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Long-term dynamics of breeding birds in broad-leaved deciduous forest on Hanikatsi Island in the West-Estonian archipelago

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The temporal dynamics (1974–2004) of the breeding bird community in broad-leaved deciduous forest on Hanikatsi Island on the eastern side of the Baltic Sea was studied. Altogether 33 bird species of seven orders were recorded. The year-to-year variation in the number of species (CV = 10.99%) and in the total numbers (CV = 15.17%) were relatively small. No significant trends in the number of bird species and in their abundances were detected, though an abrupt change in community structure took place at the beginning of the 1990s. No significant relationships between abundance of single bird species were detected, except for *Turdus merula* and *Turdus philomelos*.

1. Introduction

For the protection of island birds, we have to know the long-term dynamics and variability in the composition and numbers of bird communities. According to classical island biogeography (MacArthur & Wilson 1967, Diamond 1972, 1984), the number of species on an isolated island is the function of immigration and extention rates. But, in conditions where the isolation is not absolute, the species composition and numbers also depend on several other factors, for example, the area of the island, distance from the mainland or neighbouring island, habitat heterogenity and succession (Haila 1983, Hinsley et al. 1995a,b, Mikk & Mander 1995, Haila 2002, Tworek 2003). Haila (1983) found that in the Åland archipelago, in the northern part of the Baltic Sea, the main factor causing deviations from the expected population numbers, and differences in bird community composition, on islands is differing habitat structure compared to the mainland, and that the species dynamics of land bird communities follow mainland population trends. Most species absences from the islands can be attributed to rarity in the source area or to the lack of suitable habitats on the islands, or both. He also assumed that the land bird communities on northern islands can be regarded as "samples" taken from a surrounding avifaunal "universe". The latest investigations confirm the stochastic colonisation pattern in general, though there exist specific differences depending on species and habitat characteristics (Cappuccino & Price 1995, Bellamy *et al*. 1996, DeGraaf & Miller 1996, Haila *et al*. 1996, Fahring 2001, Bellamy *et al*. 2003, Tworek 2003, Virkkala 2004).

In our case, where a large island (Hiiumaa) and the mainland are not far from each other, the spatial isolation is slight and the sea represents a serious ecological barrier for the distribution of only a few land bird species. On the other hand, there exist other factors, like landscape fragmentation, habitat structure, edge effect, turnover rate, weather conditions and disturbances, that affect the species richness and abundance of bird species on sea islands or in woodland patches in agricultural and forest-dominated landscapes (Helliwell 1973, Levenson 1981, Diamond 1984, Barkman 1989, Hinsley *et al*. 1995a, Mikk & Mander 1995, Jokimäki & Huhta 1996, Rickets 2001, Haila 2002, Tworek 2003, Virkkala 2004).

The aim of our study was to analyse the temporal variation of the breeding bird community in a small forest on a small sea island. We expected a high year-to-year fluctuation of species composition and numbers, and a relatively small diversity and abundance of forest birds on the small sea island compared to similar forests on the mainland.

2. Study area and methods

The study area is located on Hanikatsi Island (58º46 N, 23º46 E) in the West-Estonian Archipelago on the eastern side of the Baltic Sea, about 5 km from the large Hiiumaa Island (989 km^2) and 24 km from the Estonian mainland. The area of the study plot, an isolated forest patch, is 10 ha and the size of Hanikatsi Island, where the plot is located, is 82 ha. The flora of Hanikatsi Island is rich and include 443 vascular plant species and 26 different plant communities (Mägi 1997). The main habitats for breeding birds on the island are dry and fresh grasslands (25 ha), *Juniper* shrubs (22 ha), broad-leaved and birch-dominated deciduous forests (21 ha), coastal meadows (10 ha), and reed-beds (4 ha). The list of breeding birds include 84 species of 11 orders (Leito & Leito 2004).

Hanikatsi Island has been inhabited since the end of the 17th century but since 1964 there have been no permanent inhabitants on the island. After abandonment of the island the mown and grazed meadows in the forest are overgrowing with trees and shrubs and nowadays the remnants of previous wooded meadows are seen in the southern part of the forest massif. The broad-leaved forest where the censuses were conducted has been strictly protected since 1971 and the human impact there has been small.

The main tree species of the study forest are *Tilia cordata, Quercus robur, Acer platanoides*, with less *Betula pendula, B. pubescens, Fraxinus excelsior* and *Populus tremula.* Altogether 80 species of vascular plants have been found in the study plot. *Tilia cordata*-dominated forest is more widespread, only in some locations can forest fragments dominated by *Acer platanoides* and *Fraxinus excelsior* be found. The height of the tree layer was estimated as between 7.7 and 17.1 m, 13.2 m (± 3.40, SD; n = 14) on average. The age of tree stands was estimated at 80–90 years in the middle of 1980s (Jõgiste 1989, Leito & Leito 2004).

A territory mapping technique similar to the classical mapping census method for breeding land birds (Koskimies & Väisänen 1991) was used to count birds in our study. The survey plot is fully covered with permanent parallel census transects marked on the survey map (scale 1:10,000). The distance between transects is 50 m and the width of the census belt is 25 + 25 m. Nest-findings, recordings of singing birds, and birds not singing but displaying behaviour consistent with probable or confirmed nesting were located on the visit map (scale 1:2,000). Based on this the territory pair (= breeding pair) was defined and marked finally on the species map after at least two recordings of birds in the same location. All censuses were carried out in the early morning after sunrise between 5 and 8 a.m. local time during the period 15 May and 15 June. One count took 1–1.5 hours. Night-singers were not surveyed especially. Censuses were conducted only during good weather avoiding strong wind and rain fall. Censuses were car-

Table 1. The main characteristics of the dynamics of breeding bird fauna in broad-leaved deciduous forest (10 ha) on Hanikatsi Island in the West-Estonian Archipelago in 1974–2004 (27 years). Mean, the average number of breeding pairs counted; SD, standard deviation of numbers; CV, coefficient of variation of numbers.

Species	Mean	SD	CV, %
Fringilla coelebs	14.04	2.33	16.59
Phylloscopus trochilus	6.93	2.93	42.37
Phylloscopus sibilatrix	4.59	1.34	29.13
Sturnus vulgaris	3.67	1.82	49.60
Turdus merula	3.44	1.63	47.18
Hippolais icterina	3.15	1.20	38.10
Sylvia atricapilla	2.74	1.38	50.18
Carpodacus erythrinus	2.63	1.71	65.14
Parus major	2.48	1.60	64.57
Erithacus rubecula	2.22	1.42	64.05
Luscinia luscinia	2.07	1.21	58.17
Sylvia communis	2.04	1.13	55.27
Turdus philomelos	1.93	1.17	60.97
Ficedula hypoleuca	1.74	1.51	86.67
Corvus corone	1.48	0.80	54.16
Sylvia curruca	1.44	1.09	75.19
Phylloscopus collybita	1.04	1.09	105.23
Anthus trivialis	0.89	1.25	140.70
Parus caeruleus	0.85	0.91	106.52
Sylvia borin	0.78	1.12	144.12
Columba palumbus	0.74	0.76	103.17
Troglodytes troglodytes	0.70	0.87	123.48
Turdus iliacus	0.56	0.97	175.32
Turdus pilaris	0.33	0.83	249.62
Scolopax rusticola	0.26	0.45	172.25
Buteo buteo	0.26	0.45	172.25
Jynx torquilla	0.26	0.53	202.77
Oriolus oriolus	0.19	0.40	213.76
Certhia familiaris	0.19	0.40	213.76
Cuculus canorus	0.15	0.36	244.36
Prunella modularis	0.07	0.27	360.29
Corvus corax	0.04	0.19	519.62
Strix aluco	0.04	0.19	519.62
Total species (n=33)	20.15	2.21	10.99
Total pairs (n=1,726)	63.93	9.70	15.17

ried out during the years 1974–2004. In 1977, 1986, 1990 and 1991 census were not conducted due to extremely bad weather on the island throughout the census period in May and June. It is important that all censuses have been conducted by the same person (Tiit Leito).

Ordination of bird species abundance data was performed according to Legendre and Gallagher (2001). First, the bird species abundance data table was transformed, such that in the following principal component analysis (PCA), chi-square distance is preserved among samples. This analysis approach was chosen due to the occurrence of many zeros in the bird species abundance data table. The bird species diversity was estimated using the Shannon-Wiener index (H'). The Spearman rank order correlation coefficient (r_s) was used to analyse the relationships between the numbers of different bird species over the study period. Trends in time series were studied using regular linear regression analysis, and the significance of trends was assessed by applying the Mann-Kendall test.

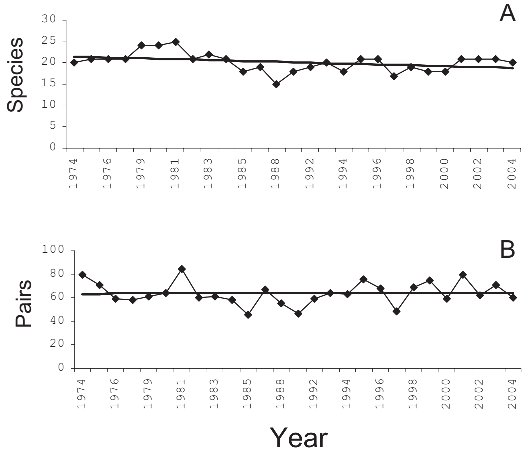

Figure 1. The annual number of (panel A) bird species and (panel B) breeding pairs of the forest bird community on Hanikatsi Island in 1974–2004. The trends indicated by the regression line (panel A: y = –0.1x + 21.6, R^2 = 0.13; panel B: y = 0.03x + 63.5, R^2 = 0.0006) are statistically not significant.

3. Results

In the breeding fauna of Hanikatsi forest, 33 bird species of 7 orders have been recorded during 1974–2004. In different years 15–25 species, 20.15 species (± 4.39, SD; CV = 10.99%; n = 27 years) on average, were observed (Fig. 1a, Table 1). The species density has been 15–25 species/10 ha, 20 species/10 ha on average (± 4.39, SD; CV = 15.17%; n = 27 years). The Shannon-Wiener index (H') of species diversity has varied between 3.69 and 4.21. There was no significant linear trend in species number or Shannon-Wiener diversity index over the study period (Mann-Kendall test, P > 0.05, n = 27).

The total number of breeding pairs has been 46–84 pairs, 63.93 pairs (± 9.70, SD; n = 27 years) on average (Fig. 1b), and the year-to-year variation in numbers has been relatively small (CV = 15.17%). There is no significant linear trend in long-term numbers of breeding pairs (Mann-Kendall test, P > 0.05, n = 27). The total bird density has been 46.0–84.0 pairs/10 ha and 63.93 pairs/10 ha (± 9.70, SD; n = 27 years) on average. The temporal variation of the total population numbers and density have been slightly larger than the variation in species number in the observation area.

Fringilla coelebs had the highest abundance (14.04 pairs on average) through all the years, followed by *Phylloscopus trochilus* (6.93 pairs) and *Phylloscopus sibilatrix* (4.59 pairs). Seven species (21%) of all the recorded bird species were breeding in every year and four species (12%) were recorded as breeding in less than five years. The numbers of *Fringilla coelebs* have been the most stable (CV = 16.59%), followed by *Phylloscopus sibilatrix* (29.13%), *Hippolais icterina* (38.10%) and *Phylloscopus trochilus* (42.37%). No significant correlations between the abundances of individual bird species were detected, except for *Turdus merula* and *Turdus philomelos* (r_s = 0.62, P < 0.001, n = 24).

The year-to-year dynamics of single species have been different. The numbers of *Turdus merula* had a statistically significant positive linear trend (Mann-Kendall test, P < 0.01). A positive non-significant trend was also apparent for *Fringilla coelebs*, *Parus major*, *Parus caeruleus*, *Corvus corone*, *Turdus merula*, *Sylvia atricapilla*, *Carpodacus erythrinus*, *Eritchacus rubecula* and *Luscinia luscinia*. The numbers of *Sturnus vulgaris* had a significant negative trend (Mann-Kendall test, P < 0.01). A negative non-significant trend is apparent for *Scolopax rusticola*, *Phylloscopus trochilus*, *Anthus trivialis*, *Sturnus vulgaris*, and *Oriolus oriolus*. For *Ficedula hypoleuca*, *Sylvia communis*, *Hippolais icterina*, *Turdus philomelos*, *Phylloscopus sibilatrix*, *Sylvia curruca* and *Troglodytes troglodytes,* no remarkable trend was detected.

Ordination of bird species abundance indicated relatively high fluctuation of the breeding bird community in the first 15 years (1974–1990), which has stabilised during the last decade (1995–2004) after a 5-year transition period in 1991–1994 (Fig. 2). The year-to-year variation in the second period is much smaller than in the first period. The first two axes (F1 × F2) of the PCA together explain 25.7% of the variation among years. The most important bird species causing this large change in the community were *Buteo buteo*, *Scolopax rusticola*, *Certia familiaris*, *Oriolus oriolus*, *Anthus trivialis* and *Turdus iliacus* (decreased in numbers) and *Parus major*, *P. caeruleus*, *Corvus corone* and *Troglodyte troglodytes* (increased in numbers).

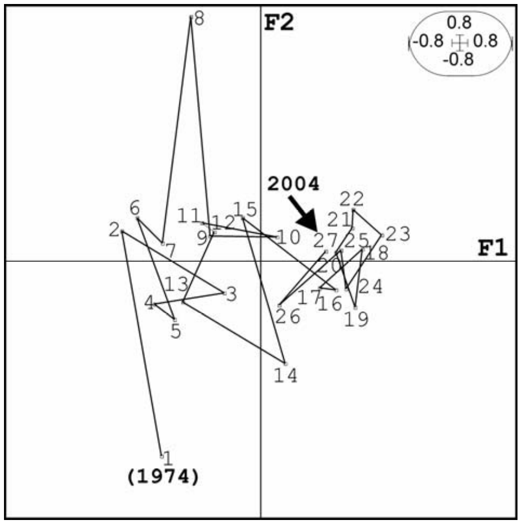

Figure 2. Ordination of years according to PCA results. First two axes (F1 × F2) together explain 25.7% of the variation among years. Consecutive years are connected with lines. The structure of breeding bird community has changed substantially at the beginning of the 1990s (locations 15 and 16).

4. Discussion

In general, the year-to-year variation in the number of breeding species has been relatively small, much smaller than we had expected. The total number of breeding pairs has varied more but also not to a large degree. The number and composition of breeding bird species in our study plot on a small sea island does not differ very much from bird communities in similar forest types on the mainland (Leito 1972, 1982, Vilbaste 1990, Leito & Leito 1995, 2004, Paakspuu 2003, Lõhmus &

Rosenvald 2005). But there exist specific differences. First, there are forest bird species common in large woodlands on the mainland but absent or rare on the small island. In the Hanikatsi forest, no species of *Falconiformes* and *Piciformes* except for *Jynx torquilla* have been recorded breeding, and *Scolopax rusticola, Buteo buteo* and *Strix aluco* have bred only in a few years. The absent species have a large breeding territory and can be considered food specialists. Probably, the food sources for those species are too limited on the island and, in bad years, even over the whole archipelago.

Another factor related to the presence-absence of a species in the study plot is the distribution type and rarity of species in the larger surrounding region. The probability of breeding of a rare species in a small wood on a small island is much lower compared to in a large woodland on a large island or on the mainland than it would be on the basis of the equal distribution of species (Haila 1983). In our study, the rarity of *Oriolus oriolus* and absence of *Ficedula parva* and *Coccothraustes coccothraustes* could be explained by this factor, together with the small size and ecological isolation of the study area (Haila 1983, Hinsley *et al*. 1995a,b, Jokimäki & Huhta 1996, Haila 2002, Tworek 2003).

The almost non-significant correlations between the abundance of individual bird species that we discovered support indirectly the hypothesis of a random assemblage of breeding birds in the community. A relatively strong correlation between the numbers of *Turdus merula* and *T. philomelos* may be an occasional coincidence related to a similar niche.

The breeding bird population trends studied by us in Hanikatsi forest are in good accordance with population trends over the whole of Estonia, calculated on the basis of long-term point counts (Kuresoo & Ader 2000) and generalized estimates evaluated on the basis of the compilation of different censuses (Elts et al. 2003). Altogether 18 species of 22 had the same trends of increase or decrease or stability. Only for one species, *Anthus trivialis*, do the trends have an opposite direction. A probable reason for decreases in Hanikatsi forest seems to be the forest succession – the former fragments of wooded meadow have been overgrowing into dense forest against species' preferences.

A question remains: what happened to the breeding bird community in Hanikatsi wood at the beginning of the 1990s, when an abrupt change took place. All that we know for certain is that it can not be a census mistake, because all censuses were conducted by the same method and by the same person. One explanation could be that it was the effect of a short-term climate change on the bird community, since this period was characterized by extremely mild winters and early springs in Estonia (Jaagus & Ahas 2000). Unfortunately, we do not have correct weather data from the study area to analyse the effect of different weather characteristics on the breeding bird community.

In conclusion, the dynamics of breeding forest bird population trends on this small sea island reflects the population dynamics at the regional level. But there are some bird species with large breeding territory like *Buteo buteo* or rare species like *Coccothraustes coccothraustes* breeding on the mainland and absent on the small sea island. The large-scale changes in the bird community have in our case most probably been caused by succession, where the impact of human activity (tree cutting, cattle grazing and later overgrowing) has played an important role, and by short-term climate change. Our study confirms rather the random sampling of birds in the community and the results are similar to those of other authors (Haila 1983, Haila *et al*. 1996, Helle & Niemi 1996, Jokimäki & Huhta 1996, Jokimäki et al. 2000, Tworek 2003, Virkkala 1992, 2004).

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Länsi-Viron Hanikatsin saaren linnuston pitkäaikaistaseurannan tulokset

Tutkimuksessa seurattiin itäisellä Itämerellä sijaitsevan Hanikatsin saaren lehtimetsissä pesivän linnuston tilaa ja sen muutosta vuosina 1974–2004. Kaikkiaan havaittiin 33 pesivää lajia, jotka kuuluivat seitsemään eri luokkaan. Vuosittain havaittiin 15–25 lajia (keskimäärin 20 lajia vuodessa). Linnuston keskimääräinen tiheys oli 64 paria 10 hehtarilla (46–84 paria/ha).

Vuosittainen vaihtelu oli vähäistä sekä lajimäärän (vaihtelukerroin 10.99 %) että yksilömäärän (vaihtelukerroin 15.17 %) kohdalla. Lintujen lajimäärässä ja runsaudessa ei havaittu merkittävää muutosta, vaikka linnusto olikin kokenut huomattavan muutoksen 1990-luvun alussa. Yksittäisten lajien runsauksien välillä havaittiin merkitsevää korrelaatiota ainoastaan mustarastailla (*Turdus merula*) ja laulurastailla (*Turdus philomelos*). Useimmilla lajeilla paikallispopulaatioiden tiheyksien suuntaukset korreloivat voimakkaasti Viron alueellisten suuntausten kanssa.

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