



Breeding Habitat Characteristics of Golden Eagle *Aquila chrysaetos* (Linnaeus, 1758), Long-legged Buzzard *Buteo rufinus* (Cretzschmar, 1829) and Peregrine Falcon *Falco peregrinus* Tunstall, 1771 in the Balkan Mountain Range, Bulgaria

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Abstract: The territories of three species of birds of prey in the Balkan Mountain Range have been described in terms of habitats and location. Territories of golden eagle *Aquila chrysaetos* (Linnaeus, 1758) and peregrine falcon *Falco peregrinus* Tunstall, 1771 had high degree of woodland and pasture and natural grasslands, while those of the long-legged buzzard *Buteo rufinus* (Cretzschmar, 1827) exhibited a greater presence of shrubby habitats and arable areas. Territories of the three species in the studied area showed low degree of heterogeneity. Golden eagle and peregrine falcon territories were located at higher elevation and had more complex topography than those of the long-legged buzzard. In the studied area, all three species located their nests on cliffs, preferring dominant position of the nests to the surrounding area. Golden eagle and peregrine falcon showed clear preference for nesting on steep cliffs. Long-legged buzzard tended to nest on more sloping terrains. Golden eagle, long-legged buzzard and peregrine falcon did not exhibit a high degree of conservatism regarding the exposure of the nesting cliffs and this factor was not a leading feature in the selection of nesting site in the studied area. However, the nests in the study area were found mainly on the southern slopes of the Balkan Mountain Range. The long-legged buzzard showed great ecological plasticity in terms of its nesting sites and breeding habitats. This adaptability, along with other factors, may favour the observed range expansion to the north over the past few decades.

Key words: raptors, nesting habitat, habitat preferences, mountain ecosystems

Introduction

The golden eagle (GE) *Aquila chrysaetos* (Linnaeus, 1758) and the peregrine falcon (PF) *Falco peregrinus* Tunstall, 1771 were numerous in Bulgaria until the beginning of the 20th century and their populations began to decline thereafter (SIMEONOV et al.

1990). Currently, the GE population in the country has been estimated at 120–150 pairs (PETROV et al. 2015) and the PF population has been assessed at about 200 pairs (STOYANOV et al. 2015). As a breeding species, the long-legged buzzard (LLB) *Buteo rufinus* (Cretzschmar, 1827) was recorded in Bulgaria in the middle of the 20th century (BOEV 1962);

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its breeding population was recently thought to comprise 800–1000 pairs (VATEV et al. 2015). These three species of raptors are common in the region of the Balkan Mountain Range; however, they are of high conservation status at the national level and, therefore, are protected by the Bulgarian Biological Diversity Act (Annexes 2 and 3). In addition, GE and LLB are listed in the Red Data Book of Bulgaria under the category VU Vulnerable (PETROV et al. 2015, VATEV et al. 2015), and PF is listed as EN Endangered (STOYANOV et al. 2015).

In the Balkan Mountain Range GE, LLB and PF prefer to nest on cliffs and to have open spaces in their foraging area, showing some adaptability depending on the available prey and the hunting techniques used to capture it. The GE uses the ascending air currents close to ridges, which allow the birds to soar and to demonstrate territorial behavior (WATSON 1997, MCLEOD et al. 2002). Similarly, the LLB is a bird that uses soaring flight (ARABADZHIEV 1962, ALIVIZATOS & GOUNTER 1997). The Balkan Mountain Range with its characteristic rock complexes and high hills provides both suitable nesting sites, as well as the ascending air currents needed by the soaring species.

The present study aims to identify some natural factors that are key to the selection of breeding habitats of the golden eagle, peregrine falcon and long-legged buzzard in the Balkan Mountain Range.

Materials and Methods

Study area

The Balkan Mountains are the biggest mountain range in Bulgaria on an area of 11,596 km², with approximate length of 530 km and width between 15 and 45 km. Its average altitude is 722 m, with Botev Peak being the highest point (2376 m). Mountainous form of temperate continental climate is predominating in the range. The seasonal precipitation distribution corresponds to the moderate continental retention regime. The forests are mainly deciduous. The coniferous forests do not form a continuous coverage in the mountain. Alpine grass vegetation is present in the highest zone (KOPRALEV 2002). Faunistically, the Balkan Mountain range is characterised by a considerable species diversity; the forest fauna holds the bulk of the species and alpine species are also found in the zone above forests (GRUEV & KUZMANOV 1994).

Field work

Data collection on the location of GE, LLB and PF nests within the territory of the Balkan Mountain Range took place between March and July in

2006–2010. Prior to the study, potential nesting sites such as cliff formations and solitary cliffs were identified based on reports of previous cases of nesting; in addition, a survey of topographic maps and maps of Google Earth™ was performed. Potential locations were explored from an optimal distance (allowing a good view of the cliffs without disturbance for the birds), depending on the field conditions. The terrain was scanned using binoculars Leica 8x42 HD-B with a laser rangefinder and a 20-60x Swarovski spotting scope. The centres of the breeding territories were mapped through triangulation based on data from a GPS device (Garmin MAP 60CSx), the binoculars' laser rangefinder, and a compass. When a position with direct visibility to the active nest was not available and its location could not be determined with the adopted accuracy, the centre of the breeding territory was set to the place most vigorously defended from other raptors, or to an inactive nest in close proximity with indications of being used in previous years. Totally, 38 territories (29 localised nests) of GE, 54 territories (38 nests) of LLB and 20 territories (six nests) of PF were identified (Fig. 1).

GIS analyses

The analyses and maps were created using ArcGIS 10.6 (ESRI, Redlands, CA, USA).

Input layers:

- Centres of breeding territories (point layer): created by GPS coordinates.
- Breeding territories (polygonal layers): conditionally presented as a circle around the centre of the breeding territory. The breeding territory includes three overlapping concentric zones:
 - Nest area: circle with a conditional radius of 500 m around the centre of the breeding territory. Often, it contains alternative nests that can be used over the years. This is the area that the birds defend most actively (TAPIA et al. 2007).
 - Core area: circle with a conditional radius of 3000 m for *Aquila chrysaetos* and 2000 m for *Buteo rufinus* and *Falco peregrinus*. This is the area, where the birds spend more than 50% of their time (MCGRADY et al. 2002, MCLEOD et al. 2002).
 - Breeding territory: circle with a conditional radius of 6000 m for *Aquila chrysaetos* (MCGRADY et al. 2002) and 4000 m for *Buteo rufinus* (ALIVIZATOS & GOUNTER 1997) and *Falco peregrinus*.
- CORINE Land Cover (2006).
- Digital Elevation Model (DEM) with 30 m pixel

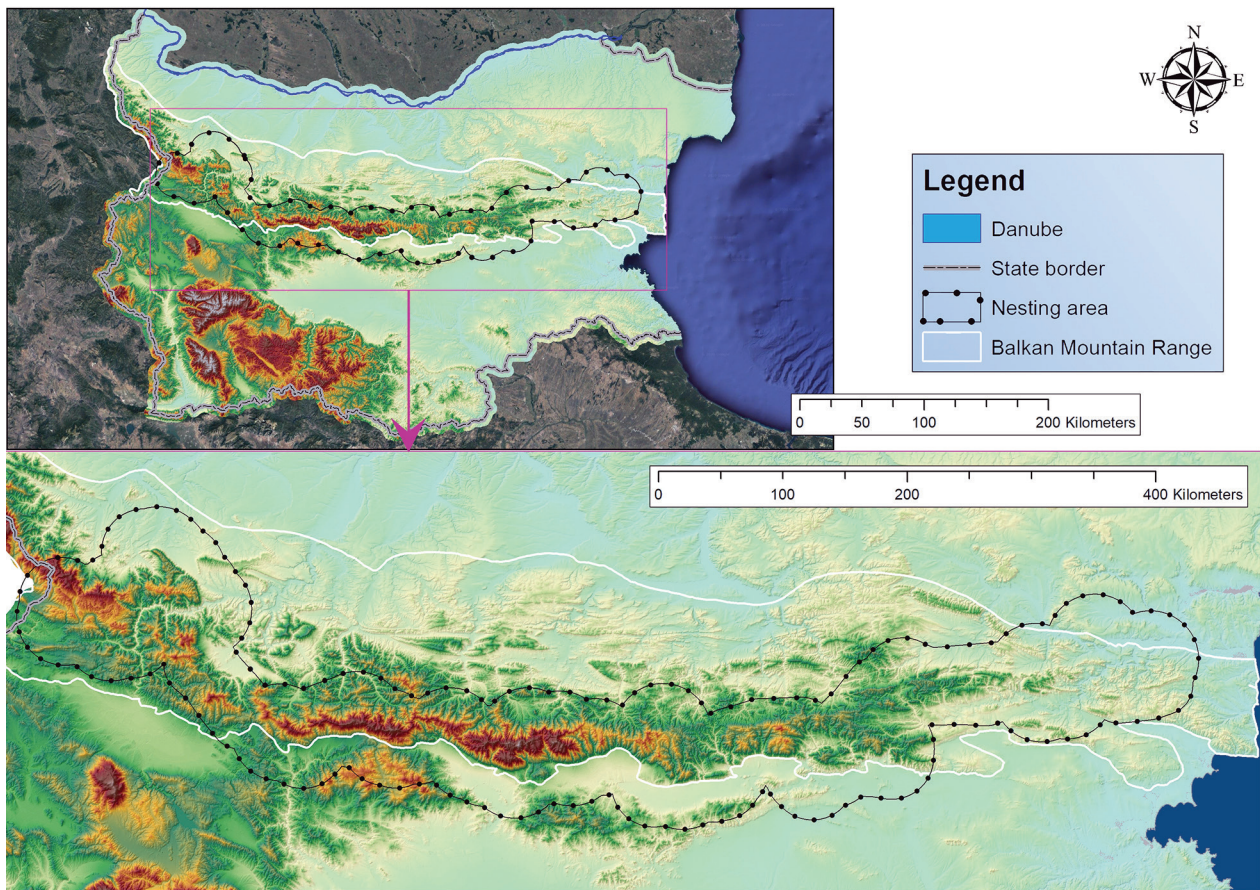


Fig. 1. Map of the Balkan Mountain Range and the study area.

size (raster) from the Shuttle Radar Topography Mission (SRTM) website, transformed to UTM35N and resampled to 20 m pixel size.

- Slope (raster) – from DEM 20 m.
- Aspect (raster) – from DEM 20 m.
- Terrain Ruggedness Index (TRI) (RILEY et al. 1999).

Breeding territory assessment parameters:

- Proportions of the different types of habitats for each zone of the breeding territory. The habitat types largely correspond to the CORINE Land Cover classes (Level 2). The difference is in the definition for the types “Pastures and natural grasslands”, “Tree-shrub and shrub-grassland communities” and “Areas without or with scattered vegetation”. The habitat types are defined according to the ecological preferences of the three species and the ability to be referenced to groups comprised of the CORINE Land Cover classes (Level 3). The grouping of Level 3 classes within the habitat types is shown in Table 1.
- Elevation in each zone (m) (minimum, average and maximum).
- Slope in each zone ($^{\circ}$) (minimum, average and maximum).
- Minimum distance from the centre of the breeding territory to a water source (m).
- Parameters for characterisation of the nest location (for nests with exactly known location):
 - Elevation for the pixel with the nest (m) – determined using DEM 20 m.
 - Percentage distribution of the nests according to the hypsometric zones (Table 2).
 - Slope for the pixel with the nest ($^{\circ}$) – determined using DEM 20 m.
 - Percentage distribution of the nests according to the degree of the slope (Table 3).
 - Aspect for the pixel with the nest ($^{\circ}$) – determined using DEM 20 m.
 - Percentage distribution of the nests according to the aspect.
- Position of the nest relative to the surrounding landscape – described by an index that represents the ratio of the altitude of the nest and the maximum altitude in the surrounding landscape calculated for each zone of the breeding territory (WATSON & DENNIS 1992).

Table 1. Types of habitats for the three target species obtained by grouping classes of CORINE Land Cover Level 3.

Type habitat	CORINE Land Cover, Level 3
Artificial surfaces	112 Discontinuous urban fabric 121 Industrial or commercial units 122 Road and rail networks and associated land 131 Mineral extraction sites 141 Green urban areas 142 Sport and leisure facilities
Agricultural areas	211 Non-irrigated arable land 221 Vineyards 222 Fruit trees and berry plantations 242 Complex cultivation patterns 243 Land principally occupied by agriculture, with significant areas of natural vegetation
Pastures and Natural grasslands	231 Pastures 321 Natural grasslands
Forests	311 Broad-leaved forest 312 Coniferous forest 313 Mixed forest
Tree-shrub and shrub-grassland communities	322 Plant communities of shrubs and grasses 324 Transitional woodland-shrub
Areas without or with scattered vegetation	332 Bare rocks 333 Sparsely vegetated areas
Water bodies	512 Water bodies

Table 2. Classification of hypsometric zones used in the study.

Hypsometric zones	Elevation (m)
lowland zone	under 200 m
hilly zone	200-600 m
low mountain zone	600-1000 m
middle mountain zone	1000-1600 m
alpine zone	above 1600 m

Table 3. Classification of degree of slope used in the study.

Degree of slope	Slope (°)
flat	0-4°
slanting	5-10°
sloping	11-20°
steep	21-30°
very steep	above 31°

Table 4. Terrain Ruggedness Index (TRI).

Ruggedness	Range
level	0 – 80 m
nearly level	81 – 116 m
slightly rugged	117 – 161 m
intermediately rugged	162 – 239 m
moderately rugged	240 – 497 m
highly rugged	498 – 958 m
extremely rugged	959 – 4367 m

Statistical analyses

Descriptive statistics, standard parametric and non-parametric tests in STATISTICA ver. 12 (STATSOFT INC. 2014) were used for the statistical analyses. The degree of heterogeneity of the habitat in the breeding territories is characterised by a Shannon-Wiener (H) function in PAST software (HAMMER et al. 2001). To determine the topographical heterogeneity of the habitat in the breeding territories, the Terrain Ruggedness Index (TRI) was used (RILEY et al. 1999) (Table 4).

Results

Totally, 38 territories (29 localised nests) of GE, 54 territories (38 nests) of LLB and 20 territories (six nests) of PF were identified.

Types of habitats in the breeding territories of species bound to classes of CORINE Land Cover – Level 3

In the territories of GE and LLB, 21 classes of land cover of Level 3 grouped within 7 types of habitats were found. In the territories of PF, 19 classes of land cover of Level 3 within 6 types of habitats were found. Among the habitat types of the latter species no roads and rail networks (within the CLC2006 resolution) were established, and no water bodies either. Proportions of the different habitat types found in GE, LLB and PF territories for Nest

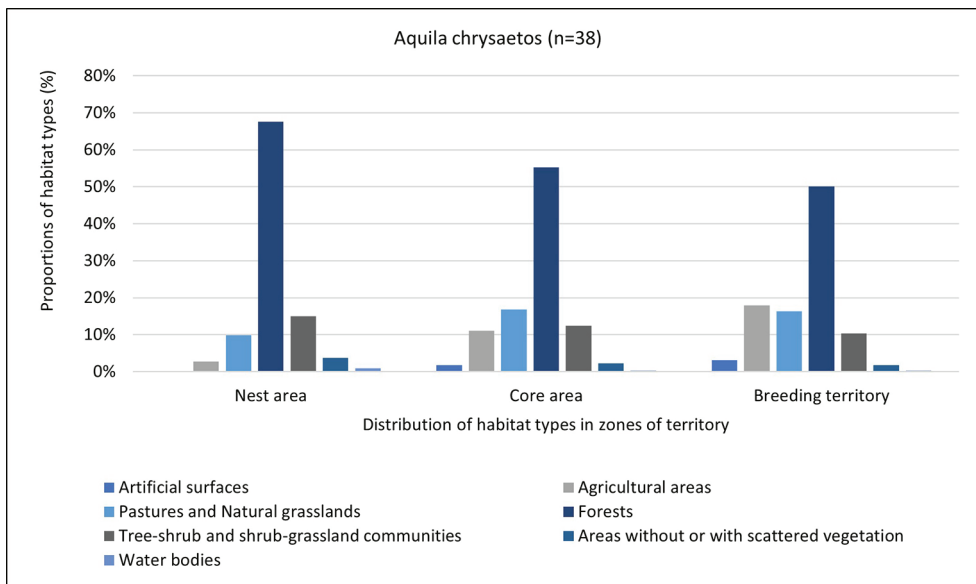


Fig. 2. Proportions of the different habitat types found in golden eagle territories for Nest area, Core area and Breeding territory, respectively.

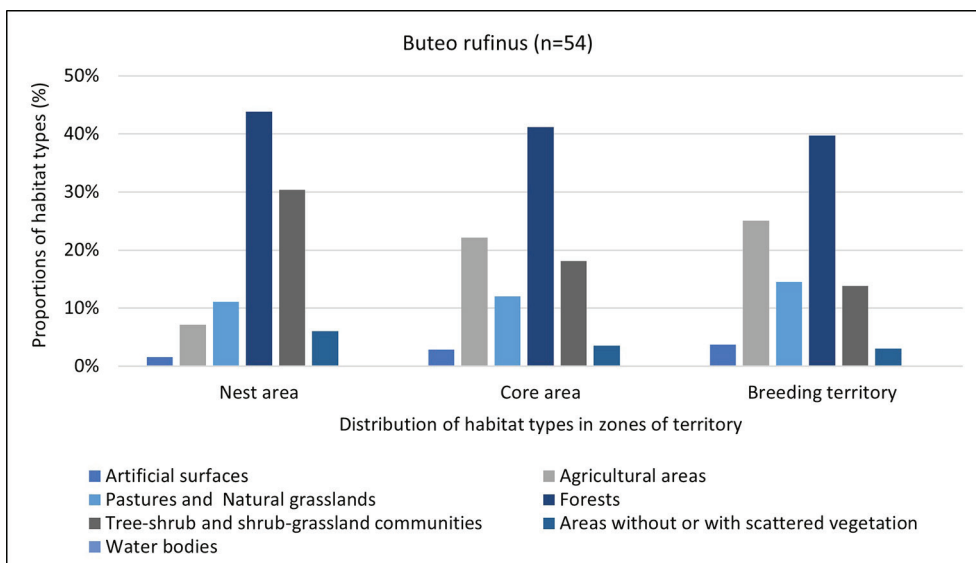


Fig. 3. Proportions of the different habitat types found in long-legged buzzard territories for Nest area, Core area and Breeding territory, respectively.

area, Core area and Breeding territory respectively are presented in Fig. 2, 3 and 4.

Statistically significant differences between Nest area, Core area and Breeding territory in GE, LLB and PF were found for the proportions of Artificial surfaces, Agricultural areas, Pastures and Natural grasslands and Forests. The results of the non-parametric one-way ANOVA are presented in Table 5.

Statistically significant differences between GE, LLB and PF in Nest area, Core area and Breeding territory were found for the proportions of Forests, Tree-shrub/shrub-grasslands communities and

Agricultural areas. The results of the non-parametric one-way ANOVA are presented in Table 6.

Habitat heterogeneity – Shannon_H

The values for Shannon_H of the breeding territories are as follows: GE: Mean = 1.77; SD = 0.27; range 1.22–2.18, n = 38; LLB: Mean = 1.85; SD = 0.24; range: 0.89–2.22, n = 54; PF: Mean = 1.78; SD = 0.35; range: 0.95–2.16, n = 20. No statistically significant differences between the three species were found in regards to this parameter (Kruskal-Wallis test: $H_{2,112} = 1.83$, $p = 0.4005$).

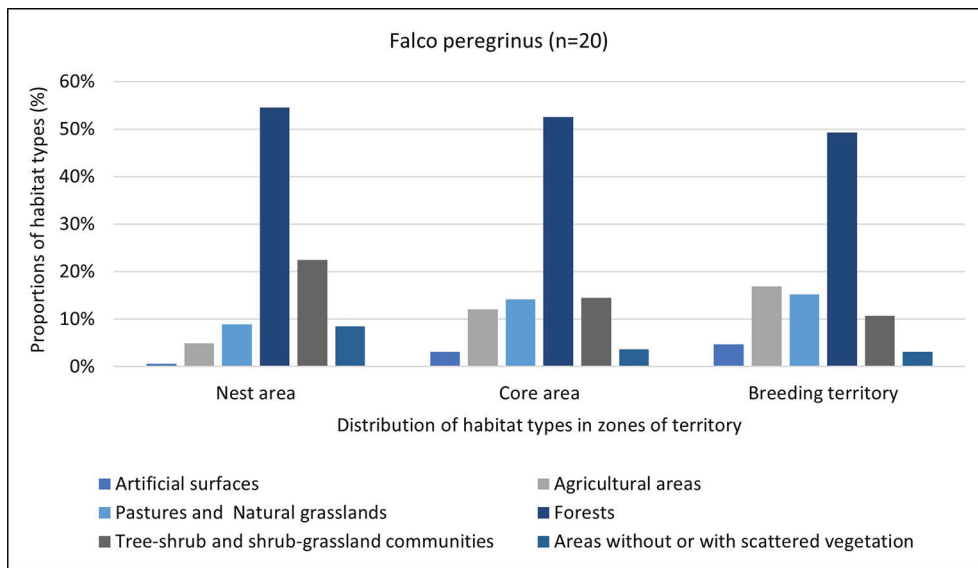


Fig. 4. Proportions of the different habitat types found in peregrine falcon territories for Nest area, Core area and Breeding territory, respectively.

Table 5. Results of the non-parametric one-way ANOVA for the proportions of the different habitat types in GE, LLB and PF – comparison between Nest area (NA), Core area (CA) and Breeding territory (BT) (* denotes statistically significant differences between species).

Land cover type	Golden eagle						
	H (2, N=114)	NA vs CA		NA vs BT		CA vs BT	
		z	p	z	p	z	p
Artificial surfaces	61.337	4.5324*	0.0000*	7.3365*	0.0000*	2.8041*	0.0151*
Agricultural areas	48.247	4.0344*	0.0002*	6.7517*	0.0000*	2.7173*	0.0197*
Pastures and Natural grasslands	22.861	3.9285*	0.0003*	4.2860*	0.0001*	0.3575	1.0000
Forests	16.603	2.8215*	0.0143*	3.9563*	0.0002*	1.1348	0.7693
Tree-shrub/shrub-grassland communities	3.307	1.8150	0.2086	0.9127	1.0000	0.9023	1.0000
Areas without or with scattered vegetation	8.225	2.1447	0.0959	2.3061	0.0633	0.1614	1.0000
Water bodies	1.892	0.0035	1.0000	0.5587	1.0000	0.5553	1.0000
Land cover type	Long-legged buzzard						
	H (2, N=162)	NA vs CA		NA vs BT		CA vs BT	
		z	p	z	p	z	p
Artificial surfaces	55.356	4.9108*	0.0000*	6.8862*	0.0000*	1.9754	0.1447
Agricultural areas	55.846	5.6944*	0.0000*	6.9918*	0.0000*	1.2974	0.5834
Pastures and Natural grasslands	14.565	2.4944*	0.0379*	3.7334*	0.0006*	1.2390	0.6461
Forests	0.217	0.1785	1.0000	0.2831	1.0000	0.4615	1.0000
Tree-shrub/shrub-grassland communities	3.428	0.3938	1.0000	1.7631	0.2337	1.3692	0.5128
Areas without or with scattered vegetation	7.124	1.7251	0.2535	2.3118	0.0624	0.5867	1.0000
Water bodies	3.51	0.1692	1.0000	0.4954	1.0000	0.3262	1.0000
Land cover type	Peregrine falcon						
	H (2, N=60)	NA vs CA		NA vs BT		CA vs BT	
		z	p	z	p	z	p
Artificial surfaces	17.357	2.4988*	0.0374*	3.8976*	0.0003*	1.3988	0.4856
Agricultural areas	25.8	3.3634*	0.0023*	4.7848*	0.0000*	1.4214	0.4656
Pastures and Natural grasslands	11.615	2.1729	0.0894	3.3408*	0.0025*	1.1679	0.7285
Forests	1.019	0.1086	1.0000	0.9235	1.0000	0.8148	1.0000
Tree-shrub/shrub-grassland communities	1.042	0.0272	1.0000	0.8963	1.0000	0.8691	1.0000
Areas without or with scattered vegetation	1.813	0.2671	1.0000	1.1996	0.6909	0.9325	1.0000

Table 6. Results of the non-parametric one-way ANOVA for the proportions of the different habitat types in Nest area, Core area and Breeding territory - comparison between GE, LLB and PF (* denotes statistically significant differences between species).

Land cover type	Nest Area						
	H (2, N=112)	GE vs LLB		GE vs PF		LLB vs PF	
		z	p	z	p	z	p
Artificial surfaces	4.954	0.6194	1.0000	0.9029	1.0000	0.4518	1.0000
Agricultural areas	11.535	2.1635	0.0915	0.6007	1.0000	2.3841	0.0514
Pastures and Natural grasslands	1.364	0.8645	1.0000	0.1301	1.0000	0.8366	1.0000
Forests	12.896	3.5884*	0.0010*	1.5262	0.3809	1.2920	0.5890
Tree-shrub/shrub-grassland communities	7.269	2.6471*	0.0244*	1.1909	0.7011	0.8844	1.0000
Areas without or with scattered vegetation	1.24	0.3858	1.0000	0.8113	1.0000	0.5442	1.0000
Water bodies	3.93	0.4286	1.0000	0.3285	1.0000	0.0000	1.0000
Land cover type	Core Area						
	H (2, N=112)	GE vs LLB		GE vs PF		LLB vs PF	
		z	p	z	p	z	p
Artificial surfaces	2.441	1.5024	0.3990	0.8659	1.0000	0.3015	1.0000
Agricultural areas	15.287	3.5659*	0.0011*	0.1930	1.0000	2.6808*	0.0220*
Pastures and Natural grasslands	2.746	1.4915	0.4075	1.3156	0.5650	0.1819	1.0000
Forests	9.477	2.8746*	0.0121*	0.3095	1.0000	1.9987	0.1369
Tree-shrub/shrub-grassland communities	5.263	2.2529	0.0728	0.6268	1.0000	1.1609	0.7371
Areas without or with scattered vegetation	0.188	0.3446	1.0000	0.3382	1.0000	0.0782	1.0000
Water bodies	1.651	0.2778	1.0000	0.3285	1.0000	0.1220	1.0000
Land cover type	Breeding territory						
	H (2, N=112)	GE vs LLB		GE vs PF		LLB vs PF	
		z	p	z	p	z	p
Artificial surfaces	0.81	0.8962	1.0000	0.4778	1.0000	0.2207	1.0000
Agricultural areas	9.37	2.6147*	0.0268*	0.2451	1.0000	2.3737	0.0528
Pastures and Natural grasslands	0.971	0.9794	0.9821	0.5356	1.0000	0.2270	1.0000
Forests	12.664	3.3010*	0.0029*	0.2977	1.0000	2.3560	0.0554
Tree-shrub/shrub-grassland communities	6.047	2.3312	0.0592	0.3499	1.0000	1.5164	0.3882
Areas without or with scattered vegetation	2.656	1.0745	0.8478	1.5215	0.3844	0.7365	1.0000
Water bodies	3.796	0.6224	1.0000	0.8228	1.0000	0.3649	1.0000

Topographic heterogeneity of the habitat – Terrain Ruggedness Index (m)

The highest TRI values have been recorded in the vicinity of the nests and the GE and PF territories have more rugged relief. The TRI values for Nest area, Core area and Breeding territory of GE, LLB and PF are presented in Table 7. Statistically significant differences with respect to this parameter were established for both Nest and Core areas between GE and LLB, and between PF and LLB. There were no statistically significant differences for Breeding territory with respect to TRI (Table 8).

Distance to water source

The distance to water source from the centres of the breeding territories was as follows: GE: Mean = 1541

m; SD = 1314 m; range: 0–4574 m; n = 38; LLB: Mean = 1703 m; SD = 1444 m; range: 91–6450 m, n = 54; PF: Mean = 1546 m; SD = 1441 m; range: 122–4451 m; n = 20. There were no statistically significant differences between the three species for this parameter (Kruskal-Wallis test: $H_{2,112} = 0.663$, $p = 0.7177$).

Location of the nests

All nests of the three species found in the studied area were located on cliffs.

Elevation of the nests and distribution of the nests (in %) by hypsometric zones

The elevation of the nests of the species in the study area were as follows: GE: Mean = 911 m; SD = 371 m; range: 181–1592 m; n = 29; LLB: Mean = 823

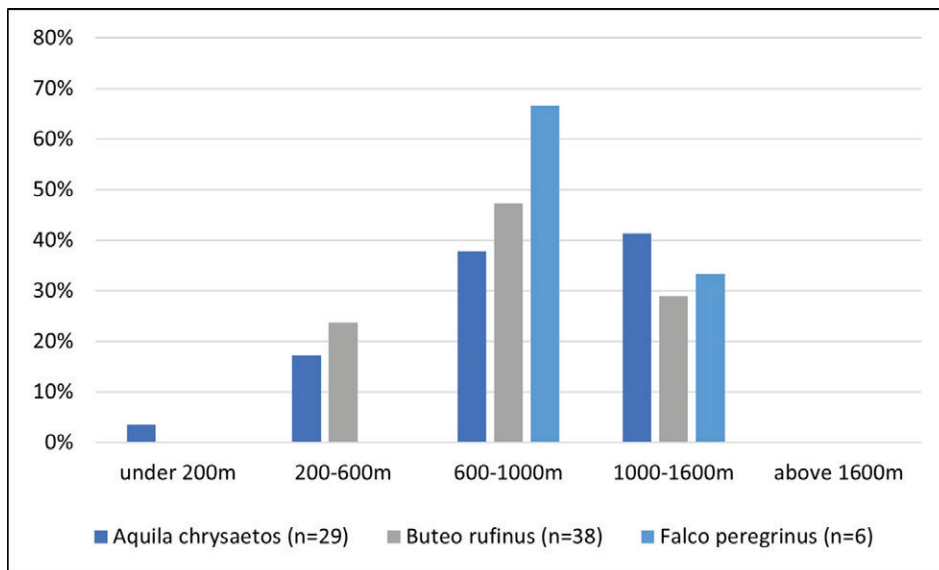


Fig. 5. Distribution of the nests (in %) along hypsometric zones.

Table 7. Terrain Ruggedness Index (TRI) for Nest area (NA), Core area (CA) and Breeding territory (BT) of golden Eagle, long-legged Buzzard and peregrine falcon.

Zones	Golden eagle (n=38)				Long-legged buzzard (n=54)				Peregrine falcon (n=20)			
	Mean	SD	Min.	Max.	Mean	SD	Min.	Max.	Mean	SD	Min.	Max.
NA	195	61	52	303	164	39	58	230	206	34	152	300
CA	167	59	47	266	140	34	34	192	169	31	110	254
BT	143	54	41	242	133	43	16	229	157	34	105	245

Table 8. Results of the non-parametric one-way ANOVA for TRI in Nest Area (NA), Core Area (CA) and Breeding territory (BT) - comparison between GE, LLB and PF (* denotes statistically significant differences between species).

Zones	Kruskal-Wallis test: H (2, N=112)	p	GE vs LLB		GE vs PF		LLB vs PF	
			z	p	z	p	z	p
			NA	18.332	0.0001	3.4090*	0.0020*	0.7800
CA	14.021	0.0009	3.3657*	0.0023*	0.0487	1.0000	2.6712*	0.0227*
BT	4.607	0.0999	1.3837	0.4994	0.8430	1.0000	2.0090	0.1336

Table 9. Position index of the nest for Nest area (NA), Core area (CA) and Breeding territory (BT) in golden eagle, long-legged buzzard and peregrine falcon.

Zones	Golden eagle (n=29)				Long-legged buzzard (n=38)				Peregrine falcon (n=6)			
	Mean	SD	Min.	Max.	Mean	SD	Min.	Max.	Mean	SD	Min.	Max.
NA	0.83	0.08	0.58	0.95	0.83	0.10	0.64	0.99	0.84	0.07	0.73	0.93
CA	0.63	0.12	0.40	0.87	0.68	0.17	0.40	0.99	0.68	0.10	0.59	0.85
BT	0.58	0.12	0.30	0.82	0.61	0.20	0.36	0.94	0.54	0.10	0.44	0.72

m; SD = 362 m; range: 204–1471 m; n = 38; PF: Mean = 859 m; SD = 211 m; range: 647–1189 m; n = 6. There were no statistically significant differences between the three species (Kruskal-Wallis test: $H_{2,73} = 1.42$, $p = 0.4917$). Most of the nests in LLB and PF were found between 600–1000 m, while those of GE – within the 1000–1600 m zone (Fig. 5).

Slope of the nest and distribution of the nests (in %) according to the degree of slope

The slope of the nests locations were as follows: GE: Mean = 31.7°; SD = 8.4°; range: 12.3–44.9°; n = 29; LLB: Mean = 23.4°; SD = 9.2°; range: 7.6–46.6°; n = 38; PF: Mean = 35°; SD = 5°; range: 30.3–43.3°; n = 6. Significant differences in this

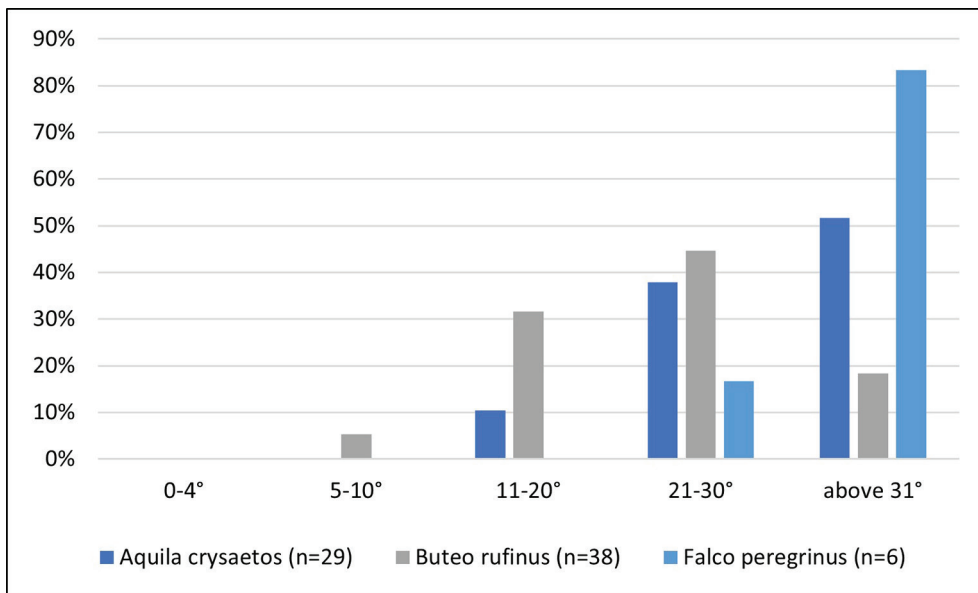


Fig. 6. Distribution of the nests (in %) according to degree of slope.

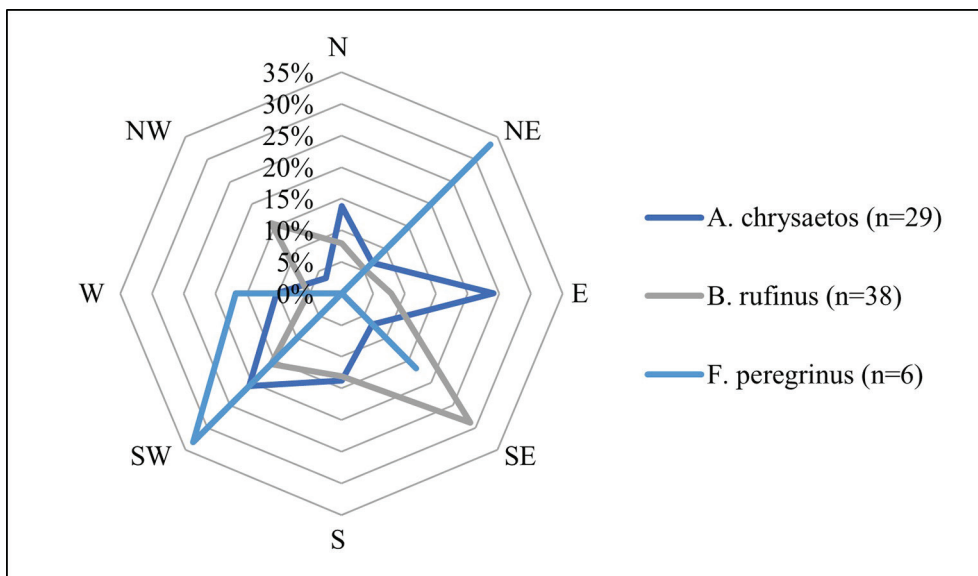


Fig. 7. Distribution of the nests (in %) according to the exposure of the nesting cliffs.

parameter were found between GE and LLB and between LLB and PF (Kruskal-Wallis test: $H_{2,73} = 16.962$; $p = 0.0002$). Most GE and PF nests were located on slopes above 31° , while those of LLB – below 30° (Fig. 6).

Distribution of the nests (in %) according to the exposure of the nesting cliffs

The analyses of data with respect to the exposure of the nesting cliffs used by all three species of raptors revealed great variation (Fig. 7). The highest percentage of cliffs with eastern exposure (24.1%)

was found in GE, while in the case of LLB nests the southern component (57.8%) predominated, but no statistically significant differences between the three species were observed.

Position index of the nest

The highest values for position index of the nest were established in vicinity of the nest. The values of position index for Nest area, Core area and Breeding territory in GE, LLB and PF are presented in Table 9. There were no statistically significant differences between the three species for this parameter.

Discussion

When comparing the three species with respect to the proportions of land cover classes in nest area, there are statistically significant differences between GE and LLB – the highest percentage of forests is observed with GE, and the lowest – with LLB; a vice versa ratio is established for shrubby habitats. The differences in the other classes of land cover are not statistically significant. Agricultural areas and Pastures and Natural grasslands have a slightly larger area for LLB. In Nest area, Anthropogenic habitats are predominantly found in LLB (though in a low percentage – 1.56%), approximately three times less (0.60%) in PF and completely absent in GE. Moving farther away from the centres of the breeding territories, the degree of woodland coverage remains highest for GE and lowest for LLB. Although the percentage of forests in GE territories decreases at the expense of open habitats – pastures, natural grasslands and cultivated areas, the forest coverage in GE territories in the Balkan Mountain Range is relatively high. Probably the species does not hunt near the nest and the open spaces where it catches prey are concentrated mainly in the core-/foraging area. At the same time, the nests, located on cliffs surrounded by forest and shrubs, are more difficult to access, hence more secure. A high degree of woodland has been identified by other authors as well (TAKEUCHI et al. 2006, EVANS et al. 2010). A low percentage of anthropogenic habitats and arable land has been found in the vicinity of PF nests. PF preferences to arable land and urban areas due to a higher abundance of synanthropic prey species (SERGIO et al. 2004, BRAMBILLA et al. 2006) is probably due to adaptation of the species in areas where its natural habitats are insufficient. Pastures and Natural grasslands, as well as open spaces without vegetation or with scattered vegetation were poorly represented. Forest cover predominated, followed by shrubby habitats to a lesser extent. Farther away from the nest, the percentage of shrubby habitats decreases more significantly, while forests decrease insignificantly and their percentage in the territories of PF remains very high – around 50%. A high degree of woodland in the PF territories has been established in other studies too (JENKINS 1994, RAGYOV et al. 2007, BRAMBILLA et al. 2010). It is believed that this species can also hunt in a more wooded area because they often catch their prey in the air (JENKINS 1994). By moving away from the nest the tendency for the largest percentage of the shrubby habitats in the LLB territories in comparison with the other two species, is also preserved.

There are also statistically significant differences between GE and LLB in terms of the percentage of arable land. For LLB, the percentage of arable land in Core area and Breeding territory is almost twice as big as that of pastures and natural grasslands, which does not coincide with published data from other areas where the percentage of arable land is lower (DEMERDZHIEV et al. 2014) or almost equal to open areas of natural vegetation (IEZEKIEL et al. 2016). It is possible that the arable land is of significant importance as a source of prey for LLB in the studied area, despite the claims of a number of authors that the species hunts mainly in pastures and only partially in arable land (SNOW & PERRINS 1998, FRIEDEMANN et al. 2016). The results found could be due to differences in the intensity of agriculture, the size of the arable blocks and the type of crops grown in the different regions. Farther away from the centres of the breeding territories the percentage of pastures and natural grasslands was found to increase for both GE and PF.

Based on the result obtained for the Shannon_H function, it can be argued that GE, LLB and PF territories in the Balkan Mountain Range are characterised by a low degree of heterogeneity and no statistically significant differences are found in this index between the three species, despite the insignificantly higher index score for LLB.

Although birds of prey supply their needed liquids mainly from their prey (WATSON 1997), streams provide clean drinking and bathing water (KOCHERT et al. 2002). In the present study, a water source was found to be present in all GE territories, in 93% of LLB territories and in 90% of PF territories. The greatest mean distance to a water source was observed for LLB. Previous authors reported a preference for nesting sites near water for this species, possibly due to the fact that mountain breeding areas of the species were not targeted during these observations (MICHEV et al. 1984, VATEV 1987, SIMEONOV et al. 1990), or that they refer to lowlands (Southern Ukraine) with large rivers and standing water basins with numerous old high trees suitable for nesting (REDINOV 2010). According to VATEV (1987), LLB positions its nest approximately 500 m away from a water source. In the present study the distance to a water source in this species varied widely (range 91 – 6450 m, $n = 54$) and the established mean distance of 1703 m suggested that the proximity of water to the centre of the breeding territory is not a prerequisite for the selection of a breeding territory for this species.

Morphologically GE is adapted for a soaring flight (MCGRADY 1997, WATSON 1997); therefore,

the characteristics of the terrain that support such flight and enable the birds to demonstrate territorial behavior (CHALMERS 1997) have an impact on the habitat preferences for this species. GE breeds and hunts in areas with a topography favouring the dynamics of their flight and increasing their energy efficiency (MCGRADY 1997), allowing them to spend less energy for hunting and bringing the prey to the nest (MCINTYRE 2004). In addition, in many mountain areas, the more rugged terrain is a prerequisite for a lower degree of human disturbance, which is probably preferred by GE (WATSON 1997). It is believed that topographical characteristics are also an important factor in the PF breeding habitat (JENKINS 1994, 2000, GAINZARAIN et al. 2000, SERGIO et al. 2004, BRAMBILLA et al. 2006, 2010, KARYAKIN & NIKOLENKO 2009). According to JENKINS & HOCKEY (2001), hunting success of PF often depends on topography. Similarly to GE, LLB often uses a soaring flight, which suggests that the terrain features that support this flight have an impact on the selection of breeding habitat; however, data on the preferences of this species in terms of topography are scarce.

In the present study, it is established that the Terrain Ruggedness Index (TRI) value is highest in the vicinity of the nest in all three species of raptors. It can be concluded that they locate their nests in that part of the territory with the highest degree of ruggedness of the relief. A rugged relief near the GE nest is also observed by MOSS (2015). It is assumed that the more rugged terrain near the nest provides better protection against predators and more favorable hunting opportunities (JENKINS 2000, SERGIO et al. 2004). Based on the TRI value, the GE and PF territories showed more complex topography. The lowest degree of ruggedness of the relief was recorded for LLB. The differences between LLB and the other two species with respect to this indicator were statistically significant in the vicinity of the nest and in the Core area, while in the peripheral parts of the territory they become negligible.

The three studied species of raptors are cliff nesting on the territory of the Balkan Mountain Range. The comparison between them reveals that the highest mean elevation of nest location is found in GE, and the lowest – in LLB. The bulk of the GE nests in the studied area fall in the middle mountain zone (41.4%) and in the low mountain zone (37.9%). The species also breeds, though less often, at a lower altitude – in the hilly zone (17.2%) and even in the lowland zone (3.5%). The GE nests in the studied area are found in the widest range of altitudes, suggesting that the species exhibits the highest altitude plasticity. Most of the LLB nests fall into the low

mountain zone (47.4%), and the rest are located in the middle mountain zone (28.9%) and in the hilly zone (23.7%). There are no nests in the lowland zone, which is unexpected because there is evidence of nesting below 200 m in other regions of Bulgaria (DEMERDJIEV et al. 2007), as well as in Romania, where, however, the colder climate is indicated as a possible factor (BALTAG & BOLBEACĂ 2014). In the Balkan Mountain Range, the PF nests are mainly located in the low mountain zone (66.7%), and a smaller part (33.3%) – in the middle mountain zone. In all three species of raptors, no nests in the alpine zone were found because this altitudinal belt is poorly represented in this mountain range.

It is assumed that the inclination of the slope affects the energy costs associated with hunting, territorial behavior displays and nesting for birds of prey, and therefore, it plays a role in the selection of a nesting site (MCGRADY 1997, WATSON 1997, MCLEOD et al. 2002, DIVITTORIO & LOPEZ-LOPEZ 2014). Steep slope facilitate flying departure during early morning and late afternoon when the thermal currents are weak (FRIEDEMANN et al. 2017). In this study, most GE nests (51.7%) were found on a very steep slope and 37.9% on a steep slope. Only 10.4% were on a sloping slope. Despite the presence of data on nesting of the species on trees in the flat areas of northern Europe (TJERNBERG 1983, WATSON & DENNIS 1992, SULKAVA et al. 1998), no nests on slanting or flat terrain were found in the study area. This species demonstrates definite preference for nesting on steep cliffs. Most of the LLB nests were located on a steep slope (44.7%) and on a sloping slope (31.6%). There were even nests on slanting slope (5.3%). Only 18.4% of the nests were located on a very steep slope. Evidently, the species prefers to nest on a steeper slope, but it tends to position its nests on a more sloping slope, which suggests that the slope is not of primary importance for the selection of a nesting site. LLB is fairly adaptable in terms of nesting sites, having in mind the numerous data about nestings on trees, pillars, quarries, and even on the ground in the absence of cliffs (YI-QUN et al. 2008, MILCHEV 2009, REDINOV 2010, FRIEDEMANN et al. 2011, DEMERDZHIEV et al. 2014). The preferences of PF for nesting on vertical cliffs on steep terrain have been well documented (JENKINS 1994, 2000, GAINZARAIN et al. 2000, SERGIO et al. 2004, BRAMBILLA et al. 2006, 2010, KARYAKIN & NIKOLENKO 2009, VAZHOV 2012). In the present study, the bulk of PF nests (83.3%) were found on a very steep slope and the remaining 16.7% – on a steep slope. No nests on sloping or slanting slope were found, nor on flat terrain. In the study area

this species shows a clear preference for nesting on very steep cliffs. When comparing the mean slope on which the nests were located, there are statistically significant differences between LLB and the other two species. LLB is defined as an opportunist regarding also the percentage distribution of its nests according to the degree of slope.

The nesting preferences of birds of prey with respect to the specific exposure have been described in a variety of studies. The suitable orientation of the nesting cliff provides adequate shelter from severe weather, which could reduce hunting opportunities and is a direct cause of mortality of chicks (RATCLIFFE 1993). In the present study, however, no pronounced preference for a particular exposure in any of the three species was observed, as well as statistically significant differences between them. In GE nesting cliffs, the eastern exposure predominated (24.1%). Similar data for this species were also available for other areas (WATSON & DENNIS 1992, MOSS 2015, SHAFAEIPOUR 2015). In most cases, LLB nesting cliffs had exposure containing a southern component (57.8%). Preference to southern and western exposure and avoidance of the north is also found in LLB by MILCHEV (2009). The nesting cliffs used by PF in the study area contained eastern, southern and western components, and clearly avoided northern exposure. GE, LLB and PF do not exhibit a high degree of conservatism regarding the exposure of the nesting cliffs and this factor is not a leading feature in the selection of a nesting site in the studied area. However, the nests in the study area were found mainly on the southern slopes of the Balkan Mountain Range.

The high values of the nest position index reveal a preference in all three species of raptors to dominant position of the nest in relation to the surrounding area. It is assumed that such a position of the nest is likely to give birds an advantage in terms of either better protection of the nest or of lower energy consumption during hunting and bringing prey to the nest (WATSON & DENNIS 1992). In the case of PF, the dominant position facilitates hunting, as the bird has a wider view of a larger area, allowing for a more effective targeting and surprising of the prey, a better assessment of tactics and achieving extreme speed in the attack, which is a prerequisite for lower energy costs and more successful hunting. It also enables the pair to demonstrate their presence and to provide more secure nest protection (NEWTON 1988, JENKINS 2000). We assume that the main advantage of the dominant position of the nest is related more to better nest security (early recognition and chasing away of the intruders) than to hunting. Further research on the preferred dominant position of GE,

LLB and PF nests in the studied area would contribute to the enlightening of this factor.

Conclusions

The comparison of the three species revealed that golden eagle and peregrine falcon territories in the Balkan Mountain Range had high degree of woodland and pasture and natural grasslands, while those of the long-legged buzzard showed a greater presence of shrubby habitats and arable areas. Golden eagle and peregrine falcon territories were located at a higher elevation and had more complex topography than those of the long-legged buzzard. All three species preferred a dominant position of the nest to the surrounding area. The long-legged buzzard showed great ecological plasticity in terms of its nesting sites and breeding habitats. This adaptability, along with other factors, may favour the observed range expansion to the north, over the past few decades (MICHEV 1982, DEL HOYO et al. 1994, GRUBAC 1999, MRLIK & LANDSFELD 2002).

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