Ornis Fennica 83:131–138. 2006

Flock composition, agonistic behaviour and body condition of wintering Bullfinches *Pyrrhula pyrrhula*

Olav Hogstad

Norwegian University of Science and Technology, Section of Natural History NO-7491 Trondheim, Norway. Olav.Hogstad@vm.ntnu.no

Received 30 January 2006, revised 20 March 2006, accepted 23 March 2006

During October–April of 1989–2003 I made observations on size and sexual composition of Bullfinch *Pyrrhula pyrrhula* flocks (ringed and unringed birds), recorded interactions between members and estimated the body condition of birds observed in a mixed forest in central Norway. The flock size did not change with ambient temperature and ranged from two to seven with a mean of 4.1 in October–January and 2.3 in February–April. During March–April, 28 of 29 flocks consisted of one male and one female. Seventeen flocks followed over 6–17 days in November–December did not change in size or sexual composition. The adult sex ratio was equal. In flocks consisting of two, four or six birds, 88–97% consisted of equal numbers of males and females. Few birds stayed in the area throughout the winter. One colour-ringed mated pair breeding in the area was observed during two winters. Two ringed females, each observed in the company of an unringed male, were repeatedly observed during two subsequent winters. Females were socially dominant over males. Adult and juvenile females had a better body condition (body mass to wing length ratio) than juvenile males, but not better than that of adult males. The body condition of the birds increased with decreasing ambient temperature.

1. Introduction

Many bird species spend the non-breeding season in flocks. The advantages of being a flock member, compared with solitary living, include improved predator avoidance and increased foraging efficiency (Pulliam & Caraco 1984). In mixed-age flocks, the males most often dominate the females and the adults dominate the juveniles of their own sex. In most social systems, the high ranking individuals generally have priority of access to contested resources (e.g. Morse 1980, Hegner 1985, Hogstad 1988a). The Bullfinch *Pyrrhula pyrrhula* differs in social behaviour from other Fringillidae in many ways (e.g. Newton 1972), for one thing, females are generally dominant over males (Newton 1972, Wilkinson 1982). The winter flock sizes are generally small, often ranging from one to 11 and, according to Wilkinson (1982), with frequent changes in composition resulting from individuals entering or leaving the flock.

As the advantages of being a flock member, compared with solitary living, include improved predator avoidance and increased feeding efficiency (Pulliam & Caraco 1984), and as a temporary increase in flock size in cold weather has been observed for several species (e.g. Lüdescher 1973, Morse 1978, Hogstad 1988b), the change in Bullfinch flock size may be related to temperature stress and energy requirements. As the temperature drops Bullfinches, like other passerine birds, increase their amount of body fat as insurance against poor feeding conditions (e.g. Newton 1969, 1972).

However, since they reduce their fat reserves when conditions improve again (Newton 1972), this is obviously a deliberate strategy (Lehikoinen 1987). If female Bullfinches are getting better access to food resources than males, their body condition should improve less sharply than in males as temperatures drop, because they would not have to carry so much fat as insurance against starvation in cold temperatures.

Moreover, as two-bird groups consisting of one male and one female are often seen together in winter, it has been suggested that Bullfinches are paired for life and probably faithful for successive breeding seasons (Nicolai 1956). Although these statements are frequent in ornithological textbooks, and the Bullfinch is well studied in general, no thorough study of free-living populations of colour-ringed birds has been made (Cramp & Perrins 1994).

As part of a field study on the winter ecology of small passerines, I made observations on the size and sexual composition of Bullfinch flocks, recorded interactions between the members and also estimated the body condition of some ringed birds. Based on the suggestions mentioned above, the following predictions should be verifiable. (1) When following a flock over time, the flock size and composition should change because of birds leaving or entering the flock. (2) Flock size should be negatively related to ambient temperature. (3) Even if winter flocks frequently change in composition, males and females should occur in pairs. If such pairs are mated, they should be observed together over a period. This can be verified by observing colour-ringed birds. (4) If females are socially dominant over males, females, irrespective of age, should win over males in agonistic interactions. (5) As a result of higher rank and consequently improved chances of foraging, females should maintain a better body condition and nutritional status than the lower ranked males. (6) There should be a negative relationship between body condition of the birds and temperature, and if females are getting better access to food resources, their body condition should improve less sharply than that of males as temperatures drop, because they would not have to carry so much fat as insurance against starvation in cold temperatures.

To test these predictions I studied sexual composition of Bullfinch flocks and aggression of ringed as well as unringed birds during 14 winters. The body condition of the birds is given as the ratio of body mass:wing length and their nutritional status was assessed using the technique of ptilochronology (Grubb 1989).

2. Material and methods

The study was conducted during October–April of 1989–2003 within a 6 km^2 study area of a mixed forest of Scots Pine *Pinus sylvestris*, Downey Birch *Betula pubescens* and Norway Spruce *Picea abies* area in Budal, 90 km south of Trondheim, central Norway (c. 63°N). Bullfinches breed regularly in the area and are seen throughout the year. The size and sex composition of Bullfinch flocks were mostly registered near sunflower-seed feeders placed more than 1 km from each other. The feeders were visited occasionally, most often with several days between each visit. Only one flock was recorded at each visit. Flocks often split into subflocks for some minutes. Two birds were considered to be members of the same flock if I assumed that they could see each other and their contact calls were judged to be mutually audible and if their movements were synchronized. As this is to some extent a subjective decision, some two-bird flocks could have wrongly been registered as a part of a larger flock. Of a total of 223 flocks observed, the ambient temperature was registered when I observed 116 of the flocks.

During 1989–1992, 21 males and 40 females were caught in feeders and banded with an aluminium ring, and in 1992–2000, 22 males and 45 females were colour-ringed. These birds were aged, and their body mass (g) and wing length (mm) were recorded. The ageing was based on plumage characters: in juveniles (1y–2y spring birds) great coverts are tipped greyish brown and carpal coverts fringed brownish. Adults have coverts of carpals tipped and edged greyish-white, and great coverts tipped greyish-white (Svensson 1992, Jenni & Winkler 1994). The sexes differ by the underbody being pink in males and pink-brown in females. After moulting in September–October, adults and young birds are not distinguishable in the field.

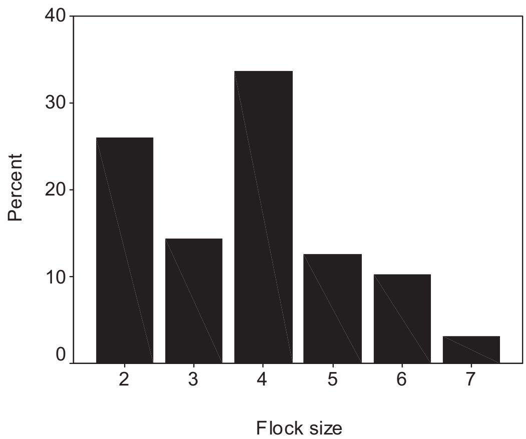

Fig. 1. The frequencies of flock size of Bullfinches observed in October–April. Figures denote sample size (N total = 223).

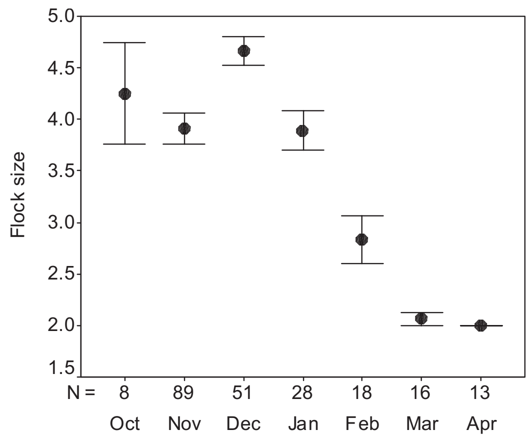

Fig. 2. Monthly flock size (mean ± 1se) of Bullfinches.

If one or more ringed birds in a flock were later observed in a flock of the same size and sexual composition, I have considered these flocks as identical. To reduce the risk of counting the same flock several times, I made only one record per week of flocks with the same size and composition. I followed and watched flocks as long as possible, frequently for 5–15 minutes, but some up to 30 minutes.

Agonistic interactions were observed at feeders. Social dominance was determined by observing winners and losers of interactions at or near a feeder, a box so small that only one bird could use it at a time. Four types of interactions were used to determine social rank. A bird was said to dominate over another if it: 1) chased the other away from the feeder; 2) made a successful supplanting attack (i.e., displaced the other from the feeder and then perched in its place); 3) when, on its approach, the other bird withdrew from the feeder; 4) caused another bird to wait until it had first fed and then left the feeder.

To find out whether differences existed in the body condition of the birds, I have used the index of body mass:wing length. The nutritional regime under which the different flock members were living was found by measuring the breadth of the growth bars along the axis of feathers (ptilochronology; Grubb 1989). The growth bars on a feather provide a day-by-day record of the nutritional status of the bird: the wider the growth bars, the better the nutritional status. The average breadth was based on the measurements of 10 bars, five on each side of the point two-thirds of the feather's length from the proximate end. This gave the average value for daily feather growth (see Fig. 1 in Hogstad 1990). During November–February 1989–1995, I collected the left outermost tail feather from 81 birds caught in feeders. These feathers had grown during October–December after the autumn moulting period (Jenni & Winkler 1994).

Statistical tests are two-tailed. Parameters preceded by ± sign are standard deviations.

3. Results

3.1. Flock size

The flock sizes ranged from two to seven with a mean of 3.76 ± 1.40 (n = 223). The flock size differed during the winter (One-way ANOVA, $F_{6, 222} = 18.64$, $P < 0.001$). The most frequent sizes were of two and four birds, together making 60% of the flocks. Singletons were not observed (Fig. 1). There was a marked difference in mean flock size between the periods October-January (mean 4.14 ± 1.29, n = 176) and February–April (2.34 ± 0.73, n = 47; $t_{221} = 9.21$, $P < 0.001$; Fig. 2). During March–April, the mean flock size was 2.03 ± 0.19 (n = 29), and no change in flock size occurred ($F_{1,28} = 0.807$, $P = 0.38$).

No relationship was found between flock size and ambient temperature during October–April (r = –0.132, P = 0.16, n = 116) or for each month separately (r = –0.434 to 0.253, P > 0.16, n = 7 – 42). Thus, a stepwise regression analysis revealed that the time of recording (i.e. month) accounted for 23% of the variation in flock size, while temperature did not enter the equation.

When observing flocks for up to 30 minutes, I never observed birds entering or leaving a flock. However, when a flock flew to another wood lot 50–75 m away, one or more birds were frequently seen foraging at the former place for some minutes before they rejoined the flock.

Thus, prediction 1 could not be confirmed, and it may be suggested that the size of Bullfinch flocks in the Budal study area are fairly constant early in the winter. However, the reduction in flock size during the last part of the winter may be a result of birds that have left the flock. On the other hand, it can also be due to mortality. Neither could prediction 2 be confirmed as flock size was not affected by temperature.

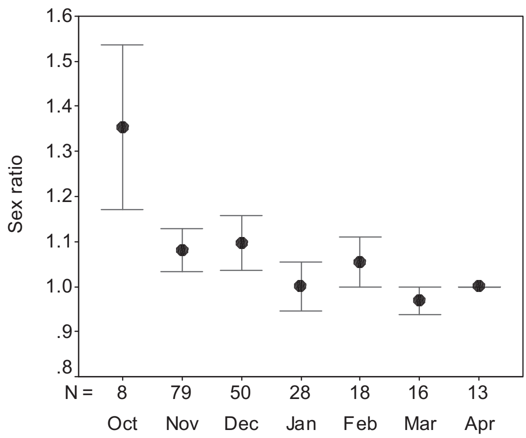

Fig. 3. Sex-ratio (male:female) in winter flocks of Bullfinches (mean ± 1se).

Thus, although the male:female ratio is close to equal during the winter, prediction 3 could not be verified because knowledge about mating is lacking.

3.2. Sexual composition

The male:female ratio (438:401 = 1.09) did not differ from an equal distribution, neither totally for October–April (438:401; $\chi^2 = 0.73$, df = 1, P = 0.39) nor for each of the months ($\chi^2 = 0.00 – 1.13$, P > 0.05). Of flocks consisting of two, four or six birds, 97%, 91% and 88%, respectively, consisted of equal numbers of male and female birds. In March and April, 28 of 29 flocks consisted of one male and one female. Courtship behaviour was frequently observed during this last period.

In 17 cases, one (n =11) or two (n = 6) colour-ringed birds in a flock were recorded over 6–17 days in November–December. No change in the size and sexual composition could be detected in these flocks, indicating that the flock composition was fairly constant over a short time period.

The number of males was higher than that of females in five of the eight flocks observed in October (small sample size, n = 8), whereas the male:female ratio was approximately equal during November–April (1.06; Fig. 3). No significant change in the male:female ratio occurred during October–April (One-way ANOVA, $F_{6,211} = 1.24$, P = 0.29).

3.3. Dispersion or site fidelity?

Of 128 Bullfinches ringed, only 23 were later observed more than 3–5 days in the study area, strongly suggesting that the birds were roaming around. That a female colour-ringed in December 1992 was seen the next day 3 km away from the ringing site strengthens the suggestion. However, some birds remained in the same locality throughout the winter. A male and a female, colour-ringed in November 1989, were observed feeding young in June the following year and seen several times during October–January 1990–1991. Although anecdotal, this is the first record of mated Bullfinches paired through two winters. Moreover, an adult female colour-ringed in December 1990 was repeatedly observed during the winter with an unmarked male. She was observed for the last time in October 1991. Another adult female, colour-ringed in November 1991, was observed in the company of an unmarked male at the same locality in December 1992. In addition, three observations from February may be associated with mated birds: a male repeatedly chased away another male that initiated courtship display towards a female.

Together these observations suggest that most

Bullfinches move around during winter, but some birds are stationary and are mated for successive seasons (prediction 3).

3.4. Agonistic interactions

When attending a feeder, females initiated and won 58% (73 of 126) of all agonistic interactions. All interactions towards males (25%) were won. Males were aggressive against other males (n = 53), and the aggressor always won in supplanting attacks. Although males sometimes tried to drive away a female from the feeder by threatening her with sleeked head feathers and an open bill directed towards her, such behaviour was ignored by the female.

Based on colour-ringed birds, it was found that some individuals were consistently dominant over others. Although the sample size is small, it may be suggested that flock members form linear hierarchies as follows: adult female > juvenile female > adult male > juvenile male (Table 1). Thus, as predicted (4), the observations seem to confirm the statement that females, adults as well as juveniles, are socially dominant over males.

3.5. Body condition and nutritional status

Both adult and juvenile females had a better body condition (body mass:wing length, adult = 0.358 ± 0.018, juvenile = 0.355 ± 0.012) than juvenile males (0.345 ± 0.017; $t_{juveniles}$ = –2.92, df = 79, P = 0.005; Table 2). The body condition of adult or juvenile females did not differ from that of adult males (juvenile females *vs* adult males; t = –1.50, df = 70, P = 0.14).

Table 1. The number of interactions won or lost by colour-ringed Bullfinches of different sex and age.

Winners	Losers		
	Juv.female	Ad.male	Juv.male
Adult female	9	5	3
Juvenile female	5	2	4
Adult male	0	1	6
Juvenile male	0	0	3

The nutritional status, based on breadth of growth bars on the tail feathers, was significantly correlated with the body condition of females (adults: r = 0.865, P < 0.001, n = 17; juveniles: r = 0.484, P=0.001, n = 41), but not in males (adults: r = 0.574, P = 0.065, n =11; juveniles: r = 0.38, P = 0.23, n =12). The nutritional status differed among age classes: adult females (mean = 3.075) ranked higher than juvenile females (2.928, t = –2.71, df = 56, P = 0.009) that ranked higher than juvenile males (2.756, t = –3.48, df = 51, P = 0.001; Table 2). Adult males (2.998) ranked higher than juvenile males (t = –5.23, df = 21, P < 0.001). No differences were found between adults or between adult males and juvenile females.

Thus, prediction 5 could not be fully verified as adult females had a better nutritional status than juveniles, but not better than adult males, and juvenile females ranked over juvenile males but not over adult males.

Table 2. Body condition (body weight in g : wing length in mm) and nutritional status based on the average breadth (mm) of 10 daily growth bars on the left outermost tail feather of Bullfinches caught after moulting in September–October.

		Wing length mean ± sd	Body weight mean ± sd	Body weight/ wing length	Breadth of growth bars ± sd
Adults	(N)				
Males	(17)	93.65 ± 1.54	32.65 ± 2.03	0.349 ± 0.02 (11)	2.998 ± 0.116
Females	(33)	92.50 ± 2.10	33.15 ± 1.87	0.358 ± 0.018 (17)	3.075 ± 0.241
Juveniles	(N)				
Males	(26)	92.85 ± 1.08	31.96 ± 1.53	0.345 ± 0.017 (12)	2.756 ± 0.106
Females	(55)	91.46 ± 1.18	32.44 ± 1.26	0.355 ± 0.012 (41)	2.928 ± 0.161

3.6. Body condition and temperature

As predicted (6), the body condition of the birds increased with decreasing ambient temperature ($r = –0.513$, $P < 0.001$, $n = 115$; Fig. 4). Except for adult males ($r = –0.483$, $P = 0.11$, $n = 12$), all categories (adult females, juvenile males and females) had significant higher body condition in cold weather ($r = –0.477$ to $–0.651$, $P < 0.005$, $n = 26 – 44$). However, although the body condition of females tended to improve less sharply ($b_1 = –0.003$, $P < 0.001$) with decreasing temperature than that of males ($b_1 = –0.004$), the rate at which body condition increased with decreasing temperature did not differ significantly among sexes ($F = 1.461$, $P = 0.23$ in a general linear model, GLM, based on sum of square statistics).

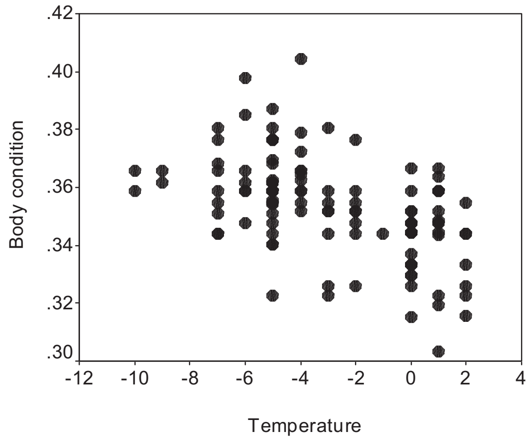

Fig. 4. The relationship between ambient temperature (°C) and body condition (body mass:wing length) of 38 males and 77 females.

4. Discussion

Winter flocks of Bullfinches in the Budal study area seem fairly constant in membership and contrast the findings from parklands in southern England where winter flocks frequently changed in composition and singletons were the commonest group category (Wilkinson 1982). In Budal the flocks with colour-ringed birds, although sample size is small, confirms the suggestion of stable flocks, as did the findings that flock size did not change with ambient temperature. The large number of singletons found by Wilkinson may be artificial because he defined a bird as single if it was 15 or more metres from the nearest member of one group. The frequent changes in flock composition found in the English study may therefore simply be a result of birds that had temporarily stayed behind when the other flock members moved, but rejoined the flock after a short time. Also the lower mean flock size in October–December (mean 2.4; Wilkinson 1982) compared to that from Budal (4.2 ± 1.3) in the corresponding period may be due to the singletons. Based on the principal benefit to be gained by joining a flock in terms of predator avoidance (Pulliam & Caraco 1984), it seems odd if the benefits differ markedly between the two areas. However, nothing is known about the predator pressure in the two areas. When Wilkinson did his study in the 1970s, the number of Sparrowhawks *Accipiter nisus* was likely to have been suppressed as a result of organochlorine pesticides (Newton 1979, 1986). If so, smaller Bullfinch flocks may be expected if predator avoidance is a main influence on flock size.

Contrary to my observations in Budal, Wilkinson recorded the highest flock sizes in March–April (mean 2.8) contrasting a mean of 2.0 (one male and one female) in Budal in the same months. As many Bullfinches die each winter from food-shortage (Newton 1972, 1993, Sammalisto 1982, Greig-Smith 1985, Dobson 1987), the marked decrease in flock size between January and March found in Budal may be caused by losses due to death. On the other hand, as courtship behaviour in Bullfinches is frequently observed in March–April (Wilkinson 1982, this study) and pair-formation occurs between January and March when birds still are in flocks (Newton 1972), flocks may split into pairs in late winter, resulting in a mean flock size of two, as found in Budal.

The number of Bullfinch pairs observed in the Budal study area during March–April was greater than the number believed to be breeding. If so, it must be a strong advantage to the Bullfinch to live in pairs when roaming around outside the breeding season (cf. Newton 1972).

The suggestion that most Bullfinches lack winter site fidelity in the Budal area contrasts findings from other areas. Based on banded birds, Rendahl (1964) found that many Bullfinches remained at or near the same locality throughout the winter in

Fennoscandia, and some birds were recorded up to 109 days. Also a radio-tracking study made in southern England showed that individuals remained largely within small areas of 1–2 ha for periods of a few weeks, occasionally making brief excursions of a few hundred metres (Greig-Smith 1985).

Females are socially dominant to males and it may be suggested that they utilize their status to secure priority of use of food resources. The better body condition of females compared to males, as found in Budal, could therefore be a consequence of social dominance. On the other hand, the body condition of the sexes did not improve differently as temperature dropped. In southern England, Greig-Smith (1985) found that wintering juveniles formed smaller energy reserves than adults, and had a poorer winter survival. Although differences in foraging behaviour between the sexes have not been examined systematically in Budal, it appears that females often use their dominance status to reserve some parts of the habitat for their own food searching. Even the mate (my assumption) was chased away. The lower winter survival of juveniles than adult Bullfinches found in England, however, was suggested as not attributable to competition with adults, but was more likely to involve relative incompetence in foraging, avoidance of predators or other activities (Greig-Smith 1985).

To conclude, most Bullfinch winter flocks in the Budal study area seemed fairly constant in size and composition early in the winter, whereas flocks decreased in size and usually consisted of one male and one female in March–April. There is still uncertainty about winter site-fidelity and whether the birds are paired for life and are faithful for successive breeding seasons. The body condition of the birds increased with decreasing temperature. Females were socially dominant over males and also had a better body condition than juvenile, but not adult, males.

Acknowledgements. I thank Per Gustav Thingstad and Fiona Proffitt (referee) for valuable comments on the manuscript.

Talvehtivien punatulkkuparvien rakenne, keskinäinen vuorovaikutus ja yksilöiden kunto

Seurasin Keski-Norjassa punatulkkuparvien kokoa, koostumusta ja keskinäistä vuorovaikutusta sekä arvioin lintujen kuntoa (paino/siiven pituus) talvien (loka – huhtikuu) 1989–2003 ajan. Lämpötilan muutokset eivät vaikuttaneet parvien kokoon, joka vaihteli kahdesta seitsemään (k.a. 4.1 lokakuusta tammikuuhun ja 2.3 helmikuusta huhtikuuhun). Maalis – huhtikuussa 28 29:stä parvesta koostui yhdestä koiraasta ja yhdestä naaraasta. 17:n parven koko tai sukupuolijakaumat eivät muuttuneet sinä aikana, kun niitä seurattiin marras – joulukuussa kuudesta 17:ään päivään. Aikuisten sukupuolijakauma oli tasainen. 88–97 %:ssa parvista, joissa oli parillinen määrä lintuja, oli yhtä monta koirasta ja naarasta. Muutamat linnut pysyttelivät tutkimusalueella läpi talven. Yksi väirirengastettu pari, joka pesi alueella havaittiin kahtena talvena. Kaksi rengastettua naarasta, joista molemmat havaittiin rengastamattoman koiraan seurassa, havaittiin toistuvasti kahden perättäisen vuoden aikana. Naaraat olivat parvissa dominoivia. Sekä aikuiset että nuoret naaraat olivat paremmassa kunnossa kuin nuoret koiraat. Vanhat koiraat olivat yhtä hyvässä kunnossa kuin naaraat. Lintujen kuntoindeksi kasvoi lämpötilan laskiessa.

References

Cramp, S. & Perrins, C.M. (eds.) 1994: The Birds of the Western Palearctic Vol. VIII. — Oxford University Press, Oxford, New York.

Dobson, A.P. 1987: A comparison of sexual and annual mortality for both sexes of fifteen species of common British birds. — Ornis Scandinavica. 18: 122–128.

Greig-Smith, P.W. 1985: Winter survival, home ranges and feeding of first-year and adult Bullfinches. — In Behavioural Ecology (ed. Sibly, R.M. & Smith, R.H.): 387–392. Blackwell Scientific Publications, Oxford.

Grubb, T.C. 1989: Ptilochronology: feather growth bars as indicators of nutritional status. — Auk 106: 314–320.

Hegner, R.E. 1985: Dominance and anti-predator behaviour in blue tits (Parus caeruleus). — Animal Behaviour 33: 762–768.

Hogstad, O. 1988a: Rank-related resource access in winter flocks of willow tit Parus montanus. — Ornis Scandinavica 19: 169–174.

Hogstad, O. 1988b: The influence of energy stress on social organization and behaviour of Willow Tits Parus montanus. — Fauna norvegica Ser. C, Cinclus 11: 89–94.

Hogstad, O. 1990: Dispersal date and settlement of juvenile Willow Tits Parus montanus in winter flocks. — Fauna norvegica Ser. C, Cinclus 13: 49–55.

Jenni, L. & Winkler R. 1994: Moult and Ageing of European Passerines. — Academic Press, London.

Lehikoinen, E. 1987: Seasonality of daily weight cycle in wintering passerines and its consequences. — Ornis Scandinavica 19: 216–226.

Lüdescher, F.-B. 1973: Sumpfmeise (Parus p. palustris L.) und Weidenmeise (P. montanus salicarius Br.) als sympatrische Zwillingsarten. — Journal of Ornithology 114: 3–56. (In German)

Morse, D.H. 1978: Structure and foraging patterns of tit flocks in an English woodland. — Ibis 120: 298–312.

Morse, D.H. 1980: Behavioral Mechanisms in Ecology. — Harvard University Press, Cambridge, Massachusetts.

Newton, I. 1969: Winter fattening in the Bullfinch. — Physiological Zoology 42: 96–107.

Newton, I. 1972: Finches. — Collins, London.

Newton, I. 1979: Population ecology of raptors. — Poyser, Berkhamsted.

Newton, I. 1986: The Sparrowhawk. — Poyser, Staffordshire.

Newton, I. 1993: Studies of west palearctic birds 192. Bullfinch. — British Birds 86: 638–648.

Nicolai, J. 1956: Zur Biologie und Ethologie des Gimpels (Pyrrhula pyrrhula L.). — Zeitschrift der Tierpsychologie 13: 93–132. (In German)

Pulliam, H.R. & Caraco, T. 1984: Living in groups: is there an optimal group size? — In Behavioural Ecology (ed. Krebs, J.R. & Davies, N.B.): 122–147. Blackwell Scientific Publications, Oxford.

Rendahl, H. 1964: Der Nordische Gimpel (Pyrrhula p. pyrrhula) im Winter. — Vogelwarte 22: 229–236. (In German)

Sammalisto, L. 1982: Winter censuses in 1981–1982. — Ornis Fennica 59: 183–190.

Svensson, L. 1992: Identification Guide to European Passerines. — Svensson, Stockholm.

Wilkinson, R. 1982: Group size and composition and the frequency of social interactions in Bullfinches Pyrrhula pyrrhula. — Ornis Scandinavica 13: 117–122.