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Importance of millipedes (Diplopoda) in the autumn-winter diet of *Scolopax rusticola*

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Abstract

Authors examined the autumn-winter diet of the woodcock *Scolopax rusticola* from 407 gizzard samples originating from Crimea and Italy, resulting in a high number of millipedes (Diplopoda) in all the samples; this prey item was particularly important in terms of weight percentage. The authors consider that calcium, highly present in millipedes, should be an important source for the woodcocks' metabolism during the autumn-winter seasons.

Keywords: woodcock, gizzard content, percentage of prey, percentage of biomass, importance of calcium, wader food

Introduction

The diet of the woodcock has been extensively studied in some countries [e.g., France (Fadat et al. 1979; Ferrand et al. 1979; Lebeurier 1982; Granval 1987), Italy (Lo Valvo 1988; Spanò & Borgo 1993) and Romania (Kiss et al. 1995)]. Generally, all authors emphasized on the importance of earthworms, beetles and insect larvae as prey items of this bird, but the importance of millipede biomass has to date not yet been highlighted.

As part of a long-term study of the woodcock in Italy (see Aradis et al. 2001, 2008, 2015; Trucchi et al. 2011), the present authors had the opportunity to obtain a sample of more than 200 illegally shot specimens from Crimea and confiscated as they were being imported to Italy. The seized birds were entrusted to ISPRA for study and incineration. In addition, a sample consisting of ca. 200 woodcocks shot in Italy were obtained from hunters. This material allowed us to present the results of our study on the winter diet of the woodcock in Crimea and Italy.

Material and methods

Woodcocks shot during daytime by hunters in October–December have been obtained between 2010 and 2018. Birds were dissected and the contents of ingluvies and gizzards were transferred into Petri dishes. These were examined with the help of a binocular microscope Wild M5 at 50X magnification. Overall, 407 woodcock gizzard contents were analyzed, of which 204 came from Crimea, captured in October–November (during autumn migration), 203 from Italy (70 from North Italy and 133 from Sicily), captured in October–December (during autumn migration and wintering). Different prey items were identified and analyzed, paying particular attention to the presence of small chaetae of earthworms to avoid their underestimation. When the state of digestion is starting, earthworms are easily recognizable, but when prey items are largely digested it is possible to detect only a small number of chaetae; in this case, we assumed at least one specimen of earthworm. The number of beetles was obtained counting head and pronotum items, that generally are found intact; when this was not possible, elytra were counted. All single or groups of segments of arthropods were isolated and counted to establish the number of specimens of each

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Table I. Fresh weight (in grams) of some arthropods found as prey of woodcock.

Taxa	Weight \pm sd
Isopoda	0.4 \pm 0.1
Diplopoda	0.5 \pm 0.2
Chilopoda	0.4 \pm 0.2
Araneida	0.2 \pm 0.15
Coleoptera	0.2 \pm 0.1
Coleoptera (larvae)	0.2 \pm 0.01
Lepidoptera (larvae)	0.2 \pm 0.1
Diptera (larvae)	0.1 \pm 0.01
Dermaptera	0.1 \pm 0.01
Annelida	0.4 \pm 0.01

species characterized by many segments (Chilopoda and Diplopoda). Some live Diplopoda and Chilopoda were collected to count the mean number of body segments; then, it was assumed that 41–51 segments should belong to only one specimen of millipede and 21 to one specimen of a centipede. In addition, to obtain the prey biomass, 25 specimens of each prey category were weighed by an electronic scale Laica BX93100 (capacity 120 g, division 0.05 g) and the average weight was calculated (see Table I).

We measured the percentage with which an item occurred relative to other items detected calculating the percentage of occurrence (% occurrence) of items [(number of times an item occurred (frequency)/total number of occurrences of all items) * 100].

Finally, because we had a sample from Italy (Sicily: 7 males and 15 females) sexed following the method reported by Aradis et al. (2015), a Chi-square test was

applied to their diet to compare the composition and search for possible differences in the diet of males and females.

Results

Percentage of prey items and prey biomass of woodcocks captured in Crimea and in Italy are reported in Figures 1–3 and Table II (compared with bibliographic data). In Crimea, Coleoptera were the most important prey (48.7%), both as adults and larvae, followed by Diplopoda (40.4%), while the percentage of other prey was negligible. Concerning the beetles, these belonged mainly to the families Hysteridae, Tenebrionidae, Carabidae and Curculionidae. As regards millipedes, they belonged mostly to the genus *Megaphyllum* (Julidae, Julida) (S.I. Golovatch, M. Zapparoli, pers. comm.). In Sicily (Italy) the percentage of prey was similar, with Coleoptera as the most important (56.1%), followed by Diplopoda (18.3%) and Annelida (11.4%). This was also the case for the Northern Italy, beetles and millipedes showed the highest percentage (60.7% and 24.5%, respectively). However, results appear different, if they are expressed as biomass (= percentage of weight). In Crimea, millipedes are indeed the highest percentage (61.3%), while beetles decrease (28.9%), in Sicily the biomass percentage of millipedes is 32.7%, that of beetles 39.6%, while in Northern Italy they are 32.7% and 57.6%, respectively (Figures 1–3).

In the gizzards, vegetable fiber occurred frequently (30% of Crimea sample, 72% of Sicily and 54% of

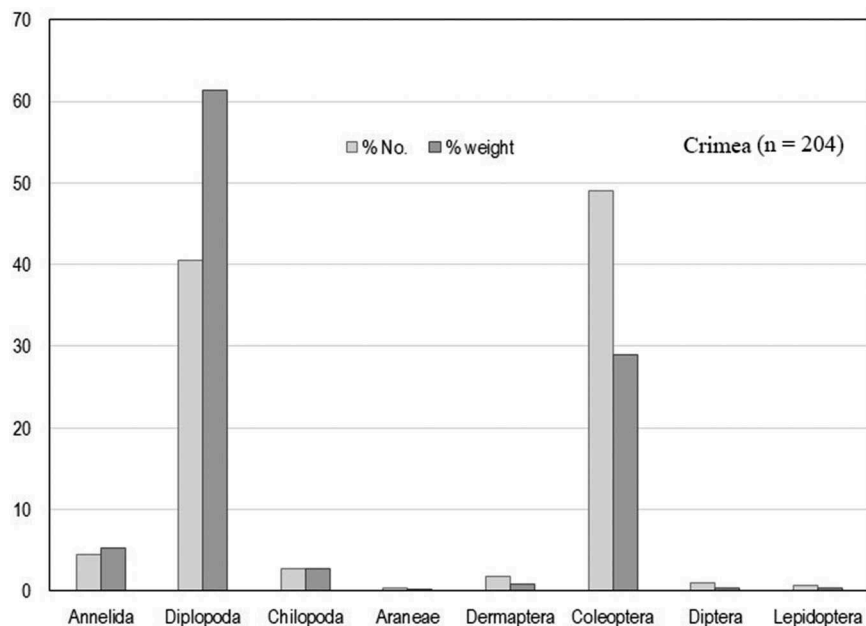


Figure 1. Percentage of prey number and prey weight belonging to the different taxa in Crimea.

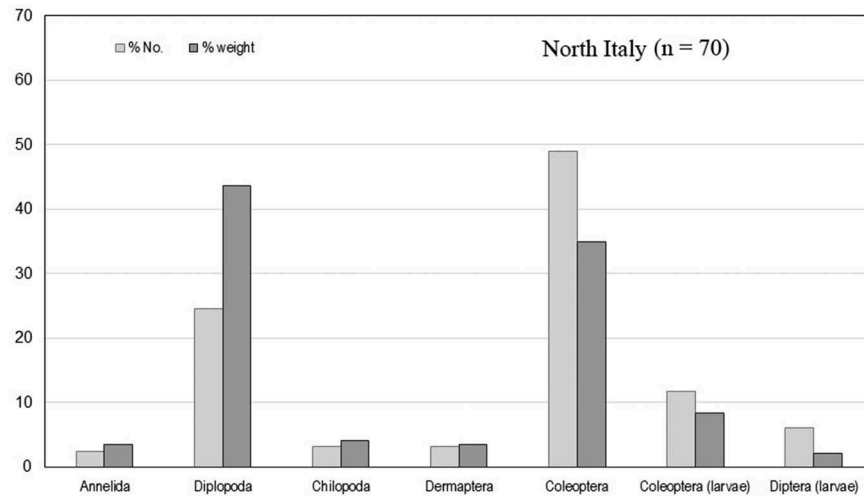


Figure 2. Percentage of prey number and prey weight belonging to the different taxa in North Italy.

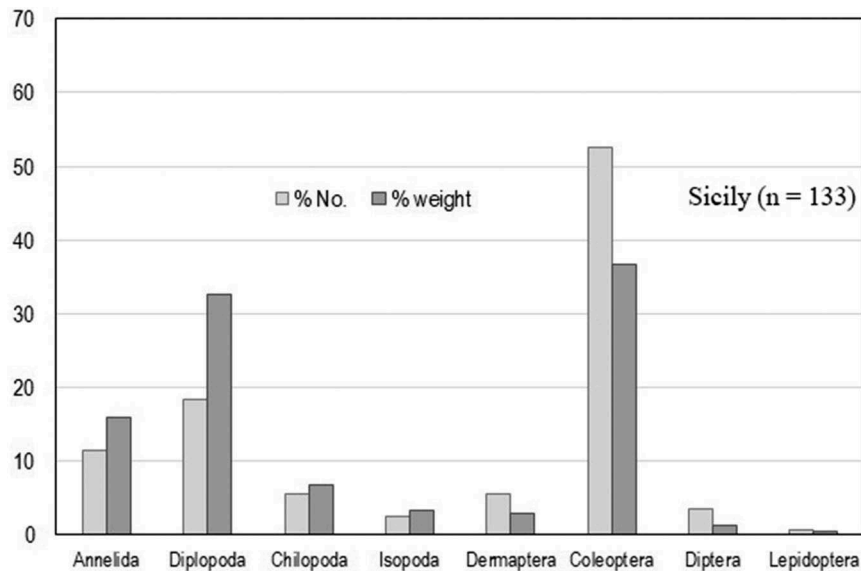


Figure 3. Percentage of prey number and prey weight belonging to the different taxa in Sicily.

North Italy ones); in addition, small pebbles (range 0.2–0.5 cm) were present in 25% of Crimea sample, 44% of Sicily and 46% of North Italy (Figure 4). Differences between prey found in the sexed sample of males and females resulted to be not significant, with the only exception for Coleoptera (Chi-Square = 5.24; DF = 1; P-Value = 0.022) (Figure 5).

Discussion

Most authors generally agree with Granval (1987) who considers earthworms as the most important prey of the woodcock, reaching 85%

(see also Duriez et al. 2005). According to Hoodless (1995), the greatest variety of prey items is taken during the autumn migration. Following Kistiyakivski (1957 in Cramp & Simmons 1983), from 42 stomachs collected during migration in Ukraine only 2% contained earthworms, while 34% spiders, 34% Diplopoda Julidae and at least 29% other myriapods. Results reported in Table II agree rather well with this point of view, highlighting that beetles and millipedes represent the main prey in different zones of the distribution and in different autumn-winter months. The diet varies with the seasons

Table II. Results of the present study and selected references on the woodcock diet in some countries of the western Palaearctic, with the percentage of main prey.

Source	% Coleoptera	% Annelida	% Diplopoda	% Chilopoda
Present study (Crimea)	48.7	4.4	40.4	2.7
Present study (North Italy)	60.7	2.4	24.5	3.21
Present study (Italy, Sicily)	56.1	11.4	18.3	5.5
Ferrand et al. (1979) (France)	40–62	0–7.0	10–25	17–18
Fadat et al. (1979) (France)	48	7.0	10	18
Lo Valvo (1988) (Sicily, Italy)	53	12.8	9.6	5.0
Spanò and Borgo (1993) (N Italy)	12.8–20	15.2–17	5.3–14.9	2.1–6.6
Kiss et al. (1995) (N Dobrogea)	67.5	1.5	27.1	2.5

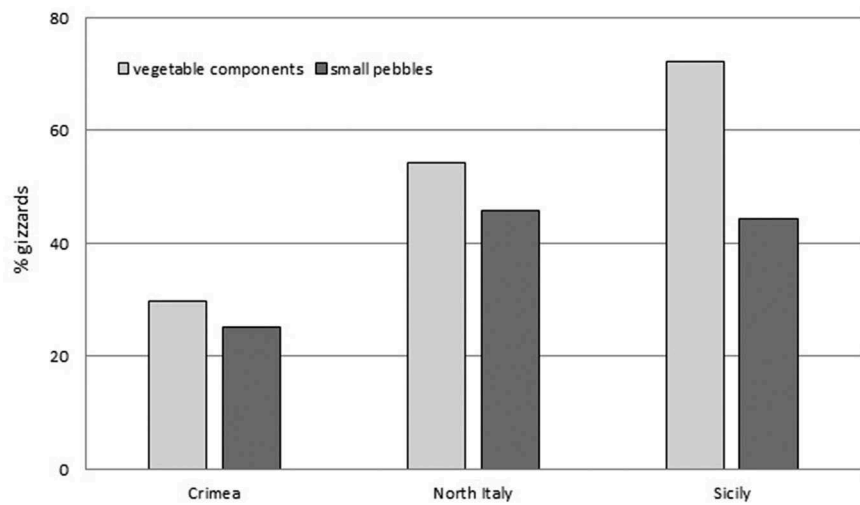


Figure 4. Occurrence percentage of gizzards in which vegetable components and small pebbles were recorded.

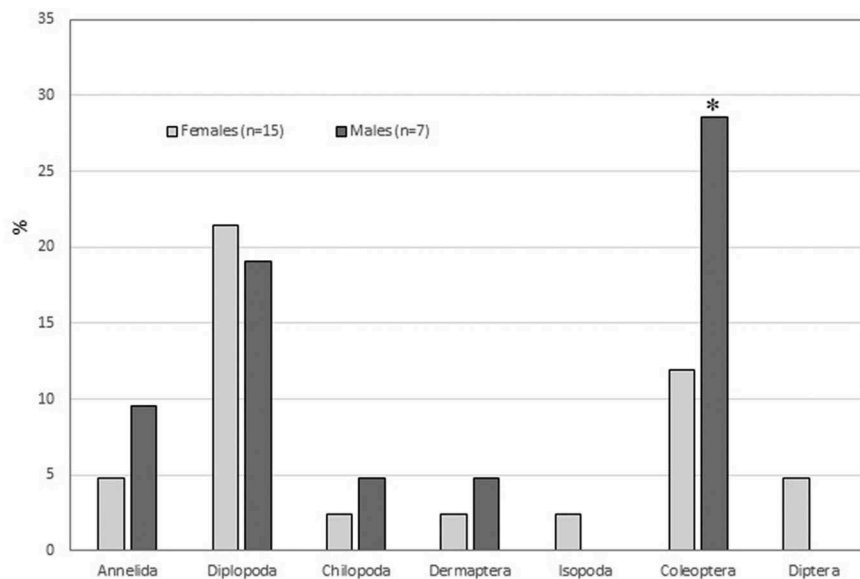


Figure 5. Comparison in the diet composition in males and females from Sicily. Significant differences were found only for Coleoptera (* Chi-Square = 5.238; DF = 1; P-Value = 0.022).

Table III. Whole-body chemical composition of calcium, potassium, and sodium (mg/g ash-free dry weight) of some arthropods found as prey of woodcock. Source: (Reichle et al. 1969; Edney 1977; Bell 1990; Zandt 1997).

Taxa	Calcium	Potassium	Sodium
Isopoda	108.9	9.4	5.1
Diplopoda	103–546	2.9–14.8	1.4–6.0
Chilopoda	0.6	7.1	9.2
Araneida	2.1 ± 0.05	7.2 ± 0.94	7.3 ± 0.24
Coleoptera	0.3–2.5	0.9 – 6.5	2.7–6.0
Lepidoptera (larvae)	4.7	50.0	9.2
Diptera	2.0 ± 0.89	1.2 ± 0.3	5.4 ± 0.05

(autumn-winter and spring-summer) in accordance with the availability of certain kinds of food, weather and soil conditions (some species will go deeper in the soil in dry conditions and earthworms are rare in sand soils, cf. Fadat 1995). In addition, Fadat (1995) highlighted the importance of vegetable components, as well as some differences of prey percentage between males and females. However, the importance of prey biomass has been rarely considered (but see Hoodless & Hirons 2007).

With regard to the importance of the different prey taken by woodcocks as a source of chemical components, it is interesting to observe the high content of calcium present in millipedes (Table III), that very probably explains the high frequency of these arthropods in the woodcock diet during migration. Calcium has important roles, other than in the content of bones (99% of organic calcium), functions in the muscular tensing, blood coagulation, secretion of hormones and neurotransmitters in the enzymatic activity. Calcium not stored in bones is diffused in the cells, extracellular fluids and plasma as calcium ion (Harlos et al. 1987). Thus, calcium highly present in millipedes should be an important source for the woodcocks' metabolism during the autumn-winter seasons. According to Karasov (1990) birds metabolize ca. 75% of the energy provided by arthropods, which in turn are generally poor in carbohydrates, but rich in proteins (Bell 1990).

woodcocks probe for their prey in soft moist places, and these are located by means of the exceptionally sensitive tips of their bills (Nethersole-Thompson & Nethersole-Thompson 1986). The tip of the woodcock's bill contains many sensitive nerve endings and Hoodless (1995) presumed that woodcocks relied on tactile and chemical cues when feeding. Indeed, according to Cunningham et al. (2013) the premaxilla of the woodcock contains two parallel, circular channels that emerge as neurovascular foramina in the dorsolateral surface of the

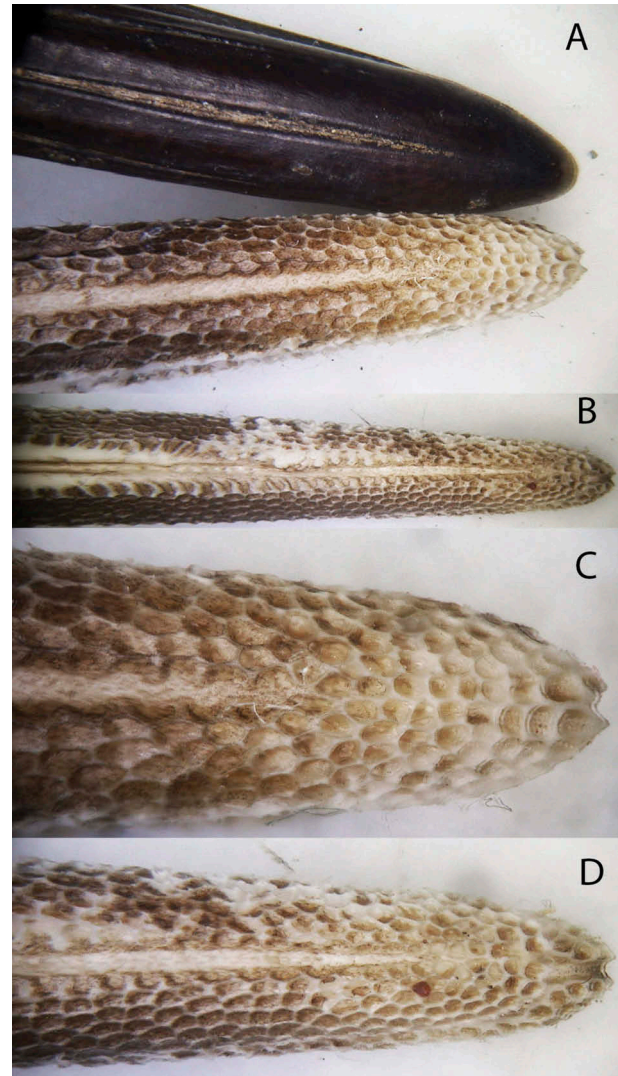


Figure 6. The tip of the woodcock: (a) the dorsal tip covered by the skin and below the same without the skin; (b) the ventral tip without the skin; (c) and (d) dorsal and ventral tip at higher magnification showing sensory pits where sensitive nerves end.

bone (Figure 6), and a large number of sensory pits, that represents a complex tactile specialization. This structure is used to detect prey hidden in the soil through vibrations. The woodcock has a highly refined method of probing; it inserts its bill to about one-third of its length, and it also turns over leaves in woods or at times investigates cow dung in the wood pasture (Burton 1974). Our results show that in general the woodcock's prey does not live in the deepest layers of the litter, but rather at the surface, below leaves and shallow soil layers; thus, the woodcock does not use its long bill only to search for prey in the deepest layers of mud or soil, but to sweep and move the surface layers of litter to locate its prey. Beetles and millipedes found in the

stomachs of woodcocks are indeed typical dwellers of the first litter layers.

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Disclosure statement

No potential conflict of interest was reported by the authors.

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