

Brief report

Population fluctuations of Siskins *Carduelis spinus*, Common Crossbills *Loxia curvirostra*, and Citril Finches *Carduelis citrinella* in relationship to flowering intensity of spruce *Picea abies*

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Annual population abundances from 1992 to 2002 of Siskins *Carduelis spinus*, Common Crossbills *Loxia curvirostra* and Citril Finches *Carduelis citrinella* were studied in relation to flowering intensity of spruce *Picea abies*. We used point count method to study the changes in abundance of the three species in the Northern Black Forest (southwest Germany). Our results indicated that Siskins and Crossbills showed large fluctuations in abundance that correlated with spruce flowering intensity in the preceding year. In contrast, abundance of Citril Finches did not correlate with spruce flowering intensity. We suggest that Citril Finches, due to their high breeding site fidelity, their less expressed exploratory breeding behaviour and their preference for pine seeds, do not react to spruce seed availability by a change in abundance as documented for the other two species.



1. Introduction

Siskins *Carduelis spinus*, Common Crossbills *Loxia curvirostra*, and Citril Finches *Carduelis citrinella* are typical breeding birds of the mountain zones of Central Europe. In the Black Forest, they are characteristic species of mountainous conifer forests in areas above 900 m.a.s.l. (Dorka 1986, Hölzinger 1997). Conifer seeds play a crucial role in the nutrition of all three species (Glutz von Blotzheim & Bauer 1997). Common Cross-

bills are widely known to feed on several conifer species, mainly on spruce *Picea abies*, mountain pine *Pinus mugo*, Scots pine *Pinus sylvestris* and larch *Larix decidua* (Reinikainen 1937, Pulliainen 1974, Glutz von Blotzheim & Bauer 1997), and even to adapt their migratory behaviour to the more or less predictable availability of these seeds (e. g. Reinikainen 1937, Gatter 1993). Crossbills show extensive exploratory movements, which allow them to breed in distinct areas from year to year. Siskins in Central Europe are known to for-

age during breeding season mainly on spruce seeds and to show large fluctuations in their abundance due to these food resources (Gatter 2000). Ringing data on Siskins has shown that birds may settle far from their native breeding places in a response to good food conditions (Hölzinger 1997). Citril Finches are general considered to show more generalist feeding behaviour (Cramp & Perrins 1994) than the other two species. However, recent studies have shown that Citril Finches depend in the spring breeding season on relatively few plant species, especially on conifer seeds of mountain pines (Förschler 2001, Borrás *et al.* 2003, Förschler *et al.* 2005, Förschler & Kalko 2006). Productivity of this pine species does not show significant fluctuations between years (Genard & Lescourret 1986, 1987).

In contrast to Siskins and Crossbills, the importance of spruce seeds for Citril Finches is contradictory. While spruce seeds in the Northern Black Forest seem to play only a subordinate role (Förschler 2001), R. Kilzer found significantly higher settlement densities in years of high spruce seed productivity at Vorarlberg/ Northern Alps (Glutz von Blotzheim & Bauer 1997). Citril Finches are generally far more sedentary birds than the other two species. They mostly breed at traditionally used breeding sites (Förschler 2002) and are not known to show large changes in breeding ranges due to food availability (*pers. obs.*). However, in Catalunya early opportunistic breeding in spring at lower elevations indicates that such opportunistic movements may also appear in this species in a response to high seed availability (Borrás & Senar 1991).

Bird populations, which rely on variable coniferous food sources show significant fluctuations in their abundance and erratic movements (Bock & Lepthien 1976, George 1968, Koenig 2001a, Koenig 2001b, Larson & Bock 1986, Svårdson 1957), whereas populations relying on stable coniferous food source do not fluctuate (Massa 1987, Benkmann 1987, 1989, Senar *et al.* 1993). The distinct basic food sources (spruces versus pines) and the degree of nomadism of the three species (erratic versus more sedentary) differ between Crossbills, Siskins and Citril Finches. Further, spruce seeds fluctuate strongly from year to year (Svardson 1957). We therefore expect that Crossbills and Siskins show pronounced variation

in their numbers which correlate with spruce fructification, whereas spruce seeds should not have the same influence on the abundance of Citril Finches. To support this hypothesis, we present the results of a point stop monitoring we conducted over ten years between 1992 and 2001 in the Northern Black Forest.

2. Material and methods

We studied population abundance of Siskins, Crossbills and Citril Finches in the Northern Black Forest (Schwarzwald) in southwest Germany. This area provides good habitat conditions (conifer-dominated forests) for all three species between the localities Kniebis (920 m) – Schliffkopf (1060 m) – Ruhestein (950 m) – Mitteltal (600 m) (district Freudenstadt) on an area of about 40 km². Dominant plant societies in the area are semi-open heath land structures (*Molinia caerulea*, *Calluna vulgaris*, *Vaccinium myrtillus*) on the summits, with open to scattered mountain pine *Pinus mugo* forest and extensive woodland on the slopes dominated by spruces *Picea abies* (Bartsch & Bartsch 1940, Murmann-Kristen 1987). Firs *Abies alba* play only a subordinate role in the study area.

For our study, we used the point stop counting method introduced by the monitoring program Dachverband Deutscher Avifaunisten (DDA) (Flade & Schwarz 1996, Schwarz & Flade 2000), where 20 point counts were distributed along 25 kilometers. During each point count all birds in the surrounding were counted for exactly five minutes counting sightings, calling and singing individuals. The sites of the point counts were at least 300 meters apart from each other to avoid double counting.

The census of the 20 point counts was conducted five times a year during good weather conditions (dry and no windy weather) in five periods, 16th–30th April, 1st–15th May, 16th–31st May, 1st–15th June and 16th–30th June. (exceptions: 2000 only 4 and 2001 only 2 countings). In total, 920 point counts were conducted between 1992 und 2001 on the same area (100 point counts per year during 1992–1999, 80 in 2000 and 40 in 2001). The elevation of the sites was between 600 m (Mitteltal) and 1050 m (Schliffkopf), on average around 920 m. The main observations were con-

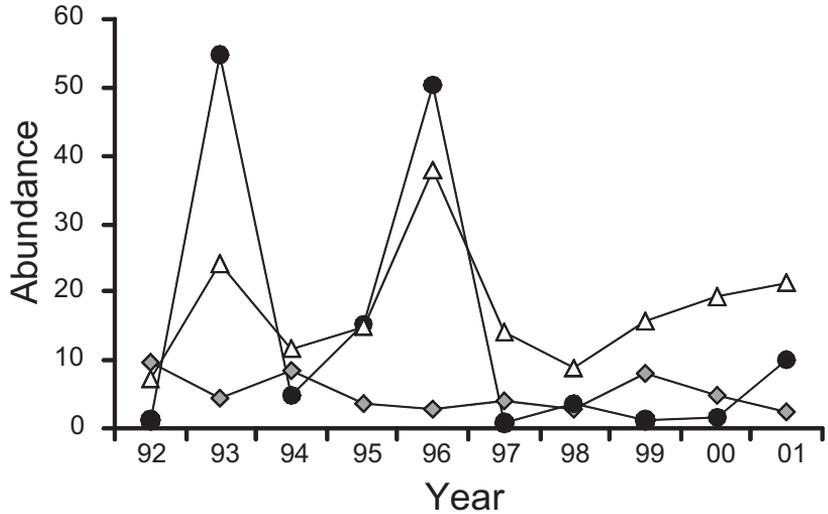


Fig. 1. Spring abundance of Siskins *Carduelis spinus* (filled circle), Common Crossbills *Loxia curvirostra* (open triangle) and Citril Finches *Carduelis citrinella* (grey rhombus), between 1992–2001 in the Northern Black Forest.

ducted in the spruce-dominated habitat type conifer forest.

We calculated abundance values for each year by averaging the number of observed birds per census. To compare between these annual abundance values and the availability of spruce seeds we used published data about the annual flowering intensity (scale 1–4) in the Black Forest and in total Germany conducted regularly by national and private forest seed farms (Eicke 1991, 1992, 1993, 1994, 1995, 1996, 1997, Schneck 1998, 1999, 2000, 2001). Index 1 = no flowering, 0–10% of all trees, 2 = weak (11–30%) flowering, 3 = average (31–60%) flowering, 4 = full (61–100%) flowering. These indices of flowering spruce are good indicators for the availability and fructification of seeds in the following year.

3. Results

Comparing the abundance of the three finch species we found high changes in abundance of Siskins and Crossbills in relationship to mast years of spruces in the Black Forest. Especially in the years 1993 and 1996, Siskins and Crossbills were extremely abundant after very good spruce seed years (Fig. 1). Siskins were significantly more abundant after a year of strong spruce flowering (Fig. 2, linear regression: $R^2 = 0.75$, $P = 0.01$). The same observation was made for Crossbills which were also significantly more abundant after a

stronger spruce flowering year (Fig. 3, linear regression: $R^2 = 0.74$, $P = 0.01$). In our study, Citril Finches showed population changes as well. However, no significant relationship was found between abundance of Citril Finches and spruce

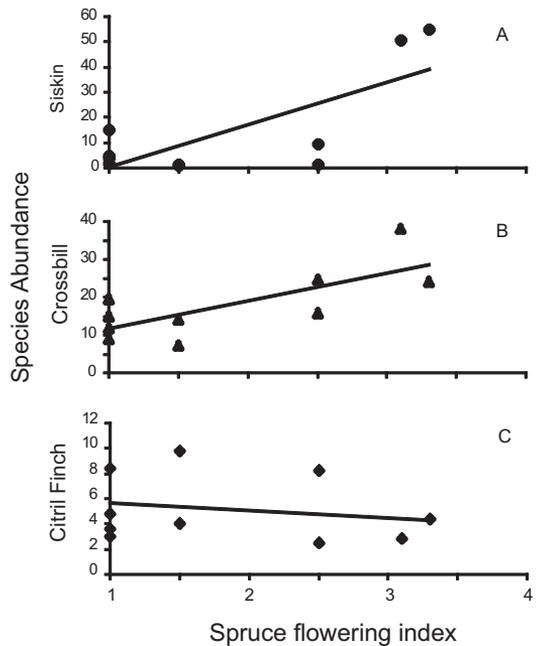


Fig. 2. Relationship of spruce flowering intensity (scale 1–4) and abundance (number of birds/ counting) in the following year of (A) Siskins *Carduelis spinus*, (B) Common Crossbills *Loxia curvirostra* and (C) Citril Finches *Carduelis citrinella*.

flowering year (Fig. 4, linear regression: $R^2 = 0.20$, $P = 0.59$).

An additional comparison of abundance values of our study area with spruce flowering indices from seed farms all over Germany revealed no significant relationships for all three species (linear regressions, Siskins: $R^2 = 0.34$, $P = 0.34$; Crossbills: $R^2 = 0.37$, $P = 0.29$; Citril Finches: $R^2 = 0.14$, $P = 0.69$).

4. Discussion

Our results show clear differences between Citril Finches on the one hand and Siskins and Crossbills on the other hand in relation to spruce flowering and fructification in the Black Forest. Siskins fluctuate strongly in abundance in correspondence with previous year's spruce flowering intensity. The abundance can be extraordinary high in years of spruce seed mass occurrence (1993 and 1996). June census may influence the number of observed birds by high productivity and registration of young birds (family groups) in late June. Numbers may be therefore somewhat higher in seed years. However, this does not change the fact that abundance values change with fructification cycles and that Siskins are extremely abundant in years of high spruce seed outcome.

What we know from observational data in the study area is that 1993 and 1996 were years with exceptional high spruce fructification in line with strong flowering intensity in 1992 and 1995. Therefore, the flowering index must have been even higher (full flowering) in the study area (Kniebis-Schliffkopf) than the values provided by the national and private tree seed farms from the total Black Forest used for comparison. In 1992 and 1995, Siskins were one of the dominant species in conifer forests and nearly as abundant as Chaffinches *Fringilla coelebs* and Coal Tits *Parus ater* (see also Schmid *et al.* 1998, Gatter 2000). In contrast, in years without spruce seeds availability the abundance of Siskins is very low (e.g. year 1997). It even seems that in such years there are almost no breeding pairs in the conifer forests of the Northern Black Forest (Förschler 2001, 2005). The only observations refer to a few birds close to villages, where they may use other planted conifer species as food sources with different fructifica-

tion cycles independent from the one of spruces. Our data confirms observational data in a larger (150 km²) frame in the Black Forest, indicating as well that Siskins reach significantly higher abundances in good spruce fructification years (see U. Dorka in Hölzinger & Dorka 1997). Similar observations were made by Spitznagel (1999) at the Rohrhardsberg area in the Black Forest during the years 1992 and 1995.

Crossbills are widely known for their extensive use of spruce seeds and their adaptation to spruce seeds mass production by their nomadic migratory behaviour (Reinkainen 1937, Gatter 1993). Our data confirms this observation. After a good spruce flowering year, we found Crossbills clearly more abundant in the following fructification year. However, the change in abundance was not as high as observed for Siskins. At most point counts we found a clearly lower abundance in years of less seed production in spruce forests. Nonetheless, Crossbills were observed each year in the Schliffkopf area, where a population exists that relies more on mountain pine seeds and seems to sustain itself there also in non-gradation years, totally independent from spruce seeds (Förschler 2005). This observation confirms the relationship of coniferous crop stability and crossbills residence as previously observed in the Pyrenees (Senar *et al.* 1993).

Finally, Citril Finches did not show any variation in abundance due to spruce mast years. In years of spruce seed mass production, Citril Finches showed a slightly lower abundance. Our data supports the prediction that spruce seeds play a subordinate role for this species (Hölzinger 1997, Förschler 2001, Förschler & Kalko 2006), which stands in contrast to other indications (R. Kilzer in Glutz von Blotzheim & Bauer 1997). There are various possible reasons for the low effect of spruce seed availability on Citril Finch abundance. Main factors may be the different migratory strategies (lack of strong nomadism) and the higher breeding site fidelity of the species (Glutz von Blotzheim & Bauer 1997, Förschler 2002). In contrast, the high migratory and nomadic style of Siskins and Crossbills may facilitate the location of good areas and hence cause larger fluctuations in population densities of those species. Another important reason may be the strong specialisation of Citril Finches to mountain pine seeds

(Förschler 2001, Borrás *et al.* 2003), which are available every year and possess higher nutritional contents than spruce seeds (Pulliainen 1974). Pine seeds are clearly preferred over spruce seeds by Citril Finches if both food items are available (Förschler & Kalko 2006).

Our observations confirm the hypothesis that bird species (Siskins and Crossbills) which rely on variable coniferous food sources such as spruces fluctuate strongly from year to year in correspondence with the availability of their main food resource (Bock & Lepthien 1976, Koenig 2001b, Svårdson 1957). This behavioural adaptation may lead to temporarily strong range expansions in these species. In contrast, bird species which rely on more stable coniferous food such as Citril Finches in the Northern Black Forest, may be considered to be more “conservative” concerning range expansions due to traditionally used breeding sites, the dependence on a stable coniferous food (see also Clouet 1990, Senar *et al.* 1993) and their less expressed nomadism. These behavioural differences may also explain the fact that the distributional range of Citril Finches remained more or less stable in the last hundred years with few range expansions.

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Kuusen siemensadon vaikutus vihervarpusen, pikkukäpylinnun ja sitruunahempon runsauteen Saksassa

Lounais-Saksassa sijaitsevan Schwarzwaldin vuoristoalueen pohjoisosassa sijaitsevalla tutkimusalueella arvioitiin vihervarpusen, pikkukäpylinnun ja sitruunahempon populaatiokokoja pistelaskennoilla vuosina 1992–2002. Koska kuusen siementen arveltiin olevan kaikkien kolmen lajin tärkeää ravintoa, saatuja kannanarvioita verrattiin kuusen kukkimista kuvaavaan indeksiin. Vihervarpusten ja pikkukäpylintujen runsaus vaihteli suuresti vuodesta toiseen, ja niiden runsaus korreloi edellisvuoden kuusen kukintaindeksin kanssa (kuusen siemenet ovat syötävissä vasta kukintaa seuraavana keväänä). Sitruunahemppojen lukumäärän vaihtelu ei ollut yhteydessä kuusen kukin-

taan. Tutkijoiden mukaan tämä johtuu siitä, että sitruunahempot syövät mieluiten männyn siemeniä. Sitruunahempot ovat alueella myös sangen pesäpaikkauskollisia, joten tutkijoiden mukaan niiden tiheydet eivät tämänkään vuoksi reagoi kuusen siemensadon vaihteluihin samalla tavalla kuin liikkuvampien vihervarpusten ja pikkukäpylintujen tiheydet.

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