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Specifics of Spatial Distribution of Nests of Some Species of the Falconiformes and Strigiformes in Strip-Like Pine Forests of Priobskoye Plateau (Altai Kray, Russia)

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Abstract: The author attempts to describe spatial niches of a greater spotted eagle (*Aquila clanga*), imperial eagle (*Aquila heliaca*), golden eagle (*Aquila chrysaetos*), white-tailed eagle (*Haliaeetus albicilla*), saker falcon (*Falco cherrug*) and eagle-owl (*Bubo bubo*) in strip-like pine forests of Priobskoye Plateau (Near-Ob' Plateau, Ob' Plateau) in Altai Kray (Altai Territory). Data of distribution of 296 nests of birds of prey that had been found in the period from 1997 to 2013 years by different researches have been analyzed. Nine parameters of spatial distribution of nests were used for analysis. Discriminant analysis shows great proximity of spatial niches of imperial eagle, saker falcon and golden eagle. Spatial niches of greater spotted eagle and eagle-owl differs significantly from niches of other species because they occupy separate subareas in modeled multidimensional space. Spatial niche of white-tailed eagle is almost adjacent to niche of imperial eagle and is distinctly separated from niches of the other species. Considering the distance between the closest neighbors' intraspecific competition is more probably more important in choosing habitats for nesting than interspecific competition.

Key words: Birds of prey · Falconiformes · Strigiformes · Environmental niche · Spatial niche · Greater spotted eagle (*Aquila clanga*) · Imperial eagle (*Aquila heliaca*) · Golden eagle (*Aquila chrysaetos*) · White-tailed eagle (*Haliaeetus albicilla*) · Saker falcon (*Falco cherrug*) · Eagle-owl (*Bubo bubo*) · Competition · discriminant analysis

INTRODUCTION

Priobskoye Plateau (Fig. 1) is a plain in the territory of Altai Kray and Novosibirsk Region of Russia. In the south it is bounded by the foothills of Altai, in the east it is separated from Biysko-Chumysh Hills by wide valley of Ob river. Priobskoye Plateau forms a definite 50-100 m level over Kulundinskaya Plain in the west.

Maximum true altitude of the plateau is 321 m. Undulate surface of the plateau with altitudes less than 0,5° is crossed by through parallel hollows of ancient drains 10-20 km wide and 50-100 m deep [1]. These hollows extend from south-west to north-east. Beds of existing rivers including the biggest Aley, Kasmala and Barnaulka are often inlaid into the bottoms of these hollows with uneven seedbed relief of wind-borne sediments.

Strip-like pine forests of Priobskoye Plateau sited along the hollows of ancient drains stands out against neighboring territories (excluding foothills of Altai) as a hotbed of diversity of big Falconiformes and Strigiformes [2, 3], listed in regional and federal Red Books [4, 5]. It is caused by unique combination of sandy wind-borne pine forest landscapes and wide water and marsh areas with big pines (*Pinus sylvestris*) as optimal substrate for building nests and rich nutritive base for big birds of prey: mainly populations of such rodents as redcheeck gopher *Spermophilus erythrogenys* and water vole (*Arvicola terrestris*) as well as dominant near-water birds.

We make attempt to describe spatial niches (i.e. a component of environmental niches) of some species of Falconiformes and Strigiformes the most typical for strip-like pine forests using mathematical methods and a complex of geoinformation and statistic applications.

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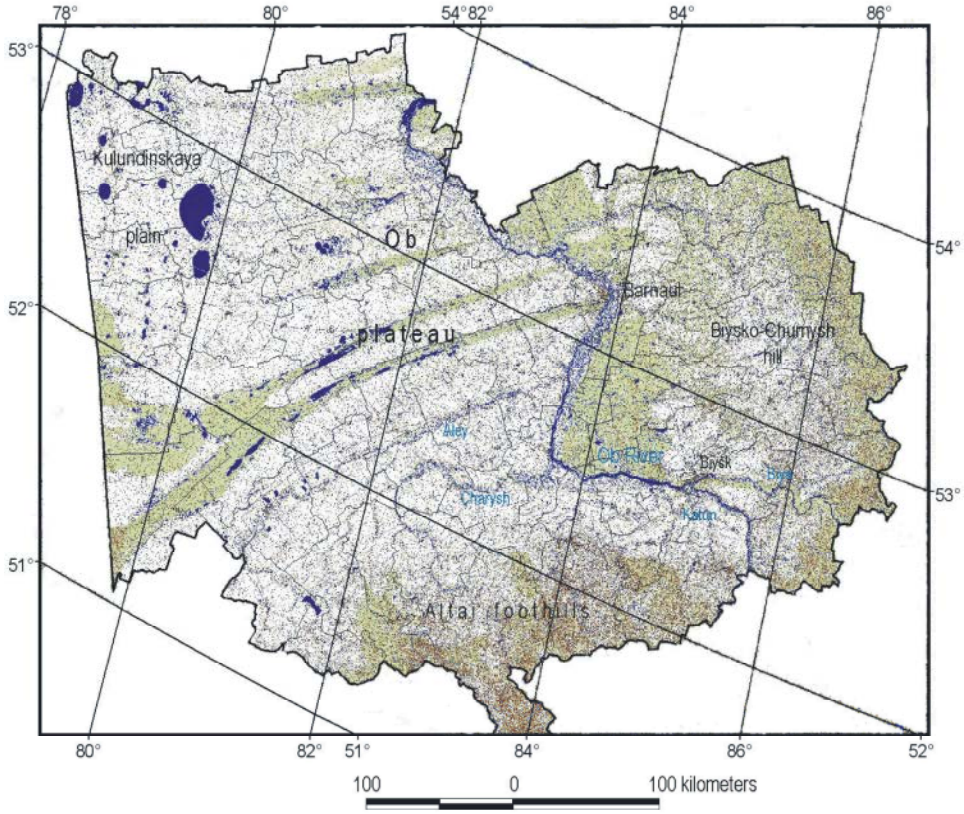

Fig. 1: Priobskoye Plateau (Ob' Plateau) in the map of Altai Kray

Data and Methodology: Parameters of spatial distribution of 296 nests of the birds of prey in strip-like pine forests of Priobskoye Plateau (o the territory of Altai Kray) were analyzed in our research. Precise coordinates of the nests have been loaded in electronic public data base (Fig. 2). These nests were found in the period from 1997 to 2013 years by several explorers [3, 6, 7, 8, 9, 10], the author among them [9, 10]. Major part of the nests was found from 2003 to 2005 years by I.V. Karyakin and S.V. Bakka with co-authors [3, 6]. We have analyzed parameters of localization of 73 nests in 44 nesting areas of greater spotted eagle (*Aquila clanga*), 112 nests in 81 nesting areas of imperial eagle (*Aquila heliaca*), 5 nests in 3 nesting areas of golden eagle (*Aquila chrysaetos*), 11 nests in 10 nesting areas of white-tailed eagle (*Haliaeetus albicilla*), 33 nests in 27 nesting areas of saker falcon (*Falco cherrug*) and 62 nests in 51 nesting areas of eagle-owl (*Bubo bubo*).

64 of 73 analyzed nests of greater spotted eagle were on pine trees (*Pinus sylvestris*), 6 – on birches (*Betula sp.*) and 3 – on aspens (*Populus tremula*). 111 of 112 nests of imperial eagle on pine trees and one – on a birch. All 5 nests of golden eagle and 11 – white-tailed eagle were on pine trees. All the nests of saker falcon were of pine trees, from them 28 – on old constructions of imperial eagle and 2 on constructions of black kite (*Milvus migrans*), one on constructions of golden eagle, one – on raven's (*Corvus corax*) and one – on magpie's (*Pica pica*). All 62 of analyzed nests of eagle owl were on ground from then 60 at pine tree foots one under turned out roots and one at the foot of the haystack.

For cameral treatment of spatial data geoinfromation application ArcView GIS 3.2a ESRI was used. Statistic processing was made using application Statistica 6.0. Gauss distribution of parameters was checked according to criteria of Shairo-Wilk and Kolmogorov-Smirnov. To define differences in spatial niches of the six listed birds of prey most typical for the territory discriminate analysis was conducted. This section of multidimensional statistic analysis is known to be an alternative to multiple regression analysis and it can be replaced with no other method [11, 12, 13]. 9 parameters of spatial distribution of nests were used in analysis (Table 1).

All the distances except the nests height were measured in GIS media with 10 m bias (more accurate measurement is impossible due to an error of satellite navigator used to define the coordinates of nests).

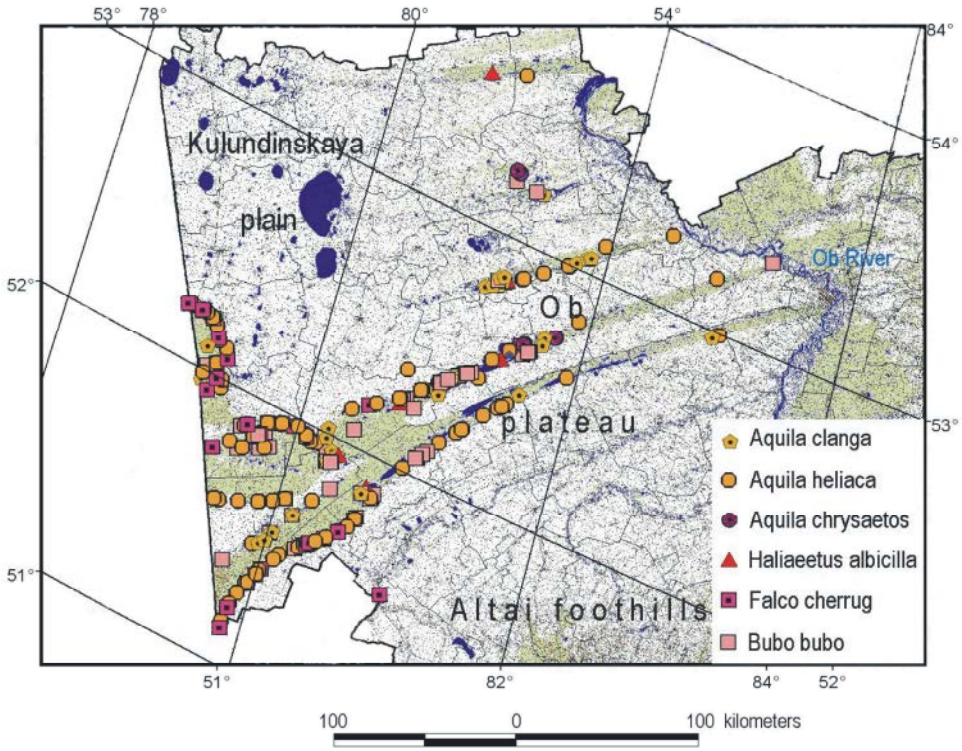

Fig. 2: Nests considered in analysis

Table 1: Parameters (M±SD, Lim, n) of spatial distribution of nests of some species of big birds of prey in strip-like pine forests of Priobskoye Plateau

	Species					
Parameter	*Aquila clanga*	*Aquila heliaca*	*Aquila chrysaetos*	*Haliaeetus albicilla*	*Falco cherrug*	*Bubo bubo*
Distance from the nearest forest edge, m	390±540, Lim 0-1900, n=45	60±150, Lim 0-1070, n=101	170±170, Lim 0-350, n=5	260±170, Lim 0-630, n=11	60±160, Lim 0-620, n=28	130±230, Lim 0-1260, n=50
Distance from settlement, m	3360±1840, Lim 360-7350, n=44	2710±2140, Lim 0-9500, n=96	4050±2310, Lim 1540-6270, n=5	4010±1380, Lim 1630-6370, n=11	3350±2660, Lim 530-13140, n=28	3090±2240, Lim 480-9760, n=51
Distance from the nearest nest of the same species, m	3270±2000, Lim 1000-8310, n=32	6380±3460, Lim 1560-14920, n=84	17740±160, Lim 17650-17920, n=3	4660±10, Lim 4650-4660, n=2	7930±2230, Lim 4590-12270, n=19	4360±3460, Lim 530-12380, n=42
Distance from the nearest nest of the other species, m	1930±1580, Lim 100-5690, n=32	3730±4330, Lim 40-22330, n=63	5630±3010, Lim 760-8210, n=5	2390±1630, Lim 470-5060, n=9	2160±2380, Lim 90-9650, n=23	1450±1220, Lim 80-5160, n=39
Distance from a lake, m	930±1290, Lim 0-4850, n=45	2540±3240, Lim 0-22330, n=96	1990±2160, Lim 250-4900, n=5	700±950, Lim 0-2700, n=11	2640±3050, Lim 390-14310, n=28	1330±1740, Lim 0-8000, n=51
Distance from a water stream, m	4860±3070, Lim 10-12460, n=34	8050±5160, Lim 220-19400, n=55	3440±1140, Lim 2220-5300, n=5	5990±3770, Lim 650-11150, n=11	10530±5720, Lim 1160-17170, n=10	8060±4730, Lim 270-19570, n=44
Distance from a marsh, m	600±850, Lim 0-3860, n=42	3060±3090, Lim 0-17700, n=96	800±730, Lim 160-1960, n=5	620±1150, Lim 0-4000, n=11	6710±4440, Lim 0-14470, n=26	1150±1430, Lim 0-8810, n=51
Distance from a road in use, m	1220±1100, Lim 20-4280, n=42	470±670, Lim 0-5030, n=96	2450±1750, Lim 30-4880, n=5	1040±910, Lim 20-2580, n=11	440±480, Lim 30-2540, n=28	770±870, Lim 20-4350, n=51
Height of nest on the trees, m	11±4, Lim 4-20, n=52	23±4, Lim 10-30, n=107	14±3, Lim 10-18, n=5	19±3, Lim 14-25, n=11	23±3, Lim 15-28, n=33	0 n=62

Nests height was measured either with a rope with known length or on eye with a certain accuracy. Height data were rounded to 1 meter. Height of all eagle own nests is 0 because all the known nests in strip-like pine trees were on ground. Distances between neighboring nests (both of the same and of different species) were measured only in

Table 2: Final table of discriminant data analysis (variables in model - 9, groups - 6; Wilks' Lambda: 0.02258; approx. F (45,571)=16.929; p<0.0000)

Parameter	Wilks' Lambda	Partial Lambda	F-remove (5,127)	p-level	Tolerance	1-Toler. (R-Sqr.)
Distance from the nearest forest edge, m	0.025195	0.896077	2.9458	0.015000	0.930068	0.069932
Distance from settlement, m	*0.023065*	*0.978818*	*0.5497*	*0.738316*	*0.841562*	*0.158438*
Distance from the nearest nest of the same species, m	0.035088	0.643429	14.0760	0.000000	0.847636	0.152364
Distance from the nearest nest of the other species, m	0.025075	0.900363	2.8108	0.019235	0.822314	0.177686
Distance from a lake, m	*0.023324*	*0.967944*	*0.8412*	*0.522909*	*0.648745*	*0.351255*
Distance from water stream, m	0.027893	0.809403	5.9812	0.000053	0.737663	0.262337
Distance from marsh, m	*0.024224*	*0.932000*	*1.8532*	*0.107159*	*0.721116*	*0.278884*
Distance from road in use, m	*0.024428*	*0.924227*	*2.0824*	*0.071792*	*0.916082*	*0.083918*
Nest height on a tree, m	0.286488	0.078805	296.9130	0.000000	0.750846	0.249154

Note: parameters included in the model in bold, not included in the model italics.

case these nests were active by the time of research meaning inhabitated or empty but occupied by birds. Relevant information is provided by database.

Major Part: It is known that position of species in space, time and functional connections with natural community occupying a certain biotope may be described in the boundaries of that biotope. This position of the species in a association with dependence from other species is its environmental niche [14, 15]. High level of protection from competition with other species is critical advantage for species. Species may exist in geographical region if in different environmental conditions they are found as members of separate communities. Such differences are the differences between communal habitats. But species may coexist in the boundaries of one community is they differs in food and other resources.

Diversity of niches among species increases in evolution due to unfavourableness of selection oriented on direct competition of species comparing advantages of selection oriented to differentiation of niches. Advantages of differentiation of niches are reliable availability of different types of recourses as a condition of support for different species and relative independence of competition for these recourses with other species [15, 16]. Complexity of description of spatial niches of birds and identification of differences between niches of different species is explained by the fact that being typical permeantes they move free between layers and subsystems that usually form mosaic in most landscapes.

Discriminant analysis of parameters of distribution of nests of greater spotted eagle, imperial eagle, golden eagle, white-tailed eagle, saker falcon and eagle owl according to parameters included into the model such as distance to the nearest forest edge, to the nearest nests of the same and of the other species, to water stream as well as nests height shows distinct differences between spatial niches of these species of the birds of prey in strip-like pine forests (Table 2, Fig. 3). Classification functions are shown in Table 3. Analysis shows that discriminant function in general classifies correctly about 94,33% of cases (Table 4) so it may be concluded that classification can be satisfactorily mapped with linear discriminant functions.

Connections between niches of species in community may be described as *n*-dimensional space if a niche in which species has there own niche with center in position that differs from the position of centers of other niches [15]. *n* discriminant variables may be interpreted as orthogonal axes of *n*-dimentional Euclidean space. Each object is a point in this space defined by the values of discriminant variables for this object as its coordinates. Scatter gram of canonic values of nest placement parameters (Fig. 3) shows the position of classes (birds in our case) in multidimensional space and may be interpreted as mapping of spatial niches of species. Diagram shows that subareas occupied in multidimensional model by imperial eagle, saker falcon and golden eagle are significantly overlapped. So it is reasonable to conclude that spatial niches evaluated according to parameters included into the model are overlapped for these species.

Niches overlapping indicates similarity of requirements of these species to inhabitations. It is proves by observed facts of nesting of saker falcon (which does not make own nests) both in old nests of imperial eagle and golden eagle. Spatial niches of greater spotted eagle and eagle owl differs significantly from the niches of other species because they occupy separate subareas of multidimensional space. Spatial niche of white-tailed eagle is almost adjacent with the niche of imperial eagle and is completely separated form the niches of other species. The greatest difference lies between the niches of imperial eagle and eagle owl because they occupy subareas of multidimensional space with the greatest distance between them.

Analysis allows us to define what parameters of 9 analyzed parameters spatial niches of considered birds of prey are mostly differed by. Such parameters as nest

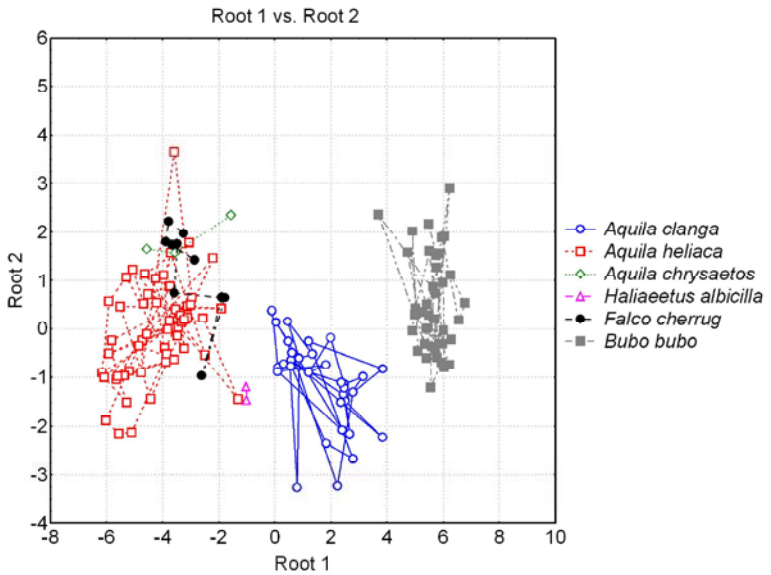

Fig. 3: Scatterogram of canonic values of nest placement parameters of birds of prey in strip-like pine forests of Priobskoye Plateau

Table 3: Classifying discriminant function coefficients for analyzed parameters

Parameter	Species					
	Aquila clanga (p=0.22695)	*Aquila heliaca* (p=0.39007)	*Aquila chrysaetos* (p=0.02128)	*Haliaeetus albicilla* (p=0.01418)	*Falco cherrug* (p=0.07092)	*Bubo bubo* (p=0.27660)
Distance from the nearest forest edge, m	0.0043	0.0022	0.0028	0.0042	0.0013	0.00081
Distance from settlement, m	0.0007	0.0008	0.0007	0.0008	0.0005	0.00048
Distance from the nearest nest of the same species, m	0.0006	0.0015	0.0026	0.0010	0.0016	0.00052
Distance from the nearest nest of the other species, m	0.0006	0.0011	0.0010	0.0007	0.0008	0.00011
Distance from a lake, m	-0.0000	0.0002	0.0003	-0.0000	0.0005	0.00012
Distance from a water stream, m	-0.0002	-0.0006	-0.0008	-0.0006	-0.0005	0.00033
Distance from a marsh, m	0.0002	0.0005	0.0005	0.0002	0.0009	0.00019
Distance from a road in use, m	0.0018	0.0006	0.0030	0.0013	0.0013	0.00189
Height of nest on the trees, m	1.7367	4.1637	3.6090	2.9089	3.6084	-0.10301
Constant	-13.5203	-52.2332	-60.1620	-29.8934	-46.3932	-5.80923

Table 4: Classification quality evaluation (Euclid metric) according to the frequency of erroneous discrimination

Species	% of correct discrimination	Species					
		Aquila clanga (p=0.2269)	*Aquila heliaca* (p=0.39007)	*Aquila chrysaetos* (p=0.02128)	*Haliaeetus albicilla* (p=0.01418)	*Falco cherrug* (p=0.07092)	*Bubo bubo* (p=0.27660)
Aquila clanga	96.87	31	0	0	0	0	1
Aquila heliaca	92.73	0	51	1	1	2	0
Aquila chrysaetos	100.00	0	0	3	0	0	0
Haliaeetus albicilla	100.00	0	0	0	2	0	0
Falco cherrug	70.00	0	3	0	0	7	0
Bubo bubo	100.00	0	0	0	0	0	39
Total	94.33	31	54	4	3	9	40

Note: rows – observed class, columns – calculated class

height and distance to the nearest active nest of the same species have the greatest value in species differentiation (according Fisher *F*-criterion). Distance from the nearest water stream (i.e. river or channel), distance from the nearest forest edge and the distance from the nearest nest of the other species of bird of prey. Distance from the nearest road in use as well as from marsh, a lake and settlement are much less important in differentiation of spatial niches of analyzed species (Table 2).

Basing of the analysis it may be concluded that the community of birds of prey of strip-like pine forests of Priobskoye Plateau is significantly different in

differentiation of spatial niches of species from analogous community in foothills of Altai at the boundaries of Priobskoye Plateau. In foothills spatial niche of eagle owl is significantly overlapped with the niches of imperial eagle and golden eagle [17, 18], while in strip-like pine forests niches of imperial eagle and eagle owl are absolutely different. According to discriminant analysis data in foothills such parameters as relief partitioning density (i.e. average distance between neighboring lowering of relief) and distance from the nearest active nest of the same species are the most important parameters in species differentiation (according Fisher *F*-criterion). Nests height in substrate (nests are both on trees and on rocks) in foothills unlike the strip-like pine forests is much less important in differentiation of spatial niches of birds of prey [17, 18]. Relief partitioning density in places of nesting of analyzed birds of prey in strip-like pine forests of Priobskoye Plateau is almost the same everywhere and insignificant comparing the same parameter in foothills of Altai. That is why this parameter was not even considered in analysis.

To answer the question what is the impact of intra- and interspecific competition on selection of inhabitations used by birds of prey for nesting in strip-like pine forests it is necessary to analyze the distances from the nearest neighbors of the same and the other species. In analyzed community intraspecific competition to the nearest active nest of the same species is in all cases much higher than from the one of the other species (Table 1). Major role of intraspecific competition is proved also by significant overlapping of spatial niches of imperial eagle, saker falcon and golden eagle (Fig. 3). T. Katzner with co-authors [19] provides the same data for community of eagles in North Kazakhstan and L.M. Novikova for natural reserve "Kerzhensky" [20]. Studying the communities of medium size birds of prey (northern goshawk *Accipiter gentilis*, common buzzard *Buteo buteo* and honey buzzard *Pernis apivorus)* in Germany made by A. Kostrzewa [21] gave different data: both intraspecific and interspecific competition are important in selection of inhabitations.

CONCLUSIONS

The results of discriminant analysis of parameters of distribution of 296 nests of 6 species of birds of prey (considering such parameters as distance from the nearest forest edge, from the nearest nests of the same and other species, from a water stream as well as nests height) shows the greater proximity of parameters of location of some nests of imperial eagle, saker falcon and golden eagle. Nevertheless differentiation of spatial niches is obvious and may be easily tracked on diagram of scatterogram of canonic values (Fig. 3). In the area of close data are data about nests that are actually close in the forest. Usually there are the nests of saker falcon made in old nests of imperial eagle.

Spatial niches of greater spotted eagle and eagle owl are significantly different from the niches of the other species because they occupy separate subareas in modeled multidimentional space. Spatial niche of white-tailed eagle is practically adjacent with the niche of imperial eagle and distinctly separated from the niches of other species.

Considering the distances between the nearest neighbors of the same and other species in strip-like pine forests of Priobskoye Plateau intraspecific competition is apparently much more important in selection of inhabitations used by the birds of prey for nesting than interspecific.

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