Diet Composition of the Canary Islands Stonechat *Saxicola dacotiae* (Meade-Waldo, 1889) on Fuerteventura

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> Abstract

The diet of Canary Islands Stonechat was determined by faeces analysis and the identification of prey fragments (invertebrates) of diverse breeding sites on Fuerteventura (Canary Islands). In the faecal samples a total of 1374 prey items was identified. They represent a broad dietary spectrum (at least 12 orders and around 30 families of arthropods) in which Hymenoptera and Coleoptera (most importantly Formicidae and Curculionidae) quantitatively dominate. Approximately half of all prey items identified had a body length of less than 4 mm, and almost 80 % less than 6 mm. Prey species, and their sizes, differ between individuals as well as between various areas and times. Probably in connection with the low biomass of the prey animals, extended energy-consuming hopping along the ground [patrolling] was rarely observed as a foraging technique. The consumption of berries (*Lycium intricatum*) represents a supplement to the diet. Within the range of prey size that is morphologically possible and energetically profitable for the Canary Islands Stonechat, the species takes, depending on the immediate environmental conditions, principally small to very small items. Compared with the size of prey taken by adults, the young are fed relatively large items. The reasons for the small size of this chat's prey animals are thought to be the limited arthropod food supply in extreme and arid climatic conditions, as well as competition pressure from other passerines. The relatively long bill (compared with other chats *S. rubetra, S. torquata*) could be interpreted as an ecomorphological adaptation enabling the species to occupy this niche.

> Kurzfassung

Die Kotproben des auf Fuerteventura (Kanarische Inseln/Spanien) endemischen Kanarenschmätzers *Saxicola dacotiae* wurden analysiert und insgesamt 1374 Beutetiere nachgewiesen. Sie repräsentieren ein breites Nahrungsspektrum (mindestens 12 Ordnungen und etwa 30 Arthropoden-Familien) in dem Hymenopteren und Coleopteren (vor allem Formicidae und Curculionidae) quantitativ herausragen. Etwa die Hälfte aller nachgewiesenen Beutetiere besitzen Körperlängen von weniger als 4 mm, fast 80 % sind unter 6 mm. Sowohl Beuteart als auch deren Größe differieren sowohl zwischen Individuen als auch den verschiedenen Gebieten und unterschiedlichen Zeiten. Wahrscheinlich im Zusammenhang mit der geringen Biomasse der Beutetiere wurde energieaufwendiges Umherhüpfen auf dem Boden („Streifsuche") seltener als Jagdmethode beobachtet. Die Aufnahme von Beeren (*Lycium intricatum*) stellt eine Nahrungsergänzung dar. In der Spanne der für die Kanarenschmätzers morphologisch möglichen und energetisch profitablen Beutetiergrößen nutzen sie unter den gegebenen Umweltbedingungen vorwiegend kleine bis sehr kleine Beute. An Jungvögel werden im Verhältnis zur Altvogelnahrung relativ größere Beutetiere verfüttert. Geringes Beutetierangebot unter den extremen, ariden Klimabedingungen sowie Konkurrenzdruck anderer Passeriformes werden als Ursachen für die kleinen Beutetiere angenommen. Ein im Verhältnis zu anderen Schmätzern (*S. rubetra, S. torquata*) relativ längerer Schnabel kann als ökomorphologische Anpassung gedeutet werden, die es ihnen erlaubt, diese Nische zu besetzen.

> Key words

Prey selection, prey size, faeces analysis, Canary Islands stonechat, *Saxicola dacotiae*, Fuerteventura.

Introduction

The Canary Islands Stonechat *Saxicola dacotiae* is endemic to the Canary Islands, today occurring only on the island of Fuerteventura. Although the relatively small population of an estimated 650 to 850 (1300)

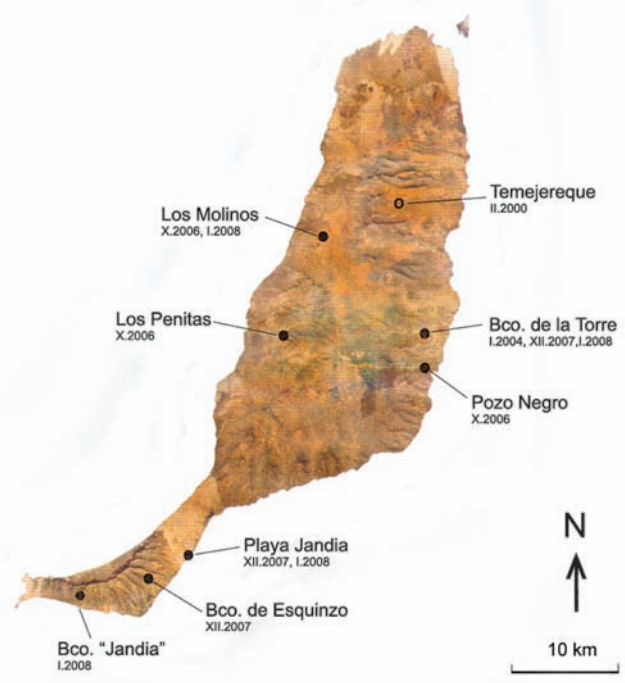

Fig. 1. Fuerteventura – overview of collecting sites and dates of Canary Islands Stonechat *S. dacotiae* faecal samples used in evaluation of diet analysis.

breeding pairs (BIBBY & HILL 1987, ANTONIO & GUTIÉRREZ 1997, MARTIN & LORENZO 2001, COLLAR 2005) is still widely distributed across the island, due to the species' habitat requirements (stony hill slopes, *barrancos*) it does not occur everywhere (ILLERA 2001). It is very probable that there has been a decline in numbers in the past two decades because of habitat destruction or alteration, though so far this has not been quantitatively confirmed. The situation of the Canary Islands Stonechat has led to both increased interest in the bird and a rise in the number of ecological studies. These have resulted in a change in the threat category of the species from 'Near-threatened' to 'Endangered' (BIRDLIFE INTERNATIONAL/EBCC 2000, ILLERA 2004b, COLLAR 2005, ILLERA *et al*. 2006). To ensure the preservation of this stonechat, protective measures are increasingly necessary.

A prerequisite of constructive species protection is extensive knowledge of the biology and ecology of the species in question. So in this case, it is very surprising that up until now no practically relevant information or quantitative statements on the diet of *S. dacoctiae* have been produced. The published information on the matter appears to be mainly repetition of findings that are based on the chance observations of a few authors in the past (BANNERMAN 1963, COLLINS 1984, CRAMP 1988, MARTIN & LORENZO 2001, URQUHART 2002, ILLERA *et al*. 2006). No detailed studies have been made until now. The results presented here are the first qualitative and quantitative data on the diet of *S. dacotiae*.

Material and Methods

This study was based on the analysis of faecal samples that were collected in 8 different breeding areas on Fuerteventura (see Fig. 1). In these 8 places we take altogether k = 255 faeces out of at least 13 different territories (= pairs) after watching stonechats on their perches (see Fig. 2 and 5). This was preceded by experience gained in several short trips to the Canary Islands, during which particular observations were made of the feeding ecology of *Saxicola dacotiae* and *Lanius meridionalis* (*cf*. GRIMM 2005, NICOLAI *et al*. 2006).

Analysis of the samples was carried out using a stereomicroscope. For this, the dried sample was dispersed in diluted alcohol or in water, then examined at a magnification of 6-10x (up to 40x) for identifiable invertebrate or plant remains. Based on these specific parts (e.g. heads, mandibles, elytra), which were separated using fine tweezers and dissecting needles then counted, a quantitative determination of the prey arthropods was possible.

Identification of the food remains was made using specialist literature in the entomological collection of the Natural History Museum in Erfurt (e.g. RALPH *et. al*. 1985, MOREBY 1988, JENNI *et al*. 1990, COSTA *et al*. 2006). In addition, a reference collection of arthropod fragments (identified at least to genus level by various specialists) from pellets of the Canary Islands subspecies of the Southern Grey Shrike from Fuerteventura was used, which had been collected in the course of an earlier study (GRIMM 2005, which see for details).

The size (length) of identified prey had to be estimated on the basis of the fragments, which had survived to very differing degrees, whereby their body proportions and corresponding known reference material were taken into account (*cf*. ROGERS *et al*. 1977, CALVER & WOOLLER 1982, NICOLAI 1992, 1998). Possible estimation errors were mostly smoothed out by the data being divided into length classes.

Results

A total of n = 1374 prey items from the collected faecal samples was analysed. They came from at least 12 orders and more than 30 invertebrate families, and represented the broad dietary spectrum of the Canary Islands Stonechat (Tab. 1). Two orders were found to be of particular importance: Hymenoptera (46 %, including ants/Formicidae with 37 %) and Coleoptera (>26 %, including weevils/Curculionidae with 11 %).

Fig. 2. Barranco la Torre – view into a territory of Canary Islands Stonechat with faeces (arrows) at a perch on rock. Photo: 28.12.2007.

Fig. 3. View into a territory of Canary Islands Stonechat at Playa Jandia. Photo: 29.12.2007.

Fig. 4. View into a territory of Canary Islands Stonechat at Barranco Jandia; the tops of rare endemic *Euphorbia handiensis* are also used as perches. Photo: 02.01.2008.

Fig. 5. Barranco la Torre – a ringed male of Canary Islands Stonechat at the perch on a rock (arrows pointed to faeces). Photo: 03.01.2008.

Also of significance, above all because of their greater body mass, were the bugs/Hemiptera and Heteroptera (6.9 %) and the unspecifically categorised group of the larvae (4.4 %). All other families were represented by less than 2–3 %, with the exception of the mainly very small cicadas.

The lengths of the prey items are set out in Tab. 2, showing that the stonechat preys on mostly (very) small arthropods. Almost half of all items had a body length of less than 4 mm and almost 80 % are under 6 mm (Fig. 6). There are some differences between the individual sites regarding both prey species and size (Tab. 1). For example, the proportion of ants ranges from 26% (Boca de Esquinzo) to almost 52 % (Los Molinos, Pozo Negro), or that of weevils from just less than 4 % (Los Penitas) to nearly 47 % (Boca de Esquinzo). Also the mean prey length ranged considerably, from 3.1 mm (Boca de Esquinzo) to 5.7 mm (Boca/Jandia) (Tab. 2).

Since material was collected several times at a particular spot in Boca la Torre, the results can be summarised according to various criteria. Firstly, faecal samples from territories immediately adjacent to each other were analysed separately. The results (Tab. 3) (divided into the most important prey groups: ants, beetles, larvae, others) differ considerably from each other ($\chi^2 = 14.36$; $p<0.01$). Even the mean lengths of the invertebrates vary by about 20 % (Fig. 7).

Separation of the results on the basis of three different collection dates is shown in Tab. 4. Here too the differences in the qualitative composition are substantial ($\chi^2 = 71.35$; $p<0.001$), although the samples are from the same season. In particular, the share of the Formicidae, Homoptera, and Heteroptera vary considerably. The mean body lengths of the prey items differ from each other by around 30 % (Fig. 8).

Apart from arthropod remains, 23 seeds of berries were found in the faecal samples. These came from at

Tab. 1. Diet analysis from faecal samples of Canary Islands Stonechat (overview).

Prey	Boca laTorre (k = 157)		Los Molinos (k = 18)		Pozo Negro (k = 15)		BocadeEscquinzo (k = 17)		Boca /Jandia (k = 24)		Playa Jandia (k = 39)		Los Penitas (k = 21)		Total (k = 291)	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Collembola	**3**	***0,4***	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**3**	***0.2***
Formicidae (ants)	239	*35.4*	60	*51.7*	50	*51.5*	25	*26,0*	48	*45.3*	62	*34.4*	30	*28.8*	514	*37.4*
Hymenoptera (without ants)	70	*10.4*	7	*6.0*	5	*5.2*	6	*6,2*	5	*4.7*	23	*12.8*	4	*3.8*	120	*8.7*
Hymenoptera (total)	**309**	***45.8***	**67**	***57.8***	**55**	***56.7***	**31**	***32,3***	**53**	***50.0***	**85**	***47.2***	**34**	***32.3***	**634**	***46.1***
Neuroptera	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**1**	***0.9***	**–**	**–**	**–**	**–**	**1**	***0.1***
Homoptera	**46**	***6.8***	**–**	**–**	**4**	***4.1***	**-**	**-**	**1**	***0.9***	**11**	***6.1***	**8**	***7.7***	**70**	***5.1***
Heteroptera	**64**	***9.5***	**–**	**–**	**9**	***9.2***	**6**	***6,2***	**6**	***5.7***	**11**	***6.1***	**9**	***8.7***	**95**	***6.9***
Saltatoria	**8**	***1.2***	**–**	**–**	**–**		**–**	**–**	**–**	**–**	**1**	***0.6***	**8**	***7.7***	**17**	***1.2***
Diptera	**10**	***1.5***	**–**	**–**	**1**	***1.0***	**–**	**–**	**–**	**–**	**2**	***1.1***	**12**	***11.5***	**25**	***1.8***
Carabidae	3	*0.4*	–	–	1	*1.0*	–	–	1	*0.9*	–	–	–	–	5	*0.4*
Curculionidae	55	*8.1*	10	*8.6*	2	*2.1*	45	*46,9*	22	*20.8*	17	*9.4*	4	*3.8*	155	*11.3*
Coccinellidae	–	–	1	*0.9*	–	–	1	*1,0*	–	–	–	–	–	–	2	*0.1*
Chrysomelidae	3	*0.4*	12	*10.3*	–	–	–	–	–	–	1	*0.6*	2	*1.9*	18	*1.3*
Hydrophilidae	–	–	–	–	–	–	–	–	–	–	–	–	1	*1.0*	1	*0.1*
Staphylinidae	2	*0.3*	–	–	1	*1.0*	–	–	–	–	3	*1.7*	2	*1.9*	8	*0.6*
Tenebrionidae	10	*1.5*	–	–	12	*12.3*	–	–	1	*0.9*	1	*0.6*	–	–	24	*1.8*
Scarabaeidae	13	*1.9*	2	*1.7*	5	*5.2*	–	–	–	–	7	*3.9*	–	–	27	*2.0*
Elateridae	1	*0.1*	–	–	–	–	–	–	–	–	–	–	–	–	1	*0.1*
Coleoptera (indet.)	61	*9.0*	17	*14.7*	2	*2.1*	8	*8,3*	10	*9.4*	19	*10.6*	5	*4.8*	122	*8.9*
Coleoptera (total)	**148**	***21.9***	**42**	***36.3***	**23**	***23.7***	**54**	***56,2***	**34**	***32.1***	**48**	***26.7***	**14**	***13.5***	**363**	***26.4***
Lepidoptera	**–**	**–**	**–**	**–**	**1**	***1.0***	**–**	**–**	**1**	***0.9***	**–**	**–**	**–**	**–**	**2**	***0.1***
Coleoptera larv.	10	*1.5*	–	–	–	–	–	–	–	–	–	–	–	–	10	*0.7*
Lepidoptera larv.	3	*0.4*	2	*1.7*	–	–	–	–	–	–	–	–	–	–	5	*0.4*
Insects-Larvae (indet.)	27	*4.0*	–	–	2	*2.1*	4	*4,2*	4	*3.8*	4	*2.2*	5	*4.8*	46	*3.3*
Insects – Larvae (total)	**40**	***5.9***	**2**	***1.7***	**2**	***2.1***	**4**	***4,2***	**4**	***3.8***	**4**	***2.2***	**5**	***4.8***	**61**	***4.4***
Insects (indet.)	**22**	***3.3***	**2**	***1.7***	**1**	***1.0***	**1**	***1,0***	**4**	**–**	**7**	***3.9***	**3**	***2.9***	**40**	***2.9***
Pseudoscorpion	2	*0.3*	1	*0.9*	–	–	–	–	–	–	1	*0.6*	1	*1.0*	5	*0.4*
Acari	1	*0.1*	–	–	–	–	–	–	–	–	–	–	–	–	1	*0.1*
Araneae	18	*2.7*	1	*0.9*	–	–	–	–	2	*1.9*	7	*3.9*	9	*8.7*	37	*2.7*
Opiliones	1	*0.1*	1	*0.9*	–	–	–	–	–		–	–	–	–	2	*0.1*
Arachnida (total)	**22**	***3.3***	**3**	***2.6***	**–**	**–**	**–**	**-**	**2**	***1.9***	**8**	***4.4***	**10**	***9.6***	**45**	***3.3***
Lithobiidae	**2**	***0.3***	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**1**	***1.0***	**3**	***0.2***
Isopoda	**–**	**–**	**–**	**–**	**1**	***1.0***	**–**	**–**	**–**	**–**	**3**	***1.7***	**–**	**–**	**4**	***0.3***
Diplopoda	**1**	***0.1***	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**1**	***0.1***
Total	**675**	***100***	**116**	***100***	**97**	***100***	**96**	***100***	**106**	***100***	**180**	***100***	**104**	***100***	**1374**	***100***
Berries (in k = 13) indet.	**4 ×**		–		**2 ×**		**–**		–		–		–		**6 ×**	
Lycium intricatum	**10 ×**		–		–		**4 ×**		–		**3 ×**		–		**17 ×**	

More detailed: Hymenoptera: Tenthredinidae (2 ×), Braconidae (9 ×), Chrysididae (7 ×), Apidae spp. (4 ×), *Lasioglossum* spec. (1 ×), Vespidae (1 ×), Ichneumonidae, Formicidae (*Messor* sp., *Camponotus* sp., *Tetramorium* sp.)
Heteroptera: Tingidae (mind. 10 ×), *Noualhieria quadripunctata* (> 15 ×)
Homoptera: Cicadellidae (mind. 1 ×), Dictyopharinae
Coleoptera: Chrysomelidae: *Aphtona* spec., *Lema* spec., Hydrophilidae: *Enochrus* spec., Tenebrionidae: *Arthrodeis* spec., *Zophosis* spec., *Hegeter* spec., *Pimelia* spec.

Tab. 2. Distribution of Canary Island Stonechat prey lengths.

Prey lengths	Boca laTorre		Los Molinos		Pozo Negro		Boca de Escquinzo		Boca /Jandia		Playa Jandia		Los Penitas		Total	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
– 2 mm	44	*8.6*	6	*5.8*	15	*15.5*	6	*7.2*	–	–	9	*8.5*	21	*30.4*	**101**	***9.7***
– 4 mm	220	***43.1***	36	*35.0*	46	***47.4***	39	***47.0***	17	*23.3*	33	*31.1*	15	***21.7***	**406**	***39.0***
– 6 mm	144	*28.2*	33	***32.0***	19	*19.6*	28	*33.7*	37	***50.7***	32	***30.2***	19	*27.5*	**312**	***29.9***
– 8 mm	57	*11.2*	18	*17.5*	12	*12.4*	6	*7.2*	12	*16.4*	22	*20.8*	10	*14.5*	**137**	***13.1***
– 10 mm	24	*4.7*	7	*6.8*	4	*4.1*	1	*1.2*	2	*3.0*	5	*4.7*	1	*1.4*	**44**	***4.2***
> 10 mm(– 20 mm)	22	*4.3*	3	*2.9*	1	*1.0*	3	*3.6*	5	*6.8*	5	4.7	3	*4.3*	**42**	***4.0***
Total	511	***100***	103	***100***	97	***100***	83	***100***	73	***100***	106	***100***	69	***100***	**1042**	***100***

least 17 berries of *Lycium intricatum*. The remaining six could not be further determined. The ripe berries of *Lycium* are normally red in colour and were clearly eaten deliberately by the Canary Islands Stonechats. They were therefore a welcome supplement to their diet.

After all, the nestlings require energy-rich (large), but also soft-bodied items. We were able to confirm this to some extent by the analysis of four faecal samples from newly-fledged young (22 February 2000, Temejereque; leg. Nicolai). The prey identified therein (n = 27) was on average substantially larger than that taken by adult birds (*cf*. Fig. 9). For instance, ants given to the young were *ca*. 40 % larger than those found in adult faecal samples from January 2004 (*cf*. Tab. 5).

Discussion

As far as we are aware, this work is the first qualitative and quantitative study on the diet of *S. dacotiae*. Hence our analysis of collected faecal samples represents the first meaningful data on the food of this bird species.

Although the samples come from a relatively restricted seasonal period (October and especially end of December/January), they were collected in three different years and in widely separated parts of the island. Hence the data presented are from a variety of territories and breeding pairs, as well as very different sites (Fig. 1) but similar habitats (see Fig. 2 to 5).

Phenologically, the sampling was carried out in the pre-breeding period, the breeding season of the chat beginning very early in the year (Bergmann 2003), with regular first clutches found from the end of January. However this varies with the time and extent of the late autumn and winter rains, which trigger vegetation growth and the start of the new food chain, from December to the beginning of February (Müller 1999, Urquhart 2002, Illera 2004a, b). Via the food supply, the rains ultimately influence the size and number of broods (Illera & Diaz 2006, 2008).

The qualitative results (Tabs. 1–4) show a broad dietary spectrum of chiefly (very) small arthropods, less than 4 mm in length, indicating a relatively non-specific choice of food. The studies of Illera (2001, 2004b) und Illera *et al*. (2006) confirm the mostly meagre food resources and the small size of the potential prey species available in the Canary Islands Stonechat territories on Fuerteventura. This food resource is even poorer on the island of Lanzarote, where the stonechat formerly bred, and so was perhaps insufficient to sustain the population. The extremely dry habitats can

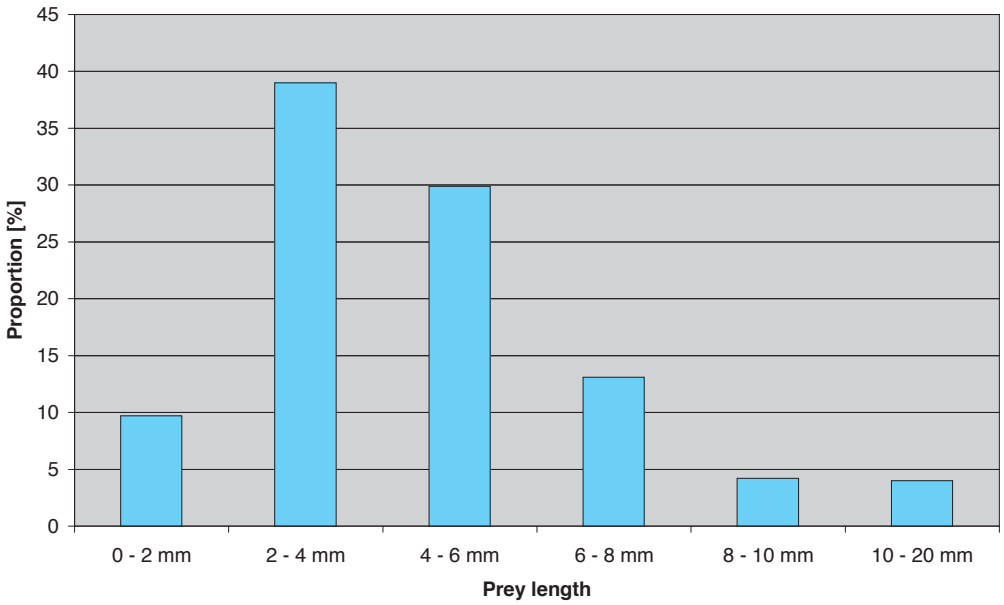

Fig. 6. Distribution of Canary Island Stonechat prey lengths (n=1042).

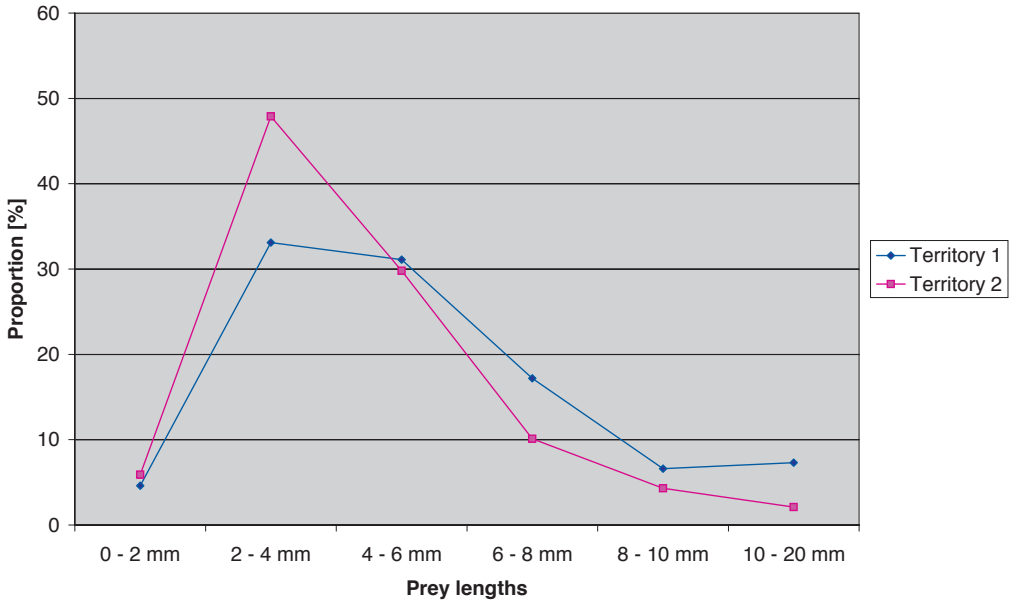

Fig. 7. Comparison of prey lengths in two immediately adjacent territories (Boca la Torre / 28.12.2007, 03.01.2008); Terr. 1: n = 151, Terr. 2: n = 188.

hardly support larger arthropod prey. In addition, even for the smallest food items there will be competition pressure from the common Berthelot's Pipit *Anthus berthelotii* and probably also from lizards *Gallotia* sp. The more profitable large arthropod prey animals (e.g. beetles Tenebrionidae, Scarabaeidae) are either too big for the chat to deal with or are preferentially predated by the local Southern Grey Shrike *Lanius meridionalis koenigi* (*cf*. GRIMM 2005, PADILLA *et al*. 2005).

S. dacotiae is a typical perch forager, spotting prey from a raised perch (bush, rock, etc.) then seizing it in the bill after a brief sallying flight in the air, or following a pounce after a swoop to the ground (ILLERA 2004b, 2006). Prey is taken most commonly on the ground or from short vegetation. In the open the birds land mostly on both feet (see Fig. 10), then they can pursue their prey with rapid further hops before picking it up and returning to the original perch or flying to a new one. Hopping around on the ground for any length of time ('patrolling'), in the manner of Northern Wheatear *O. oenanthe* and Black Redstart *Phoenicurus ochruros* (KNEIS & LAUCH 1983, NICOLAI 1992), appears to be less frequently used as a search strategy by Canary Islands Stonechat. However no quantitative observations of the species' foraging behaviour have been made. Also, it is to be expected that this chat is

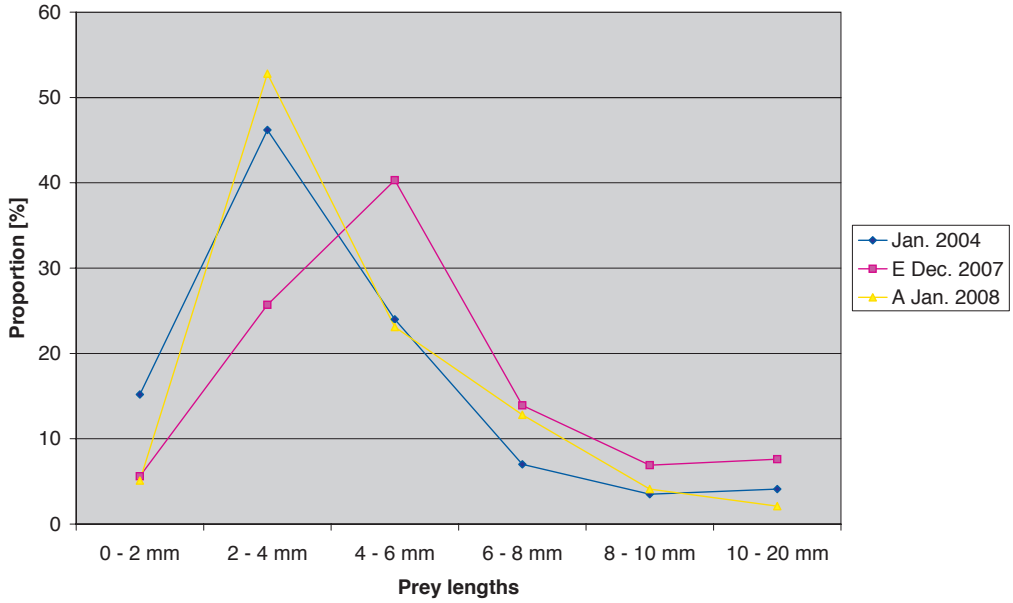

Fig. 8. Comparison of samples from territories at one site (Boca la Torre) at different times (2004: n = 171, 2007: n = 144, 2008: n=195).

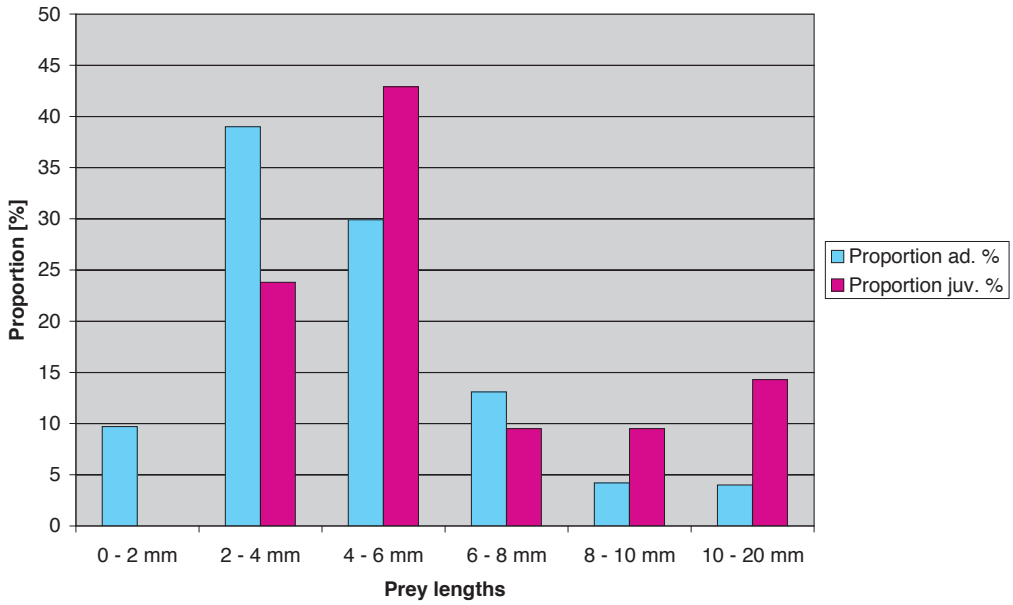

Fig. 9. Comparison of length of prey taken by adult birds (see Fig. 2) with that fed to newly fledged young (n = 27).

quick to adapt and to employ various feeding techniques depending on circumstances, as do Whinchat *S. rubetra* and Common Stonechat *S. torquata* (Moreno 1984, Glutz von Blotzheim & Bauer 1988, Bastian & Bastian 1996).

For the Canary Islands Stonechat, the low biomass of its small prey requires a relatively large effort in energy and time during foraging. In addition, they cannot afford to be discriminating in their choice of prey, given the habitat's poor food supply and the pressure from food competitors. In this regard, the conditions on the island of Fuerteventura, far from major migration routes, are quite different from those on Mediterranean islands with respect to the supply and range of food available to breeding birds and passage migrants (Marchetti *et al*. 1996, 1998). On the other hand, the fact that *S. dacotiae* occurs here at all is perhaps evidence of a successful adaptive strategy to extreme conditions. The other two congenerics, *S. rubetra* and *S. torquata*, more or less identical in size, catch and eat as a rule clearly larger prey (Flinks & Pfeifer 1987, Martinez-Cabello et al. 1991, Bastian & Bastian 1996, Revaz *et al*. 2008). The habitats of the Canary Islands appear to be quite unsuitable for these two species just for that reason, hence they are relatively rare even as migrants or visitors (Martin &

Tab. 3. Comparison of two immediately adjacent territories at one site (Boca la Torre / 28.12.2007, 03.01.2008).

Prey	Territory 1 (k = 49)		Territory 2 (k = 57)	
	n	%	n	%
Collembola	**–**	**–**	**3**	***1.3***
Formicidae (Ants)	63	*34.4*	121	*52.8*
Hymenoptera (without Ants)	20	*11.0*	24	*10.5*
Hymenoptera (total)	**83**	***45.4***	**145**	***63.3***
Homoptera	**1**	***0.6***	**4**	***1.7***
Heteroptera	**15**	***8.3***	**15**	***6.6***
Saltatoria	**1**	***0.6***	**1**	***0.4***
Diptera	**4**	***2.2***	**–**	**–**
Carabidae	2	*1.1*	1	*0.4*
Curculionidae	21	*11.6*	11	*4.8*
Elateridae	–	–	1	*0.4*
Tenebrionidae	4	*2.2*	6	*2.6*
Scarabaeidae	8	*4.4*	4	*1.7*
Coleoptera (indet.)	19	*10.5*	20	*8.7*
Coleoptera (total)	**54**	***29.8***	**43**	***18.8***
Insects (indet.)	**3**	***1.7***	**1**	***0.4***
Insects-Larvae (indet.)	**13**	***7.2***	**11**	***4.8***
Arachnida	**6**	***3.3***	**6**	***2.6***
Diplopoda	**1**	***0.6***	**–**	**–**
Total	**181**	***100***	**229**	***100***

Tab. 4. Comparison of samples from territories at one site (Boca la Torre) at different times.

Prey	Jan. 2004 (k = 51)		28.12.2007 (k = 45)		03.01.2008 (k = 61)	
	n	%	n	%	n	%
Collembola	**–**		**3**	***1.4***	**–**	**–**
Formicidae (ants)	55	*20,8*	87	*40.5*	97	*49.7*
Hymenoptera (without ants)	26	*9,8*	28	*13.0*	16	*8.2*
Hymenoptera (total)	**81**	***30.6***	**115**	***53.5***	**113**	***57.9***
Homoptera	**41**	***15.5***	**–**	**–**	**5**	***2.6***
Heteroptera	**34**	***12.8***	**22**	***10.2***	**8**	***4.1***
Saltatoria	**6**	***2.3***	**–**	**–**	**2**	***1.0***
Diptera	**6**	***2.3***	**2**	***0.9***	**2**	***1.0***
Carabidae	—	—	2	*0.9*	1	*0.5*
Curculionidae	23	*8.7*	19	*8.8*	13	*6.7*
Elateridae	—	—	—	—	1	*0.5*
Chrysomelidae	3	*1.1*	—	—	—	—
Staphylinidae	2	*0.8*	—	—	—	—
Tenebrionidae	—	—	—	—	10	*5.1*
Scarabaeidae	1	*0.4*	5	*2.3*	7	*3.6*
Coleoptera (indet.)	22	*8.3*	27	*12.6*	12	*6.2*
Coleoptera (total)	**51**	***19.2***	**53**	***24.7***	**44**	***22.6***
Insects (indet.)	**18**	***6.8***	**4**	***1.9***	**–**	**–**
Insects - Larvae (indet.)	**16**	***6.0***	**9**	***4.2***	**15**	***7.7***
Arachnida	**10**	***3.8***	**7**	***3.3***	**5**	***2.6***
Lithobiidae	**2**	***0.8***	**–**	**–**	**–**	**–**
Diplopoda	**–**	**–**	**–**	**–**	**1**	***0.5***
Total	**265**	***100***	**215**	***100***	**195**	***100***

Tab. 5. Comparison of sizes of ants taken by adult birds (Boca la Torre, I. 2004) and fed to young (Temejereque, II. 2000).

Length of ants	Barranco de la Torre (n = 46)	Temejereque (n = 8)
- 2 mm	7	–
- 4 mm	21	–
- 6 mm	16	4
- 8 mm	2	2
-10 mm	–	2
x ± s	3,6 ± 1,5	6,5 ± 1,8

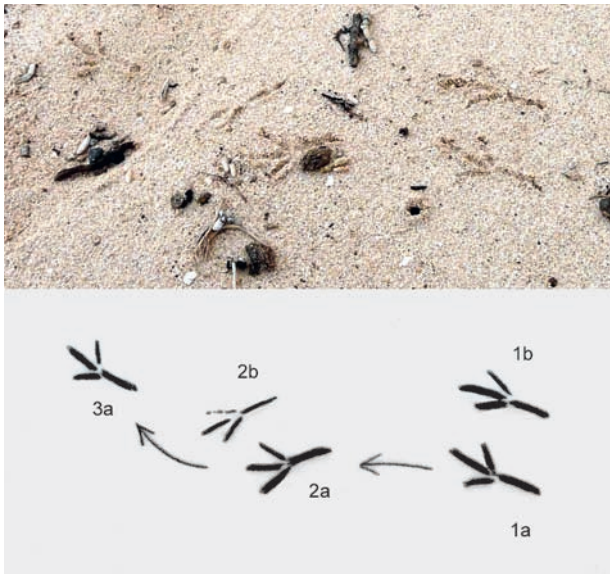

Fig. 10. Footprints of Canary Islands Stonechat in fine sand while hunting for insects; in the order 1a, b landing, 2a, b pursuit by jumping with stronger pressure of the left foot, 3a take-off with the impression of the left foot only.

Fig. 11. An adult male of Canary Islands Stonechat – note the fairly long and pointed bill (in comparison with *S. torquata*). Photo: 02.01.2008.

Lorenzo 2001), although the islands lie on the edge of their migration routes and winter quarters. Other competitors with similar food requirements and foraging strategies, such as *Phoenicurus* spp. and *Oenanthe* spp. (Kneis & Lauch 1983, Glutz von Blotzheim & Bauer 1988, Nicolai 1998, 2002), are rather rare on Fuerteventura.

Regarding the body size and proportions of the three *Saxicola* species, it is likely that the clearly shorter wing length of *Saxicola dacotiae* can be attributed to its sedentary lifestyle (*cf*. measurements in Cramp 1988, Winkler & Leisler 1992). The tarsus and tail lengths of the three species are virtually the same, and probably also their body weights but we have no data on Canary Islands Stonechat. What is however very noticeable is the longer bill of *S. dacotiae* (6-8% longer as *S. rubetra* and *S. torquata*). This can be interpreted as an ecomorphological adaptation (Leisler & Winkler 1985) for intensive foraging for terrestrial arthropods and for picking up very small prey items. According to Leisler (1992), migratory birds, which have longer wings than their close relatives, catch more of their insect prey in the air than the more sedentary related species. They also preferentially feed on seasonally occurring larger invertebrates.

In contrast to frequent statements in the literature of how common 'flies' are in the diet of *Saxicola dacotiae* (Thanner 1905, Polatzek 1908/09, Löhrl 1987, Müller 1999, Urquhart 2002), we found very few Diptera in our material (< 2 %). These authors apparently made their observations at a time when there was a temporarily good supply of these insects that was being exploited by this adaptable stonechat. Löhrl (1987) even helped the birds by making places where flies were abundant accessible to them, and the flies were readily taken.

Given the seasonal changes in the abundance of potential prey, it is very likely that the range of food taken in spring and summer will be different. Especially 'caterpillars' (insect larvae in the broadest sense, but principally Lepidoptera), which appear in the growing season and are used most importantly to feed the young. The Saltatoria (grasshoppers and crickets) also appear in greater numbers later in the year. Both of these groups of prey animals are mentioned by URQUHART (2002) as part of the nestling diet. It can be assumed that *S. dacotiae* feeds its young selectively, as is well known from related birds like other *Saxicola*, *Phoenicurus*, or *Oenanthe* (FLINKS & PFEIFFER 1987, 1988; NICOLAI 1992, 2002; BASTIAN & BASTIAN 1996, COLLAR 2005).

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Literature

ANTONIO, J. & GUTIÉRREZ, L. (1997): Tarabilla Canaria – *Saxicola dacotiae*. – In: SEO/BirdLife: Atlas de las aves de España. (Lynx) Barcelona.

BANNERMAN, D. A. (1963): Birds of the Atlantic Islands. Vol. I: A History of the Birds of the Canary Islands and of the Salvages. Edinburgh & London.

BASTIAN, A. & BASTIAN, H. V. (1996): Das Braunkehlchen. – Sammlung Vogelkunde. Wiesbaden.

BERGMANN, H.-H. (2003): Insel-Endemit Kanarenschmätzer. – Falke, **50**: 197–200.

BIBBY, C. J. & HILL, A. A. (1987): Status of the Fuerteventura Stonechat *Saxicola dacotiae*. – Ibis, **129**: 491–498.

BIRDLIFE INTERNATIONAL/EBCC (2000): European Bird Populations. Estimates and trends. Cambridge, UK: Bird Life International (BirdLife Conservation Series N 10).

CALVER, M. C. & WOOLLER, R. D. (1982): A technique for assessing the taxa, length, dry weight and energy content of the arthropod prey of birds. – Austr. Wildl. Res., **9**: 293–301.

COLLAR, N. J. (2005): [Thrushes] Fuerteventura Stonechat *Saxicola dacotiae*. – In: DEL HOYO, ELLIOTT & CHRISTIE (ed.): Handbook of the Birds of the World; Vol. 10. (Lynx) Barcelona (p. 783).

COLLINS, D. R. (1984): Studies of West Palearctic Birds. – 187. Canary Islands Stonechat. British Birds, **77**(10): 167–171.

COSTA, C., IDE, S. & SIMONKA, C. E. (Edit.) (2006): Insectos Inmaduros; Metamorfosis e Identificación. Monografias Tercer Milenio S.E.A., vol. 5.

CRAMP, S. (1988): Handbook of the Birds of Europe, the Middle East and North Africa. Vol. 5. Oxford.

FLINKS, H. & PFEIFER, F. (1987): Nahrung adulter und nestjunger Schwarzkehlchen (*Saxicola torquata rubicola*) einer westfälischen Brutpopulation. – Vogelwelt, **108**: 41–57.

FLINKS, H. & PFEIFER, F. (1988): Einfluß des Nestlingsalters auf die Nahrungszusammensetzung nestjunger Schwarzkehlchen (*Saxicola torquata*). – J. Ornithol. **129**: 317–324.

GLUTZ VON BLOTZHEIM, U. N. & BAUER, K. M. (1988): Handbuch der Vögel Mitteleuropas. Bd. **11/I**, Passeriformes (Teil 2). – Aula Verlag Wiesbaden.

GRIMM, H. (2005): Zur Ernährung des Kanaren-Raubwürgers *Lanius meridionalis koenigi*. – Ornithol. Jahresberichte Museum Heineanum, **23**: 11-28.

HERRERA, C. M. (1983): Significance of ants in the diet of insectivorous birds in southern Spanish mediterranean habitats. – Ardeola, **30**: 77–81.

ILLERA, J. C. (2001): Habitat selection by the Canary Islands Stonechat (*Saxicola dacotia*) (Meade-Waldo, 1889) in Fuerteventura Island: a two-tier habitat approach with implications for its conservation. – Biological Conservation, **97**: 339-345.

ILLERA, J. C. (2004a): Tarabilla Canaria (*Saxicola dacotiae*). – In: Libro rojo de las aves de España. SEO/Bird Life-Dirección General de Bioversidad/Ministerio de Medio Ambiente. Madrid: 327–328.

ILLERA, J. C. (2004b): Biogeografia y ecologia de la Tarabilla Canaria con implicaciones para su conservación. – PhD Thesis, University of La Laguna, Tenerife.

ILLERA, J. C. (2005): Divorce in the Canary Islands Stonechat (*Saxicola dacotiae*). – Wilson Bulletin, **117**: 317–319.

ILLERA, J. C. & DIAZ, M. (2006): Reproduction in an endemic bird of a semiarid island: a food-mediated process. – J. Avian Biology, **37**: 447–456.

ILLERA, J. C. & DIAZ, M. (2008): Site fidelity in the Canary Islands Stonechat *Saxicola dacotiae* in relation to spatial and temporal patterns of habitat suitability. – Acta Oecologica, **34**: 1–8.

ILLERA, J. C.; DIAZ, M. & NORGALES, M. (2006): Ecological traits influence the current distribution and range of an island endemic bird. – J. Biogeography, **33**: 1192–1201.

JENNI, L.; REUTIMANN, P. & JENNI-EIERMANN, S. (1990): Recogniziability of different food types in faecess and in alimentary flushes of Sylvia warblers. – Ibis, **132**: 445–453.

KNEIS, P. & LAUCH, M. (1983): Untersuchungen zum Nahrungserwerb des Steinschmätzers *Oenanthe oenanthe* (Turdidae). – Zool. Jahrbuch Physiol., **87**: 381–390.

LEISLER, B. (1992): Habitat selection, coexistence of migrants and Afrotropical residents. – Ibis, **134** suppl. 1: 77–82.

LEISLER, B. & WINKLER, H. (1985): Ecomorphology. – Current Ornithology (R.F. JOHNSTON, ed.), Vol. 2: 155–186.

LÖHRL, H. (1987): Beobachtungen am Kanarenschmätzer (*Saxicola dacotiae*). – Vogelwelt, **108**: 105–109.

MARCHETTI, C.; BALDACCINI, N. E. & LOCATELLI, D. P. (1996): Consistency and overlap of the diet of seven passer-

ine trans-saharian migrants during spring stopover at two Mediterranean sites. Italian. – J. Zoology, **63**: 149–155.

Marchetti, C.; Locatelli, D. P.; van Noordwijk, A. J. & Baldaccini, N. E. (1998): The effects of prey size on diet differentiation of seven passerine species at two spring stopover sites. – Ibis, **140**: 25–34.

Martin, A. & Lorenzo, J.A. (2001): Aves del Archipelago Canario. (Francisco Lemus, ed.) La Laguna.

Martinez-Cabello, A., Soler , M. & Soler, J. J. (1991): Alimentacion de la Taraballa comun (Saxicola Torquata) en el sureste de la Peninsula Iberica durante el periodo otono-invierno. – Ardeola, **38**(2): 317–326.

Moreby, S. J. (1988): An aid to the identification of arthropod fragments in the faeces of gamebird chicks (Galliformes). – Ibis, **130**: 519–526.

Moreno, J. (1984): Search strategies of Wheatears and Stonechats: Adaptive variation in perch height, search time, sally distance and inter-perch move length. – J. Animal Ecology, **53**: 147–159.

Müller, H. E. J. (1999): Frühe Zweitbrut und verlängerte Jungenpflege beim Kanarenschmätzer *Saxicola dacotiae*. – Limicola, **13**: 74–79.

Nicolai. B. (1992): Untersuchungen zur Nahrung und zum Nahrungserwerb des Hausrotschwanzes (*Phoenicurus ochruros*). – Ornithol. Jahresberichte Museum Heineanum, **10**: 75–105.

Nicolai, B. (1998): Zu Vorkommen und Ernährung des Hausrotschwanzes *Phoenicurus ochruros* auf Mallorca im Winter. –J. Ornithol., **139**:67–70.

Nicolai, B. (2002): Feeding of Black Redstart *Phoenicurus ochruros* at post-nuptial migration on Menorca. – Anuari Ornitològic de les Balears, **16**: 15–22.

Nicolai, B.; Grimm, H.; Seelig, K.-J.; Weihe, F.; Schmidt, F.-U.; Hellmann, M.; Schneider, R. & Briesemeister, E. (2006): Ornithologische Beobachtungen auf Fuerteventura (Kanarische Inseln). – Ornithol. Jahresberichte Museum Heineanum, **24**: 83–99.

Padilla, D. P.; Nogales, M. & Pérez, A. J. (2005): Seasonal diet of an insular endemic population of Southern Grey Shrike *Lanius meridionalis koenigi* on Tenerife, Canary Islands. – Ornis Fennica, **82**: 155–165.

Polatzek, J. (1908/09): Die Vögel der Canaren. – Ornithol. Jahrbuch **19**: 81–119, 161–197; **20**: 1–24, 117–134, 202–210.

Ralph, C. P.; Nagata, S. E. & Ralph, C. J. (1985): Analysis of dropings to descrive diets of small birds. – J. Field Ornithol., **56**(2): 165–174.

Revaz, E.; Schaub, M. & Arlettaz, R. (2008): Foraging ecology and reproductive biology of the Stonechat *Saxicola torquata*: comparison between a revitalized, intensively cultivated and a historical, traditionally cultivated agroecosystem. – J. Ornithol., **149**: 301–312.

Rogers, L. E.; Buschbom, R. L. & Watson, C. R. (1977): Length-weight relationship of shrub-steppe invertebrates. – Ann. Entomol. Soc. Amer., **70**: 51–53.

Thanner, R. v. (1905): Ein Sammelausflug nach Fuerteventura. – Ornithol. Jahrbuch, **16**: 50–66.

Urquhart, E. (2002): Stonechats: a Guide to the Genus Saxicola. Christopher Helm. London.

Winkler, H. & Leisler, B. (1992): On the ecomorphology of migrants. – Ibis, **134** suppl. 1: 21–28.