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Nest Habitat Separation in Three European Raptors: *Accipiter gentilis*, *Buteo buteo* and *Pernis apivorus* - A Multivariate Analysis

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INTRODUCTION

The analysis of raptor habitats has advanced considerably in the last few years. Quantitative investigations have introduced highly sophisticated statistical tools into raptor ecology (Andrew & Mosher 1982; Janes 1985; Moore & Henny 1983; Newton *et al.* 1979; Reynolds *et al.* 1982; Titus & Mosher 1981). Nowadays the wide-spread use of computers and programme packages, designed for nearly every problem, have made it possible for wildlife ecologists to test field data adequate to their web-like structure of possible relationships by the use of multivariate statistical methods.

This paper deals with (a) a special method for habitat measurement of forest-dwelling raptors of medium size and (b) habitat separation as decribed in the literature (Glutz *et al.* 1971; Cramp & Simmons 1980) and as established by my own data. The main questions are: which habitats do Common Buzzards, Goshawks and Honey Buzzards choose? and which factors affect habitat choice?

Cody (1968, 1985) pointed out three types of habitat separation (for his grassland species) which are a universal concept for the measurement of habitat selection in birds:

1. VHS - Vertical habitat separation
2. HHS - Horizontal habitat separation
3. FS - Food specialisation.

For most European raptors, food specialisation is well known, especially for the three species in question. They are widely separated: Common Buzzards feed on small mammals, e.g. mice; Goshawks feed mostly on birds and larger mammals, and Honey Buzzards feed on social wasps, nestling passerines and frogs (Uttendörfer 1939, 1952).

So the question was: how are these raptor species separated in vertical and horizontal habitat separation? At first glance, they seem to be very similar because they all use old forests for breeding, sometimes even the same nests in different years. With the help of aerial photographs and statistical tools such as discriminant analysis (=DA), I have tried to provide an answer.

METHODS AND INVESTIGATION AREA

The study area, called the Niederrheinische Bucht, is situated near Cologne and Bonn on the west side of the river Rhine. It covers 1,000 km^2 on a strip of 20 x 50 km. It contains 16.4% forest in different sections:

Table 1. List of measured variables. Var. No. 1-16 given in ha, 17-20, 22-28, 30-32 in m. Var. No. 21 = n cases, 29 = %. For computing, some variables were log-transformed; because of skewness No. 9 and 29 must be excluded.

Var. No.	Var. Name	Var. Definition
Horizontal-Habitat-Separation:		
1	WALDGROE	overall size of wood (0-4,575 ha)
2	WAFLAECH	size of woodland in plot
3	LICHTUNG	area of openings in woodland
4	GRUENLAN	area of meadows
5	ACKUOEDL	area of cultivated land
6	BEBAUT	area of built-up land
7	OEFFSTRA	area of traffic roads
8	BAUMREIH	area of tree-rows on cultiv. land
9	GEWAESSE	area of water
10	WALDLAND	= Var. No. 2 + 3
11	OFFELAND	= Var. No. 5 + 4 + 8 + 9
12	BEBALAND	= Var. No. 6 + 7
13	WARAAUS	length of forest edge (to open land)
14	WARAINN	length of forest edge (to openings)
15	WARABEBA	length of built-up forest edge
16	WARANUTZ	= Var. No. 14 + 15 - 16
17	ABPFAD	distance from nest to next forest path
18	ABWEG	distance to next forest road
19	ABSTRASS	distance to next traffic road
20	ABSTSTOE	distance to next point of human disturbance
21	STOERSUM	number of points of disturbance within 200m from nest
22	ABBERAND	distance to edge of woodlot
23	ABLICHTU	distance to next opening
24	ABSTWARA	distance to next forest edge
25	ABSTOFLA	distance to next open area (Var. No. 3, 4, 5)
Vertical-Habitat-Separation:		
26	BAUMHOEH	tree height of nesting tree
27	HORSTHOEH	nest-height
28	BHD	diameter of trunk at height of 1.5 m
29	DECKPROZ	% estimated degree of tree-cover around nest
Intra- and interspecific competition:		
30	ABST HB	distance to next active Goshawk nest
31	ABST MB	distance to next active Buzzard nest
32	ABST WB	distance to next active Honey Buzzard nest
33	REVIERSUM	number of occupied territories within 2 km diameter around nest

(a) the old woods of the Ville, the Kottenforst and the Rheinbacher Wald; (b) the re-afforested parts of the Rheinische Braunkohlengebiet, where opencast coalmining is carried out. This area is mostly planted with poplar trees; and (c) islands of wood and copses from 5-120 ha of the Börde on a fertile loess soil plain. This part is the most used for agriculture in our rather densely populated area. For a map see Kostrzewa (1985); the raptor community is described in Kostrzewa *et al.* (1985).

The climate is oceanic-influenced. We have a mean temperature of 9°C and an annual precipitation of 650 mm.

Data of horizontal habitat separation (HHS) were sampled in 113 ha circular plots (600 m in diameter around the occupied nest) taken from recent (1982) aerial photographs. Vertical habitat separation was measured in the field. Intra- and interspecific competition was ascertained by 'nearest-neighbour-distance' to each species' nesting place. Each plot is characterised by a set of 33 variables (Table 1).

For computing I used such common programme packages as SPSS and BMDP, running a CONTROL DATA CYBER 76 or 72 mainframe. The variables were normalised, standardised, and different sets were evaluated by stepwise discriminant analyses (=DA) and principal component analysis (=PCA).

The following numbers of plots have been surveyed: 52 for the Common Buzzard, 28 for Honey Buzzards and 25 for Goshawks. All breeding places with changes during the study period, e.g. tree-felling, road-building, etc., were excluded from analysis. The data acquired were sampled from 1980 to 1984. Each nest was used about twice by the same species in statistical mean (1-5 times).

RESULTS AND DISCUSSION

Vertical-habitat-separation

In VHS parameters (Var. No. 26-29) no significant differences could be found (Fig. 1). There are slight differences in tree species used by the raptors, but broad-leaved trees are in general greatly preferred (it was not possible to compute tree species in my analyses). Accordingly VHS is not an important factor of habitat separation between these species.

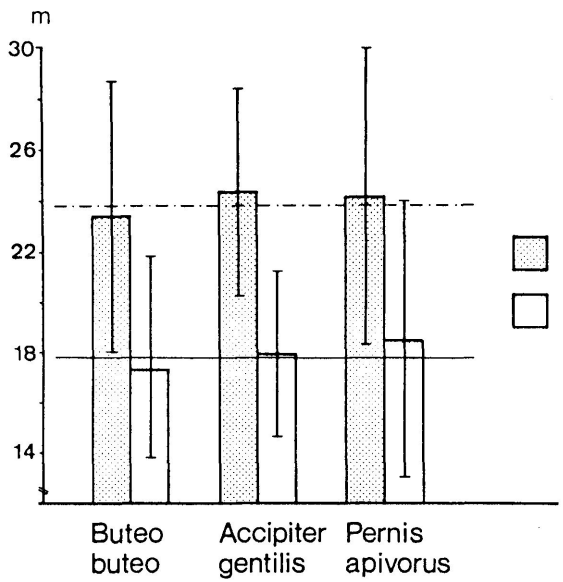
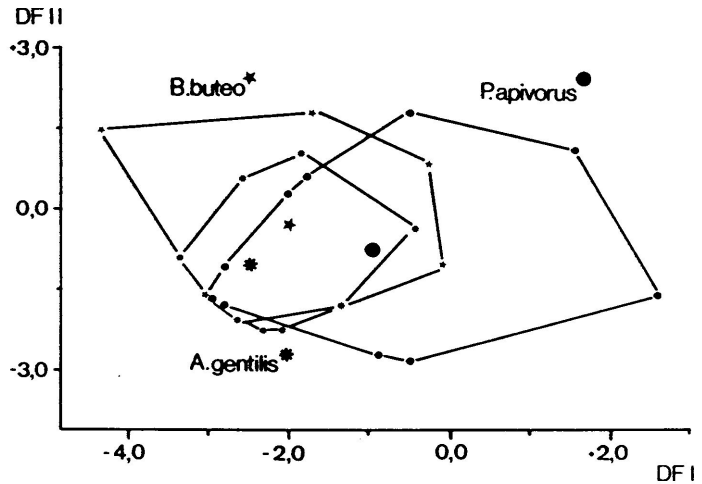


Figure 1. Selection of nest-height (white columns) and tree-height (dotted columns) in three raptor species.

Horizontal-habitat-separation

In these parameters habitat separation was evident for different sets of variables. As a first step I wanted to test my 113 ha plot method. From the literature we know the general habitat use of the species in question (see Cramp & Simmons 1980 or review in Kostrzewa 1986). Ornithologists have used different variables to describe raptor habitats. Besides others, the most commonly used are my variables Nos. 1-5, 8, 10-14, 16, 23-28 (Table 1) which describe an ecological environment. After performing the discriminant analysis with this set of data, I found that my plot method exactly reflects the known habitat choice, as described in Figure 2 and Table 2.

Figure 2. First step DA analysis with 'ecological environment'. Involved are 18 variables (No. 1-5, 8, 10-14, 16, 23-28). Var. No. 9 and 29 must be excluded because of skewness. DF = discriminant function.



The results show that Common Buzzards prefer plots of mixed forest and open land lying close to the edge of the wood. Goshawks prefer places with open land but much more forest area and larger distances to wood edges.

Honey Buzzards often choose wider woodland areas but show no special preference as to distance to wood edges; one can find them close to the edge or in the centre of large forests (cf. Kostrzewa 1985).

Table 2. Correlation coefficients of discriminant functions and F-statistics (for all values p <0.0001) for Figure 1.

Var. No.	Var. Name	DF I	DF II	F-Value
2	WAFLAECH	- 2.80	1.00	3.71
1	WALDGROE	0.86	0.04	3.31
11	OFFELAND	- 1.78	0.71	4.65
8	BAUMREIH	0.45	0.28	3.81
24	ABSTWARA	0.11	- 1.32	4.13
Eigenvalue		0.32	0.08	
% Eigenvalue		80.88	19.12	
Canonical Correlation		0.50	0.27	

This first DA step should test my 'plot method' and the variables used, and we have seen that it works. But why? From the measurement of nearest-neighbour-distance I was able to estimate the territory size of each species in our area. For Common Buzzards we found 150 ha, for Honey Buzzards 700 ha minimum and for Goshawks territory sizes of over 1,000 ha. So my measured plot represents the core area around the nest, which is the centre of activity within the breeding territory and the home range. That is why I believe the plot area must be very important for habitat choice.

As a second step I incorporated all 33 variables. Now we have added parameters to the analysis describing human disturbance and competition variables (Table 1). Figure 3 and Table 3 show the results: the species are now more separated from each other and some other variables are due to

habitat choice; the 'forest-variables' remain important, but two other groups of parameters become important too: about one third of variables stem from human interference, especially from built-up areas and roads, which are avoided by these raptors. Another third comes from interspecific competition. The diagram shows that the overlap of the species is therefore much less than in Figure 2.

Figure 3. Second step DA analysis. Involved are all (=31) variables.

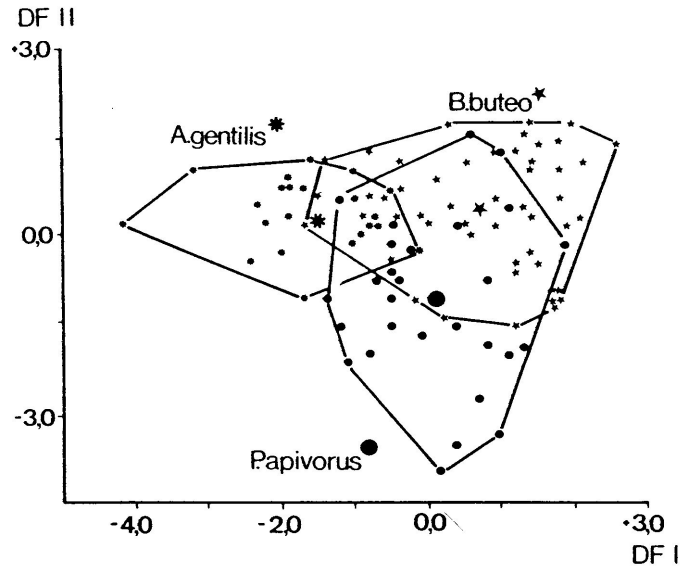
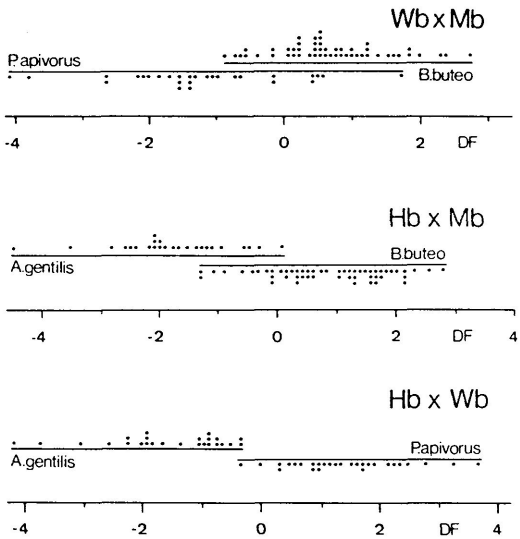


Table 3. Correlation coefficients of discriminant functions and F-statistics (for all values p ‹ 0.0001) for Figure 2.

Var. No.	Var. Name	DF I	DF II	F-Value
2	WAFLAECH	- 0.85	0.37	10.38
1	WALDGROE	0.03	- 1.02	11.92
8	BAUMREIH	- 0.36	0.37	7.88
6	BEBAUT	- 0.31	- 0.24	7.34
7	OEFFSTRA	- 0.49	- 0.02	6.93
19	OBSTRASS	- 0.39	0.48	8.46
30	ABST HB	- 1.13	- 0.50	19.06
32	ABST WB	- 0.58	- 0.22	9.29
31	ABST MB	0.33	- 0.47	14.57
Eigenvalue		0.92	0.44	
% Eigenvalue		67.06	32.94	
Canonical Correlation		0.69	0.55	

The next diagram shows the overlap between pairs of species more clearly (Fig. 4); it is very high between Common Buzzard and Honey Buzzard, medium between Buzzard and Goshawk and clear-cut between Goshawk and Honey Buzzard.

Figure 4. Comparison of pairs of raptors to show the specific overlap in habitat choice. Variables as Figure 3.



All results from the different DAs are supported by the principal component analysis (cf. Kostrzewa 1986).

To summarise my results, the niche overlap and influence of competition variables indicate that competition plays a significant role in this raptor community.

Since autumn 1986 I have been working on a programme to ascertain competition between conspecifics or other raptor species by computing individual breeding success versus nearest-neighbour-distance. The primary results support my view that habitat choice is strongly influenced by intra- and interspecific competition (Kostrzewa unpubl.).

Secondly I wish to point out how far raptor habitats are influenced by man as we have seen above. Goshawks especially are the first to abandon disturbed nesting places, followed by Common Buzzards. Only the Honey Buzzard is more tolerant of human activities.

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