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Seasonal variation in the diet of citril finches *Carduelis citrinella*: are they specialists or generalists?

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Abstract The seasonal variation of food selection in mountainous citril finches was studied in the Black Forest. citril finches show a strong seasonal variation in quantity and quality of food plants. From November to March, only a few plants have been observed as diet, namely seeds of the germander and the mountain pine (period of food restriction). From April to June, the seeds of a few key food plants such as the dandelion, common sorrel, vernal grass, and mountain pine gain special importance during breeding and the rearing period of the young (period of food specialization). Finally, from June/July to October, citril finches enter into a generalist period with a wide variety of seeds of herbs and grasses (period of food generalization). The changes in food selection are well adapted to the changing resource availabilities and climatic conditions of the Black Forest mountains. In direct comparison to other finches, pure mountain-dwelling species such as citril finches and Syrian serins show a clearly higher seasonal variability in food selection than do lowland species such as goldfinches, linnets, and greenfinches.

Keywords Mountain birds · finches · citril finch *Carduelis citrinella* · Food adaptation · Seasonal diet selection · Specialization

Introduction

The citril finches *Carduelis citrinella* are endemic to some mountain zones of western and southwestern Europe,

800 m a.s.l. (Cramp and Perrins 1994). The northern distribution limit of their range is located in the Black Forest (Dorka 1986). Here, the birds live mainly in the semi-open mountain pine *Pinus mugo rotundata* and spruce *Picea abies* forests on the higher summits, 900 m a.s.l. (Dorka 1986; Förschler 2002). As mountain birds, citril finches are often exposed to fast changes in climate conditions. Even in early summer, they may experience sudden periods of severe weather such as late onsets of winter or heavy rainfalls during several days that often lead to unpredictable food shortages (e.g. Frey 1989a,b; Rauter et al. 2002). Under those preconditions, rearing opportunities, in particular, the quantity and quality of available food, profoundly affect the survival and recruitment of offspring (Newton 1989). Resource availability and resource use are key factors for the maintenance of stable populations. This raises the question of how citril finches cope with the low predictability of food resources and, especially, how their food selection behaviour is adapted to these seasonal changes. In earlier studies, special emphasis was given mainly to the food selection during the breeding season (Förschler 2001; Förschler and Kalko 2006) and during summer (Sabel 1965; Mau 1980). Considering these data supplemented by long-term observations in the Black Forest, we may by now draw a picture of the changes of food selection throughout the year.

Materials and methods

Unpublished data from long-term observations in the Black Forest (1990–2006) and published references on the nutrition of citril finches (Sabel 1965; Mau 1980; Hölzinger and Dorka 1997; V. Dorka in Glutz von Blotzheim and Bauer 1997; Förschler 2001; Förschler and

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Table 1 Number of species within plant families with seeds consumed by the citril finches *Serinus citrinella* in the Black Forest throughout the year

Plant families	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Asteraceae					2	2	8	9	4			
Betulaceae							1	1	1	2		
Boraginaceae								1				
Caryophyllaceae				1			1					
Chenopodiaceae									1			
Cyperaceae							2	1				
Dipsacaceae								1				
Gentianaceae						1	1					
Juncaceae ^a									1	2		
Lamiaceae	1	1	1	1				2	1	1	1	1
Pinaceae	1	2	2	3	2	1	2	1	1	2	2	2
Poaceae					1	4	8	10	2			
Polygonaceae					2	1	3	2	2	1		
Ranunculaceae							2	2				
Rosaceae				1			2	3		1		
Total	2	3	3	6	7	9	30	33	13	9	3	3

^a *Juncus effusus* and *Juncus squarrosus*: It is not clear if the birds feed on the seeds of the genus *Juncus* because observational data suggest that they may forage on the case bearer larvae (*Coleophoridae*) that are wrapped in the larval sacculus in the *Juncus* species (V. Dorka, personal communication) rather than on seeds. Sources: Landbeck 1834, 1846; Sabel 1965, 1970–1985, unpublished; Mau 1980; Dorka and Stadelmaier 1991; Hölzinger and Dorka 1997; V. Dorka in Glutz von Blotzheim and Bauer 1997; Förschler 2001, and personal observation; U. Dorka, personal communication

Table 2 Annual food composition of citril finches *Serinus citrinella* in the Black Forest

Plant species	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Sources
<i>Agrostis tenuis</i>							•						KS
<i>Alchemilla vulgaris</i>								•					KS
<i>Alnus viridis</i>										•			KS
<i>Alopecurus pratensis</i>						•	•	•					VD, MF, KM, KS
<i>Anthoxanthum odoratum</i>						•	◆	•					VD, MF, KS
<i>Arnica montana</i>							•	•					KS
<i>Betula pendula/Betula pubescens</i>							•	•	•	•			MF, KS
<i>Carex canescens</i>							•						KS
<i>Carex pilulifera</i>							•	•					MF
<i>Chenopodium album</i>									•				KS
<i>Chrysanthemum leucanthemum</i>								•					VD, MF
<i>Cirsium vulgare</i>							•						MF
<i>Dactylis glomerata</i>						•	•	•					KS
<i>Dactylis polygama</i>								•					KM
<i>Filipendula spec.</i>										•			KS
<i>Gentiana lutea</i>						•	•						KS
<i>Glyceria fluitans</i>								•					KM
<i>Hieracium lachenalii</i>							•	•	•				VD, MF, KM
<i>Hieracium laevigatum</i>								•					KS
<i>Hieracium spec.</i>						•	•						HS
<i>Holcus lanatus</i>							•						VD
<i>Hypochoeris radicata</i>							•	•	•				MF, KM, KS
<i>Juncus effusus</i>										•			KS
<i>Juncus squarrosus</i>									•	•			KS
<i>Knautia selvatika</i>								•					KS

Table 2 (continued)

Plant species	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Sources
<i>Leontodon autumnalis</i>								•	•				MF, KM, KS
<i>Leontodon helveticus</i>							•	•					MF, KM, KS
<i>Leontodon hispidus</i>							•	•					MF
<i>Matricaria discoidea</i>								•	•				MF, KM
<i>Molinia arundinacea</i>									•				UD, VD
<i>Myosotis spec.</i>								•					KS
<i>Phalaris arudinacea</i>								•					KS
<i>Phleum pratense</i>							•	•					KS
<i>Phleum spec.</i>								•					KS
<i>Picea abies</i>							•			•	•	•	MF
<i>Pinus mugo</i>	◆	◆	◆	◆	◆	◆	•	•	•	•	◆	◆	UD, VD, MF, HS
<i>Pinus sylvestris</i>		•	•	•	•								VD, MF, HS, CL
<i>Poa annua</i>					•	◆	◆	•	•				MF, KS
<i>Poa pratensis</i>							•	•					MF, KM, KS
<i>Polygonum aviculare</i>									•				MF
<i>Potentilla erecta</i>							•	•					MF
<i>Ranunculus aconitifolius</i>							•	•					MF, KS, KM
<i>Ranunculus polyanthemus</i>							•	•					KS, KM
<i>Rumex acetosa</i>					•	◆	◆	•					VD, HS, KM, KS
<i>Rumex acetosella</i>					•		•		•	•			VD, MF, KS
<i>Rumex alpinus</i>							•	•					KM, KS
<i>Sanguisorba officinalis</i>							•	•					MF
<i>Sorbus aucuparia</i>				•									MF
<i>Stellaria graminea</i>							•						MF
<i>Stellaria media</i>				•									MF
<i>Taraxacum officinale</i>					•	◆	•						VD, MF, KS
<i>Teucrium scorodonia</i>	•	•	•	◆				•	◆	•	•	•	UD, VD, MF, CL
<i>Thymus serpyllum</i>								•					KS
<i>Tussilago farfara</i>					•								MF
Insectivorous food													
<i>Aphidina</i>						◆	◆						MF
<i>Coleophoridae</i>										•			VD
<i>Psyllina</i>					•								MF

Juncus effusus and *Juncus squarrosus*: It is not clear if the birds feed on the seeds of the genus *Juncus* because observational data suggest that they may forage on the case bearer larvae (*Coleophoridae*) that are wrapped in the larval sacculus in the *Juncus* species (V. Dorka, personal communication) rather than on seeds. • At least one record; ◆ more than 20 records. Sources: UD U. Dorka, personal communication; Hölzinger and Dorka 1997/VD Dorka and Stadelmaier 1991, V. Dorka in Glutz von Blotzheim and Bauer 1997; MF Förschler 2001, and personal observation; KS Sabel 1965, 1970–1985, unpublished; HS H. Schneider in Hölzinger and Dorka 1997; CL Landbeck 1834, 1846; KM Mau 1980)

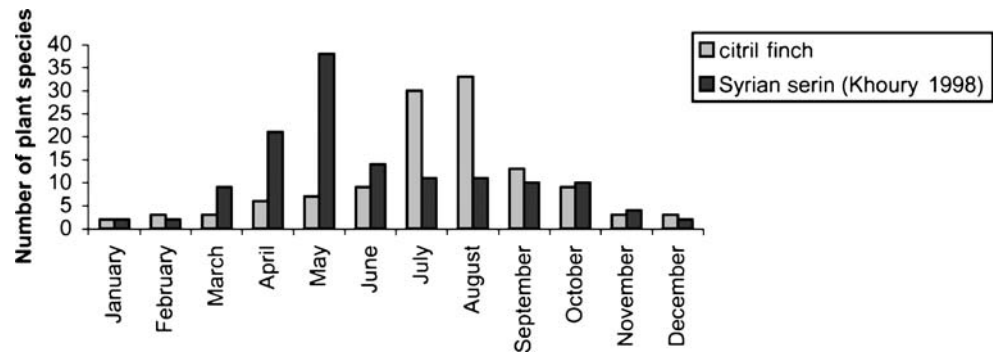
Kalko 2006) are summarized to illustrate the change from a rather monotonous to a more diversified diet selection in citril finches throughout the year in context of the species biology. The data were compared with the published information about annual changes in diet composition in some other finches, in particular, Syrian serin *Serinus syriacus*, greenfinch *Carduelis chloris*, linnet *Carduelis cannabina*, and goldfinch *Carduelis carduelis* (Newton 1967; Glück 1980a,b; Khoury 1998, 2003).

Results

Up to now a total of 54 plant species from 15 families were noted as food source of citril finches in the Black Forest

(Tables 1 and 2). Furthermore, a few insects of three orders (*Psyllina*, *Aphidina*, *Lepidoptera*) have been also observed in their diet (Table 2). The number of food plants used by citril finches show large seasonal variations with a maximum of 33 species in July and only two species in January (Table 1). Mountain pine seeds (family Pinaceae) play a key role as an all-year-round food resource with a peak in winter and spring. Moreover, the germander *Teucrium scorodonia* seems to be of particular importance in winter (Table 2). In summer and autumn, citril finches nourish mainly from seeds of herbs and grasses of the families *Gramineae* and *Compositae* (Table 1). The food selection of citril finches shows, similar to the one of Syrian serins, a much larger seasonal variation as compared with other *Carduelis* species (Figs. 1 and 2).

Fig. 1 Annual diet composition of the mountain-dwelling citril finches *Carduelis citrinella* (this study) and Syrian serins *Serinus syriacus* (Khouri 1998, 2003) given as number of plant species per month with seeds consumed by the finches



Discussion

Borras et al. (2003) distinguish in the Catalanian pre-Pyrenees three periods of diet composition for citril finches: first, an “arvensis” period from November to January where birds feed mainly on the goosefoot *Chenopodium*; second, an “arboreal” period from February to May with the main food plants being the black pine *Pinus nigra* and the mountain pine; and third, a “pratensis-ruderal” period from June/July to October with preference for seeds of herbs and grasses. Similarly, the annual diet composition in the Black Forest may be divided into three phases in relation to the species’ biology: (1) In the wintering period from November to March—period of food restriction—a few plants provide sufficient food for citril finches, and birds forage predominantly on seeds of the mountain pine and the germander (Förschler 2001). Up to now, only four food plants could be verified for this period. (2) During the breeding season from April to June—period of food specialization—the birds feed on a combination of few abundant and temporarily alternating key species of high nutritional value, an observation that has also been made for the serin *Serinus serinus* (Valera et al. 2005). The seeds of mountain pines in April and May, dandelion in May, common sorrel in May and June, and vernal grass in June are predominantly taken (Förschler 2001). (3) Finally, in the postbreeding period from June/July to October—period of food generalization—citril finches form larger flocks and feed on a great variety of herbs and grasses with half-ripe seeds (Sabel 1965; Mau 1980).

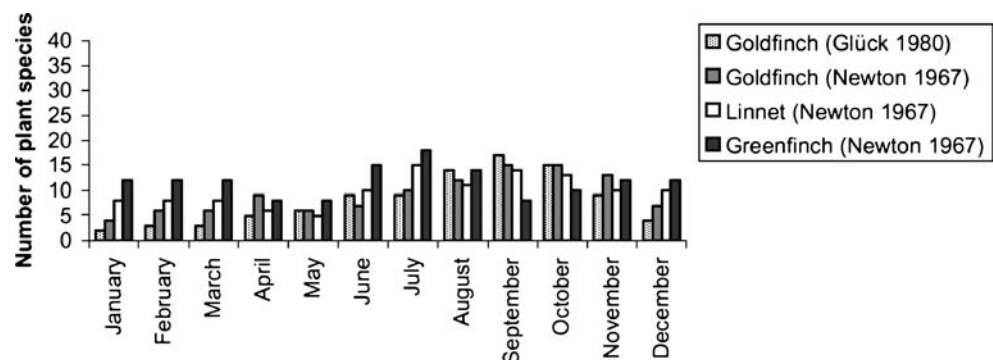
Additionally in autumn, the larvae of the case bearers of the genus *Coleophora* may also provide a major part of the daily food intake (V. Dorka, personal communication).

Thus, citril finches are switching in their annual diet composition from a clearly “unilateral” feeding behaviour with only few feeding plants per month to a “multilateral” feeding behaviour with a large variety of feeding plants per month. The morphologically similar Syrian serin in Jordania, a species that is also restricted to few mountainous areas, shows a very similar food selection pattern (Khouri 1998, 2000, 2003). Syrian serins depend in winter (December/January) almost exclusively on seeds of the mugwort species *Artemisia sieberi* that constitutes up to 96–99% of their food. However, whereas the greatest variation in feeding plants of Syrian serins is found during the breeding season (Khouri 1998, 2000, 2003), citril finches show the largest variation in summer after the breeding season.

Characteristic changes in the diet composition in time and space may be found also for other European finches of the genus *Carduelis*, such as greenfinches, linnets, and goldfinches (Newton 1967; Glück 1980a,b; Frey 1989a,b), but the seasonal variation between the “specialist” and “generalist” diet selection is less pronounced than in citril finches and Syrian serins. Obviously, both mountain-dwelling species show a higher seasonal variability in the food selection than do the three “lowland” *Carduelis* species.

Although food selection behaviour may evolve quickly, the ambivalence of the citril finch diet is of particular interest, as it reflects somehow the ongoing uncertainty

Fig. 2 Annual diet composition of the goldfinches *Carduelis carduelis*, the greenfinches *Carduelis chloris*, and the linnets *Carduelis cannabina* (Newton 1967; Glück 1980b) given as number of plant species per month with seeds consumed by the finches



about the taxonomical status of the species within the *Serinus* or *Carduelis* complex (Nicolai 1957; Arnaiz-Villena et al. 1998, 1999; van den Elzen and Khoury 1999; Zamora et al. 2006). Being regarded as a *Serinus* species for a long time, the citril finch has recently been allocated to belong to the genus *Carduelis* due to mitochondrial phylogenetics (Arnaiz-Villena et al. 1998, 1999; Zamora et al. 2006). On one hand, the preference in summer for seeds of grasses and herbs such as the composites *Asteraceae*, sweet grasses *Poaceae*, knotweed *Polygonaceae*, goosefoot *Chenopodiaceae*, mugwort *Artemisia*, and shepherd's purse *Capsella* resembles the typical diet of the *Serinus* species (Eber 1956; Newton 1985; Fey 1990; Cramp and Perrins 1994; Glutz von Blotzheim and Bauer 1997; Khoury 1998, 2003). On the other hand, the extensive use of pine seeds by citril finches is rather exceptional amongst the *Serinus* group. Temporarily, citril finches behave more like food specialists for seeds of mountain pines (Förschler 2001), similar to the common crossbills *Loxia curvirostra* and siskins *Carduelis spinus* (Förschler et al. 2006). The long and sharp bill of the citril finch, which is more alike to that of the goldfinch and the siskin than to the *Serinus* species, is well suited for both fetching pine seeds out of semi-open cones and for opening the flower calyx of composites, as well as for separating grass seeds from glumes.

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