitats. Pedunculate oak-hornbeam woodlands (K1a) have the narrowest seasonality range, beech woodlands (K5) have the range of medium size and sessile oak hornbeam woodlands (K2) have the highest value of it. BIOCLIM-5 the maximum temperature of warmest month has the widest range in sessile oak hornbeam woodlands (K2), the narrowest one in pedunculate oak-hornbeam woodlands (K1a) and beech woodlands (K5). Among ranges in minimum temperature of coldest month (BIOCLIM-6), the highest one is observed in pedunculate oak-hornbeam woodlands (K1a), the medium sized one is realized by sessile oak hornbeam woodlands (K2) and the narrowest range occurs in the beech woodlands (K5). BIOCLIM-7 the temperature annual range differs pedunculate oak-hornbeam woodlands (K1a) by a lower value from sessile oak hornbeam woodlands (K2) and beech woodlands (K5), that show a higher and similar one. By BIOCLIM-8 the mean temperature of wettest quarter, sessile oak hornbeam woodlands (K2) display the highest value of it, and pedunculate oak-hornbeam woodlands (K1a) and beech woodlands (K5) have a lower value of range. BIOCLIM-9 the mean temperature of driest quarter, highest range is represented in pedunculate oak-hornbeam woodlands (K1a), the medium sized one is realized in sessile oak hornbeam woodlands (K2) and the narrowest range occurs in the beech woodlands (K5). In case of mean temperature of coldest quarter (BIOCLIM-11), range order of the mesic deciduous woodland habitats is similar to that of mean temperature of driest quarter, because of the variable superimposition.

According to ranges and means of analysed variables in mesic deciduous woodland habitats, functional groups of temperature responses can be defined. Similarity in that of pedunculate oak-hornbeam woodlands (K1a) with beech woodlands (K5) but dissimilarity of sessile oak hornbeam woodlands (K2) was established by BIOCLIM-1, -5 and -8. Gradual change among the habitats was detected by BIOCLIM-6, -9 and -11 from pedunculate oak-hornbeam woodlands (K1a) through sessile oak hornbeam woodlands (K2) to beech woodlands (K5) by descending order but by BIOCLIM-8 by ascending order. In order of sessile oak hornbeam woodlands (K2) through beech woodlands (K5) to pedunculate oak-hornbeam woodlands (K1a) narrowing ranges are detected by temperature seasonality of the year (BIOCLIM-4).

There was a strong superimposition between the summarized temperature envelope of semi-natural habitats (Á-NÉR) and mesic deciduous woodlands (K) as it was verified by the absence of any significant difference (Fig 1, Table 1 and 2). Differences are anticipated among peak distribution of habitat types and/or to envelopes of semi-natural habitats. Results are introduced as the similarity or dissimilarity to semi-natural habitat distribution as the realized regional temperature envelopes.

Among temperature variables, all of them show a continuous distribution as a summarized temperature niche characterized with one, two, three or four Gaussian peaks per curves. BIOCLIM-1 the mean annual temperature have no significant difference in any habitats as well as the Á-NÉR distribution. Highest proportion of habitat envelopes occur at medium values of the range. BIOCLIM-2 the mean diurnal temperature presents two-peaked distributions, habitat envelopes are differentiated in the range with significant differences by sessile oak hornbeam woodlands (K2) and beech woodlands (K5) at

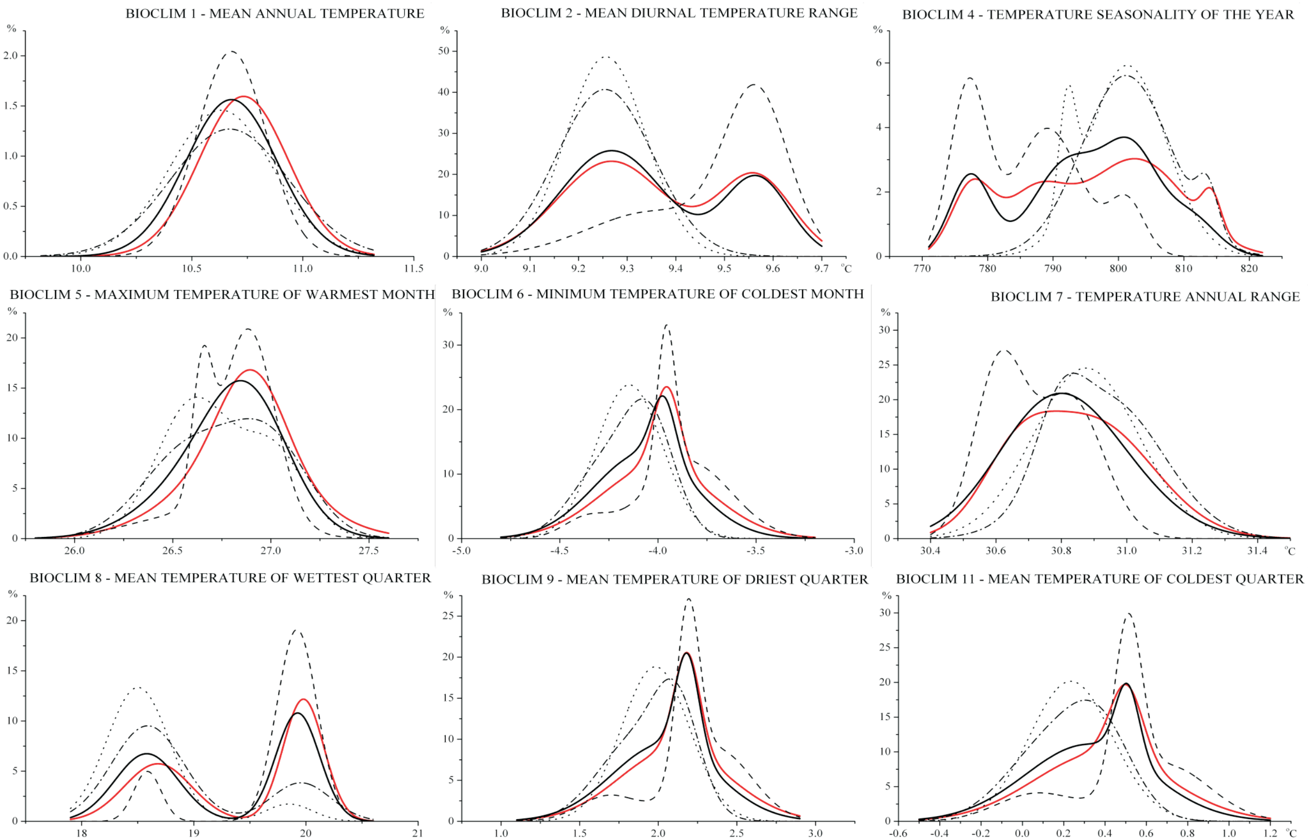

Fig 1: Summarized temperature envelopes of mesic deciduous woodlands on relative occurrence in the landscape regions. Signs: □□ semi-natural habitats (Á-NÉR), □□ mesic deciduous woodlands (K), – – lowland pedunculate oak-hornbeam woodlands (K1a), –·– sessile oak-hornbeam woodlands (K2), ··· beech woodlands (K5).

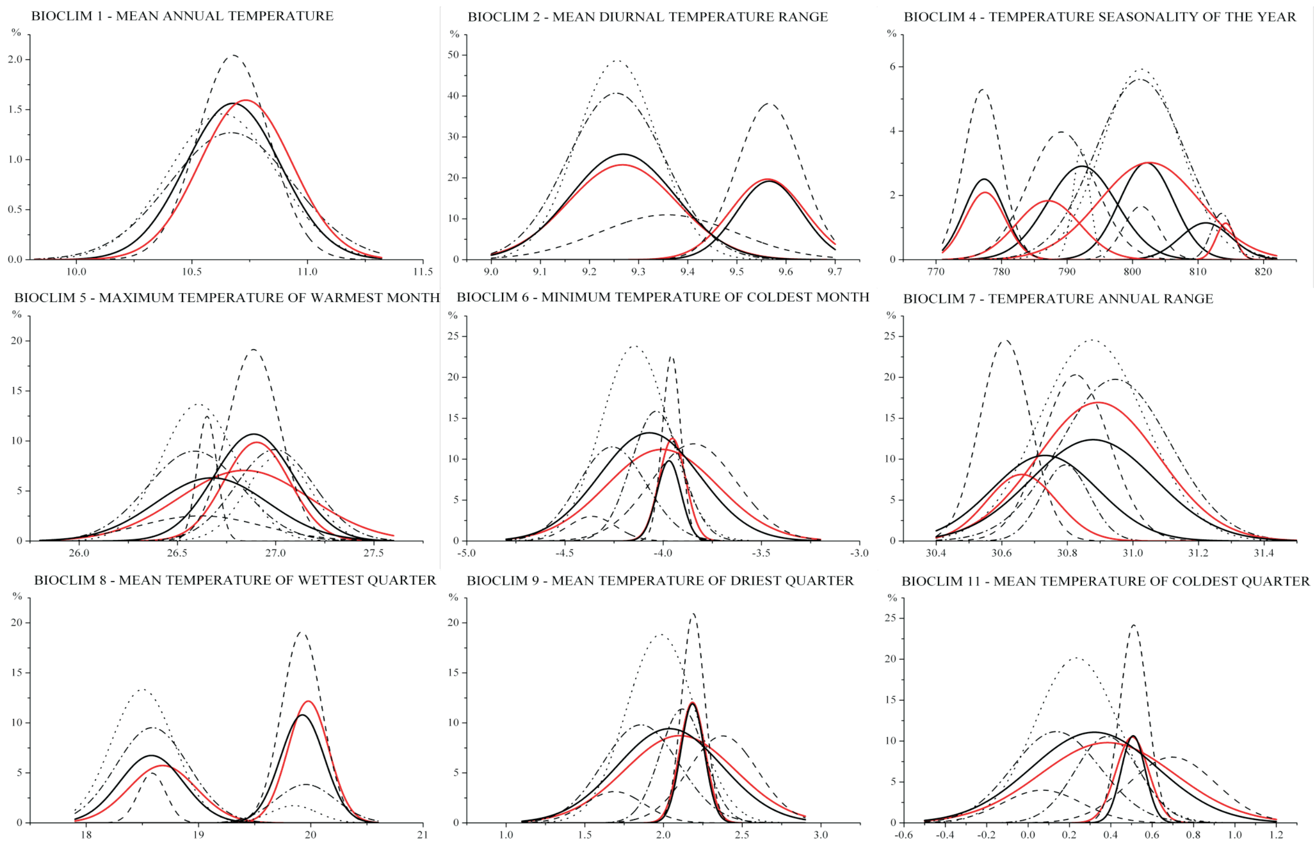

Fig 2: Multipeak temperature envelopes of mesic deciduous woodlands on relative occurrence in the landscape regions. Signs: semi-natural habitats (Á-NÉR), mesic deciduous woodlands (K), – – lowland pedunculate oak-hornbeam woodlands (K1a), –·– sessile oak-hornbeam woodlands (K2), ··· beech woodlands (K5).

lower values to pedunculate oak-hornbeam woodlands (K1a) at higher values as well as to semi-natural habitats (Á-NÉR). BIOCLIM-4 the temperature seasonality of the year resulted shifting in distribution with no significant differences among habitat envelopes. Pedunculate oak-hornbeam woodlands (K1a) is positioned at lower values, sessile oak hornbeam woodlands (K2) and beech woodlands (K5) are done at higher values of the range. BIOCLIM-5 the maximum temperature of warmest month, show a continuous regional envelope, but two-peaked habitat envelopes without any significant differences to each other. BIOCLIM-6 the minimum temperature of coldest month has three-peaked distribution without any significant differences in summarized curves. Sessile oak hornbeam woodlands (K2) and beech woodlands (K5) are positioned at lower values, pedunculate oak-hornbeam woodlands (K1a) are done at medium and higher values of the range. BIOCLIM-7 the temperature annual range, are similar to previous variable, but with two hardly overlapping peaks by Á-NÉR and K habitats also. Among mesic woodland habitat types have two-peaked distribution positioning at the medium values of the range, with the exception of pedunculate oak-hornbeam woodlands (K1a) at the lower values of the range. BIOCLIM-8 the mean temperature of wettest quarter, has two-peaked splitted curve at all of distribution. Habitat envelopes are fitted by and imbalanced relation, sessile oak hornbeam woodlands (K2) and beech woodlands (K5) are prevailed at the lower values, pedunculate oak-hornbeam woodlands (K1a) are done at the higher ones. BIOCLIM-9 the mean temperature of driest quarter present a two-peaked ditribution without any significant difference in envelopes to each other. Pedunculate oak-hornbeam woodlands (K1a) are positioned at a little bit higher values than sessile oak hornbeam woodlands (K2) and beech woodlands (K5) int he range. BIOCLIM-11 the mean temperature of coldest quarter has a similar distribution to the previous, but significant difference is resulted among woodland habitats. Pedunculate oak-hornbeam woodlands (K1a) show a characteristic curve at medium and high values opposite to sessile oak hornbeam woodlands (K2) and beech woodlands (K5) that are positioned at lower values, but not to semi-natural habitat envelope (Á-NÉR).

Table 2: Relations of summarized temperature envelopes for semi-natural habitats (Á-NÉR), mesic deciduous woodlands (K), lowland pedunculate oak-hornbeam woodlands (K1a), sessile oak-hornbeam woodlands (K2) and beech woodlands (K5) in the landscape regions. Significant differences are signed by level of probability. BIOCLIM-2 the mean diurnal temperature range, BIOCLIM-11 the mean temperature of coldest quarter

BIOCLIM-2	Á-NÉR	K	K1a	K2
Á-NÉR				
K	ns			
K1a	ns	ns		
K2	$p<0.001$	$p<0.001$	$p<0.001$	
K5	$p<0.001$	$p<0.001$	$p<0.001$	ns

BIOCLIM-11	Á-NÉR	K	K1a	K2
Á-NÉR				
K	ns			
K1a	ns	ns		
K2	ns	ns	$p<0.001$	
K5	ns	ns	$p<0.001$	ns

Discussion

Previous studies suggest, that temperature variables could have a less significant role in the existence of woody habitat types in the landscape region, opposite to precipitation ones (SALAMON-ALBERT et al. 2010a,b, 2011). According to our current results, some temperature variable was investigated forming significant difference to semi-natural regional envelope or among some type of mesic deciduous woodlands. In spite of relative narrow ranges of temperature variables, whole multipeak distributions were resulted for the regions, but the exception of BIOCLIM-3 the isothermality as the ratio of mean diurnal range/temperature annual range.

Among temperature variables formulating range and seasonality, BIOCLIM-2 the mean diurnal temperature range resulted less complicated but significantly different habitat envelopes: sessile oak hornbeam woodlands (K2) and beech woodlands (K5) occur at low, pedunculate oak-hornbeam woodlands (K1a) does at medium and high values. BIOCLIM-4 resulted the most complicated regional and habitat envelopes containing four Gaussian multipeaks by the regional habitats as well as in the woodland types. Along yearly temperature seasonality scale habitats are placed in ascending order: pedunculate oak-hornbeam woodlands (K1a) are positioned at low and medium, beech woodlands (K5) at medium and sessile oak hornbeam woodlands (K2) at medium to high values of seasonality. The third member of temperature variety, BIOCLIM-7 show a similar shift of mesic woodlands to the temperature seasonality of the year by pedunculate oak-hornbeam woodlands (K1a) appear at lowest values, sessile oak hornbeam woodlands (K2) and beech woodlands (K5) does at medium and highest values of the range. Variables representing absolute minimum and maximum values, mesic woodland habitats are weakly diffrentiated by BIOCLIM-5 and BIOCLIM-6. There is a moderate shifting in pedunculate oak-hornbeam woodlands (K1a) to the higher values by the minimum temperature of coldest month additionally. Among mean variables of temperature, all of mesic woodland habitats are distributed identical to semi-natural woodland habitats by BIOCLIM-1 the mean annual temperature and BIOCLIM-8 the mean temperature of wettest quarter. By BIOCLIM-9 the mean temperature of driest quarter and BIOCLIM-11 the mean temperature of coldest quarter, pedunculate oak-hornbeam woodlands (K1a) are shifted into the higher values of the range, and significantly differed from by sessile oak hornbeam woodlands (K2) and beech woodlands (K5) by the latter one.

Evaluating temperature preference described by habitat envelope, BIOCLIM-1 and BIOCLIM-5 is not relevant for habitat differentiation in any way. Various patterns represented by the multipeak ratios in habitat distribution is represented by BIOCLIM-8 the mean temperature of wettest quarter. By mean temperature variables a moderate shifting in habitat envelope of pedunculate oak-hornbeam woodlands (K1a) are indicated, sessile oak hornbeam woodlands (K2) and beech woodlands (K5) are differential from it but similar to each other. The most significant differentiation was resulted by range and seasonality variables (BIOCLIM-2, -4, -7), describing pedunculate oak-hornbeam woodlands (K1a) as a highly separated habitat type with higher diurnal but lower seasonal and yearly values in temperature envelopes.

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