Sixth European Woodcock and Snipe Workshop

Proceedings of an International Symposium
of the Wetlands International Woodcock and Snipe Specialist Group
25–27 November 2003

Edited by Y. Ferrand

WETLANDS INTERNATIONAL

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Edited by Y. Ferrand
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Foreword

Every five years on average, the Woodcock and Snipe Specialist Group (WSSG) of Wetlands International and IUCN –The World Conservation Union will organise a workshop to provide information on Woodcock and Snipe research whereby the WSSG members are offered the opportunity to meet and improve the efficiency of the network. The sixth workshop was held in Nantes (France) under the auspices of the French Ministry of ecology and sustainable development. It is the second one to be held in this country. All previous ones were held in European countries (Denmark, Great Britain, Germany, Poland).

The majority of participants came from European countries, including the European part of Russia. Of course, although the monitoring of the Woodcock and Snipe populations in the south-western part of Europe is absolutely needed, the extension of the Woodcock and Snipe research to include the core of their breeding range is one of the important steps taken in the last years.

Our group should be able to provide information and recommendations on the conservation of Woodcock and Snipe species. This has clearly been defined in a memorandum by which we are associated to Wetlands International and these proceedings contribute to answer this request.

We also should keep in mind that the WSSG responsibility encompasses other species in the world. A challenge for our group is to extend our knowledge to extra-European species, especially in Asia, South America and Africa. The presentation of a paper on the African Snipe (*Gallinago nigripennis*) is with this end.

The majority of communications presented in this Sixth Workshop is Woodcock-oriented. However, for Snipe species our knowledge must be greatly improved.

Moreover, many of them suffered habitat losses and need to be studied more deeply to maintain or improve their conservation status. I wish that the balance be established in the coming years thanks to several Snipe research projects.

Insofar as Woodcock and Snipe species are mainly game birds, we must closely keep in touch with the hunter associations. Several representatives of these organisations attended the workshop and showed their great interest in our work. Of course, we greatly need fundamental knowledge, for example to provide population models but we must also help the hunting managers in providing information and advice. We must work together to find the right way to manage Woodcock and Snipe populations and to ensure that the hunting rules will be understood and well accepted by the hunters. In my opinion, this is one of the keys to a sustainable use of Woodcock and Snipe species.

I want to express my sincere thanks to *Office national de la chasse et de la faune sauvage* and the *Conseil régional des Pays de la Loire* for their financial support in organising this workshop. I also want to thank Wetlands International for its financial help in publishing the proceedings.

On the behalf of all the WSSG members, I would like to thank the ONCFS team of the Nantes Station for their precious help during the organisation of the workshop and for the very successful field trip.

Finally, I would like to thank all participants thanks to whom this workshop took place in a both serious and convivial atmosphere.

Yves Ferrand
Co-ordinator of WSSG

Population estimates and trends of the world's Woodcocks and Snipes with special reference to globally threatened species

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The recent publication by Wetlands International of Waterbird Population Estimates – third edition (WPE3) provides a useful starting point for the evaluation of numbers and population trends of the world's waterbirds. Altogether, 26 of the 868 species recognised as "waterbirds" by Wetlands International are Woodcock and Snipe species, and information is presented in WPE3 on all of them, subdivided into 51 biogeographical populations. Estimates are now available for a majority (30, 58%) of the world's Woodcock and Snipe populations, but population trends have only been estimated for 20 populations (39%). At global level, these known trends break down as follows: increasing, 0 (0%); stable, seven (35%); decreasing, 11 (55%); extinct, two (10%). The fact that 65% of Woodcock and Snipe populations for which information is available are decreasing or extinct gives considerable cause for concern.

A total of 10 species (37% of the Woodcocks and Snipes) qualify as Globally Threatened or Near Threatened under IUCN Criteria. Of these, four have ranges of distribution in Asia, two in Oceania, two in South America, one in Africa and one breeds in Europe and North Asia and migrates to Africa. A high proportion (eight out of 10) of these Globally Threatened species are sedentary, and a majority of these (six species) are specialised island forms. Red Data lists are compiled by IUCN at species level; more threatened Woodcock and Snipe populations would be identified as deserving of conservation action if these lists were compiled at the level of sub-species or biogeographic population. For example, the Subantarctic Snipe is recognised by BirdLife International and IUCN as Near Threatened at species level, but two sub-species have actually gone extinct.

Of the 51 Biogeographical populations of Woodcock and Snipe recognised in WPE3, 21 (42%) are lacking an estimate of numbers, and trend information is lacking for 31 (61%). Fundamental work is urgently needed on these little-known species and populations to act as a basis for their conservation. Many species whose population trend is unknown at present are likely to be declining, and expansion and refinement of monitoring is also necessary for relatively numerous and widespread species to identify those which are nevertheless declining.

Introduction

Woodcock and Snipe species are well-studied in Europe and North America, where five species occur. The 21 species found in other parts of the world are relatively poorly known, and rather a high proportion are Globally Threatened. This paper reviews the conservation status of the world's Woodcock and Snipe species at the level of the 51 biogeographic populations into which they are currently divided for the purposes of conservation management. Data-deficient populations and geographic regions are identified, and basic life-cycle characteristics of species with shared population trends are examined.

Methods

The information presented in this paper was compiled during preparation of the publication Waterbird Population Estimates – Third Edition (Wetlands International 2002) (WPE3). When attempting to conserve or manage any species, it is important to know the number of individuals that exist, whether that number is increasing, stable or decreasing, and where those individuals live. WPE3 attempts to provide this information for all 868 species in the world recognised by Wetlands International as being waterbirds. The publication is produced on behalf of the Ramsar Convention on Wetlands, for whom its principal function is to act as the basis of the Ramsar 1% criterion,

under which any site regularly holding more than 1% of a waterbird population qualifies under the Convention as a Wetland of International Importance.

The information in WPE3 is updated every three years, in line with the cycle of Conferences of the Parties to the convention. Wetlands International's extensive networks of experts and partners ensure that the publication is comprehensive and authoritative (Figure 1).

Figure 1. Networks contributing to the Wetlands International Waterbird Population Estimates series.
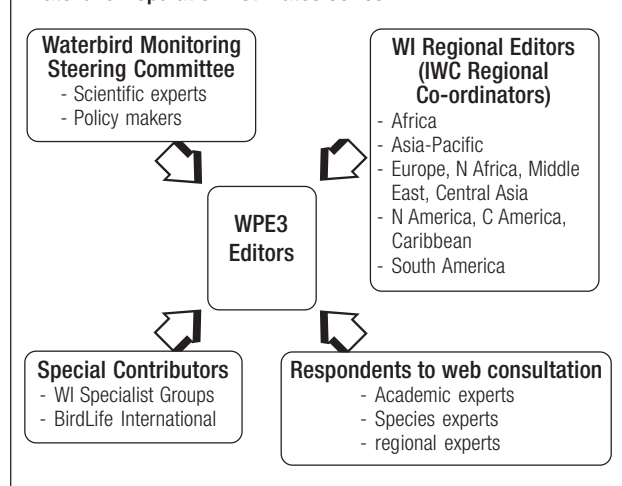
Production of the triennial estimates and the associated information is thus an extensive networking exercise. For the first and second editions, A Waterbird Monitoring Steering Committee comprising scientific and policy experts, mostly from Europe, co-ordinated activity, and the Wetlands International Specialist Group networks and BirdLife International Globally Threatened Birds programme and World Birds Database provided a mass of information to the co-authors at Wetlands International headquarters. For the Third Edition, these networks were complemented by a very effective team of regional editors, who were usually heavily involved in the International Waterbird Census (IWC) in their region, together with a large number of respondents to a three-month period of consultation (April–June 2002) when draft tables were made available on the Wetlands International website. For Woodcocks and Snipes, a high proportion of the estimates came from the Co-ordinators of the Woodcock and Snipe Specialist Group, and the expertise of BirdLife International on Globally Threatened species was also invaluable.

The International Waterbird Census is a major source of information for Waterbird Population Estimates, but Woodcocks and Snipes are not well covered by the census methodology because of their secretive habits and, in the case of Woodcocks, preference for woodland habitats (Delany *et al.* 1999, Gilissen *et al.* 2001). IWC started in Europe in 1967, and now covers over 20,000 sites in 110 countries with the participation of over 15,000 counters, most of whom are voluntary observers. Despite these levels of coverage and participation, the numbers of Woodcocks and Snipes recorded represent a tiny proportion of their estimated populations (Table 1).

It may be the case that the number of birds counted by IWC is representative of overall numbers, so that IWC can provide the basis of population trends, but numbers of Eurasian Woodcock and Jack Snipe counted in Europe each year are so small that this seems unlikely. The number of Common Snipes are higher – totals in the second half of the 1990s varied between 15,500 and 21,500 – but were low compared with the population estimate, and these count totals may not be representative of overall numbers.

Results

Review of the world's Woodcock and Snipe populations

Tables 2, 3, 4, 5 and 6 summarise the information presented in WPE3 for all species of Woodcocks and Snipes. Each table provides a summary of a particular group of species, separated on the basis of their taxonomy and geographic ranges. Many of the population estimates are expressed by code letters to emphasise that they are only approximate and that caution should be exercised in their use. These codes translate as follows:

A: <10,000
B: 10,000–25,000
C: 25,000–100,000
D: 100,000–1,000,000
E: >1,000,000

The world's seven Woodcock species are divided into 12 biogeographic populations. Six population estimates and five trend estimates are available. Only the Eurasian Woodcock (*Scolopax rusticola*) has a high population which is apparently not declining. The American Woodcock (*Scolopax minor*) is also numerous, but both its populations are considered to be in decline (Kelley 2001). The remaining five species, divided on the basis of their taxonomy into seven populations, are all specialised island forms in Asia and Oceania. All are very poorly known. The Bukidnon Woodcock was only discovered, in the Philippines, in 1993 (Kennedy *et al.* 2001). The Sulawesi Woodcock (*Scolopax celebensis heinrichi*) is known only from three specimens, and the nominate, although very poorly known, is considered to be near-threatened (del Hoyo *et al.* 1996). The Amami Woodcock (*Scolopax mira*) and the Moluccan Woodcock (*Scolopax rochussenii*) both have populations estimated at below 10,000 individuals and declining (BirdLife International 2000). The Dusky

Table 1. The number of Woodcocks and Snipes recorded by the International Waterbird Census in Europe, 1995–1999, were low relative to their estimated overall abundance.
Source: Wetlands International IWC database.

	1995	1996	1997	1998	1999
Eurasian Woodcock	92	166	248	104	122
Common Snipe	17,843	15,888	15,522	18,751	21,561
Jack Snipe	178	152	172	217	395

Table 2. Information presented in WPE3 for Woodcocks.

Species	English name	Subspecies and population	Geographic Range	Population estimate	Trend	1% level
Scolopax rusticola	Eurasian Woodcock	*rusticola*, Europe	Europe, N Africa	>15,000,000	STA	20,000
		rusticola, W Asia (bre)	W Siberia, SW Asia	C/D	-	-
		rusticola, C and E Asia (bre)	N Asia, S and SE Asia	25,000	-	-
Scolopax mira	Amami Woodcock	*mira*	Ryukyu Is	2,500–10,000	DEC	60
Scolopax saturata	Dusky Woodcock	*saturata*	Sumatra and Java	-	-	-
		rosenbergi	New Guinea	-	-	-
Scolopax celebensis	Sulawesi Woodcock	*celebensis*	NE and C Sulawesi	-	-	-
		(*heinrichi*)	N Sulawesi	-	-	-
Scolopax bukidnonensis	Bukidnon Woodcock	Philippines	Luzon, Mindanao	-	-	-
Scolopax rochussenii	Moluccan Woodcock	N Moluccas	Obi and Bacan Is	2,500–10,000	DEC	60
Scolopax minor	American Woodcock	Atlantic N America (bre)	Atl SE N America	Total, both populations:	DEC	-
		Inland E N America (bre)	Inland SE N America	5,000,000	DEC	-

Woodcock (*Scolopax saturata*) is considered to be not uncommon in New Guinea, but distribution and numbers in Java and Sumatra are unknown. Kennedy *et al.* (2001) present a strong argument for splitting Dusky Woodcock into two species, Javan Woodcock (*Scolopax saturata*) and New Guinea Woodcock (*Scolopax rosenbergi*) on the basis of their strikingly different plumage and biometrics, together with their sedentary habits and 2,500 km geographical separation.

The Chatham Snipe (*Coenocorypha pusilla*) is very scarce and remains vulnerable to introduced predators. Two of the five subspecies of Subantarctic Snipe (*Coenocorypha aucklandica*) are more numerous, but this species is similarly vulnerable, with *barrierensis*, known only from a single specimen taken in 1870, presumed long-extinct, and *iredalei* also extinct (del Hoyo *et al.* 1996). The Jack Snipe (*Lymnocryptes minimus*) is widespread in the old world, but numbers are very poorly known, three of the four populations are lacking estimates, and only the roughest of estimates exists for the population wintering in Europe and North Africa (Kalchreuter, 2002).

Estimates exist for all seven populations of the five species of Asiatic Snipes in Table 4, but most are of the low-quality letter code variety. Pintail Snipe (*Gallinago stenura*), although widespread in north, south and South-east Asia, has estimates for each of its populations of C/ D, translating as 25,000–1,000,000 – a large range indicating the high level of uncertainty about numbers of this species. Swinhoe's and Latham's Snipes, *Gallinago megala* and *Gallinago hardwickii* have more restricted ranges, and lower, but uncertain estimates. Garnett and Crowley (2000) report decreases in numbers of Latham's Snipes wintering in eastern Australia. Solitary Snipe (*Gallinago solitaria*) is less widespread and numerous still, but its use of extensive, high-altitude habitats suggests that it may be relatively secure (del Hoyo *et al.* 1996). Wood Snipe (*Gallinago nemoricola*) has a population below 10,000 which appears to be declining, and qualifies as Globally Threatened (BirdLife International 2000).

The four species in Table 5 are divided into 12 populations for which estimates of varying quality are available. Accurate population estimates are unavailable for either of

Table 3. Information presented in WPE3 for small Snipes.

Species	English name	Subspecies and population	Geographic Range	Population estimate	Trend	1% level
Coenocorypha pusilla	Chatham (Island) Snipe	Chatham Islands	Chatham Islands	2,000	STA	20
Coenocorypha aucklandica	Subantarctic Snipe	*aucklandica*	Auckland Islands	20,000	-	200
		meinertzhagenae	Antipodes Islands	8,000	-	80
		heugeli	Snares Islands	1,100	-	11
		barrierensis	Little Barrier Island	0	EXT	-
		iredalei	Stewart Islands	0	EXT?	1
Lymnocryptes minimus	Jack Snipe	NE Europe (bre)	Europe, N and W Africa	E	STA	-
		W Siberia (bre)	W Siberia, SW Asia, NE Africa	-	-	-
		S Asia (non-bre)	Siberia, S Asia to Myanmar	-	-	-
		E, SE Asia (non-bre)	Siberia, S China, Vietnam	-	-	-

Table 4. Information presented in WPE3 for Asiatic Snipes.

Species	English name	Subspecies and population	Geographic Range	Population estimate	Trend	1% level
Gallinago solitaria	Solitary Snipe	*solitaria*	C Asia C Siberia, S Asia	B/C	-	1,000
		japonica	E Siberia, E Asia	A	-	100
Gallinago hardwickii	Latham's Snipe, Japanese Snipe	E Asia (bre)	E Siberia and Japan, E Australia	C	DEC	1,000
Gallinago nemoricola	Wood Snipe	S and SE Asia	Himalayas and Tibet, S and SE Asia	2,500–10,000	DEC	60
Gallinago stenura	Pintail Snipe	S Asia, E Africa (non-br)	Siberia, S Asia and E Africa	C/D	-	-
		E and SE Asia (non-br)	Siberia, E and SE Asia	C/D	-	-
Gallinago megala	Swinhoe's Snipe	Central Asia (bre)	C Asia, S Asia to Australia	C	-	1,000

Table 5. Information presented in WPE3 for large African, European and North American Snipes.

Species	English name	Subspecies and population	Geographic Range	Population estimate	Trend	1% level
Gallinago nigripennis	African Snipe	*nigripennis*	S Mozambique and S Africa	B	-	250
		aequatoralis	E Africa	B/C -	1,000	
		angolensis	SW Africa	B/C	-	1,000
Gallinago macrodactyla	Madagascar Snipe	Madagascar	E Madagascar	A	-	100
Gallinago media	Great Snipe	Scandinavia (bre)	Scandinavia, Africa	18,000–51,000	STA	350
		W Siberia, NE Europe (bre)	NE Europe, Africa	D	DEC?	10,000
Gallinago gallinago	Common Snipe	*gallinago*, Europe (bre)	N Europe, Europe and W Africa	>2,400,000	DEC	20,000
		gallinago, W Siberia (bre)	W Siberia, SW Asia and Africa	>1,500,000	-	15,000
		gallinago, S Asia (non-br)	Russia, S Asia	D/E	-	-
		gallinago, E and SE Asia (non-br)	Russia, E and SE Asia	D	-	10,000
		faeroensis	Iceland, Faeroes, Scotland	570,000	STA?	5,700
		delicata	Americas	1,000,000–3,000,000	DEC	20,000

Table 6. Information presented in WPE3 for South American Snipes.

Species	English name	Subspecies and population	Geographic Range	Population estimate	Trend	1% level
Gallinago paraguaiae	South American Snipe	*paraguaiae*	NE South America	-	STA	-
	Magellan Snipe	*magellanica*	S South America	C/D	STA	-
		magellanica	Falkland/Malvinas Is	15,000–27,000	-	210
Gallinago andina	Puna Snipe	Central Andes	C Andes	-	-	-
Gallinago nobilis	Noble Snipe	N South America	N South America	-	-	-
Gallinago undulata	Giant Snipe	*undulata*	N South America	-	-	-
		gigantea	C South America	-	DEC	-
Gallinago stricklandii	Fuegian Snipe	S South America	S South America	A	DEC	100
Gallinago jamesoni	Andean Snipe	N Andes	N Andes	-	-	-
Gallinago imperialis	Imperial Snipe	NW South America	Peru and Colombia (isolated sites)	-	-	-

the African breeding species, African Snipe (*Gallinago nigripennis*) and Madagascar Snipe (*Gallinago macrodactyla*), and trends have not been estimated for any of their populations (Dodman, in review). Madagascar Snipe is very poorly known but undoubtedly uncommon, and its habitats are under threat (BirdLife International 2000). Breeding populations of Great Snipe (*Gallinago media*) have undergone marked long-term decline in Central and Eastern Europe, but appear to be stable in Scandinavia (Kalas, 2002). Common Snipe (*Gallinago gallinago*) is by far the most numerous and widespread of all the Snipe species, but two of the six populations with known trends appear to be declining, those breeding in North America (Sauer *et al.* 2001) and in Europe (Stroud *et al.* 2004).

The 10 populations of seven species of Snipes occurring in South America are especially poorly known, and estimates only exist for three populations. South American Snipe (*Gallinago paraguaiae*) has a geographically extensive range and its numbers are considered to be stable (PTZ Antas in litt.) The Falkland Islands race of this species is the only South American Snipe whose population is reasonably well known (Woods and Woods 1997). Three Andean species, Puna Snipe (*Gallinago andina*), Andean Snipe (*Gallinago jamesoni*) and Imperial Snipe (*Gallinago imperialis*) are poorly known, although Puna Snipe is widespread and Andean Snipe is probably not rare. Noble Snipe (*Gallinago nobilis*), Giant Snipe (*Gallinago undulata*), Fuegan Snipe (*Gallinago stricklandii*), and Imperial Snipe (*Gallinago imperialis*) are all seriously data-deficient, although Giant Snipe is rather widespread. Imperial Snipe (*Gallinago imperialis*) is known only from a few specimens, and was thought to be extinct for over a century before rediscovery in 1967 (del Hoyo *et al.* 1996).

Quality of estimates of the world's populations of Woodcocks and Snipes

Estimates are presented in WPE3 in a number of ways, and these give an idea of the quality of each estimate. Estimates presented as a single figure, for example 2,000 for the Chatham Snipe, are usually of the highest quality. Estimates presented as numerical ranges, for example 15,000–27,000 for the Falkland Islands population of the South American Snipe, are by their nature of lower quality. Estimates presented as a single letter, for example, C (representing an approximate range of 25,000–100,000) for Latham's Snipe are of lower quality still. Finally,

estimates presented as two letters, for example B/C (representing an approximate range of 10,000–100,000) for two of the populations of African Snipe, are the least reliable of all. Table 7 indicates the quality of population estimates for the world's Woodcocks and Snipes by presenting the number of estimates in each Ramsar region falling into each of these categories.

The highest quality data are available for Woodcocks and Snipes in North America, where, however, there are only two species occurring in three populations, and estimates are only available at species level. The quality of estimates for species occurring in Europe are also relatively high, with all populations having some sort of estimate, and numerical estimates available for four out of seven populations. Oceania also enjoys good data quality, but this is because only five species occur, two of which, the Chatham Snipe and the five subspecies of the Subantarctic Snipe have small, relatively well-known populations on islands which are not difficult to estimate. *Scolopax* (*saturata*) *rosenbergi* is apparently widely distributed in New Guinea but remains very poorly known, and Latham's and Swinhoe's Snipes migrate from north Asia to Australia but their populations are only known to the one letter code level. In Africa, estimates exist for 11 out of 12 of the populations which occur, but the quality of most estimates is low: seven of the 12 estimates are letter codes, and three are two-letter codes. Asia has the largest number of Woodcock and Snipe populations but the quality of estimates is low, with seven out of 22 lacking estimates and a further 11 estimates being single or two-letter codes. The quality of estimates in South America is lowest of all, with eight out of 12 populations lacking estimates.

Table 7. Quality of population estimates of the world's Woodcocks and Snipes in each Ramsar region.

Ramsar region	Number of populations*	Single Number	Numerical Range	Single letter code	Two letter code	No estimate
			Type of estimate			
Africa	12	0	4	4	3	1
Europe	7	1	3	3	0	0
Asia	22	0	4	6	5	7
Oceania	9	6	0	2	0	1
South America	12	0	2	1	1	8
North America	3	1	1	0	0	1
Total	65	7	15	15	9	19

* 14 populations occur in more than one Ramsar region

Combining these regional populations globally, estimates exist for 46 out of 65 regional populations (71%), and most estimates are of moderate quality, with 15 presented as numerical ranges and 15 as single letter codes.

Patterns of population sizes and trends (changes in numbers) of the world's Woodcock and Snipe populations

Figure 2 shows the frequency distribution of population size ranges for all the world's 51 Woodcock and Snipe populations. Six populations presented as ranges which straddle the range categories presented have been included in the higher category (i.e. the upper end of their range estimate has been used in the graph). Nearly one third of Woodcock and Snipe populations (16 in all, or 31%) fall into the unknown category.
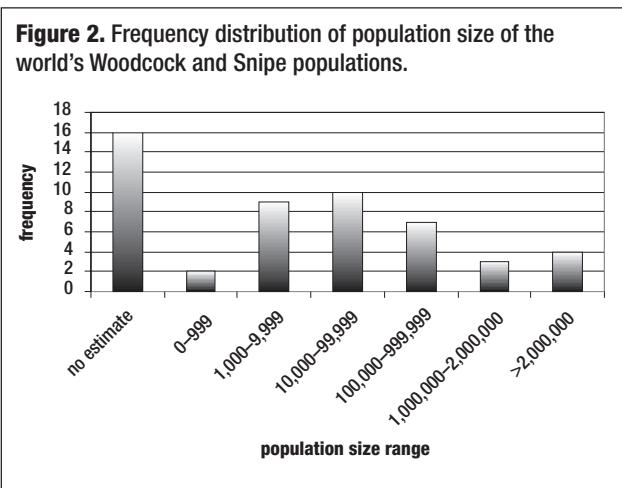
Figure 3 shows that an even higher proportion of Woodcocks and Snipes (61%) have unknown population trends than have unknown estimates. This compares with 50% of all 868 populations of waterbirds presented in WPE3 having unknown trends. Of 19 populations of Woodcocks and Snipes for which trends are available, 10% are extinct (compared with 5% of all waterbird populations) 55% are declining (compared with 46% of all waterbird populations) 35% are stable (compared with 36% of all waterbird populations) and none at all are increasing (compared with 19% of all waterbird populations).
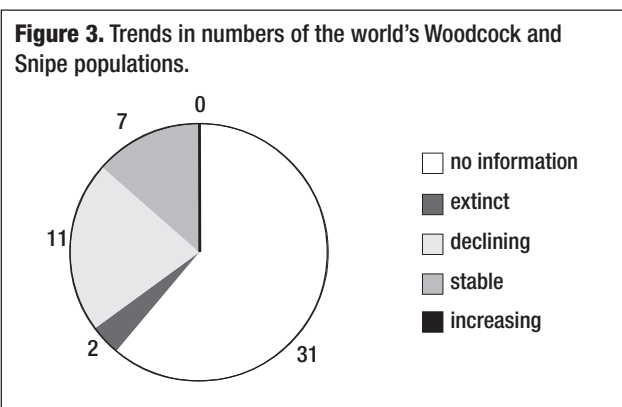
The world's Woodcocks and Snipes are thus more poorly known than waterbirds as a whole, and the population trends that are known indicate that the proportions of extinct and declining populations are higher than is the case among waterbirds as a whole. In addition, there is not a single Woodcock or Snipe population that is known to be increasing. These trends are indicative of a species group in trouble.

Globally threatened Woodcock and Snipe species

Those populations of Woodcocks and Snipes which are Globally Threatened according to IUCN criteria are listed in Table 8.

Figure 2. Frequency distribution of population size of the world's Woodcock and Snipe populations.

Figure 3. Trends in numbers of the world's Woodcock and Snipe populations.

IUCN Red-Listing occurs at species level, and 10 out of 26 species of Woodcocks and Snipes (38%) (16 out of 51 biogeographic populations (31%)) are considered to be Globally Threatened. Table 8 includes three basic life-history characteristics and shows whether each species is sedentary, island-dwelling or a long distance migrant. No fewer than 80% of globally threatened Woodcock and Snipe populations are sedentary. This is a considerably higher proportion, than is found within Woodcock and Snipe species as a whole, of which 27 out of 51 populations (53%) are sedentary. Altogether, 60% of Globally Threatened Woodcock and Snipe populations are

Table 8. Populations of the ten most threatened Woodcock and Snipe species in the world.
(For an explanation of the IUCN Red List categories and criteria, see http://www.redlist.org/info/categories_criteria2001.html)

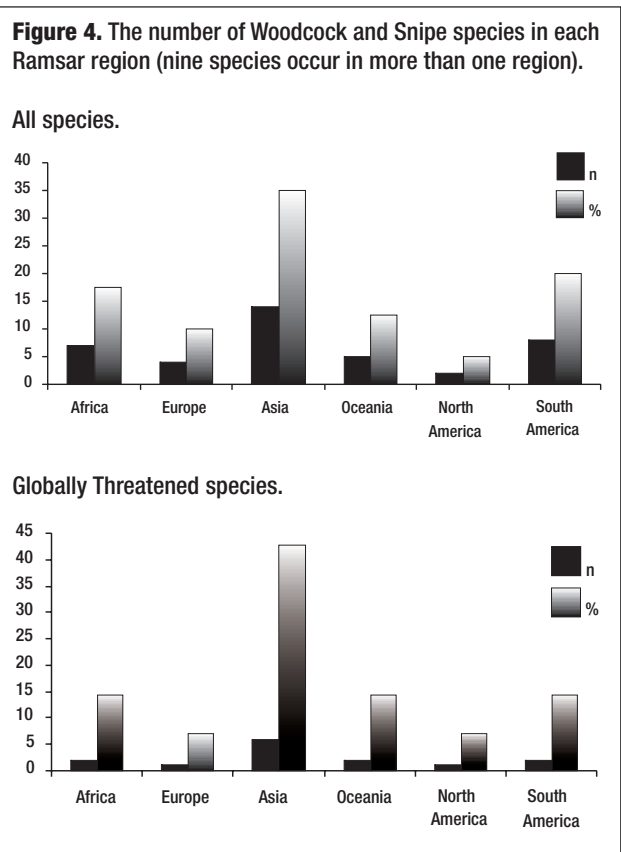| Species and population	IUCN category	Distribution	Sedentary	Island	Migrant
Amami Woodcock *Scolopax mira*	VU	Asia (Ryukyu)	X	X	-
Sulawesi Woodcock *Scolopax celebensis celebensis*	NT	Asia (Sulawesi)	X	X	-
Sulawesi Woodcock *Scolopax celebensis (heinrichi)*	NT	Asia (Sulawesi)	X	X	-
Moluccan Woodcock *Scolopax rochussenii*	VU	Asia (Moluccas)	X	X	-
Chatham Island Snipe *Coenocorypha pusilla*	VU	Oceania	X	X	-
Subantarctic Snipe *Coenocorypha aucklandica aucklandica*	NT	Oceania	X	X	-
Subantarctic Snipe *Coenocorypha aucklandica meinertzhagenae*	NT	Oceania	X	X	-
Subantarctic Snipe *Coenocorypha aucklandica heugeli*	NT	Oceania	X	X	-
Subantarctic Snipe *Coenocorypha aucklandica barrierensis*	NT	Oceania	X	X	-
Subantarctic Snipe *Coenocorypha aucklandica iredalei*	NT	Oceania	X	X	-
Wood Snipe *Gallinago nemoricola*	VU	Asia	-	-	X
Madagascar Snipe *Gallinago macrodactyla*	NT	Africa	X	X	-
Great Snipe *Gallinago media* (Scandinavia, br)	NT	Africa, Europe	-	-	X
Great Snipe *Gallinago media* (NE Europe, W Siberia, br)	NT	Africa, Asia, Europe	-	-	X
Fuegian Snipe *Gallinago stricklandii*	NT	Neotropics	X	-	-
Imperial Snipe *Gallinago imperialis*	NT	Neotropics	X	-	-

island-dwelling and 20% are long-distance migrants. Sedentary, island-dwelling forms do appear to be at particular risk.

Figure 4 shows the overall number of Woodcock and Snipe species occurring in each Ramsar region, and the number of Globally Threatened Woodcock and Snipe species in each of these regions. The proportions of all species and of Globally Threatened species are very similar in each region, and this group of birds appears to be under a comparable level of threat all over the world. Just under half of the world's Woodcocks and Snipes occur in Asia and Oceania, while just over half of the Globally Threatened species occur in these regions.

Red-Listing occurs at species level and as a result of this, a number of threatened sub-species and biogeographic populations which are in trouble are not officially recognised as such. Table 10 gives details of two Woodcock sub-species and three Snipe sub-species which would meet the IUCN Red List criteria if they were recognised as full species. The arbitrary nature of these categories and criteria is illustrated by the tenth taxon in the table, the morphologically similar (though only distantly related) Australian Painted Snipe. The Greater Painted Snipe (*Rostratula benghalensis*) is a widely distributed but scarce species formerly thought to have African, Asian and Australian populations. The Australian population is sufficiently distinct to have been considered a sub-species, *Rostratula benghalensis australis* for many years. Lane and Rogers (2000) presented strong evidence that this is in fact a separate and endangered species, which comfortably meets the IUCN Red List criteria. Bird taxonomy is far from perfect, and the importance of the decisions of taxonomists to the globally threatened status of taxa is considerable. It would seem to make sense to consider taxa at the most detailed taxonomic level accepted taxonomic level (sub-species or biogeographic population) when considering their Red List status.

Two sub-species of Subantarctic Snipe (*Coenocorypha aucklandica barrierensis*) and *Coenocorypha aucklandica iredalei* are extinct, but the species is considered Near Threatened under IUCN Criteria, meaning that these extinct sub-species are only recognised as having a relatively low threat status (Table 9). It would be possible to deal with such anomalies with this and other species by

Figure 4. The number of Woodcock and Snipe species in each Ramsar region (nine species occur in more than one region).

All species.

Globally Threatened species.

applying Red List criteria at the level of sub-species or biogeographic population. This would also increase the sensitivity of Red-Listing as a tool for identification, classification and protection of animals at risk of extinction.

Poorly known populations

It is clear that compared to most other waterbird groups, population estimates and trends are relatively lacking for Woodcock and Snipe species. This is no surprise to those familiar with their secretive habits and preference for impenetrable habitats. It is, nevertheless, crucial to the conservation of these species that efforts are made to find out more about them. Table 10 lists all 13 Woodcock and Snipe populations detailed in WPE3 for which information is lacking on population size and trend, together with the Ramsar regions in which they occur. It is striking that 75% of the most poorly known populations occur in Asia and South America (44% in Asia and 31% in South America).

Conclusions and discussion

Numerical estimates are available for 58% of Woodcock and Snipe populations, but most are imprecise. Trend estimates are available for 39% of Woodcock and Snipe populations. These known trends break down as follows: none are increasing, 35% are stable, 55% are decreasing and 10% extinct. Altogether, 38% of Woodcock and Snipe species are categorised as Globally Threatened by BirdLife International, using IUCN Red List criteria. More of these Globally Threatened species occur in Asia and Oceania than in the other four Ramsar regions combined, but this is largely a reflection of the overall global

Table 9. Should Red-Listing occur at sub-species or population level?

Sub-species or biogeographic population	Distribution	Estimate	Trend
Rostratula (benghalensis) australis Australian Painted Snipe	Australia	<10,000	DEC
Scolopax saturata saturata Dusky Woodcock	Sumatra, Java	three specimens	-
Scolopax celebensis heinrichi Sulawesi Woodcock	N Sulawesi	-	-
Coenocorypha aucklandica barrierensis Subantarctic Snipe	Little Barrier Is, NZ	0	EXT
Coenocorypha aucklandica iredalei Subantarctic Snipe	Stewart Is, NZ	0	EXT
Gallinago solitaria japonica Solitary Snipe	East Asia	A	-

Table 10. Woodcock and Snipe species lacking both population estimate and trend estimate in WPE3.

Species	English name	Sub-species and population	Africa	Europe	Asia	Oceania	S America	N America
Scolopax rusticola	Eurasian Woodcock	*rusticola*, W Asia (bre)	-	X	X	-	-	-
Scolopax saturata	Dusky Woodcock	*saturata*	-	-	X	-	-	-
Scolopax saturata	Dusky Woodcock	*rosenbergi*	-	-	-	X	-	-
Scolopax celebensis	Sulawesi Woodcock	*celebensis*	-	-	X	-	-	-
Scolopax celebensis	Sulawesi Woodcock	*(heinrichi)*	-	-	X	-	-	-
Scolopax bukidonensis	Bukidnon Woodcock	Philippines	-	-	X	-	-	-
Lymnocryptes minimus	Jack Snipe	W Siberia (bre)	X	X	X	-	-	-
Lymnocryptes minimus	Jack Snipe	S Asia (non-bre)	-	-	X	-	-	-
Gallinago andina	Puna Snipe	Central Andes	-	-	-	-	X	-
Gallinago nobilis	Noble Snipe	N South America	-	-	-	-	X	-
Gallinago undulata	Giant Snipe	*undulata*	-	-	-	-	X	-
Gallinago jamesoni	Andean Snipe	N Andes	-	-	-	-	X	-
Gallinago imperialis	Imperial Snipe	NW South America	-	-	-	-	X	-

distribution of the world's Woodcock and Snipe species. A majority of Globally Threatened Woodcock and Snipe species are sedentary, and most of these are island forms. A significant minority of Woodcock and Snipe populations remain data-deficient and a disproportionate number of these are concentrated in Asia and South America. Refinement of IUCN Red List Criteria may be possible and desirable.

Recommendations arising from this review include:
- developing robust and sustainable methods of monitoring both widespread and specialised forms;
- making special efforts to estimate numbers and trends of globally threatened and data deficient populations; and
- giving high priority to populations in Asia and South America.

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Woodcock

Woodcock (*Scolopax rusticola*) breeding biology in Pico Island (Azores – Portugal)

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In the Azores the Woodcock (*Scolopax rusticola*) is considered a resident breeding species, but there is little information about its biology and ecology. The archipelago comprises nine main islands. Presently the Woodcock is a game species in five of them. Pico, the second largest island (433 km^2), located in the Central Group, was chosen by the regional hunting administration to develop studies that, for the first time, could give crucial information for an appropriate hunting management. Traditionally, the Woodcock was hunted when roding, from late January till mid-March. This work presents some of the results obtained since the beginning of the studies in December 2000, namely those concerning their breeding biology, and hunting activity.

The number of contacts with roding Woodcocks was recorded at two fixed listening points, in 2001 and 2002, located at different altitudes. Roding activity started in the middle of January – early February and ended more or less abruptly in early July. The number of contacts increased until April then decreased to a minimum level in early May. Afterwards, it increased again to a medium level. A total of 14 clutches and 12 broods (a total of 27 juveniles, with ages between a few hours and two–three weeks) were found, mainly during 2001 and 2002. The mean clutch size was four (n=8) and the mean number of hatched eggs/clutch was 3.13 (s.d.=0.99). Distribution of clutches (first egg dates) throughout the breeding season, calculated from nests and the estimated age of broods, showed a greater frequency of clutches in March. During the 2000/2001 hunting season (February 2001), 95% of the birds shot during roding, (n=20) were males, and among these, about 74% were adults (≥1 year). In a sample of 44 males shot from January till early March (2001 and 2002), a significant correlation between six spermatogenesis stages and testicular index (Stronach, 1983) was observed. Among males shot in February (2001 and 2002; n=31) the adults presented significantly higher values of testicular index than young males. Implications of these results for hunting management and some aspects of the breeding biology of these population are discussed.

Introduction

In the Azores archipelago the Woodcock (*Scolopax rusticola*) is considered a resident breeding species (Chavigny and Mayaud 1932, Bannerman and Bannerman 1966, Le Grand 1983). Presently its hunting is allowed in five of the nine islands that compose the archipelago. Considering the little information available about its biology and ecology in the archipelago, the Regional Hunting Administration (Direcção Regional dos Recursos Florestais – DRRF) chose the island of Pico to develop studies that, for the first time, could give crucial information for the appropriate conservation and management of these insular populations. The studies began in late 2000, as a result of a co-operation protocol between DRRF and the Research Centre in Biodiversity and Genetic Resources (CIBIO, University of Porto). The first results concerning the distribution and relative abundance of Woodcock in Pico island during the breeding season, obtained during 2001, can be found in Machado *et al.* (2002).

In the Azorean archipelago, Woodcock was traditionally hunted when roding, from end January till mid-March. As stated by Stronach (1983), one of the criteria to terminate the hunting season is the onset of the reproductive cycle or breeding season; to define the latter, signs like roding, nest initiation or egg laying and the development of reproductive organs (which precedes any reproductive activity) can be taken into account. One of the main goals of the present work was to evaluate the adequacy of the hunting season with respect to the reproductive cycle of the species, using those factors. Additionally, it was intended to i) define the pattern of roding-intensity variation throughout the breeding season, in order to establish the better period to make an annual census; ii) define the distribution of clutches (first-egg dates) during the breeding season; iii) determine some reproductive parameters, such as clutch size and hatchability.

Methods

Study area: the island of Pico (Azores)

The Azores archipelago, located in the North Atlantic Ocean (36–39º N 25–31ºW), comprises nine main islands of volcanic origin. Together with those of Madeira and the Canaries, the Azorean native cloud forest is considered to be a remnant of the old Tertiary forests that once covered southern Europe (Tutin 1953 *in* Ramos 1993). Presently, due to cattle production, more than half of Azorean land is pasture (Garcia and Furtado 1991 in Borges 1999).

The island of Pico is the largest island of the central group, and the second largest one in the archipelago, with an approximate area of 433 km^2. The landscape is marked by its volcanic peak (2,351 m), from which the

island got its name, located in the western end of the island. The introduction of the exotic tree *Pittosporum undulatum* has affected this island particularly and its natural vegetation is greatly altered. Nevertheless, in Pico is possible to find some of the more important areas of the archipelago's natural vegetation.

Since the 1999/2000 hunting season, the island of Pico is divided into two main areas (Figure 1) and the permission to hunt Woodcock changes from area to another on an annual basis of permutation.

Variation in roding activity

The fieldwork was carried out from February to July 2001 and from January to July 2002. The methodology used was that developed by Ferrand (1989, 1993), which is adapted to the specific behaviour of Woodcock males during the breeding period. Observations took place at dusk, during the display (roding) period of males, at fixed listening points. The number of Woodcocks seen and/or heard (contacts) was recorded. By convention, simultaneous contacts were recorded as the respective number of birds.

In order to obtain precise data about the seasonal variation in roding activity, two listening points (P1 – Candelária, 370 m high; P2 – Ribeira das Calhetas, 850 m high) were established in 2001. According to local hunters, these points corresponded to places where the abundance of roding males was traditionally known to be high. In 2001, P1 and P2 (Figure 1) were visited weekly or fortnightly, depending on favourable weather conditions. In 2002, the same listening points were visited with a higher periodicity (two or three visits per week).

Age and sex determination

The age of full-grown birds was determined by an analysis of wing moult stage (Clausager 1973), complemented by observation of *bursa Fabricius* presence/absence, after dissection. Two age classes were considered: young (<1 year) and adult (≥1 year) birds.

Their sex was determined by dissection and gonad observation.
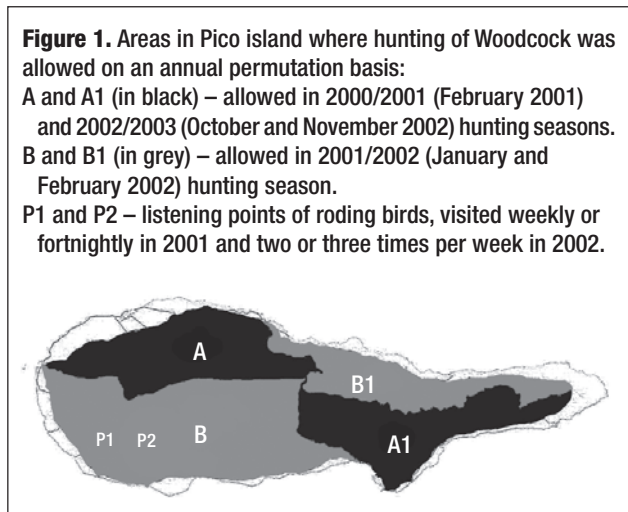
Evaluation of the male's sexual development

To evaluate the male's sexual development, full-grown birds (n=77), captured by different methods, were analysed.

Birds shot for the project

With the co-operation of some local hunters (with pointing dogs), a few birds were shot periodically. This allowed to analyse 19 males: 13 captured between December 2000 and early March 2001; six captured between January 2002 and March 2002.

Birds shot by hunters during the hunting season

Hunters were requested to report the sex of the birds shot during the hunting season and to cut a wing for age determination. Some allowed that entire birds were analysed and, therefore, it was possible to analyse the following numbers of males: six captured during the 2000/2001 hunting season (February 2001), 37 captured during the 2001/2002 hunting season (January and February 2002) and 14 captured during the 2002/2003 hunting season (October and November 2002).

One bird killed by accident during ringing operations in September 2002 was also analysed.

Sex development (stage of reproductive cycle) was determined according to Stronach (1983):
- the long and short axes of the left testicle were measured using a calliper (precision: ± 0.05mm); a testicular index was calculated: long axis multiplied by short axis;
- the testes were extracted and fixed in *Bouins* fluid; when large, they were cut into two pieces so that the fixative could penetrate more easily; after that the testes were washed in 70% alcohol, stored in fresh 70%, and, when required for sectioning, processed by standard histological methods; embedded in paraffin wax the testes were sectioned with a standard microtome; the sections were stained with hemalumen-eosin.

Six stages of spermatogenesis were identified using the criteria described by Stronach (1983):
1. spermatogonia only;
2. spermatogonia dividing, but only a few spermatocytes present;
3. many spermatocytes;
4. spermatocytes and spermatids;
5. spermatids and a few spermatozoa;
6. many spermatozoa in bunches.

Clutches and broods

During the breeding season (2001, 2002 and 2003) some areas were checked, by "cold searching", to find nests and broods. Resident people were also requested to report any nest or brood detected. During the 2003 breeding season it was not possible to maintain the search efforts developed in the two previous years.

For the nests/clutches found some variables were determined when possible:

Figure 1. Areas in Pico island where hunting of Woodcock was allowed on an annual permutation basis:
A and A1 (in black) – allowed in 2000/2001 (February 2001) and 2002/2003 (October and November 2002) hunting seasons.
B and B1 (in grey) – allowed in 2001/2002 (January and February 2002) hunting season.
P1 and P2 – listening points of roding birds, visited weekly or fortnightly in 2001 and two or three times per week in 2002.

- hatching date
- laying date of the first egg; according to Hoodless and Coulson (1998): the hatching date – 22 days – one day/egg (error: ± five days).

The juveniles captured among observed broods were weighed (precision: ± 2 g) and their bill length measured by Fadat's method (1995) – with a ruler (precision: ± 0.5 mm), between the mandibles, with one extremity touching the commissure.

Results and discussion

Variation in roding activity

In 2001, the census began in the second week of February. At that time, a relatively high number of contacts with roding birds was already observed at listening points (Figure 2). In 2002, the census began in the third week of January but the first contacts with roding birds were only registered in February (Figure 2). If the number of contacts increases progressively at the beginning of the breeding season, as is the case of 2002 and in continental Europe (Hirons, 1983; Ferrand, 1989), the results obtained seems to indicate that the beginning of roding activity in Pico island may occur between the end of January and the beginning of February.

When comparing the two years, lower values in the number of contacts were frequently obtained in 2002 at both points (Figure 2). An explanation for that comes from the fact that they were located in the area where hunting was allowed in 2002 but not in 2001. The 2002 roding period was probably shorter for the same reason, i.e., the hunting pressure in January–February has diminished the number of males and consequently the number of contacts. These results seemed to confirm that the method used is sufficiently sensible to detect variations in relative abundance.

The two listening points presented the same pattern of variation in the number of contacts, in both years, (except for P2 in 2001, when, due to the lower frequency of visits, the pattern was not evident): an increase in the number of contacts until early March, followed by a period of some stability of these values, that ended with the registration of maximum values at the beginning or the middle of April; after that, the number of contacts dropped to the lowest values in the beginning of May, and raised again to medium values; the roding activity stopped at the end of June or the first week of July.

The studies concerning the behaviour of Woodcocks have revealed that, after meeting a receptive female, the male will stay with her for a few days, until the clutch is laid, before resuming display (roding) flights (Hirons 1983, 1987, Ferrand 1989). Therefore, the decrease observed in the number of contacts between April and May could be explained by an increase in the number of females available for pairing (after a first peak of clutches) with, consequently, an increase in the number of pairs on the ground. The males posterior abandonment of females and return to roding may explain the new increase in the
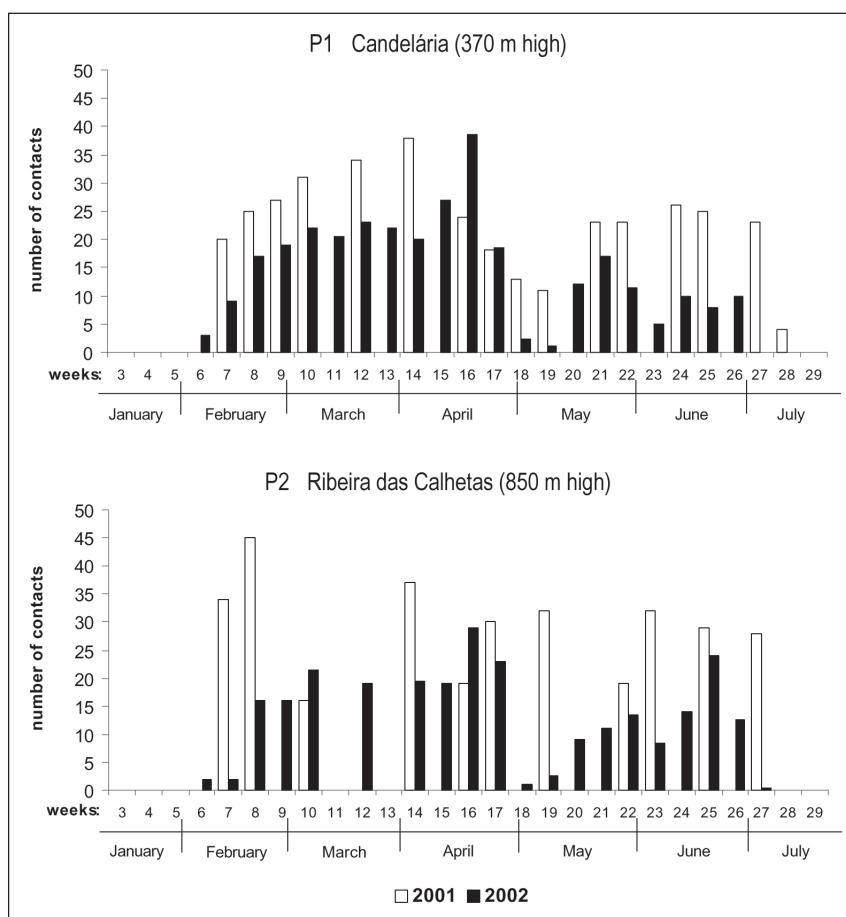
Figure 2. Weekly variation in the number of contacts with roding birds at listening points P1 and P2, in 2001 and 2002; week numbers according to the official calendar.

number of contacts registered in May. Hence, these results suggest that, regularly, an important number of females could get two clutches in the same breeding season.

For an annual monitoring of the relative abundance of birds, the census should be made during a period of certain stability in the number of contacts with roding birds, at high levels. At the two listening points, the variation over time in the number of contacts was very similar, a fact that pointed clearly to the period between the beginning of March and the middle of April as the more appropriate one to census roding males.

Clutches and broods

A total of 14 nests/clutches were found (seven in 2001, six in 2002 and one in 2003). When considering only the clutches that, with certainty, reached the hatching stage, the mean number of eggs per clutch was four (n=8). The corresponding mean number of eggs hatched per clutch was 3.13 ± 0.99 (n=8).

A total of 12 broods were found (seven in 2001, four in 2002 and one in 2003), which correspond to a total of 27 juveniles observed (with ages between a few hours and two–three weeks): 15 in 2001, nine in 2002 and three in 2003. Five juveniles were measured at their birthday and a few days later.

For four juveniles kept in captivity, Marcström (1994) found that their body weight grew constantly and regularly during the thirty days of monitoring. From the relation between body weight and bill length of the juveniles observed in Pico during the present study (Figure 3), it is possible to note that the bill growths proportionally to body weight (rs=0.92; p<0.001; n=30). Considering the five juveniles that were measured twice, the corresponding average daily growth rate of the bill was 1.65 ± 0.22 mm per day.

Hence, and considering that, at least during the first weeks of life, the bill growths in a regular way, and considering the importance of the mean daily bill growth, bill length was used to estimate the age of those juveniles for which the hatching date was unknown. Once the hatching date estimated, and assuming that all clutches had four eggs, it was possible to estimate the first-egg dates (see Methods).

Considering the first-egg dates estimated from clutches and by "counting back" from located broods, it was possible to notice that the earlier clutch was already initiated in February and the latest one in June (Figure 4). As observed in France (Ferrand 1989) and England (Hoodless and Coulson 1998), the higher frequency of clutches was observed in the second half of March. A second peak of clutches may be possible in May, but the
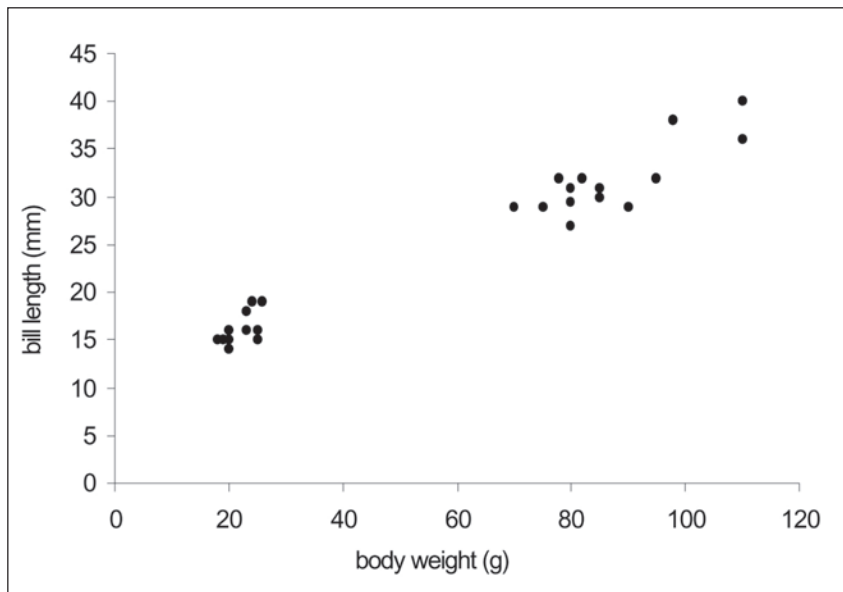
Figure 3. Relation between body weight and bill length [measured between mandibules, according to Fadat (1995)] of juveniles (n = 30; r_s = 0.92; p<0.001) observed during the three years.
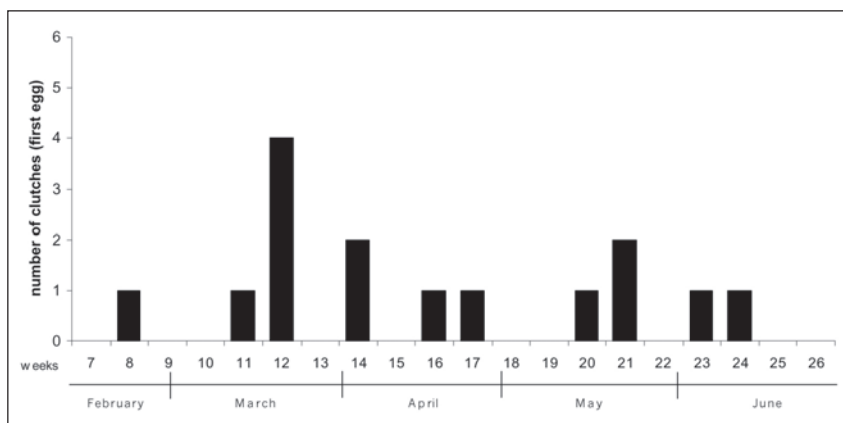
Figure 4. Weekly distribution of clutches (first egg dates) throughout the breeding season, estimated from known laying or hatching dates and from the estimated age of broods found during the three years.

data is still scarce. As seen before, the variation in roding activity seemed to reinforce that possibility.

A second lay in the same season after a successful first brood, has never been observed (Ferrand and Gossmann 2001). Nonetheless, observations of nesting females surrounded by her young suppose that this does happen (von Zedlitz 1927 and Pay 1037 in Ferrand and Gossmann 2001). Moreover, the total time span between laying and raising the young is less than two months. As stated by Ferrand and Gossmann (2001), in those regions where the breeding period stretches over four or five months, a second clutch may, in theory, be laid. The Woodcock breeding period in the Azores seemed to accomplish that.

Male sexual development

In the sample of birds shot when roding, during the 2000/ 2001 hunting season (February 2001; n=24), it was not possible to determine the sex of four birds. For the others, 95% were males, of which 74% were adults (Figure 5); only one female (adult) was shot.

The results obtained by the testicular analysis of 44 males showed good correlations between the state of spermatogenesis and the testicular index, in both class ages and for all birds (see also Figure 5):
- young (n=18) - rs = 0.96; p < 0.001
- adult (n=26) - rs = 0.88; p < 0.001
- all males (n=44) - rs = 0.91; p < 0.001.

For a testicular index value greater than 200, only the spermatogenesis stages five and six (maximum development stages) were observed (Figure 5). For a testicular index equal to 300 or higher, only stage 6 was observed. Hence, the testicular index can be used to estimate the degree of male sexual development and to analyse its temporal variation. To compare the sexual development of young and adult males, the 2001 and
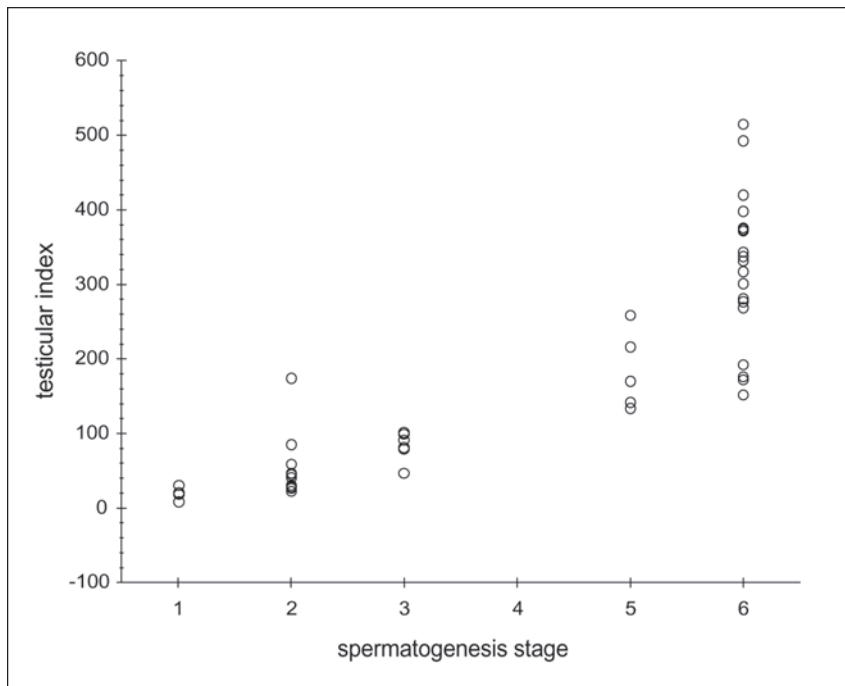
Figure 5. Relation between spermatogenesis stage and testicular index values (r_s=0.91; p<0.001; n=44).
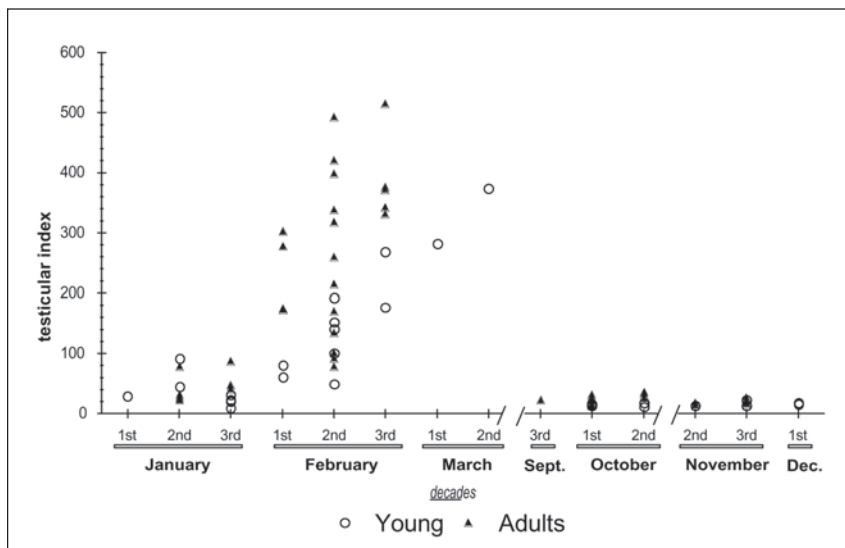
Figure 6. Temporal distribution of young and adult testicular index values; birds captured during 2001 and 2002 (year not individualised); n=77 (47 adults and 30 young); decade=10-day period.

2002 corresponding data were aggregated (Figure 6). During January no significant differences were observed between young (n=7) and adult (n=7) birds. In February, adults (n=22) presented testicular index values that were greater (U=40.0; p<0.05) than for young (n=9).

When ignoring the age classes (Figure 7), no significant differences were observed between the testicular index values of males captured in January 2001 (n=7) and January 2002 (n=7). But among the males captured in February, 2001 males (n=9) presented higher testicular index values (U=26; p<0.01). In both years, the males captured in January (2001, n=7; 2002, n=9) showed lower testicular index values (U=0; p<0.001 and U=4; p<0.001, respectively) when compared with males captured in February (2001, n=7; 2002, n=22).

Conclusions

With variations from year to year (mostly due to variations in weather conditions), the roding activity in Pico island (and probably throughout the archipelago of the Azores) may start between the end of January and the beginning of February. The annual variations in the onset of male sexual development were in accordance with variations in the onset of roding activity: the males shot in February 2001 presented higher testicular index values when compared to males shot in February 2002 (in 2002 the roding activity began later). In both years, the males' sexual development was greater in February than in January.

Considering the first-egg dates estimated from clutches and by "counting back" from located broods, it was possible to notice that the clutches were laid from February till June, and that the higher frequency of clutches occurred in the second half of March. A second peak of clutches seemed possible in May.

Therefore, the breeding season is quite long in these regions. It goes from February till July or even August.

The mean number of eggs per clutch was four and the mean number of eggs hatched per clutch was 3.13 ± 0.99.

The results clearly show that hunting roding birds, in February, may compromise the reproductive success of the species. This hunting method is very selective: the majority of the shot birds are adult males. These were sexually significantly more developed than the young males, in February. Another hunting method applied in February could have a similar effect: perturbation of the beginning of the breeding season.

Meanwhile, being aware of these results, in 2002 the regional hunting administration displaced the hunting season to October–November, where it has stayed until the present.

The present study also seemed to demonstrate that the annual permutation between to main areas of the island to allow hunting of Woodcock, is a wise management measure that may benefit the species. This allows that, each year, half of the island may function as a reserve. The reserves seemed to bring some benefits to the Woodcock population by allowing a greater survival rate and longevity (with the corresponding benefits in terms of reproductive potential) for a fraction of the individuals (Fadat, 1989 in Ferrand and Gossmann, 2001). If the permutation should be made not annually but only after two or three years, this will be a matter for another study.

For the annual monitoring of the relative abundance of birds, based on species characteristics, the census of roding males is one adequate methodology. The observed variation in roding activity clearly showed that the period between the beginning of March and the middle of April is the most appropriate one to make such censuses in the Azorean archipelago.
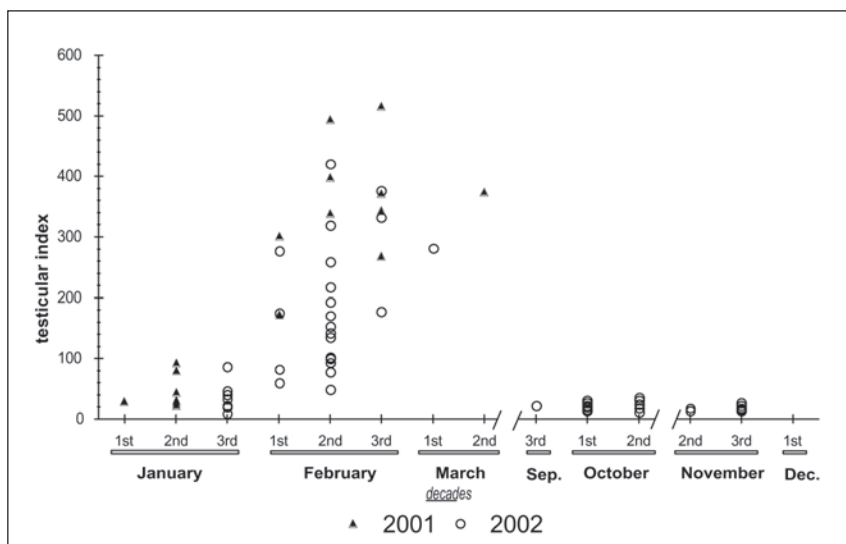
Figure 7. Temporal distribution of the 2001and 2002 bird testicular index values (age class not individualised); n=75 (2001, n=17; 2002, n=58); decade=10-day period.

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Woodcock hunting bag statistics in Russia since 1996

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Woodcock hunting is popular in different regions of Russia and takes place every year in spring as well as in autumn. In European Russia, it is usually organised in April–May for up to 10 days and from August to December during 60–90 days in accordance with the administrative districts and individual provinces. In addition to time limitations, Woodcock hunting is officially restricted by bag limits for every day of hunting. The common bag limits range from two to five birds for one hunter per day. Hunting seasons and bag limits are founded on nothing except historical practices. In spring and autumn, the start of the hunting seasons is co-ordinated with the hunting seasons for other gamebird species, which causes dissatisfaction among hunters. The main Woodcock hunting methods are: shooting of males during roding in spring, shooting in autumn with or without the help of a dog and shooting during the evening flights from the forest to feeding areas. Whereas the first two methods are mainly practiced in the central regions of Russia, the last one refers to the southern regions of the country.

Until the mid-90s no regular censuses of Woodcock hunting bags had been conducted in Russia. In 1996, the proposal of the "Woodcock" Group to organise such census was accepted by the national Hunting department, and the official information on Woodcock hunting licences is now collected through its regional organisation. As of 1998, and also on the initiative of the members of the "Woodcock" Group, a regular census of the autumn Woodcock bags and some other species of small gamebirds has been organised. Thus, to date, information has been collected for seven spring and five autumn hunting seasons.

As a result of these works, the estimation of the total Woodcock bag is made for the country as a whole, the individual regions and hunting seasons. It is estimated at 140,000–150,000 males in spring and 40,000–50,000 males and females in autumn. Information on factors affecting the bag dynamics of this species is being gathered. It revealed that the individual bag of one hunter in spring is about one bird for the whole season, while in autumn it is estimated at about 0.1 bird for the season. This confirms the poor basis of the existing excessive bag limits, which really do not limit Woodcock hunting.

Introduction

Woodcock hunting is quite popular in many regions of Russia, and takes place every year in spring and in autumn. The main hunting methods are shooting of males during roding in spring, shooting during daytime with (or without) dog and during their evening flights from the forests to their feeding places in autumn. The first method is most common in Central Russia and the last two ones in the southern regions.

Before the mid-90s no regular Woodcock hunting bag counts were made in Russia. Woodcock bag-size monitoring started in 1996. It was initiated by the "Woodcock scientific group" with the support of the Hunting Department of the Russian Federation and ONCFS (Fokin and Blokhin 2000). Last years' information has been collected by the State Game Counts Service (Gosokhotutchet) of Russia.

Methods

The source of information for game-bird bag counts is the personal permit form for shooting. Initially, this was a permit for a territory of game management, now it is a personal state licence for an administrative district. Each hunter must purchase the licence before the hunting season, and return it filled out with his data on the birds he shot after the end of the hunting season. We designed a special report form for this data collection system.

First of all, the regional branches of the Hunting Department and their offices in the districts, should collect as many completed licences as possible, and analyse them first. Each regional branch prepares a report (in table form) for the Centre of Gosokhotutchet. The report contains information for each administrative district, on their hunting season dates, the numbers of licences given (sold) to hunters, the numbers of returned filled-out licences and the numbers of Woodcocks shot by hunters who returned their licences.

The present article is based on these report tables, that has been collected for further analysis by the Centre of Gosokhotutchet after each hunting season.

We got estimations of the total bag size through an extrapolation of the average bag per one licence to the total number of licences given-out. For a data comparison for large areas and European Russia as a whole, in some cases we replaced the absent data by average figures of previous years.

Results

Spring shooting

Data distribution

In 1996, we addressed an information request to all regional branches of the Hunting Department, except in

North Caucasus where spring shooting at roding is not allowed. We got information from 56 regions of the Russian Federation (80% of requests). The most complete data were obtained for European Russia and the Ural. Besides the Caucasus, Woodcock shooting was not allowed in some forestless regions in the southern parts of the Volga and Ural areas (Astrakhan', Volgograd, Kalmykia, Kurgan), and in the Murmansk region at the northern limit of the Woodcock range.

In Siberia and the Russian far east, Woodcock shooting is not popular and only 1% of the total Russian bag was taken here. In 1996, Woodcock shooting was banned in all regions of west Siberia (no information from the Altai). In 12 regions (i.e. 21% of the Asiatic Russia information based on available data), the Woodcock shooting season was not opened.

Due to the distribution of such a return rate in the latest years, we requested information only in the Hunting Department regional branches of European Russia and Ural area. We obtained data from 30–38 regions every year.

Similarly to 1996, the Woodcock spring shooting season was not opened in 2002 in North Caucasus. Spring shooting was completely prohibited in the Perm' region in 2002 and 2003. In Asiatic Russia, Woodcock spring shooting was not opened in eight regions of west Siberia (no data from the Altai again), in Buriatia, Tchita and Evenkia in east Siberia, and in Evreiskaya and Khabarovsk in the Russian far east. The total numbers of shot Woodcocks in Irkutsk, Krasnoyarsk, Ust'-Orda and Khakasia in east Siberia and in Primorie in the far east, was only slightly more than 1,000, and only about 4,000 in the Sakhalin region. Thanks to the estimated bag size given by the Sakhalin hunters in the Asiatic part, the total bag for Russia increased by 3.6%.

Dates and duration of spring shooting

The beginning of the Woodcock shooting season is everywhere related to the shooting dates for other gamebird species (migratory ducks and geese, and resident capercaillie and black grouse). Hunters are "reasonably unsatisfied" by this situation, particularly in the Central area.

In the majority of the regions the spring shooting season lasts 10 days. There can be two or three 10-day shooting periods of a total duration of 11 to 38 days, in some large regions with a sufficient difference in bird arrival dates between groups of administrative districts. There were seven to 19 such regions in different years, but we did not find any significant trends here.

In European Russia as a whole, the spring shooting season opened on 2–5 April, and closed on 19 May–5 June. Thus the duration of the season was 47 (1996) to 63 (2000) days or 1.5 to two months. In spring, migrating Woodcocks will first arrive in the southern regions. Here (Belgorod, Saratov, Tambov regions) the opening dates of spring shooting are the earliest. The latest spring hunting season always closes in the northern area, in Arkhangelsk and Komi.

Spring 2002 came unusually early. Shooting at roding started simultaneously on 22–23 March in a certain number of southern and western regions (Belgorod, Voronezh, Kursk, Kaliningrad, Lipetsk, Tambov), and on 29–30 March in the regions of the Central area (Briansk, Kaluga, Orel, Tula, Riazan'), i.e. about 10–12 days earlier in comparison with the usual dates. Thus, in early April shooting at roding had already finished in some regions (Kaliningrad, Black-Soil Centre area). Early roding was not intensive, so shooting was not successful and the total bag size in these regions was low. In the majority of regions the spring hunting season finished before the Woodcock migration peak.

Popularity of spring shooting

These last years the greatest number of licences for Woodcock shooting were given to hunters in the Moscow (18,000), Nizhniy Novgorod (10,000) and Yaroslavl (8,000) regions. In the other regions, e.g. in Arkhangelsk (11,000–16,000) and Vologda (1,000–19,000) licences allowed shooting of several gamebird species, including Woodcock. We cannot give the number of licences which corresponds to shooting at roding. In the Central area, hunters were given approximately 60,000 licences, about half of the number of total licences for spring hunting in European Russia and Ural. For shooting at roding, much less licences are taken by the hunters of the Volga–Viatka and northern areas (15% each), and very few in other areas.

In spring 2002, about 83,000 hunters attended roding in the Central area – 1.5 times more than the average number for previous years. However, this represented only 39% of the total number of licences issued in European Russia. Significantly more licences were taken by hunters of the northern area [47,000 (22%)].

With a gamebird licence a hunter may shoot waterfowl, capercaillie, black grouse and Woodcock. There are local restrictions for certain huntable species. So, the number of licences is not equal to the number of hunters who attended roding. In regions where the Woodcock, traditionally, is not a popular game (e.g. northern area), the number of Woodcock hunters is much lower than the number of licences. We suppose that in the late 90s, 109,000 to 130,000 (on average about 120,000) hunters (10–14% of those registered in the same regions) attended roding in different years. At the beginning of new century, 130,000–210,000 (average for three years – 170,000) hunters attended roding, i.e. by 30% more than compared to the late '90s.

Bag sizes

Bag size calculations are made on the basis of information obtained by filed licences, so it is very important that the greatest number of them be returned. Data collected in the Hunting Department over the last eight years show that the average return rate is 40 to 80%, although in some regions it may amount to 90%.

Until 1999, the largest bag size was registered in the Moscow region – 23,000 Woodcocks per spring on average. Bags were twice as less in the Yaroslavl', Nizhny Novgorod and Tver' regions. 6,000–8,000 Woodcocks

were shot at roding in Kaluga, Vologda, Smolensk, Kostroma, Vladimir and Leningrad respectively. Bags were less than 1,000 Woodcocks in each of about half of the European and the Ural regions, particularly in the Volga and Black-Soil Central areas.

In 2002 and 2003, about 13,000 Woodcocks were shot in the Moscow region – twice as less in comparison with the average bag of previous years. In the Kaluga region, only 2,000 Woodcocks were taken. The bag size decreased elsewhere in European Russia where early-spring hunting season dates were registered. At the same time the bag sizes were relatively stable and even slightly increased in Vladimir, Ivanovo, Kostroma, Smolensk and some other regions. A map of the average spring bag size distribution is shown in Figure 1.

For the period 1996–2001, we calculated that 134,000–160,000 (on average 149,000) Woodcocks were shot each spring in 40 regions of European Russia and the Ural. A great part of the bag – 66,000 to 86,000, i.e. 46–59% (79,000; 53%, on average) – was taken in 12 regions of the Central area. About 25% was taken in the Volga–Viatka area, less in the north-west area, and still less in other areas (Figure 2).

In 2002 and 2003, the Woodcock spring-bag size significantly decreased (Figure 3). In 2002, the bag size was estimated at only 144,000 Woodcocks. It was significantly less in the Central area (66,000; 46%), but greater in northern (18,000; 13%) and north-west ones (21,000; 15% – see also Figure 4). For the remaining areas the relative part of the total bag in European Russia and Ural was similar to the previous years, but the absolute numbers of shot Woodcocks decreased.

Figure 2. Proportion of Woodcock spring bag size by area, in European Russia and the Ural (numbers of shot Woodcocks in thousands).
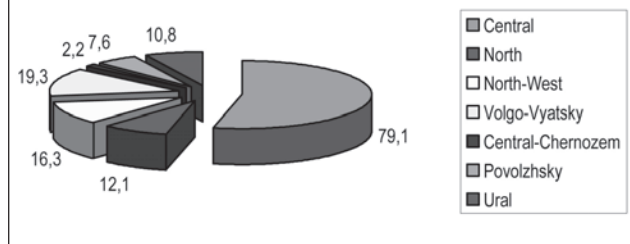
Figure 3. Woodcock spring bag-size dynamics by area, in European Russia and the Ural (% of total bag size for 1996–2003).
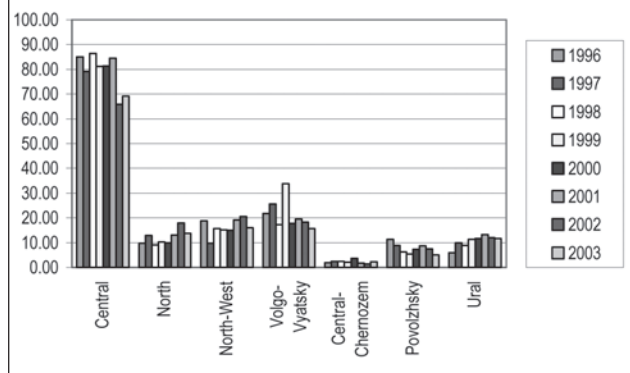
Figure 1. Distribution of Woodcock spring bag size in European Russia and the Ural (average number of shot birds in 1996–2003).

Hunting bag (number of Woodcocks shot)

Moscow region (19,322)
6,000–12,000
1,000–5,999
<1,000

Area	No	Region	Area	No	Region
North	1	Arkhangel'sk	Volga-Viatka	26	Kirov
	2	Karelia		27	Marii El
	3	Vologda		28	Nizhny Novgorod
	4	Komi		29	Chuvashia
Baltic North-west	5	Kaliningrad	Volga	30	Penza
	6	Leningrad		31	Saratov
	7	Novgorod		32	Ulianovsk
	8	Pskov		33	Samara
Central	9	Briansk		34	Volgograd
	10	Vladimir		35	Tatarstan
	11	Ivanovo		36	Mordovia
	12	Kaluga		37	Bashkortostan
	13	Kostroma	Ural	38	Perm'
	14	Moscow		39	Sverdlovsk
	15	Orel		40	Udmurtia
	16	Ryazan'		41	Tcheliabinsk
	17	Smolensk		42	Orenburg
	18	Tver'		43	Komi-Perm'
	19	Tula	North Caucasus	44	Adygea
	20	Yaroslavl'		45	Kabardino-Balkaria
Black-Soil Centre	21	Belgorod		46	Karachaevo-Cherkesya
	22	Voronezh		47	North Osetia
	23	Kursk		48	Krasnodar
	24	Lipetsk		49	Stavropol'
	25	Tambov		50	Rostov

Figure 4. Woodcock spring bag-size dynamics in the north-west area, by region (% of total bag size for 1996–2003).
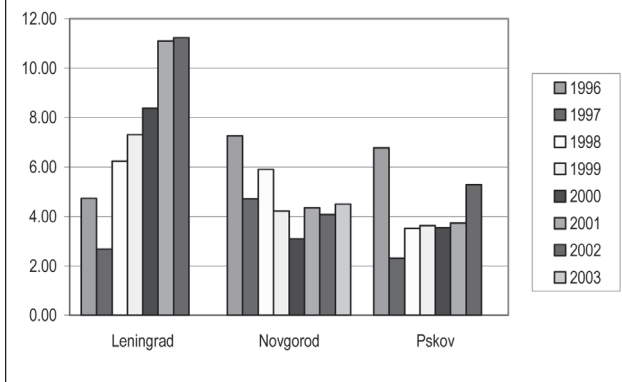
There were no steady trends in bag-size dynamics by regions or areas. Growth was only observed in the Leningrad, Pskov (Figure 4) and Marii-El regions.

Bag sizes of individual hunters

The estimated bag sizes are not similar (i.e. higher) to the actual bag sizes (Blokhin and Mezhnev 2002).

There were no regions in Russia where on average two Woodcocks or more were shot per licence in spring ,for eight years. In European Russia as a whole, the average spring bag size in different years was 0.7 to 1.2 Woodcocks per licence. In 2002, the best results were registered in the Tcheliabinsk, Pskov, Tver' and Yaroslavl' regions where on average 1.5–1.7 Woodcocks per hunter were shot during the spring season. In 2003, the best results were observed in the Tcheliabinsk (2.4 Woodcocks per licence), Novgorod (1.5), Kostroma and Yaroslavl' (1.2), and Tver' (1.1) regions.

Thus the average individual bag sizes were generally low. At the same time some local bag sizes appeared to be extremely high:
• in 1996, 4.6 Woodcocks per spring licence in the Tambov region, 3.3 in Mordovia, 2.9 in Penza, 2.6 in Kursk, 2.5 in Smolensk;
• in 1997, 4.1 in Briansk, three in Tcheliabinsk.

So, we have some doubts about the reliability of primary data (Blokhin and Mezhnev 2002). After the transition to a new licences system in the early 2000s their reliability should be significantly increased.

Autumn shooting

Data distribution

We requested data on autumn Woodcock shooting in all regions of European Russia, including North Caucasus and the Ural. After a first count attempt in 1996, the data obtained were quite incomplete – 22 regions only were presented. In later years we got information from 32 to 40 regions. For five years we collected data in 48 regions, except Voronezh and Bashkortostan. For Asiatic Russia

very incomplete data were collected for the first time in 2001 (Altai, Irkutsk, Primorie). Here the bag size is very small.

In some regions, Woodcock hunting is not allowed (Murmansk, Astrakhan', Kalmykia, Ingushetia, Tchetchnia). In many regions the autumn shooting season was not opened every year (Kaliningrad, Volgograd, Kurgan, Orenburg, Kabardino-Balkaria, Karathaevo-Tcherkesia, North Osetia).

Dates and duration of autumn shooting

As a rule, autumn Woodcock shooting is allowed as of the last Saturday of August, or the first one of September, simultaneously with the season for forest Tetraonidae and doves.

The opening dates of the summer-autumn hunting season have no significant correlation with the longitude or latitude of a region. For example in 2001, the earliest opening date of the hunting season was registered on 4 August in Tchuvashia (Volga-Viatka area), only for pointing dog owners. A week later (11 to 13 August), hunting started in seven regions of north-west, Central and North Caucasus, on 17 to 19 August in 24 regions of all areas, on 25 August in 11 regions, on 1 and 8 September in three and four regions consecutively (majority located in the Southern part, but also the Vladimir region in the Central area and Kurgan in the Ural). The opening dates of the summer-autumn hunting season were differentiated by groups of administrative districts in the Komi (north) and Sverdlovsk (Ural) regions.

Hunting is allowed up to the birds' departure, till late October or late November, i.e. for about 60 to 90 days. The period of autumn concentration is relatively short, so the actual duration of the Woodcock hunting season is significantly less than its allowed duration. In the southern parts of the Woodcock range (e.g. in the Krasnodar region) shooting starts in October, when great numbers of migrating northern Woodcocks will concentrate here. In this region, shooting continues up to 31 December.

Autumn shooting popularity

There are no special licences for Woodcock shooting in autumn. So, it is hardly possible to calculate the real parameters of autumn Woodcock hunting popularity through a licence analysis. Information in reports of the Hunting Department regional branches is quite inconsistent. In some regions, the data on the total number of sold licences for game bird hunting are presented, in other ones only the data on the number of licences are used for Woodcock shooting. In the same region, the approach may differ from year to year.

For example, in autumn 2001, the hunters in 36 regions of European Russia obtained about 311,000 licences permitting Woodcock shooting. Similarly, in the previous years the greatest number of licences had been given in the Central area (23.3%) and in the north (19.8%), and significantly less in the Volga (14.7%), Black-Soil Central (12.8%) and Caucasus (11.2%) areas.
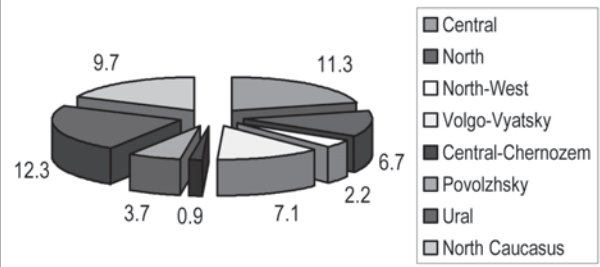
Bag sizes

Under the above-mentioned circumstances it is hardly possible to calculate the real number of Woodcock hunters, and also the real bag size of the species. For many regions (Arkhangel'sk, Kaluga, Tula, Nizhny Novgorod, Samara) the fluctuations of calculated bag sizes that may sometimes differ by ten times or more, are a consequence of the different ways the licences are counted.

The maximal average for the 1998–2002 bag size was registered in the Sverdlovsk region (5,100 Woodcocks), followed by Nizhny Novgorod (4,400), Stavropol' and Krasnodar (3,900–4,000 each), Kurgan (2,900, only for the year 2000), Tver' and Tcheliabinsk (more than 2,000 each) (Figure 8). The bag sizes for these and nine other regions (more than 1,000 shot Woodcocks each) amount to 41,800 birds, i.e. 77.6% of the total bag size. A map of the average autumn bag-size distribution is shown in Figure 5.

During the five-year period, the greatest number of Woodcocks was shot by hunters in the Ural (22.8% of the total bag) and Central (21.0%) areas, and a smaller number in the North Caucasus (17.9%), Volga-Viatka (13.1%) and northern (12.5) areas. Bag size was insignificant in the Black-Soil Centre area (1.7%) (Figure 6).

Statistics based on official data are the following. In 1998–2002, the hunters in European Russia returned 53–59% of the given licences after the autumn hunting season. The average annual total bag size for 48 regions during the five years of the study, is estimated at about 54,000 Woodcocks. The extrapolation of the data from eight areas shows a steady decrease in bag size from 1998 to

Figure 6. Proportion of Woodcock autumn bag size in European Russia and the Ural, by area (numbers of shot Woodcocks in thousands).

Figure 7. Woodcock autumn bag-size dynamics by areas in European Russia and the Ural, by area (% of total bag size for 1996–2003).
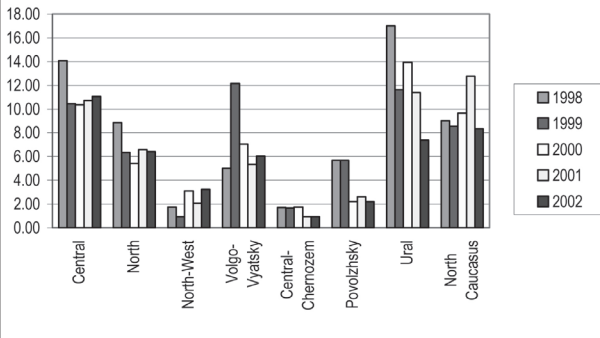
Figure 5. Distribution of Woodcock autumn bag sizes in European Russia and the Ural (average number of shot birds for 1998–2002).

Hunting bag (number of Woodcocks shot)

- \>4,000
- 3,000–4,000
- 1,000–2,999
- <1,000

Area	No	Region
North	1	Arkhangel'sk
	2	Karelia
	3	Vologda
	4	Komi
Baltic North-west	5	Kaliningrad
	6	Leningrad
	7	Novgorod
	8	Pskov
Central	9	Briansk
	10	Vladimir
	11	Ivanovo
	12	Kaluga
	13	Kostroma
	14	Moscow
	15	Orel
	16	Ryazan'
	17	Smolensk
	18	Tver'
	19	Tula
	20	Yaroslavl'
Black-Soil Centre	21	Belgorod
	22	Voronezh
	23	Kursk
	24	Lipetsk
	25	Tambov

Area	No	Region
Volga-Viatka	26	Kirov
	27	Marii El
	28	Nizhny Novgorod
	29	Chuvashia
Volga	30	Penza
	31	Saratov
	32	Ulianovsk
	33	Samara
	34	Volgograd
	35	Tatarstan
	36	Mordovia
	37	Bashkortostan
Ural	38	Perm'
	39	Sverdlovsk
	40	Udmurtia
	41	Tcheliabinsk
	42	Orenburg
	43	Komi-Perm'
North Caucasus	44	Adygea
	45	Kabardino-Balkaria
	46	Karachaevo-Cherkesya
	47	North Osetia
	48	Krasnodar
	49	Stavropol'
	50	Rostov

2002, i.e. from 63,000 to 46,000 birds. However, no such steady trends were noted for the other areas (Figure 7) or regions (Figure 8).
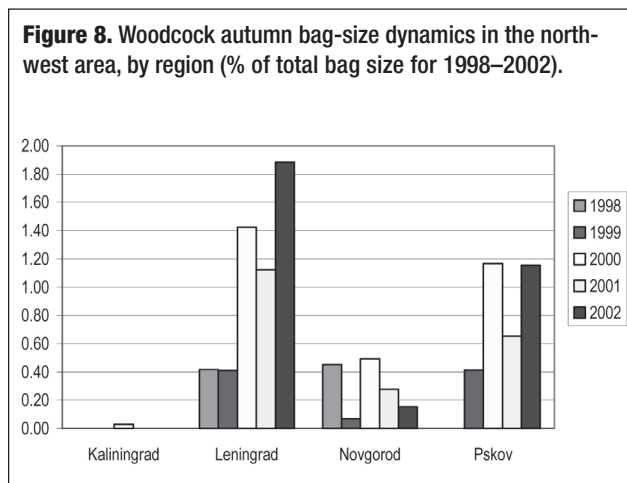
Bag sizes of individual hunters

Outside the hunting periods , Woodcock shooting is officially limited by an allowable bag size per hunting day. The common bag limit is up to five birds per hunter per day. This parameter is established by authority for each region, and is only based on the traditional hunting practices. Similarly to the spring season and because the success of autumn shooting is quite low, the allowable bag number did not restrict the real bag.

The average individual bag size in European Russia was 0.1 to 0.3 Woodcock per licence. In 1998 and 1999 this parameter was two to three times greater than in the next years. The most successful Woodcock bag was recorded in the North Caucasus area (0.2 to 0.7 Woodcocks in different years) and the lowest success was registered in the Black-Soil Centre (0.02 to 0.1) and Volga (0.03 to 0.3) areas. The greatest success was observed in the Kostroma region in 2000 (2.1 Woodcocks per hunter per season), in Leningrad in 1999 (1.8), in Tver' in 2002 (1.8), in Kaluga in 1998 (1.7) and in 2001 (0.7). Besides the above-mentioned data, more than one Woodcock per hunter per autumn season was shot in the Perm, Kabardino-Balkaria and Stavropol regions. In the remaining regions tens and even hundreds of hunters were related to each shot Woodcock in autumn.

Discussion

The highest annual hunting bag average was registered in the Moscow region (20,000 Woodcocks), followed by Nizhny Novgogrod, Tver', Vologda and Yaroslavl' (13,000–14,000 each), Kaluga, Sverdlovsk, Smolensk and Vladimir (7,000–8,000 each).

In the Central area, during the spring and summer hunting seasons, 90,000 Woodcocks were shot on average, 26,000 in Volga–Viatka, 23,000 in Ural, 18,000 in the north and north-west resp., 11,000 in Volga, 10,000 in North Caucasus and only 3,000 Woodcocks in the Black-Soil Centre area.

Figure 8. Woodcock autumn bag-size dynamics in the north-west area, by region (% of total bag size for 1998–2002).

The annual hunting bag average for European Russia including the Ural, is estimated at 200,000 Woodcocks.

The approach by licence counts, by region, was variable. So, all the further calculations of hunting popularity, the total and individual bag sizes based on the licences and discussed in the present article, are only comparatively accurate.

One way to solve this problem is by a sample analysis of primary data (licences) by the Centre of State Game Count Service (Gosokhotutchet).

Another way is by the distribution of questionnaires among the hunters. The distribution and analysis of such questionnaires is part of the "Woodcock scientific group" activity (Romanov *et al.* 2002). The results have shown that only about a half of the Moscow pointing-dog owners were hunting. The hunters with dog shot 2.8 Woodcocks on average, and up to 20 birds maximum during the autumn season. Woodcock represented about 9% of small game birds in the bags of these hunters. Preliminary calculations were based on official data on pointing dog numbers registered by the hunting organisations and on the distribution of questionnaires or a telephone inquiry among this category of hunters.

In Russia, there are about 8,800 registered pointing dogs (more than 6,800 of which are located in the European part), and about 8,500 spaniels (more than 6,100 consequently).

The above-mentioned calculations gave an estimate of about 50,000 Woodcocks for the autumn bag size in European Russia – thus very close to the official data based on licence analysis.

In spring 2003, we distributed special questionnaire forms called "Individual card of Woodcock shooting at roding" among hunters in the Moscow and Ivanovo regions. We collected and analysed 196 of such forms. 54% of the respondents attended roding only during one day of the 10 allowed, 73% for four days or less, and 16% during the whole 10-day spring hunting season. The opinion of 57% of them was that roding was worse, and of 34% that compared to the previous year it was better. 42% of the hunters did not shoot any Woodcocks during the spring. The successful hunters shot on average 2.4 Woodcocks per spring. The average bag was 1.4 Woodcocks for all hunters. The maximum bag for one hunter was 18 Woodcocks per season and six per evening. Losses of wounded birds represented 16% of the shot birds, i.e. 0.2 Woodcock lost per hunter. The individual bag size estimated by a licence analysis was only 0.6–0.7 Woodcock, i.e. almost twice as less as the bag numbers obtained by the questionnaires. This situation is quite understandable, because the hunters with dogs are traditionally much more interested in Woodcocks than "average" hunters.

Conclusion

The regional branches of Russian Hunting Department have been collecting official data on Woodcock spring

shooting every year since 1996 and on autumn shooting since 1998. Thus, up to now information has been collected for eight spring and five autumn seasons. The early data are not very reliable but all are uniform and thus comparable. On the basis of this information, we estimated the Woodcock bag from the western Russian boundary to the Ural, by area, region, and hunting season. The total bag size is about 150,000 males in spring and 54,000 Woodcocks of both sexes in autumn. The average individual bag size is about one Woodcock per spring hunting season and about 0.1 Woodcock per autumn hunting season. These estimations confirmed that the current official restrictions of the individual bag sizes, which are based on no precise data, are actually not limiting the hunting exploitation of the Woodcock populations.

In Russia, the Woodcock is the only far-migrating bird species (beside ducks and geese) allowed for shooting both in spring and autumn. Russia has to share the responsibility for the monitoring of migratory bird resources and their bag sizes while preserving their stability and sustainable exploitation.

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Assessment of the abundance of Woodcock over the last ten hunting seasons in France

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The study of Woodcock migration is one of the objectives of the Club National des Bécassiers (CNB). Moreover, reliable data on Woodcock abundance is needed to manage the species and defend the hunters' interest as well.

CNB has a network in place to collect data from its members' hunting trips. About 1,000 CNB members participate every year in this collection. These data are used for the calculation of a hunting index of abundance (ICA). This index is the number of different Woodcocks seen during a hunting trip the duration of which has been standardised at 3.5 hours (ICA = number of Woodcocks seen x 3.5 / number of hunting hours).

Results are obtained at "départemental", regional and national levels. They are calculated for a 10-day period, a month and a year. The large dataset provides objective information on Woodcock numbers. This information is well supported by ringing results and biological data.

ICAs allow to estimate intra- and inter-annual variations of abundance and, in this way, are an important part of Woodcock population monitoring.

The results of the last 10 years do not show an alarming decrease in the Woodcock population.

Introduction

The wise use of game species requires to set up a population monitoring scheme to estimate their status of conservation. Such monitoring has to be based on quantitative and qualitative data. Among these, knowledge of demographic trends appears to be essential.

For a game bird like the Woodcock, it is clear that data collected by hunters can be very useful since this species is very secretive. This led the *Office national de la chasse et de la faune sauvage* (ONCFS) to organise data collections based on hunting trips in France since the mid-70's (Fadat 1979). A hunting index of abundance was calculated every year by ONCFS till the mid-90s (Fadat 1994).

Since 1993/94, information was also collected by a Woodcock hunter association, the *Club national des bécassiers* (CNB). In 1996–97, ONCFS and CNB decided by mutual agreement to estimate ICA every year in France only from CNB data.

This was possible thanks to the CNB status which clearly mentions studies on Woodcock biology as an objective for the Association and also because of its organisation at a national scale. The CNB groups about 4,000 Woodcock hunters using pointing dogs who are spread over different regions of France.

This paper aims to present intra- and inter-annual variations of ICA for the last ten years.

Methods

Data collection

Data collection is organised on a voluntary basis. Through the CNB Magazine, every member receives a form on which he has to write down: the date of every hunting trip, the duration and the number of Woodcocks seen and shot. After the hunting season is closed, these data must be transferred as soon as possible to a national responsible.

About 1,000 hunters participate in this study every year.

Data analysis

A hunting index of abundance (ICA) is calculated from these data. This index is the number of different Woodcocks seen during a hunting trip the duration of which has been standardised at 3.5 hours. Therefore, ICA = number of Woodcocks seen x 3.5 / number of hunting hours.

ICA can be obtained at a national, regional or "départemental" level depending on dataset size. This can be estimated for a year, a month or a 10-day period.

Only analysis at a national level are presented here.

Results and discussion

The data set for the 1993/94–2002/03 period is presented in Table 1.

Table 1. Synthesis of collected data from which ICA was estimated from 1993/94 to 2002/03.

Hunting season	1993/94	1994/95	1995/96	1996/97	1997/98	1998/99	1999/00	2000/01	2001/02	2002/03
Nb forms analysed	429	629	729	864	804	797	846	919	988	923
Nb hunting hours	48,906	80,297	104,388	109,607	106,198	98,222	94,094	111,619	111,567	101,727
Nb flushed Woodcocks	14,494	28,920	40,170	42,221	34,791	35,961	36,537	37,739	48,409	31,444
Average nb hunting hours / hunter	114	128	143	127	132	123	111	121	113	110

Inter-annual variations

Inter-annual variations of ICA are shown in Figure 1. ICA appear to vary from year to year but no significant trend can be detected. The highest ICA value was registered during the season 2001/02 and the lowest in 1993/94 and 2002/03.

When we separate the migration period (September to December) we observe that the corresponding ICA values are higher than the annual values except in 1996/97, 2000/01 and 2002/03. This could mean that movements could have occurred during the winter, for example due to climatic conditions.
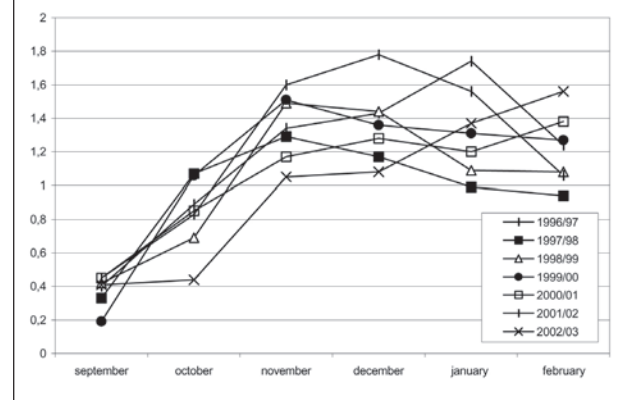
Intra-annual variations

The intra-annual variations can be analysed either by month or by 10-day period.

Monthly variations are presented in Figure 2 for the period 1996–97 – 2002–03. These clearly show the pattern of Woodcock abundance in autumn–winter in France. The more common pattern is the following: numbers increase from September to November then decrease to February. The autumn–winter 1997/98, 1998/99 and 1999/00 follow this pattern. Autumn–winters 1996/97 and 2001/02 present an delayed abundance peak in December and January. In 2000/01, no peak can be detected. Finally, a very atypical autumn–winter is the 2002/03 one when abundance increased continuously till February.

ICA variations by 10-day periods are presented in Figure 3 for two hunting seasons in order to illustrate the interest of such information. In 1998/99, a clear peak occurred at the end of November/beginning of December. Then ICA values stayed rather low. Woodcock hunters felt this season to be an average one because of the rather low abundance in the second part of the season. In fact, the annual ICA value was not so bad. In 1999/00, the situation was different. No pronounced migration peak was noted but Woodcock abundance was maintained at a rather high value throughout the hunting season. Again, since the hunter's feeling was that this was an average season, then annual ICA value was one of the highest of the last 10 years.

Figure 2. ICA monthly variations for seven hunting seasons (1996/97 to 2002/03).

Figure 1. Inter-annual variations of ICA (annual and September–December period) from 1993/94 to 2002/03.
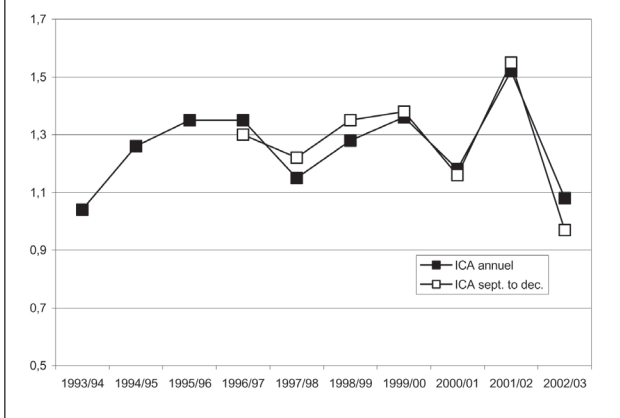
Figure 3. ICA variations for 10-day periods during the hunting seasons 1998/99 and 1999/00. (Sept. 1: 1st 10-day period of September, Sept. 2: 2nd 10-day period of September.)

Such pattern does not appear in a monthly representation which tends to "smooth" such an event. Moreover, we can observe that values registered in November and December are not sufficient to judge the quality of a hunting season. In 1998/99 and 1999/00, ICA monthly values were very similar in November and December, but really different in January and February.

These results show that ICA can greatly contribute to our knowledge of the Woodcock migration pattern on an annual basis. The hunter's feeling can be affected by a too restricted vision of the situation. Data collection at a large scale and during throughout hunting season, appears to be more efficient to understand the migration phenology as a whole.

Bias of the method

Analysis of ICA may give rather precise information on migratory and wintering Woodcock numbers. This is particularly true for the CNB network insofar as its members are Woodcock specialists who are prospecting the same hunting territories the same way, every year.

However, some bias can be noted in the ICA calculation. First, because of the participants voluntary basis no sampling design has been established for data collection. This leads to over-evaluate some regions, like Brittany for example, in the dataset. Also, hunters who make 100 or 1,000 hunting hours are pooled in the estimation at the same level. The hunting effort is not taken into account and if it greatly varies from one year to an other, the inter-annual comparisons could be affected.

We consider that ICAs alone are probably not sufficient to get precise information on the Woodcock demographic trends but should be added to other indices like the nocturnal index of abundance estimated by ONCFS. A good correlation between these two indices encourages confidence in the accuracy of the estimates (Ferrand *et al.* this issue). Any census method has bias and CNB's ICA contribute to get a reliable information on Woodcock trends.

Conclusion

Because of their implication in the data collection, the Woodcock hunters are aware of the conservation status of the species. Therefore, they should be more inclined to react in case of a demographic problem. Now, Woodcock numbers are considered to be stable in Europe (Ferrand and Gossmann 2001, Wetlands International 2002) but hunters and researchers consider this situation as fragile because of a probable increase of hunting pressure. To prevent any decrease in the Woodcock populations, the French Woodcock hunters, and especially the CNB, asking that a bag limit be set. Several French regions have already introduced such a regulation. A national bag limit promoted by CNB is in progress and should be applied in the coming years.

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Individual wintering strategies in the Eurasian Woodcock

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To survive in winter, each bird has to resolve an adaptive trade-off between the need to feed and the avoidance of predation. In the Woodcock, this trade-off is expressed at the level of habitat selection. The risk of predation was higher in meadows that Woodcocks frequent at night than in woodlands but the biomass of food (earthworms) was ten times higher in meadows than in woodlands. The monitoring of radio-tagged birds indicated individual strategies of over-wintering.

Regarding space use, a third of Woodcocks remained in a unique site throughout the winter, while the other individuals visited several sites, alternatively or successively. The choice of strategy seems to depend on the efficiency of individuals to forage and escape predators. The use of meadows at night, which varies among individuals, gives another explanation to the starvation / predation trade-off. Most of the Woodcocks were active during the day (in forest) and at night (in meadows), but some of them were completely diurnal and stayed in the forest at night. The decision to go to meadows at night seemed to be taken every evening, according to the success of foraging during the day in the forest. In the case of successful feeding by day, the bird was not obliged to risk going to meadows. When the patch started to be depleted, the bird could not achieve all its needs and was obliged to go to meadows at night (where there was always enough food) and/or change its diurnal site. Therefore, the trade-off between feeding and predation risk depends on the efficiency of the bird to find a good patch of food in the forest and to exploit it optimally during the day.

Introduction

In winter, birds face a trade-off between acquiring enough food and avoiding predators (Cuthill and Houston 1997). Thus, birds must take behavioural decisions to satisfy this trade-off between conflicting needs (Ludwig and Rowe 1990; McNamara and Houston 1994). The parameters of this trade-off can vary between different habitats. For example, a particular habitat can be richer in food but might present a greater predation risk. It is therefore important to study the costs and benefits that each individual can expect from each habitat. This could certainly influence habitat selection and could, in turn have important consequences for conservation and management of the species (Goss-Custard and Sutherland 1997).

The Eurasian Woodcock (*Scolopax rusticola*) wintering in western Europe has to face this trade-off. To date, it has been generally believed that Woodcocks use two contrasting habitats: they rest in woodlands or hedges by day and satisfy their food requirements in fields at night (Cramp and Simmons 1983; Hirons and Bickford-Smith 1983). The investigation of individual strategies of habitat use and behaviour is an important step towards an understanding of the starvation / predation trade-off (Lima and Dill 1990). To understand what influences decisions, it is necessary to assess the potential costs and benefits associated with the different habitats (predation risk, energetic losses, food availability and division of foraging effort). For Woodcocks, one of the main benefits of going to fields, and especially meadows, is the much higher biomass of earthworms (their main food item) compared to woodlands (Granval and Bouché 1993). Conversely, energy expenditure at night in fields has been shown to be correlated with air temperature and wind speed (Wiersma and Piersma 1994; Duriez *et al.* 2004), and energetic costs are thus likely to be higher in fields than in woodland. Predator-induced mortality appeared to be higher in fields at night than in woods (at least 75% of deaths in fields), probably because their main predators were nocturnal mammals (Duriez *et al.*, 2005a, this issue p. 54–60). Therefore, in wintering Woodcocks, site use may reflect the trade-off between foraging and predation risk, conditioned by foraging success during the day and the thermoregulatory expenses associated with nocturnal feeding.

More generally, the Eurasian Woodcock faces several threats in winter (concentration of populations, high hunting pressure, alteration and loss of habitats and sensitivity to climatic events, details in Duriez *et al.*, 2005b, this issue p. 54–60). Woodcock population size and demographic trends are difficult to estimate because of the huge breeding and wintering area of the species, and because of its secretive behaviour. However, survival analyses conducted on ringing recoveries concluded that survival rates of both adult and first-year birds were very low in France (Tavecchia *et al.* 2002). Indeed, the conservation status of the Woodcock was declared as vulnerable (Heath *et al.* 2000), but recently revised as stable because of the lack of reliable data on European populations and the general lack of knowledge concerning the Asian population (Wetlands International 2002). Management and conservation measures are rare and mostly concern hunting regulation. In most European

countries, hunting is limited by time period and/or bag size. The creation of hunting-free reserves has rarely been considered, mostly again because of the lack of knowledge in behaviour and ecology of the species in winter that preclude efficient conservation measures and management of the habitat.

This paper describes a study of Woodcock ecology and behaviour in winter, based on 65 radio-tagged birds in western France. We first describe the site use of Woodcocks and the existence of individual strategies, and we then investigate the trade-off between starvation and predation risk using recordings of activity rates. These results are discussed in terms of improving management and conservation of the species, particularly in the context of the creation of reserves for Woodcocks.

Methods

Study site

We collected data from December to April, during three consecutive winters (1999–2000, 2000–2001 and 2001–2002, hereafter 2000, 2001 and 2002 winters respectively). The study area (c. 1800 ha) was located in Brittany, the main wintering region for Woodcocks in France (Fadat 1991), and was comprised of the Beffou forest (48°30'N, 3°28'W) and the surrounding bocage. The topography was composed of small hills and valleys (altitude range: 160–322 m). The bocage was composed of small woods (< 1 ha) and fields (mean 0.8 ha, range 0.07–10 ha) enclosed by old woody hedges. Woodcock hunting has been prohibited in the Beffou forest since 1995 but is allowed in the surrounding woods and hedges. The winter climate in Brittany is oceanic: rainy and windy with mild temperatures (mean 5°C). Weather data (standard air temperature, rainfall, wind direction and speed) were collected hourly at the Météo France's station at Louargat (14 km from the Beffou forest).

Capture methods and radio tracking

 We captured Woodcocks at feeding sites (in fields surrounding the forest) at the beginning of the night with a spotlight and a landing net fitted to a two–four-metre pole (Gossmann et al. 1988). We captured 65 Woodcocks for the three years: 22 in 2000 (15 adults and seven yearlings), 22 in 2001 (eight adults and 14 yearlings) and 21 in 2002 (seven adults and 14 yearlings). Birds were fitted with a ring and aged (adult or yearling) using wing feather details and moult status (Clausager 1973; Fadat 1995).

Each bird was fitted with a radio-transmitter (TW3, Biotrack®, UK), weighing seven, nine or 12 g (2–4% of body mass) according to the battery size and the presence of an activity tiltswitch. In winter 2000, radio-tags were secured on the back with a Teflon ribbon two-loop backpack harness (Kenward 2001). Because seven Woodcocks in 2000 were found dead of starvation after the bill caught in the upper loop of the harness, in the winters of 2001 and 2002, the radio-tags were glued on the back and secured with a single-loop wire harness, passing around the belly and behind the wings (McAuley et al. 1993, Duriez et al. this issue, p. 55).

Each bird was located two to three times per week during the day and two to three times per week at night until departure in winter 2000 and four to five times per week in the following winters. During the day, we approached Woodcocks by circling to 10 m or less. Woodcocks did not leave diurnal sites during the day (except when disturbed) or only moved by walking (usually <100 m, personal observation). At night, Woodcocks were also approached by circling and located to the nearest 50 m because they were more likely to fly, especially during clear moonlight nights.

Analysis of radio-telemetry data

We recorded each location on a habitat map using a Geographic Information System (GIS; ArcView® 3.2, ESRI, Redlands, California, USA). The study of movements was mostly based on the distances between locations, calculated using the Animal Movement extension in ArcView (Hooge et al. 1999). For all analyses, we compared birds with similar number of locations. The number of locations varied according to the date of capture of the bird (December to mid January) and the date of the end of monitoring (death or migration starting during the last ten days of February). The study period was limited to January and February (excluding December with scarce locations, and the pre-migratory period in March). During the entire study period, we only had three days of frost in January 2000 and four days in February 2001. Because several consecutive days of freezing ground changed the behaviour and habitat selection of Woodcocks (Hirons and Bickford-Smith 1983; Wilson 1983), we excluded from the analyses the data obtained during the days of frost because accurate analysis of movements was not possible.

At twilight, most Woodcocks leave their diurnal site to reach a nocturnal site by a flight hereafter called a "commuting flight". The commuting index, calculated for each bird, was the number of nights spent in fields as opposed to forest / the total number of locations at night.

Activity data recording

Among the 65 Woodcocks, 11 birds (five adults and six juveniles) in winter 2001, and 23 birds (eight adults and 15 juveniles) in 2002 were fitted with a radio-transmitter (Biotrack® TW3) with an activity tiltswitch, consisting of a small tube containing a mercury bead (angled at 10° below the level of the bird's back). The posture of the bird changed the position of the mercury bead, and the signals were consequently sent with a different pulse rate (Figure 1). We used variation in pulse rates as an indication of activity and the continuous pulse rates (slow or fast) as inactivity. In winter, the Woodcock's activity can include foraging, preening, walking or flying. The time spent in flight was very short (a few minutes at twilight) and could be detected by the increase in the signal strength. Details on the methods of activity recording are given in Duriez et al. (2005c).

In 2001, 11 Woodcocks were recorded between one to seven times during the season. Activity recording was initiated around 1,200 hours and run for 24 hours to get the activity rate during one afternoon, one full night and

Figure 1. Illustration of the principle of activity monitoring in Woodcocks using activity tilt-switch radio tags (not to scale). When the bird was resting (left), the mercury bead was at the rear of the tag and the signals were sent with a slow pulse (period of 1,200 ms). When the bird was probing (right), the bead moved to the front of the tag and the signals were sent with a fast pulse (period of 800 ms). (From Duriez *et al.* 2005c).
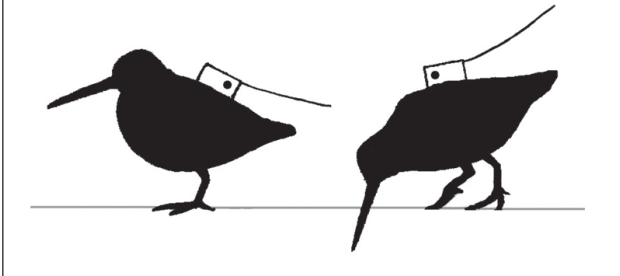
one morning. In 2002, 23 Woodcocks were followed between one to six times during the season and 17 individuals were recorded several days successively (three to nine days). Combining both years and all individuals, Woodcock activity was recorded during 256 days and 159 nights, due to the general procedure of sampling two days spanning one night.

Activity rates were recorded with an automatic data logger (Televilt® RX-900) powered by a 12-V car battery. If the signal was constant, the logger was recording every minute the following parameters: date, time (at the nearest second), pulse period and signal strength. Each time the signal received was variable (strength or pulse period), the logger stored the new parameters to the nearest second. The data logger was connected to two types of antennas, according to the geographic and topographic location of the bird recorded. Most of the time, the logger was connected to a nine-element directional Yagi antenna, located at the highest point of the area (322 m) and in the centre of the study zone. If the bird could not be heard from this place, then the logger was taken nearer the bird (less than 200 m) and connected to a CB car omni-directional whip-antenna. At twilight, once the bird had moved from forest to fields (or vice-versa), we checked if the signal could still be heard and adjusted the direction of the nine-element antenna or took the logger closer to the bird. We assumed that Woodcocks were faithful to the field chosen at the beginning of the night. Even if a bird was moved during the night, the data logger could record it owing to the increase in signal strength and/or loss of signal, and the data from this night were then excluded from the analysis. Activity files were processed with a program developed by Y.T., using a programming interface of Sigma Plot software 2001. Details of activity data treatments are given in Duriez *et al.* (2005c).

Habitat description

Habitat was described at two levels: stand type and humus type. In woodlands, we defined five classes of stands, based on the vegetation structure: 'Plantation' (10–15 yrs, 28% of study area), 'Coppice' (15–30 yrs, 15%), 'Deciduous timber' (30–120 yrs, 31%), 'Coniferous timber' (30–120 yrs, 22%) and 'Wet forest' (various age

and height, 4%). Deciduous stands (plantations, coppices and timbers) mostly contained beech (*Fagus sylvatica*) and oak (*Quercus robur*) and (*Q. sessiliflora*). Coniferous stands (plantations and timbers) were mostly sitka spruce (*Picea sitchensis*), common silver fir (*Abies alba*), grand fir (*A. grandis*), or Scots pine (*Pinus sylvestris*) and maritime pine (*Pinus pinaster*). 'Wet forests' were characterised by Willows Salix sp., alders (*Alnus glutinosa*) and poplars *Populus* sp. and by the presence of soggy soil and typical wetland plants (greater tussock sedge (*Carex paniculata*) and common rush (*Juncus conglomeratus*)).

Because humus types depend on many factors (biotic such as vegetation, soil fauna and macrofauna; and abiotic such as the nature of geologic substrate, slope and hydrology), humus description can serve as an indicator of invertebrate activity in unperturbed soils (i.e. woodlands but not fields). Following Jabiol *et al.* (1995), three types of humus were determined: mors (13% of samplings), moders (34%) and mulls (53%). Mors were characterised by the accumulation of litter resulting from an acid substrate and scarcity of earthworms. Mulls were characterised by only a thin litter layer resulting from an active and abundant soil fauna. Moders were in the intermediate situation. Because humus could change across short distances (within 10 m) and was difficult to map, the availability of humus types was the proportion of each type of humus in a systematic sampling based on a 200 x 200 m grid covering the entire forest and extended to several surrounding woods (182 points).

Nocturnal 'field' habitat was divided into four classes: grazed meadows (53% of area) and ungrazed meadows (17%) (a meadow was characterised as 'grazed' if it showed actual or recent grazing with cow dung, footprints and short vegetation), 'sown' (13%, wheat and grass) and 'stubbles' (17%, maize and wheat).

Earthworm sampling

We sampled earthworms using the standardised method described by Bouché and Alliaga (1986). This method is a combination of two complementary extraction techniques: a chemical extraction by 0.4% formalin application to expel active earthworms from the deep soil to the soil surface, and a physical extraction by hand-sorting soil cores (30 x 30 x 10 cm) to collect additional earthworms that did not respond to the chemical extraction.

Earthworm sampling was performed in both diurnal and nocturnal sites used by Woodcocks (i.e. woodlands and fields) from January to March 2001 and 2002. To select a plot for earthworm sampling, we flushed a radio-tagged Woodcock (birds flushed usually returned to the same site on the following day), in the early morning (around 09:00 hours) in diurnal sites (woodlands) and when dark (around 20:00 hours) in nocturnal sites (fields). Because earthworm populations are highly aggregated in patches (Poier and Richter 1992; Rossi *et al.* 1997), earthworm formalin extraction was done on an area of six 1-m² plots (three 1-m² spaced 10 m apart in a triangle at the Woodcock place and three other 1-m² plots in a randomly chosen place 50 m away) to take into consideration the variability of the horizontal distribution of earthworms biomass. Then, within each of the six square metres, two

soil cores (30 x 30 x 10 cm) were dug and hand-sorted. For each sampling place, i.e. each diurnal or nocturnal site used by Woodcocks, the earthworm biomass value was the mean of the six square plots and was expressed as kg (fresh weight worm) per hectare. Details of the earthworm sampling procedure and calculations are fully described in Duriez *et al.* (in press a).

Only 44 (39%) of a total of 113 diurnal and nocturnal sites used by Woodcocks were sampled. Thus, for the 61% of remaining sites lacking measured earthworm biomass, we used the mean value calculated for the habitat type (the combination of planting and humus types in woodlands, or field type, details in Duriez (2003)). Humus types can give another indication of earthworm availability in non-sampled sites. For the GLMM procedures, because the distribution of the mean earthworm biomasses was not normal, even when log-transformed, we transformed them into classes (by day: class 1 = "<60 kg/ha"; class 2 = "61–90 kg/ha"; class 3 = "91–140 kg/ha"; at night in fields: class 4 = "141–700 kg/ha"; class 5 = "701–1000 kg/ha"; class 6 = ">1001 kg/ha").

Statistical analyses

Unless specified, means are reported one standard deviation (SD) and were compared with Student's *t*-tests or General Linear Models (GLM) with Tukey's post-hoc tests, using SPSS 10.0 software (SPSS 1999). The normality of the variables was assessed with non-parametric Kolmogorov-Smirnov tests. Where data were not normally distributed, medians were compared with non-parametric Mann-Whitney tests or Kruskal-Wallis tests. To avoid pseudo-replication (Hurlbert 1984), when

analysing the factors affecting the duration of stay in the same site, or the activity rates, we used the mean values for each individual, or we used General Linear Mixed Models (GLMM) with individual * age as a random variable to give the same weight to every individual, whatever the number of recordings (Littel *et al.* 1991). Similarly, to estimate the probability of going to fields at night, we performed a mixed logistic regression with individual * age as a random variable using the Glimmix macro in SAS v. 8 (SAS Institute 2000). Correlations between movement parameters and individual characteristics were performed with non-parametric Spearman rank correlations.

Results

Individual strategies of space use

The patterns of site use by Woodcocks was very variable among individuals, which appeared to be distributed along a continuum of strategies, from sedentary to very mobile. We used the distributions of distances between consecutive locations, by day and at night, to categorise these different strategies. We attributed each individual to a single category of strategy and compared them (Figure 2). The mean distances between consecutive locations per individual ranged from nine to 347 m by day and 30 to 616 m at night. If the bird never changed site during the winter, the site use was classed as "UNIQUE". In this case, the distances between locations were uniformly low (e.g. bird A, Figure 2). If the bird was faithful but, when changing site, never came back to a previously used site, the site use was "SUCCESSIVE", and the distances between

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Figure 2. Examples of site use by day by three individuals (similar examples can be found at night). On the map on the left, grey areas are woodlands and white areas are fields. The lines show the movements between consecutive diurnal locations. The graphs on the right represent the variations in dates of the distances between consecutive diurnal locations (in m). Interpretation:
Bird A used a unique site by day: for unique birds, the distance rarely exceeded 50 m.
Bird B used four sites successively (the order of sites are indicated on the map and the numbers and horizontal lines on the graph indicate the duration of stay in each site): in successive birds, the distances were low except when birds changed sites.
Bird C used two main sites (numbers on the map) and three temporary sites, alternatively: in alternative birds, distances were often large and irregular. (From Duriez *et al.* 2005d).
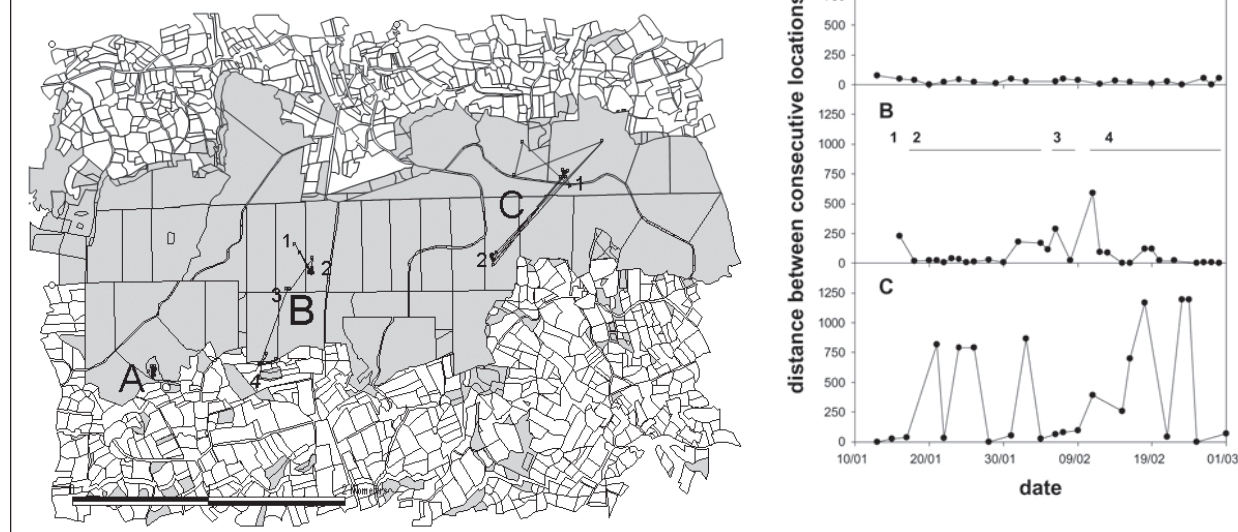
locations were generally low, except several peaks when the bird changed site (e.g. bird B, Figure 2). If the bird commuted regularly or irregularly between several sites, the site use was "ALTERNATIVE" and the distances between consecutive locations were irregular and with several peaks (e.g. bird C, Figure 2).

Diurnal movements

Thirty-one birds (48%) exhibited alternative site use compared to 22 birds (34%) that used a unique site and only 12 (18%) with successive site use. The duration of stay (number of days) in the same diurnal site was influenced by the age of the individual (adults < yearlings) and to a lesser extent by the mean earthworm biomass, but not by the habitat (forest or bocage) (GLMM Glimmix on 319 observations of 63 individuals (two birds living only in hedges were removed because biomass values were not available in hedges): $R^2 = 0.67$, $P = 0.014$ for age, $P = 0.060$ for mean earthworm biomass, $P > 0.1$ for habitat).

Use of bocage and fields

By day, the bocage around the forest (hedges or woods) was used at least once by 25 birds (39%) and it was the only habitat for nine birds (14%). Twenty Woodcocks (31%) used hedges at least once and six birds (9%) used exclusively hedges throughout the entire winter. The percentage of locations in bocage or in hedges was not significantly different between the three strategies of site use (Kruskal-Wallis tests: $\chi^2_2 = 0.58$, $n = 65$, $P = 0.75$ for the % locations in bocage and $\chi^2_2 = 2.58$, $n = 65$, $P = 0.28$ for the % locations in hedges).

At night, for the 65 Woodcocks, the mean commuting index was 0.85 ± 0.23 but the range between 0 and 1 indicates that the frequency of commuting was very variable among individuals (Figure 3). While 28 birds (43%) always left the forest at night, 26 birds (40%) left the forest between 70 and 99% of evenings, and 11 birds (17%) left the forest less than 70% of evenings. There was no difference in commuting index value between ages (Figure 3; Mann-Whitney $U = 524$, $n = 65$, $P = 0.98$). In

2001, two individuals (one adult and one yearling) never left the forest at night during the period considered, and were removed for the analyses of nocturnal movements and habitat (below).

Nocturnal movements

Thirty-nine birds (62%) showed alternative site use, 21 birds (33%) had a unique site and only three birds (5%) had a successive site use. There was a trend for 79% of diurnal alternative birds to be alternative at night, while the successive and unique birds by day had equal chances to behave as alternative or unique at night (2 x 2 chi-square test of diurnal site use vs. nocturnal site use: $\chi^2_4 = 5.78$, $n = 60$, $P = 0.069$).
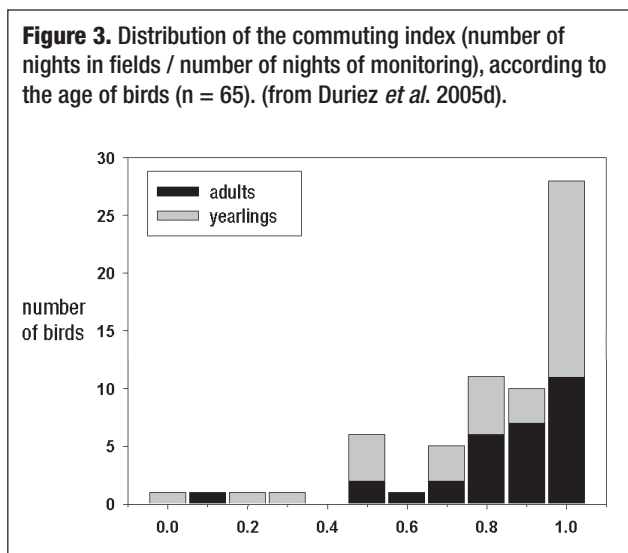
The small sample size of successive nocturnal birds precluded interesting comparisons with alternative birds concerning nocturnal site use. For this reason, we removed the three successive nocturnal birds in the following analyses. There was no difference in mean earthworm biomasses between nocturnal sites used by birds following unique and alternative strategies ($t\ 50 = -0.68$, $P = 0.50$, $n = 54$). The duration of stay in the same nocturnal site was not influenced by the age nor the earthworm biomass or the habitat (meadows or cultures) (GLMM Glimmix on 357 observations of 63 individuals: all $P > 0.05$). The distances between the nocturnal sites used by a bird varied from 120 m to 3.44 km (mean 383 ± 341 m, median = 292 m, $n = 324$ movements between sites).

Strategies of activity time-budgets

Description of activity patterns

The 34 birds used for activity recordings were assigned to four behavioural strategies: two birds never commuted from forest to fields at night (strategy 'NEV'); 13 individuals sometimes commuted (strategy 'SOM'); 15 individuals always commuted (strategy 'ALW') and three birds always used hedges ('HEDGE'). One individual was assigned no strategy because it was shot early in the season. We first describe the patterns of activity for all birds and then compare the three strategies of birds that stayed in woodlands by day (birds that stayed in hedges have not been considered in the following analyses because of the low sample size and lack of information about earthworm biomasses in hedges).

Combining diurnal and nocturnal activity, yearlings were always more active than adults (100 to 150 min on average, differing according to the strategy (see Figure 3 in Duriez et al. 2005c). By day, the activity duration was only influenced by age, with yearlings more active than adults and there was no significant difference according to the air temperature, the earthworm biomass or the humus type (Table 1). Nocturnal activity was related to age, nocturnal temperature, previous day humus type and diurnal activity. At night in fields, yearlings were also more active than adults and in general, Woodcocks were more active at low nocturnal air temperatures, and when they had shown little activity and were in a patch of poor humus quality (i.e. low earthworm abundance) during the previous day (Table 1, Figure 4).

Figure 3. Distribution of the commuting index (number of nights in fields / number of nights of monitoring), according to the age of birds (n = 65). (from Duriez et al. 2005d).

Table 1. Results from general linear mixed models (GLMM) examining the duration of activity (dependent variable) in relation to Woodcock age, year, air temperature, earthworm biomass and soil humus, by day (all individuals staying in woods) and at night (only individuals in fields). Earthworm biomasses were grouped into classes and individual * age was included as a random variable (see methods). (From Duriez *et al*. 2005c).

Period	R^2	Variable	df	*F* test	*P* value	Estimate (min)	Interpretation
Day [a]	0.55	Intercept				215.65	
		Age	1.26	5.50	0.027	-90.50	Adult < Yearling
Night [b]	0.57	Intercept				334.60	
		Night air T°C	1.52	14.03	0.0005	-11.63	
		Activity previous day	1.52	17.21	< 0.001	-0.41	
		Age	1.20	6.87	0.016	-83.27	Adult < Yearling
		Humus previous day	2.52	5.24	0.008	162.53	Mor
						20.40	Moder
						0	Mull

a 172 recordings for 28 individuals; variables removed from the model (*P*>0.05): year, diurnal T°C, diurnal earthworm biomass, humus, earthworm biomass * age, earthworm biomass * T°C

b 78 recordings for 23 individuals; variables removed from the model (*P*>0.05): year, age, nocturnal earthworm biomass, earthworm biomass * age, earthworm biomass * T°C, diurnal activity * diurnal earthworm biomass, diurnal activity * T°C.

Figure 4. Nocturnal activity in fields at night, calculated from the GLMM in Table 1, according to the duration of activity the previous day and the humus type the previous day (solid line = mor, dashed line = moder and dotted line = mull). The top graphs show the results for a mean nocturnal air temperature of 3°C and the bottom graphs for a temperature of 12°C. Left hand graphs show the results for adults and the right hand graphs for yearlings. (From Duriez *et al*. 2005c).
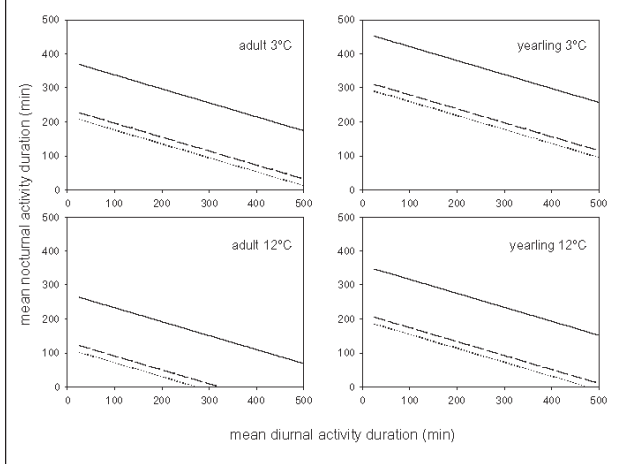
Figure 5. Mean activity durations SE in normal weather according to the strategy of habitat use, by day and at night. The sample sizes at the top of columns are the number of individuals. When pooling both ages, activity rates were higher by day than by night for the birds staying in woods (*t*-test t_9=3.26, *P*=0.010), but they were not different for the birds going to fields (*t*-test t_{53}=0.84, *P*=0.406). By day, 28 individuals were recorded for 171 days in total (GLMM: R^2=0.53, *P*=0.011 for Age, *P*=0.043 for Year and *P*=0.003 for Strategy [commuting]). At night, 26 individuals were recorded for 107 nights (GLMM: R^2=0.48, *P*>0.05 for Age and for Year, and *P*=0.002 for Strategy [commuting]). (From Duriez *et al*. 2005c).
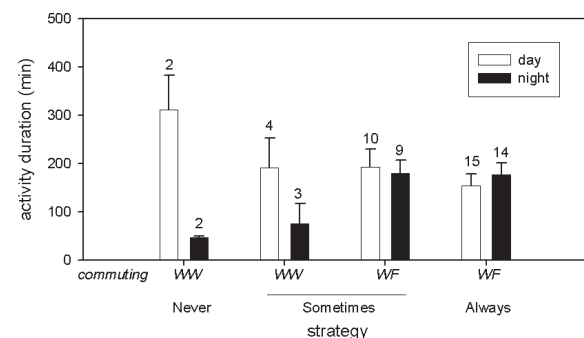
Strategies of activity rates

Woodcocks that spent the day in woodland and the night on fields (i.e. performed a commuting flight) are hereafter abbreviated to 'category WF' for Wood/Fields, and others spending the day and the night in woodlands are abbreviated as 'category WW' for Wood/Wood (no commuting). By day, activity durations for the category WW (strategies NEV and SOM) were significantly higher than for the category WF (strategies SOM and ALW) (Figure 5). At night, activity durations for the category WW (strategies NEV and SOM) were lower than for the category WF (strategies SOM and ALW) (Figure 5). In summary, when Woodcocks stayed in woodlands at night, they were more active by day, but almost inactive at night (most of the mean 60 minutes of activity recorded at

night being around twilight, i.e. in the first or last hour of the night), while they were similarly active by day and at night when going to fields at night. In all strategies, yearlings were more active by day compared to adults, but not at night in the fields.

Links between activity and resources

Habitat types did not influence activity durations. Activity rates did not differ between stand types in woodlands (ANOVA: $F_{4,46}$=0.39, *P*=0.81), nor between humus types (ANOVA: $F_{2,45}$=0.98, *P*=0.38). When they stayed in woodlands at night, birds usually remained in the same area as during the day. Nocturnal activity rates were not different among field types (meadows or stubbles; ANOVA: $F_{1,32}$=0.87, *P*=0.36).

In our study zone, the mean earthworm biomass in meadows (928 ± 273 kg/ha, N=33) was 13 times higher than in woodlands (71 ± 47 kg/ha, N=43. Woodcocks that did not commute (WW category) lived in diurnal sites that were slightly richer in earthworms than those of commuters (WF birds), but the nocturnal sites (fields) used by the latter were 12 times richer than the nocturnal sites in woodlands (Figure 6).

Decision making

The probability of visiting fields at night was negatively influenced by the duration of diurnal activity and the night air temperature (mixed logistic regression with Glimmix macro; Table 2, Figure 7).

Discussion

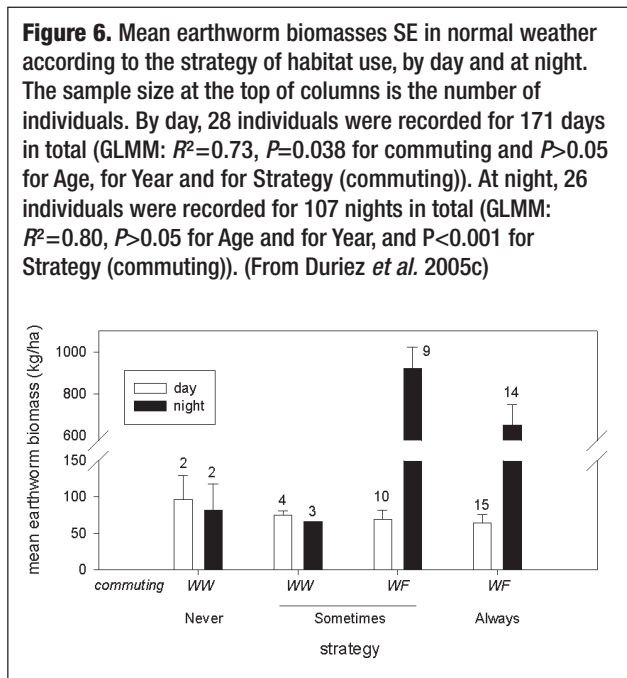### Individual strategies of movements

Our study was the first to illustrate the existence of individual strategies of spatial use and movements in wintering Woodcocks. The 65 Woodcocks monitored showed a general pattern of use of woodlands by day and fields at night, as described in the three previous

studies of radio-tagged Woodcocks with small numbers of individuals (Hirons and Bickford-Smith 1983; Wilson 1983; Hoodless 1994). Hirons and Bickford-Smith (1983) and Hoodless (1994) reported a high fidelity to both diurnal covers and nocturnal fields. However, our higher sample size showed a pattern of movements by day and at night that was more complex than previously believed.

By day, 52% of our birds used unique or successive strategies and 48% used alternative strategies. We hypothesise that birds using unique or successive sites showed the same over-wintering strategy. We predict that these individuals stayed in the same site as long as it could offer enough food or protection against predators. Birds might stay all winter in an optimum site, while in less favourable sites, they would have to move when food was depleted or when disturbance was too high. This hypothesis of fidelity until food is depleted below a threshold level is supported by the fact that, by day, birds stayed longer in the same diurnal site if the earthworm biomass was high, regardless their strategy. However, the earthworm biomass at the diurnal sites of unique birds was not significantly higher than that at sites used by successive and alternative birds.

Alternative strategies could be explained by: 1) a temporary disturbance inciting the bird to find a shelter elsewhere and come back when the nuisance has ceased; and/or 2) the need to keep some food reserves. Exploiting several sites alternatively could lead to a better knowledge of the environment, and consequently the discovery of suitable alternative sites in case of disturbance by predators. By day, the three strategies would reflect the ability of individuals to find rich patches of food and to exploit them optimally.

Nocturnal movement strategies were characterised by the relative absence of successive birds and the use of several alternative sites by most birds. The low number of birds following a successive strategy at night was perhaps due to the higher earthworm biomass of patches compared to woodlands. Because the food biomasses in the nocturnal sites of birds adopting the three strategies


Figure 6. Mean earthworm biomasses SE in normal weather according to the strategy of habitat use, by day and at night. The sample size at the top of columns is the number of individuals. By day, 28 individuals were recorded for 171 days in total (GLMM: R^2=0.73, P=0.038 for commuting and P>0.05 for Age, for Year and for Strategy (commuting)). At night, 26 individuals were recorded for 107 nights in total (GLMM: R^2=0.80, P>0.05 for Age and for Year, and P<0.001 for Strategy (commuting)). (From Duriez *et al.* 2005c)

Table 2. Logistic regression of the probability of visiting fields at night according to the duration of diurnal activity and the mean air temperature at night (periods of frost and last week of monitoring excluded). (From Duriez *et al.* 2005c).

Variable	df	*F* test	*P* value	Estimate
Intercept				12.99
Diurnal activity duration	1.67	9.89	0.0025	-0.018
Nocturnal air temperature	1.67	14.05	0.0004	-0.452

The analysis concerned 95 evenings of decisions on 26 individuals. The factors year, age, mean earthworm biomass and humus were not significant (*P*>0.05)

Figure 7. Probability of visiting fields at night according to the diurnal activity duration and the nocturnal air temperatures (four curves) (results from the logistic regression in Table 2). (from Duriez *et al.* 2005c).
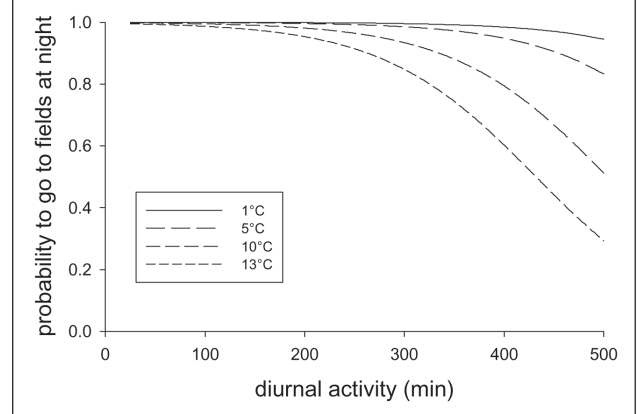
were not different and the duration of stay was not linked to earthworm biomass, the causes for nocturnal strategies were perhaps variation in individual foraging efficiency, a different sensitivity to predation risk, or territoriality (Duriez *et al.* 2005d).

Winter activity rates in Woodcocks

This study provides evidence for diurnal activity, probably foraging, by Woodcocks under non-freezing weather conditions in winter. Daytime was the main feeding period for individuals that stayed in the woods at night (WW). Even for the birds that went to fields at night (WF), feeding occurred for an appreciable part of the day (about 200 min per day).

By day and at night, young Woodcocks were always more active than adults. Such a difference in activity duration among age-classes could be due to differences in physiology or in foraging efficiency. Since the plumage insulation and the morphometric measurements did not differ between yearlings and in adults (Boos 2000; Duriez *et al.* 2004), the hypothesis of higher energetic needs in yearlings can be excluded. Moreover, the food biomass was not lower in the diurnal sites chosen by yearlings. Therefore, the difference in activity was probably due to lower foraging efficiency in young birds. This difference in foraging efficiency could be the result of taking longer to find rich patches of earthworms, and/or poorer feeding skills with which to exploit them.

At night, the increase in activity duration when the air temperature decreased probably resulted simultaneously from higher energetic needs for thermoregulation in cold temperatures, especially in open habitats such as meadows (Wiersma and Piersma 1994), and a lower availability of earthworms which burrow deeper in the soil at low temperatures. The absence of a relationship between activity and air temperature by day was perhaps due to the higher protection from wind chill effects (responsible for most of the thermoregulatory demands) provided by the scrubby habitat in woods (Thompson and Fritzell 1988; Bakken 1990). At night in meadows, we hypothesise that the high biomass of food available did not constrain the intake rate and that this was influenced by the energetic needs resulting from the air temperature and foraging success during the day. Indeed, the duration of nocturnal activity increased when a bird was not as active and/or remained in a zone of poor feeding quality, such as mor type humus, during the day. Nocturnal activity thus varied in relation to diurnal foraging success.

Decision rules and trade-off between foraging and predation risk

The decision to go to fields was linked to activity in the diurnal site and the mean temperature at night, i.e. the same variables that explained the duration of nocturnal activity. Because diurnal activity was probably linked to foraging success, the decision to go to fields was also indirectly linked to the foraging success during the day. We hypothesise that the most efficient individuals were those who could find a rich patch of earthworms in woods by day. These efficient birds could benefit from staying in the wood at night (i.e. saving energy and avoiding

predation risk), but to do so, would have to increase their daylight foraging time (i.e. activity rate) to reach their required daily food intake. This can only be achieved if forest patches hold enough food to allow feeding for several hours, but because densities of preys are always lower than in fields, overall daily activity time may be slightly longer. The birds which found the best patches in woods could exploit them throughout the winter (strategy NEV). Other birds are likely to have found good patches that allowed them to stay in woods at night for a few days or weeks until depletion. Then they were forced to go to fields until they found another suitable patch (strategy SOM). The birds of the ALW strategy were those which did not find food-rich patches in their diurnal sites.

We believe that the decision as to whether or not to go to fields at night involves a trade-off between starvation and predation risks (Lima and Dill 1990). The existence of these strategies in the Woodcock was unknown before our study. The very small proportion of birds that never went to fields (n = 2) probably reflected the scarcity of very rich feeding sites in woodlands. These two individuals spent the day in wet forests with mull type humus. In the wintering population, there were probably other very efficient individuals which never went to fields at night but they were impossible to monitor since we only captured birds in fields.

Implications for management

None of our birds left the study zone during the three winters. This confirmed the high fidelity to the winter quarters suspected in other studies using capture-mark-recapture data (Wilson 1983). From the analysis of ringing recoveries in the same winter during eight years, (Gossmann *et al.* 1994) found that 87% of Woodcocks were shot at a distance of less than 20 km from the ringing location. Hence, a reserve could effectively protect a population for an entire winter.

Woodcocks are particularly at risk when they are outside the main forest complex (i.e. in the hedges and woods of the bocage by day and in fields and meadows at night), because terrestrial predators (foxes, cats and mustelids) are known to prospect in fields at night and to follow hedges (Harris and Woollard 1990), and 70% of cases of predation occurred in the bocage (Duriez *et al.* 2005a). Moreover, hunting occurring in the bocage by day, was responsible for half of the mortality (Duriez *et al.* 2005a). The use of the bocage was more important than expected. The relatively high fidelity to hedges and the equivalent use of hedges by birds of the three strategies indicate that they are not a secondary or temporary habitat, but an important habitat, sometimes preferred to woodlands. The use of hedges was known during the migration stopovers but underestimated in winter (Ferrand and Gossmann 1995). This choice of hedges implied a real strategy for wintering.

This important use of bocage around the forest emphasise that efficient hunting-free reserves to protect Woodcocks must integrate the woods and hedges around the protected forest complex to account for the behaviour of alternative and successive birds. Because most of the

hedges and woods used in the bocage were within 1 km from the forest, this distance should serve as a buffer with no hunting allowed around the protected area.

In winter, it was thought that all Woodcocks frequented fields at night (Hirons and Bickford-Smith 1983; Wilson 1983; Ferrand and Gossmann 1988; Granval and Bouché 1993). Our study showed a great variability of commuting behaviour among individuals. Meadows, extensively used by most Woodcocks, are declining in most of the winter range of the species (Pain and Pienkowski 1997; Vickery *et al.* 2001) and changes in agricultural practices (excessive use of organic manures, nitrogen fertilisers and pesticides, replacement of meadows grazed by cattle by tall hay-meadows) decrease the density and availability of earthworms (Edwards 1998). 95% of Woodcock telemetry fixes were located within a radius of 1 km around the forest complex (Duriez *et al.* 2005a). An efficient reserve should provide optimally managed meadows within this radius.

Individual behaviour and movements are important parameters to take into account for the sustainable management of Woodcock. By changing sites more often than unique birds, alternative birds increase their risk of leaving the protected area and visiting the hunting area. If our hypothesis of foraging efficiency is correct, the management of protected forests favouring suitable zones (forestry practices respecting soil macrofauna and shrub cover, reviewed in Granval and Muys (1992)) could result in some birds with alternative strategies adopting unique strategies and consequently staying in the forest. Our study revealed unknown patterns of space use in Woodcocks in one forest in Brittany, but more studies are needed in other parts of the winter range, in similar environments to verify the conclusions, as well as in completely different habitats, for example British moorlands, pine forests in the French Landes, or Mediterranean shrublands.

Acknowledgements

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What census method for migrating and wintering Woodcock populations?

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Monitoring trends of Woodcock (*Scolopax rusticola*) populations requires reliable census methods during the breeding and wintering periods. A method has been devised at a national scale for breeding populations but not for migrating and wintering ones. We tested indices based on hunting activity: numbers of Woodcocks seen (ICA) or shot (ICP) /hunter/hunting trip, and on ringing activity: numbers of Woodcocks seen /ringing trip, collected between 1990–91 and 2002–03. The pattern of yearly variations did not vary from an index to another during the study period. We propose to use these indices to estimate the variations in migrating and wintering Woodcock abundance despite bias in data collection. Because the duration of ringing trips is not standardised, an index based on the numbers of seen Woodcocks/hour during the ringing trip (IAN; index of nocturnal abundance) could be more appropriate. Advantages and difficulties of the hunting-based and ringing-based indices are discussed. We propose to use both indices better interpret demographic trends.

Introduction

Monitoring of the demographic trend of a population requires to agreement on a census method. For birds, many methods can be used (for a review, see Sutherland 1996; Bibby *et al.* 2000). Most methods are based on direct observation of birds and calls associated with demonstrative behaviours. Some surveys monitor several species (Breeding bird survey in USA, Common Birds Census in Great Britain, for instance), others focus on one species.

The European Woodcock (*Scolopax rusticola*) poses many problems, especially its secretive behaviour. A census method for the breeding Woodcock population has been devised (Ferrand 1993) and conducted in France since 1992 (Ferrand and Gossmann 2000a), in Switzerland (Vaud canton) since 1989 (Estoppey 1988) and in Russia since 1999 (Blokhin and Fokin this issue p. 43–46). A breeding Woodcock survey started in Britain in 2003 (Hoodless *et al.* this issue p. 47–53).

However, a large-scale census method for wintering Woodcocks has not been clearly defined. Although such a method would be useful to determine sustainable use of the Woodcock populations. Two surveys devising a wintering census method: one based on diurnal transects in Scotland (Summers and Buckland 1996), the other based on nocturnal census in Cornwall (Hoodless 1994).

In France, a large wintering Woodcock survey has been conducted since 1976 using hunting data to estimate the abundance of wintering Woodcock (Fadat 1979). Indices (number of seen and shot Woodcocks/hunter/hunting trip) have been collected by *Office national de la chasse et de la faune sauvage* and *Club national des bécassiers*. Observations during ringing trips is another method which should also be explored. In France, ringing operations have been conducted since the beginning of 1990's (Ferrand and Gossmann 2001). These surveys allow us to estimate an index of abundance. However, their main objective is to ring large numbers of Woodcocks and precise census rules are not established for the ringers.

This situation leads to the collection of heterogeneous data among ringer teams and from one year to another for the same teams.

The objective of our study is 1) to analyse the potential bias of an index of abundance based on observations linked to ringing 2) to compare this index with independently measured indices of abundance (Fadat 1979).

Material and methods

Nocturnal observations

In autumn-winter, Woodcocks are in the forests during the day and in open areas especially permanent meadows, at night (Ferrand and Gossmann 1988). This behaviour offers the opportunity to catch the birds during the night using a spotlight and a large hand net (Gossmann *et al.*, op. cit.). Only two people are required. Currently, 400 trained ringers are working in France from October to March. Some of teams worked at the same sites very regularly (one or two times per week) during a limited period of time (usually three hours). Others worked throughout the night, but only when the weather conditions were optimal for catching (rain, wind, moonless), and sometimes during several subsequent nights. Most birds were caught in November and December.

A nocturnal index of abundance (IAN) can be calculated from the observations made during the ringing trips. We defined this index as the mean number of seen Woodcocks per ringing trip. The calculation for all the ringing trips made during a ringing season allows to determine an annual national index.

Because the number of "départements" involved in ringing from one year to another increased (Figure 1), and as well as the number of ringing teams, the sample size varied during the study period (1990–91 to 2000–01). The variability caused by this heterogeneity was tested from a subsample of "départements" where ringing activity stayed constant during the study period.

Were selected 21 "départements". All but two of these "départements" are situated along the Channel-Atlantic coast (Figure1).

Cynegetic indices of abundance

Cynegetic indices of abundance are the average of Woodcocks seen or shot during each hunting trip. Fadat (1979) recommended using the ICA2 index, which is based on the number of shot birds, weighted by the ratio of the number of trips with >1 shot Woodcock/total number of trips. Hunting data have been collected and ICA2p's have been calculated through a non-permanent hunter sample. (Fadat, 1994a) from the mid-1970s through 1996–97. Since 1993–94, a specialist hunting association, the Club national des bécassiers, also has collected data from its members and calculated annual hunting indices. These indices are equal to the number of Woodcocks shot (ICP) or seen (ICA) per trip and per hunter.

Statistical analysis

The correlations between the temporal series of IAN, ICA, ICP and ICA2p were analysed with the Pearson's product-moment correlation coefficient.

Results

Nocturnal index of abundance

One or more teams works in 75 French "départements" which encompasses the primary area of the wintering range in France. Around 1,100 sites ranging from 20 to 150 ha are regularly visited. During every ringing trip the date, the number of Woodcocks seen, and the number caught are noted for each site. Total numbers of Woodcocks encountered every year from 1990–91 to 200–01 ranged from 3 932 to 14 986 birds, depending on the number of teams and trips (Table 1).

The inter-annual variations of the nocturnal index of abundance are shown in Figure 2. This index varied from 4.5 to 9.5 during the study period.

Biases of the nocturnal index of abundance

Inter-annual heterogeneity of data collection

The variations in a second index calculated from a more homogeneous sample (21 "départements"; see method) are shown in Figure 2.
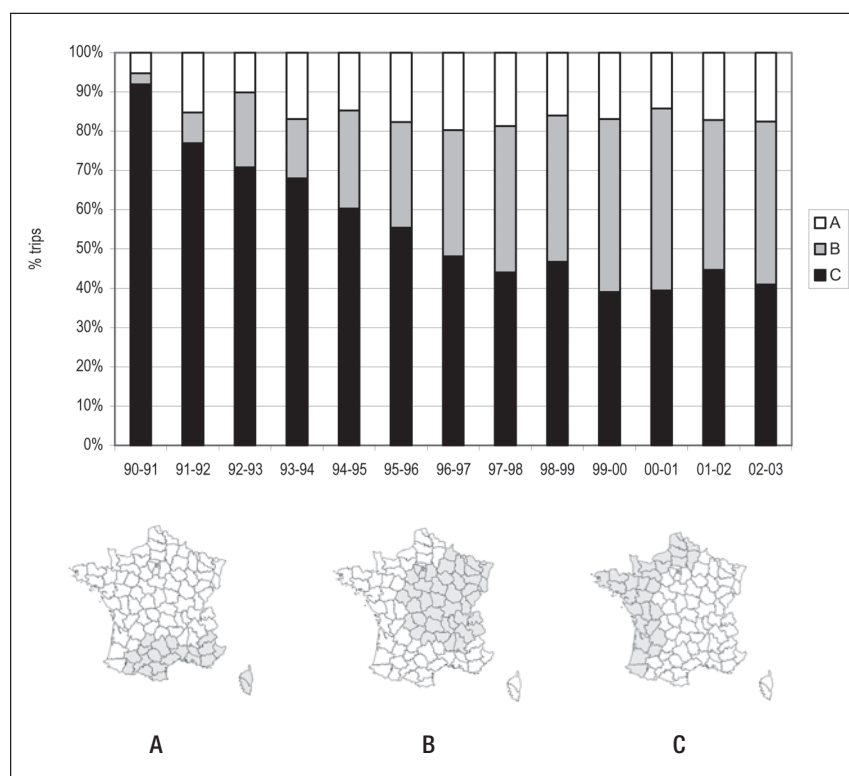
Figure 1. Proportion of three different French regions in the distribution of ringing trips since 1990–91.

Table 1. Number of ringing trips, seen and ringed Woodcocks from 1990–91 to 2002–03 in France.

Year	1990– 1991	1991– 1992	1992– 1993	1993– 1994	1994– 1995	1995– 1996	1996– 1997	1997– 1998	1998– 1999	1999– 2000	2000– 2001	2001– 2002	2002– 2003
Nb. ringing trips	641	765	857	1105	1275	1368	1656	1741	1775	2164	2618	2295	2361
Nb. seen Woodcocks	3932	4112	3864	5623	7533	10225	10806	10629	11684	14220	14986	16024	16283
Nb. ringed Woodcocks	1025	984	875	1387	2033	2761	2735	2814	3181	3593	3995	3707	3417

The trend of the two indices were highly correlated (r = 0.95; p<10^{-3}). Therefore, we believe that the bias from the data collection's heterogeneity does not affect the IAN inter-annual variations. The coefficients of variation (CV) of the number of ringing trips was high and averaged 68.4% annually and 45.0% from one "département" to another.

Methodological bias

The IAN Survey can be considered an alternative line transect. This method is usually used to estimate the abundance or density of a bird population during the breeding period. However, their application to wintering populations is possible (Hildén 1987; Rykova 1999). Several sources of bias can alter the results (cf. Sutherland, W.J. 1996; Bibby *et al.* 2000) especially those linked to the experience of observers (i). Moreover, this survey method requires that all birds are detected (ii), bird density does not modify the probability of detection (iii), birds did not move before their detection (iv), no double counting of birds occurs (v), and the distance of detection to the transect is known (vi).

The variability of the observers' experience, and their efficiency to detect the birds can be reduced if we only used data from experienced ringers. We believe two years of experience is sufficient. Following these protocols, biases (i), (ii) and (iii) will be reduced.

Unfortunately, we will never be able to satisfy biases (iv) and (v). Indeed, behaviour of Woodcocks greatly varies from one bird to another and also in relation to the weather conditions and to the time of observation (Gossmann *et al.*, op. cit.). Some birds fly away from the spotlight while others do not move. Some birds use only one meadow and others use several. Birds are shyer during a full moon than a new moon. Rain and wind make it easier to approach the birds but frost makes it more difficult.

Estimation of distance to the transect (vi) is essential if the objective is to estimate density or size of the population (Burnham and Anderson 1984). The IAN is a simple index of abundance, expressed in number of birds observed per trip and is not intended to assess wintering bird densities. The purpose of IAN is to detect fluctuations in abundance from one year to another. The hypothesis of similar behaviour each year in response to this census method for the entire population, seems strong enough to consider that if a bias exists its annual variations should be small.

Migrating and wintering populations

We surveyed Woodcocks from October to March. This period includes migrating birds (till 15 December) as well as wintering birds (Clausager 1974; Nyenhuis 1990). In November, the numbers of birds on the census sites could be biased high because of the population would include Woodcocks that will winter on the study area and Woodcocks that are in transit. If all the ringing trips are made in November in one particular year and in December another year, for example, the results would be difficult to analyse even if the weather and migration pattern were the same. Analysis of ringing trips over seven years (1996–97 to 2002–03, Figure 3) shows that annual patterns are similar (W=0.879, p<0.01; Kendall coefficient of concordance). Between 47% and 56.3% of the ringing trips occur in November and December.
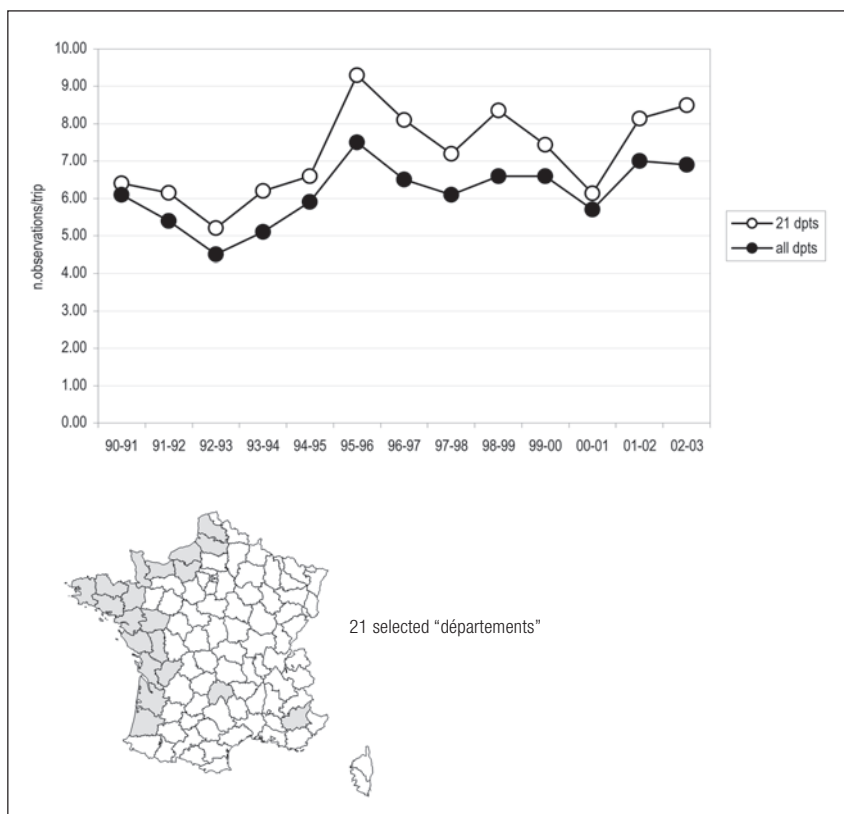
Figure 2. Inter-annual variations of a Woodcock nocturnal index of abundance (Nb. observations/ringing trip) calculated for all ringing "départements" and for 21 "départements" where the observations were made without interruption from 1990–91 to 2002–03.
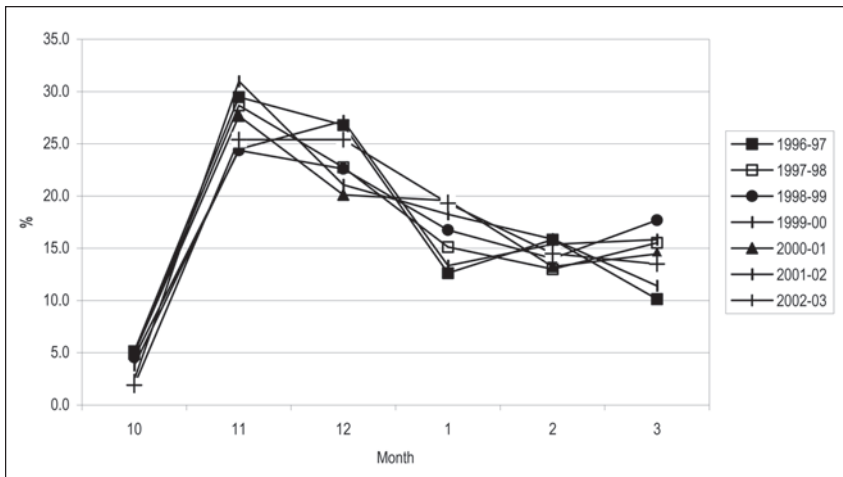
Figure 3. Monthly distribution of number of trips from 1996–97 to 2002–03.

III-2-4 Trip spatial variability

The haphazard schedule for ringing trips could be a source of bias. However, these trips usually occur in a non-random manner. Because experienced ringers try to catch a large number of birds, and have limited time, they tend to choose the best sites, which they will visit several times in a ringing season and from one season to another. As Harris (1986) suggested these replicates in data collection provide a better reliability of results.

Variability of ringing trip numbers

The IAN value can be biased by variations in the number of ringing trips in relation to bird abundance. If Woodcocks are abundant the ringers usually work more often. In fact, the correlation between the annual IAN and the number of trips is not clear for all the "départements" (R=0.518 ; n=13; p=0.07) and for the 21 "départements" located on the Channel-Atlantic coast where Woodcock abundance is strongly linked to the number of migrating birds in November (R=0.489; n=13; p=0.09) as well.

Wintering movements

The Woodcock population is not closed and wintering Woodcocks move around. Behaviours vary among birds and within winter for the same bird (Duriez *et al.*, this issue) Some birds do not leave the forest at night, others alternatively stay in the forest during several nights and go to meadows during others. Moreover, during cold weather, part of the population may migrate to milder regions (Gossmann and Ferrand 2000) or stay in the forest during the night and day (Wilson 1982; Duriez *et al.*, this issue). This population is hunted during the winter as shown from ring recoveries (Gossmann *et al.* 1994).

Comparison between IAN and cynegetic indices of abundance

Because of gaps in the indices of abundance derived from hunting data, we compared the ICA2p (see above) annual variation to IAN variation for the period 1990–91 to 1996–97 and the ICP (see above) variations were compared to the IAN during the period 1993–94 to 2002–03 (Figure 4). The annual variation between the IAN and ICA2p are similar (r=0.94; p<0.01). However, patterns of variation

were different between IAN and ICP (r=0.39; p=0.271). The difference was caused by the 2002–03 season. When these data were omitted, the pattern was similar (r=0.83; p=0.005).

Because the IAN uses the number of Woodcocks seen during ringing operations, we also compared the IAN fluctuations and the ICA (see above) fluctuations from 1993–94 to 2002–03. Again, the trends were similar without the 2002–03 data (r=0.83; p=0.007) but different when this data was included (r=0.62; p=0.056).

Trend of migratory and wintering Woodcock numbers

When estimating the demographic trend of migratory and wintering Woodcocks from these indices one should consider the fluctuation of these indices and the Woodcock abundance level. The striking synchrony of IAN and ICA probably reflects the fluctuations in the population size from 1990–91 to 2002–03 with a good reliability. Woodcock numbers decreased in the first part of this period until 1992–93. Numbers increased in the following years with a peak in 1995–96. A decrease occurs again during two seasons and finally a slight increase at the end of the 90s. Fadat (1994b) assumed that Woodcock abundance followed a nine-year cycle which cannot be tested from our data.

Another question is: did the abundance level vary? What is the general demographic trend beyond the annual fluctuations? To answer this question we assessed the trend of the IAN based on the number of Woodcocks seen/hour as proposed above. Such data are available from 1996–97 to 2002–03 (Figure 5). A statistical test shows a significant increase of IAN during the last seven years (Z=5.78, p<0.0001; Jonckheere test).

Discussion

What is the biological significance of these indices?

The two types of indices (IAN and (cynegetic) hunting indices) that we compared were independently measured, during different periods of the day and in different
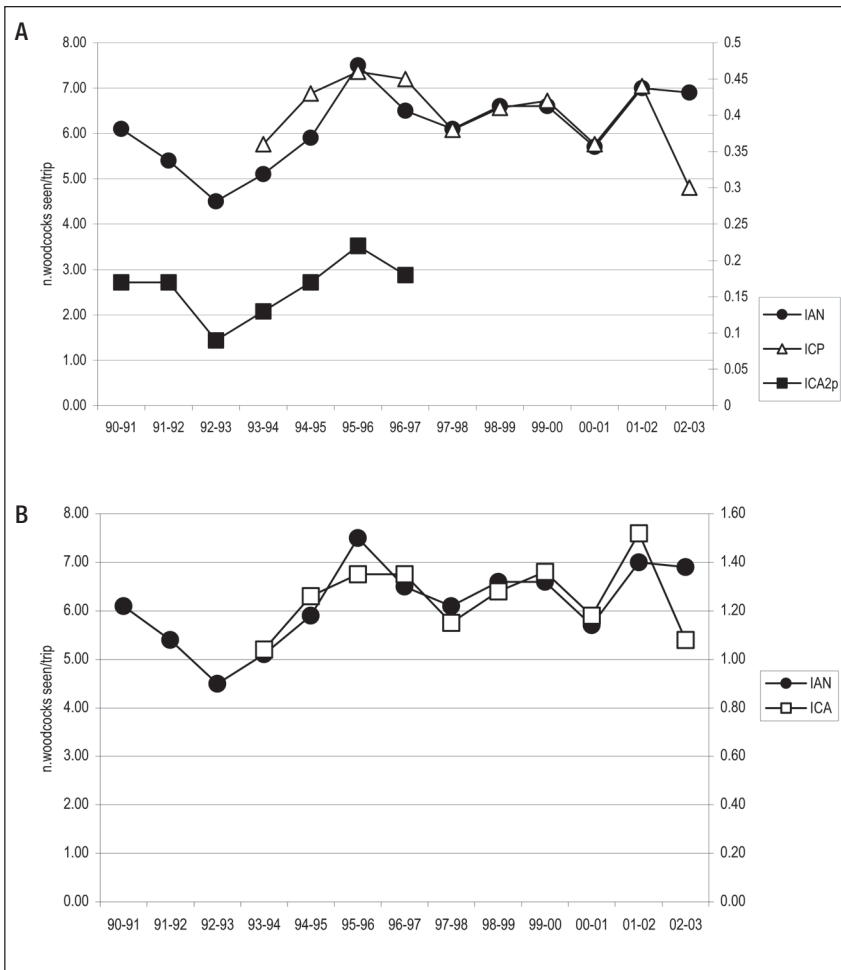
Figure 4. Inter-annual variations of the Woodcock nocturnal index of abundance estimated from ringing trips (IAN), a cynegetic index of abundance estimated from shot birds (ICP), a weighted cynegetic index estimated from shot birds (ICA2p) [A] and a cynegetic index of abundance estimated from seen birds (ICA) [B].
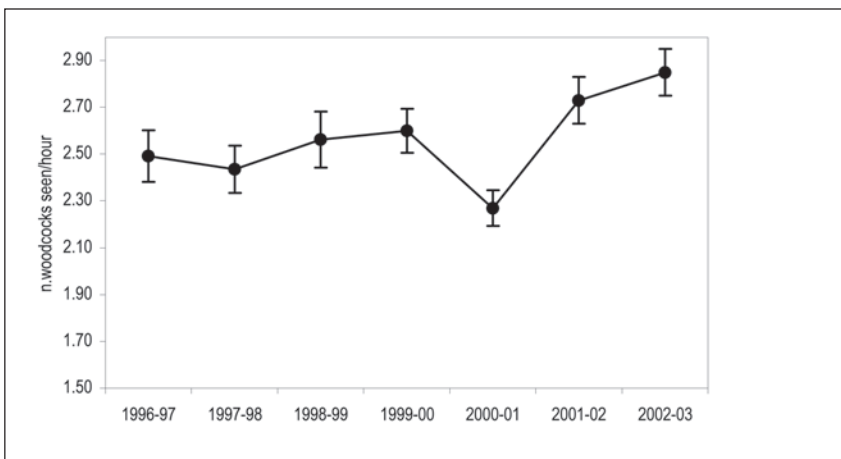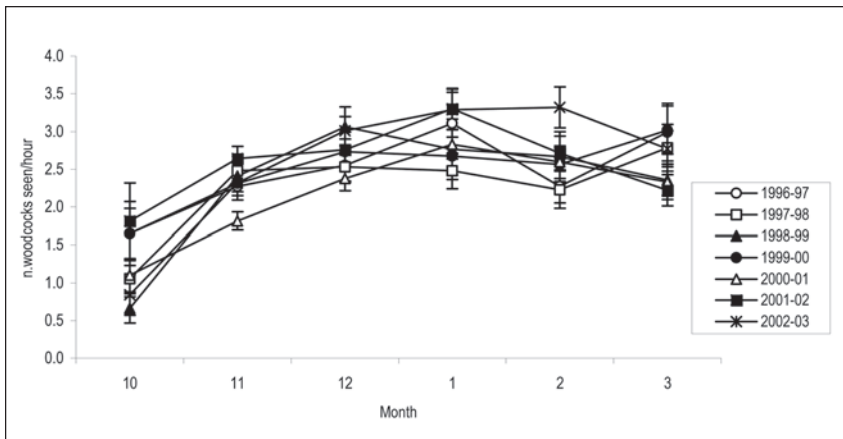

Figure 5. Inter-annual variations of IAN (based on the number of Woodcocks seen/ hour) from 1996–97 to 2002–03.

habitats. However, the same migratory and wintering Woodcock population was sampled.

The annual trends of these indices show similar patterns. Indeed, the gap inconsistency that occurred in 2002–03 was caused by an unusual Woodcock hunting season. Unusually cold weather occurred during the winter of 2001–02 (in December) and probably affected the European Woodcock population. In 2002 poor breeding success occurred in the primary breeding area of the species. This was confirmed by the low age-ratio found in the Danish Woodcock hunting bag [0.8 (2.2 in average); Clausager, this issue]. Moreover, In autumn 2002, the numbers of migrating Woodcock seemed low compared

to the previous years. A cold weather occurred again in winter 2002–03 (in January) and caused the birds to migrate farther south. Because of these successive events, Woodcock hunting was severely restricted in January and February 2003 to protect the Woodcock population. Three regulation rules were applied depending on "département": close of the hunting season, temporary hunting ban or bag limit reduction. In total, 85 "départements"/90 applied at least one regulation rule. Consequently, the (cynegetic) hunting indices were calculated using data from a shorter season length than usual that took place mostly during the migration period. In contrast, the IAN was based on the usual time period. Moreover, the large decrease in hunting pressure and the

Figure 6. Monthly variations of IAN (based on the number of Woodcocks seen/hour) from 1996–97 to 2002–03.

movement of Woodcocks to the milder areas during the cold spell led to high densities in the western and south-western part of France. Because the IAN increased from January the annual value seemed rather high.

Except for unusual occurrences (as in 2002–03) and despite significant bias these indices follow the same trend. Therefore we believe that both measure abundance of Woodcocks and the bias inherent in these indices probably have a weaker effect than bird abundance.

Which method to monitor migratory and wintering Woodcocks?

Based on our results, hunting indices (ICAs) and IAN can be used to monitor migratory and wintering Woodcocks. Although ICAs have biases that are difficult to estimate without a sampling design and precise data collection they are strongly linked to hunting pressure. If the number of hunters visiting a hunting territory or if the amount of time spent hunting vary, the numbers of Woodcocks seen or shot per hunter (=ICA) will vary accordingly. Therefore, the ICAs values will be different even if the Woodcock abundance stays stable. A recent analysis of the French hunting bags showed that the hunting pressure has probably increased during the last 15 years (Ferrand and Gossmann 2000b). Unless the catch per unit effort is known (Seber 1982; Lancia *et al.* 1996) or if the hunter sample is constant and homogeneous (for example, only Woodcock specialists), the interpretation of ICA at a national scale could be rather tenuous (Nichols *et al.* 2001). However, thanks to ICAs, Woodcock hunters largely participate in the monitoring of their game species. This is an important advantage that helps the wildlife managers when it is necessary to change the hunting regulations.

However, we believe a long-term monitoring of migrating and wintering Woodcocks in France should not only be based on data from volunteers but primarily from professionals. Indeed, this work is expensive and time-consuming and the survey must not be threatened by a lack of motivation or a "political" change. Most of the ringer teams are professionals. The collection of data to calculate IAN does not hamper the ringing operations but, gives an additional value to this work. Moreover, the ringers have been trained and belong to a national network devoted to the Woodcock studies. An attempt to

census Woodcocks at night in Cornwall (Great Britain) was considered (conclusive) successful by Hoodless (1994), which also supports the use of this kind of data.

However, the results of the 2002–03 season lead us to be cautious in the interpretation of a single index. Clearly, ICAs are linked to hunting regulations, which can vary from one hunting season to another and also within the same hunting season. IAN is not linked to hunting regulations. As far as possible, we propose to use both indices for a better interpretation of trends. The comparison of these two indices could be very useful to assess the effect of hunting regulations.

Because the trips occur during the post-nuptial migration in the first part of the ringing season and during wintering in the second part, the calculation of two different annual IAN's could be considered. In fact, the IAN monthly values are low in October but peak in November, and stay rather stable until March (Figure 6). A clear split in the IAN does not occur.

We believe that the collection of these data needs some standardisation. The effort at each ringing sites must be the same every time, e.g. all the meadows in each site must be searched in a way that covers the sampled area. Harsh climatic conditions must be avoided. Finally, because the true trip duration varies from one team to another, we propose to retain an IAN based on the number of Woodcocks seen per hour.

Conclusion

After establishing and expanding a breeding-Woodcock census method, this study presents a complementary tool for the monitoring of the species in autumn–winter. Applying this method over a significant part of the wintering area should help the management of European Woodcock population.

But the monitoring of such an elusive species cannot be based only on the numbers' trend. The trend of demographic parameters such as annual survival rate, the quality of habitats, or the hunting bag level are necessary as well. For example, the ringing results have recently led to an estimate of the survival rates of Woodcocks ringed in France, from 1984 to 1997 (Tavecchia *et al.*, 2002).

The objective must be to implement an integrated monitoring as defined by Baillie (1990). The aim is not only to detect possible trends in the abundance levels but also to propose information which could explain these trends.

Acknowledgements

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National roding censuses in Russia

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From 1999 on, National roding censuses have been organised in 19 to 35 provinces of the afforested area of European Russia and Ural by the "Woodcock Moscow Group" together with "Rosokhotrybolovsoyuz", the largest Russian hunter association. Questionnaires and methods were distributed among hunter societies and through hunting newsletters.

The National censuses are conducted on the same day and for the whole country – the last Saturday of May, although the census methods allow the day of observations to be postponed to the next few days. On 80% to 90% of the census points roding began as of 21.00 to 23.00h.

The accumulation of information is going on and a database of roding census data is being created. We have already processed 8,750 questionnaires from 41 provinces. More than 71,000 contacts with Woodcock are registered. The provinces where the census was best organised are the Moscow Region, Sverdlovsk, Ivanovo and Chelyabinsk.

The intensity of male roding correlates with the number of females nesting in the same area. Therefore the number of contacts with roding Woodcock males, registered for two hours at a census point, can be regarded as an index of abundance.

The provinces with very intensive roding (more than 10 contacts on average) are the following: Tver, Arkhangelsk, Chelyabinsk, Kaliningrad. In Russia, the average roding intensity for the last five years was 7.3 to 9.8 contacts for two hours of observations. For different provinces roding intensity varied from 2.6 to 16.4 contacts.

Data collection enables to relate roding intensity to habitats, census time, weather and the degree of anthropogenic damage of an area.

Introduction

The majority of Woodcock wintering in Europe are nesting in the Russian forests. For a long time, it has been a necessity to monitor the number of this species during the display period. However, this has been put into practice in our country only in the last years thanks to the financial and methodological support of the French Office national de la chasse et de la faune sauvage.

National roding censuses have become one of the important components of the monitoring effort of the East-European Woodcock populations. Russian hunters among whom many are Woodcock hunting specialists, made a valuable contribution to this process. Since 1999, the national roding censuses have been organised by the "Woodcock" Moscow group together with "Rosokhotrybolovsoyuz" – the largest Russian hunter association.

Methods

Information on a regular census, together with questionnaires and methods, were distributed to hunter societies and also given in hunting newspapers to encourage readers to participate in the survey. The general results of the national roding censuses are published annually.

A questionnaire is filled out by one observer for one evening of roding observed at one census point. The data collected are the following: location of the census point, census date, description of the roding site (forest age and composition), time of beginning and end of observations, time when roding starts, number of seen and heard Woodcock, number of contacts with two, three and more birds at the same time.

The questionnaire form and census methods are not expected to be changed in order to provide comparable information from one year to another.

According to the methods, the observer should choose an open place in a forest, suitable for roding and convenient for observations (clearing, forest edge, wide forest road, etc.) and note every seen or heard Woodcock, independently of the distance, during two hours from the beginning of the observations.

According to our information, roding reaches its maximum intensity and stability between the 20 May to the 20 June in Russia (Fokin and Blokhin 2000). Therefore, the national roding census is conducted on one common day for the whole country – the last Saturday of May.

The analysis of the time at which males start roding is important from a methodological point of view in order to choose the optimum time to start the census. It was supposed that in late May–early June it is better that the census be carried out from 21.00 to 23.00h. (On 80% to 90% of the census points roding began as of 21.00 to 23.00h).

Results

Data collection

The national roding censuses, conducted on the last Saturdays of May 1999–2003, have already covered 41 provinces and republics, as members of the Russian

Federation. For the five-year survey period almost 9,000 questionnaires have been taken into account by the analysis. More than 71,000 contacts with Woodcock have been registered. At present time, all information is going to be transferred into a data-base.

Between 19 and 35 provinces of the European Russia and Ural forest zones, except the Northern Caucasus, were covered every year. The following provinces turned out to have provided the best organisation: the Moscow Region (1,358 participants), Sverdlovsk (980), Ivanovo (727), Chelyabinsk (635), Vladimir (519), Ulyanovsk (437), Tatarstan (443), etc.

Roding intensity by regions

The analysis of questionnaires revealed that the most intensive roding activity has been observed during the first national roding census in 1999, when 64 contacts were registered in one of the points in the Kaliningrad province, and in some points in the Sverdlovsk province and Mariy El (54 contacts each). In the following years this value did not exceeded 45. For the survey period, the provinces with very intensive roding (more than 10 contacts on average) appear to be the following: Tver, Arkhangelsk, Chelyabinsk, Kaliningrad (Figure 1). The average roding intensity was between 7.3–9.8 contacts (for two hours of observations) for the whole of Russia. For the different provinces the average roding intensity varied from 2.4 to 16.4 contacts. This range is even greater when the data are split by administrative regions. The general pattern of roding dynamics for the last five spring seasons in different regions in Russia, and the examples for the Central region and the Ivanovo province are presented in Figures 2, 3 and 4.

No roding sites

The absence of roding at a census point will also characterise roding intensity in a given area, but only when the census points are distributed at random.
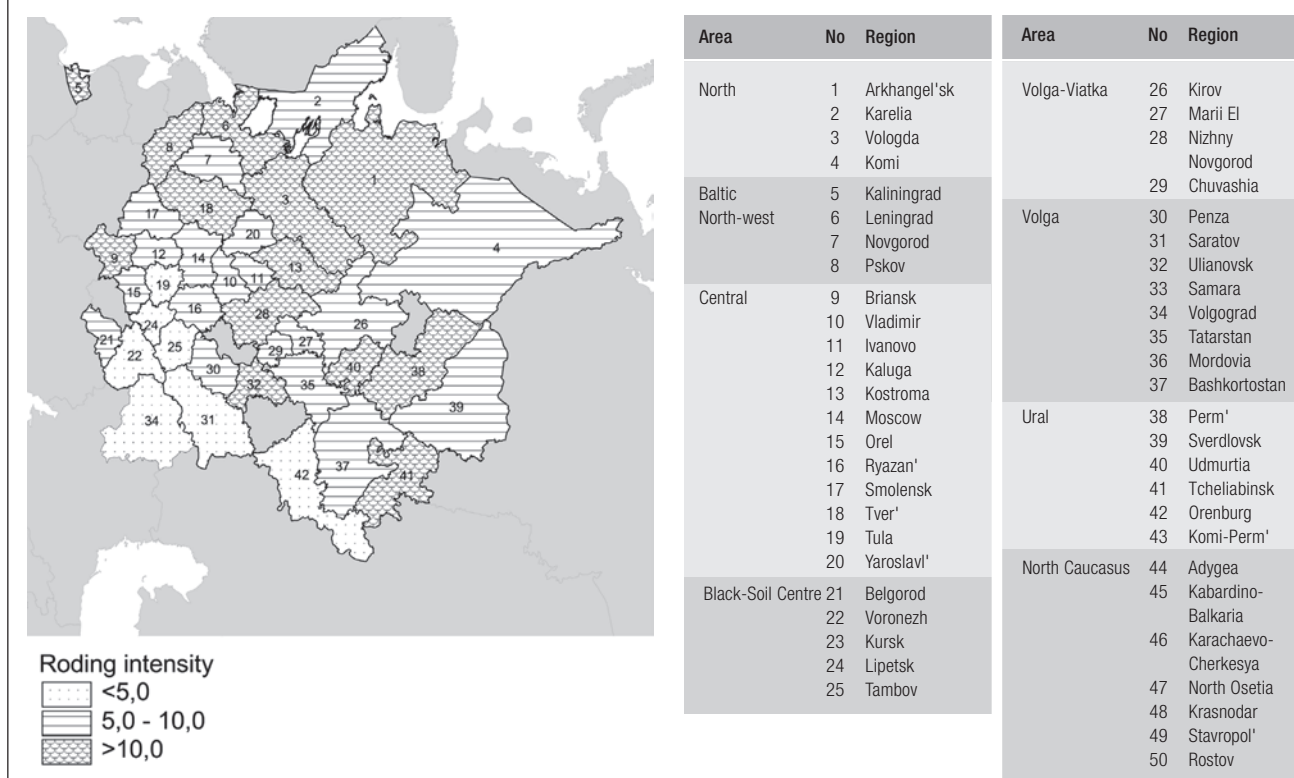
During the first census in 1999, no roding was observed at 40% of the census points in the Orenburg province, at 27% in the Tula province, 23% in the Voronezh province, 8% in the Moscow region.

During the fourth census in 2002, the census points with no roding only represented 1.6% of the total (n = 1,741) throughout Russia. They were located in only seven provinces. For example, there was no roding at 33.3% of the census points in the Orenburg province, 9.6% in the Tula province, 8.3% in the Chuvashia, in 4.2% in the Tambov province and at 4% of the census points in the Moscow Region.

In 2003, no roding was observed at 2.3% of the total number of census points (n = 1,847) in 11 provinces. The absence of roding mainly registered in the Central-Chernozem region: at 37.5% of the census points in the Lipetsk province, 30.8% in Belgorod, 20.4% in Voronezh, 3.6% in Tambov, and in the Central region: at 5.9% of the census points in the Ryazan province, 2.9% in the Moscow Region.

These low values may be indicative of a deliberate (not accidental) choice of the place and time when the census was made by the observers, in combination with favourable weather for roding.

Figure 1. Distribution of roding intensity in European Russia and Ural (average for 1999–2003).

Area	No	Region	Area	No	Region
North	1	Arkhangel'sk	Volga-Viatka	26	Kirov
	2	Karelia		27	Marii El
	3	Vologda		28	Nizhny Novgorod
	4	Komi		29	Chuvashia
Baltic North-west	5	Kaliningrad	Volga	30	Penza
	6	Leningrad		31	Saratov
	7	Novgorod		32	Ulianovsk
	8	Pskov		33	Samara
Central	9	Briansk		34	Volgograd
	10	Vladimir		35	Tatarstan
	11	Ivanovo		36	Mordovia
	12	Kaluga		37	Bashkortostan
	13	Kostroma	Ural	38	Perm'
	14	Moscow		39	Sverdlovsk
	15	Orel		40	Udmurtia
	16	Ryazan'		41	Tcheliabinsk
	17	Smolensk		42	Orenburg
	18	Tver'		43	Komi-Perm'
	19	Tula	North Caucasus	44	Adygea
	20	Yaroslavl'		45	Kabardino-Balkaria
Black-Soil Centre	21	Belgorod		46	Karachaevo-Cherkesya
	22	Voronezh		47	North Osetia
	23	Kursk		48	Krasnodar
	24	Lipetsk		49	Stavropol'
	25	Tambov		50	Rostov

Roding intensity
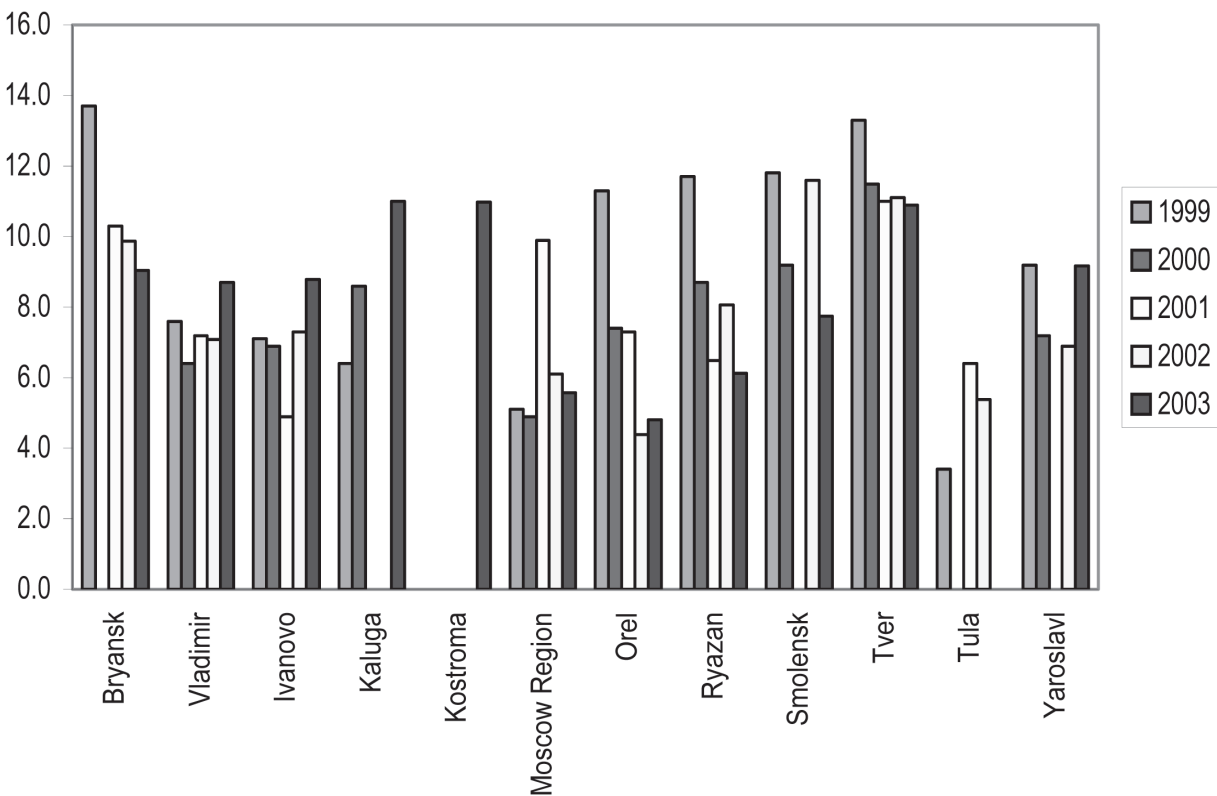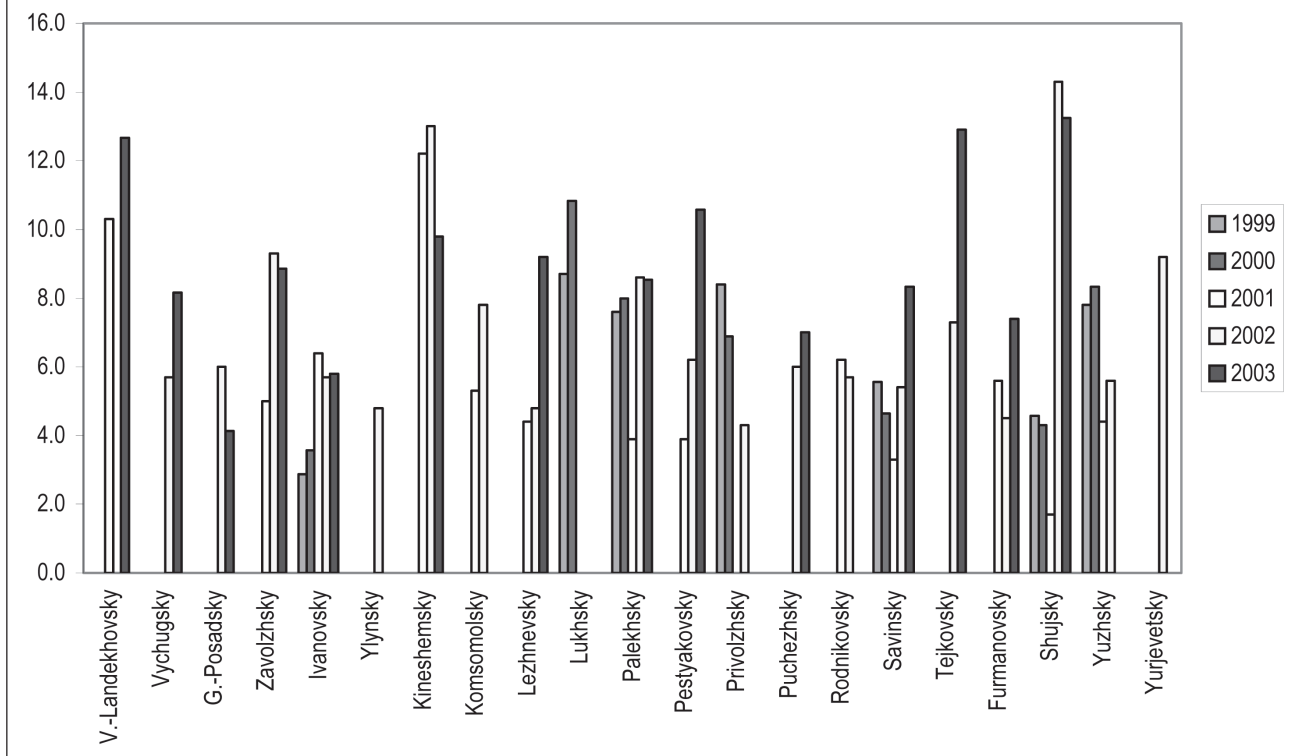- <5,0
- 5,0 - 10,0
- >10,0

Figure 2. Average roding intensity in regions of Russia in 1999–2003 (number of contacts).
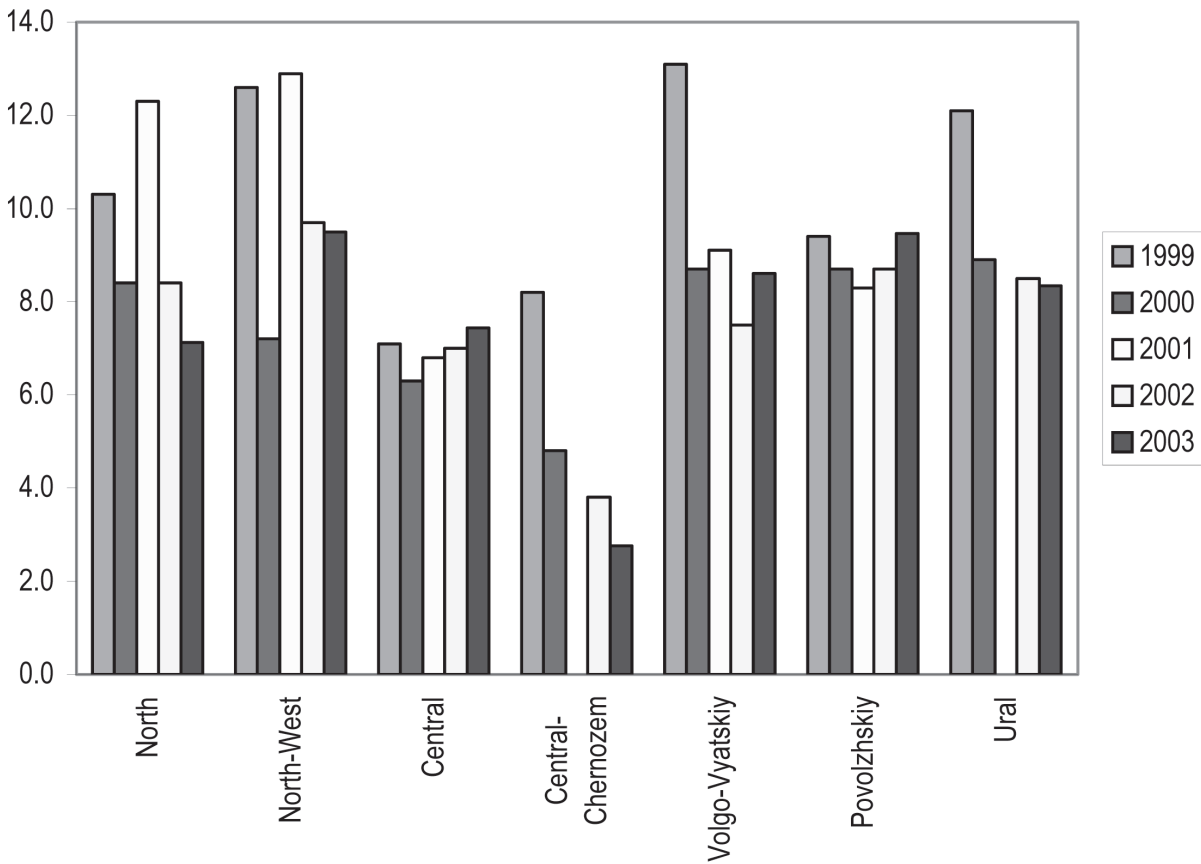
Figure 3. Average roding intensity in the provinces of the Central region in 1999–2003 (number of contacts).

Figure 4. Average roding intensity in the districts of the Ivanovo province in 1999–2003 (number of contacts).

Discussion and conclusion

The collected data allow to determine the relative factors which could have an impact on roding intensity: habitats, census time, weather, degree of anthropogenic damage. Roding intensity may be analysed at different levels: the administrative region where the census is organised or the glade or clearing chosen by the observer. Roding intensity depends on the weather conditions at the census-area level, like in late spring for example, but also on those at the very census day. In favourable weather (warm, no wind) a maximum number of males will participate in roding. Of course, the weather conditions may differ from one region to another and the census design may allow to postpone the day of observation to the next few days, if at that time the weather is expected to be favourable for roding in this region – this is done to minimise the influence of the weather factor on census results. Thus, according to the information obtained by the fourth national roding census 2002, the observations were made on the set Saturday only in 63.2% of the census points, and in the other 36.8% within the allowable two-week period after 25 May. In 2003, the last Saturday of May fell on the 31st. The fifth national roding census was carried out on this day only in 76.6% of the census points (in 74.3% in the Moscow region, in 70.5% in the Chelyabinsk province, in 43.8% in the Sverdlovsk province).

Wintering and spring migration conditions may also have an impact.

Roding census results are directly associated with the area visible at each point of observations. Depending on this, census results may substantially differ even in relatively-close located points. We believe that mass long-term information could level these biases and would allow to consider some results to be reliable.

Because of Woodcock behaviour and ecology, the present survey has shown that a complete quantitative census of the Woodcock populations is unreal. The roding intensity of males is closely associated with the number of females that are nesting in a particular area, and do not participate in roding. Therefore one can only consider the number of contacts registered for two hours at a census point to be an index of abundance. This relative census method at listening points is used in several European countries (Ferrand and Gossmann 2001). It is the basis of the national roding censuses made by hunters, and of control censuses on "large squares" simultaneously carried out by the Woodcock Specialists Group.

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Development of a survey method for breeding Woodcock and its application to assessing the status of the British population

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In a recent review of the population status of birds in the UK, the Eurasian Woodcock (*Scolopax rusticola*) was 'amber listed' as a bird of conservation concern because of an apparent long-term decline in breeding numbers and range. However, to date the available data have consisted of incidental sightings of Woodcock during the course of general bird surveys rather than counts of roding males. In 2003 The Game Conservancy Trust and The British Trust for Ornithology undertook a survey of breeding Woodcock with the aim of producing population estimates for England, Scotland and Wales. We present data on seasonal and evening patterns of roding activity which were used to decide upon our survey method. These indicated that in Britain, May and June are the most appropriate months for surveying roding Woodcock and that 83% of Woodcock passes at a fixed point should be detected in a one-hour survey commencing 15 mins. before sunset. Owing to appreciable variation in roding activity between evenings, we used the maximum count of registrations from three visits to each survey location in analyses of the national survey data. The survey showed large regional differences in the occurrence of Woodcock and in numbers of registrations at woods where Woodcock were present. Overall, Woodcock were present at 43% of woods surveyed (*n* = 900) and the mean number of registrations at these sites was 9.5 0.4 (*n* = 390). Controlling for the effects of region and woodland density, numbers of registrations were higher in mixed woodland than in conifer woods and were highest in deciduous woods.

Introduction

In a recent review of the population status of birds in the UK, the Eurasian Woodcock (*Scolopax rusticola*) was 'amber-listed' as a bird of conservation concern because of an apparent long-term decline in breeding numbers (-76%, 1974–1999) and range (-31% 1968/72–1988/91, Gregory *et al.* 2002). However, the species' population size is unknown and the current estimate is based upon sightings of Woodcock made during the course of general bird surveys rather than counts from dedicated surveys (Gibbons *et al.* 1993). The British Trust for Ornithology's (BTO) Common Birds Census index for the Woodcock was certainly suggestive of a decline in breeding Woodcock numbers between 1967 and 1988, but the data were biased towards areas of higher human population density, particularly south-east England (Marchant *et al.* 1990). It is unclear whether the difference in distribution and abundance of Woodcock between the 1968–72 and 1988–91 BTO Breeding Atlas periods is a result of the change in methods from unconfined surveys to timed visits and neither survey is likely to have yielded realistic estimates of breeding density.

A survey method capable of yielding information from which population trends can be reliably assessed is needed. Woodcock are likely to be sensitive to habitat change because they have specific habitat requirements, particularly during the breeding season. Young stands of trees with high earthworm availability and dense ground vegetation are highly utilised for feeding and brood rearing and areas with more open ground vegetation are used for nesting (Hirons and Johnson 1987). Changes in agricultural practice, such as the loss of permanent pastures which constitute optimal winter feeding areas, may be important and the species is widely hunted in winter. Annual monitoring of the American Woodcock (*Scolopax minor*) has highlighted a long-term population decline which appears, at least in part, to be related to habitat loss and alteration on the breeding grounds (Dwyer *et al.* 1983, Sauer and Bortner 1991, Sepik *et al.* 1993).

Owing to their cryptic plumage and secretive behaviour, the presence of breeding Woodcock in many woods may remain unnoticed. However, the unique roding flights performed by males above the woodland canopy at dawn and dusk provide an opportunity to confirm their presence. Estimation of the number of breeding birds is more problematic. In small-scale studies, the number of females can be estimated from the number of nests and broods located during systematic searches with dogs and the number of males can be estimated from captures of roding birds, but in both cases efficiency is unknown. Where more than two or three sites are involved, estimation of the number of roding males from visual counts is the only feasible technique, but this is complicated by seasonal and daily variation in roding activity and by repeat sightings of the same males.

In order to improve knowledge of the status of the breeding Woodcock population in Britain, a large-scale survey was planned for 2003. A survey method based on registrations of roding males at fixed points, similar to those employed in France and Russia (Ferrand 1993, Ferrand *et al.* 2003, Fokin and Blokhin 2000), was envisaged to provide baseline population index figures for

England, Scotland and Wales against which future repeat survey estimates could be compared. There is evidence that the number of registrations of roding birds during evening counts is related to the number of males displaying at a site and hence that it provides an index of male abundance (Ferrand 1987, Hoodless 2004). However, the magnitude of variation in evening counts and the extent to which this can be minimised by appropriate timing and consideration of other factors, such as weather conditions, is poorly documented. The aim of this study was to refine previous methods of assessing Woodcock abundance from counts of roding males in the context of application to UK situations. Some preliminary data from the 2003 survey on regional and habitat differences in Woodcock occurrence and abundance are presented.

Methods

Roding Woodcock surveys

Surveys of roding Woodcock at dusk were undertaken to enable examination of seasonal and diurnal patterns of roding activity. Surveys were undertaken from ride intersections, glades or felled areas within mature woodland and wet or windy evenings (with constant rain or wind speed exceeding Beaufort force 3) were avoided. On each occasion that a Woodcock was seen or heard, a separate registration was noted with the time to the nearest minute. The total number of Woodcock registrations during each survey was defined as the sum of all Woodcock seen and heard, plus those only seen or only heard.

Intensive surveys were made at Whitwell Wood, Derbyshire (53°18'N, 1°13'W) during March-June 1991 and 1992 (n = 20 and 21) and at Millden, Angus (56°53'N, 2°46'W) during May-June 1992 (n = 22). All of these surveys were made by the same observer at the same viewing point within each wood. Surveys commenced approximately 30 minutes before sunset and the last registration was judged to have been made if 30 minutes elapsed during which no further birds were seen or heard. The air temperature was recorded at 20.00 BST each evening.

Extensive surveys were made during May–June 2002 at 46 sites throughout Britain where Woodcock were known to be present. The surveys were undertaken by 37 observers, each making all the visits to between one and three sites. Observers were encouraged to familiarise themselves with the Woodcock's roding call prior to undertaking surveys. Up to four survey visits, each at least one week apart, were made to each site. Counts commenced on average 7±1 mins. before sunset and finished 59±2 mins. after sunset. Weather conditions during each count were recorded as categorical variables as follows: cloud cover 0 = 0–33% cover, 1 = 34–67%, 2 = 68–100%, rain 0 = dry, 1 = drizzle, 2 = light rain and wind 0 = calm, 1 = breeze, 2 = light wind.

Site selection for the national survey

Our aim was to achieve surveys at 1,000 randomly selected locations and to stratify these locations by region

and woodland area. Because roding Woodcock are generally associated with woodland, the biologically appropriate sampling unit is the stand of trees. In order to target woods to be surveyed, all 1-km² squares containing at least 10% woodland were identified from the Land Cover Map 2000, available at a 1-km² resolution through the Countryside Information System (Howard and Bunce 1996). The Land Cover Map 2000 is a classification of habitats based on spectral data recorded by satellites (Fuller *et al.* 2002). We specified four woodland categories as 1-km² squares that contained, respectively, 10–30 ha, 31–50 ha, 51–70 ha and 71–100 ha within the Land Cover Map 2000. Using the GIS package MapInfo 7.5 (MapInfo Corporation 2002) we sought to determine the number and size of regions that would ensure that each region had similar proportions of squares belonging to the four woodland size classes, whilst taking account of the number of potential surveyors within each region.

We used a dataset containing information on the numbers of BTO members within the 118 BTO regions and manipulated region boundaries at the 10-km² level until the numbers of members within each new region were as parsimonious as possible. It was not possible to achieve exactly the same number of members in each region because of a strong bias in BTO membership towards areas of high human population density, particularly south-east England. The proportion of total BTO members within each new region was used to calculate the number of survey squares required per region. We then calculated the number of woodland squares available within each size class within each region. Finally, we specified that all selected squares had to be at least 2-km apart, to ensure the independence of counts at each survey point, and randomly selected the desired number of woodland squares from those available within each size class and region.

Survey site stratification resulted in 11 geographical areas containing similar proportions of the four woodland size classes (Figure 1). It was not possible to further stratify by type of woodland owing to pronounced geographical differences in the extent of deciduous and conifer woodland: more deciduous woodland in southern England and more conifers in northern England and Scotland.

National survey method

For the national survey, three visits, each at least one week apart, were made to each site during May and June owing to the variability in roding activity between evenings. Observers were instructed to conduct surveys in the largest wood within the random square. Observers were allowed to move up to 400 m outside the square to find a suitable observation point if the wood was partly overlapped by the survey square. This means that in practise the minimum distance between two survey points was at least 1.2 km. Survey effort should be standardised across sites and so surveys commenced 15 mins. before sunset and lasted 60 mins. (see Results for justification). All Woodcock registrations were recorded to the nearest minute. The maximum count was used in analyses rather than the mean because this should better approximate to the total number of males at a site.

Figure 1. Boundaries of regions used for the Woodcock survey. Regions were selected on the basis that each contained similar amounts of woodland within four size classes.
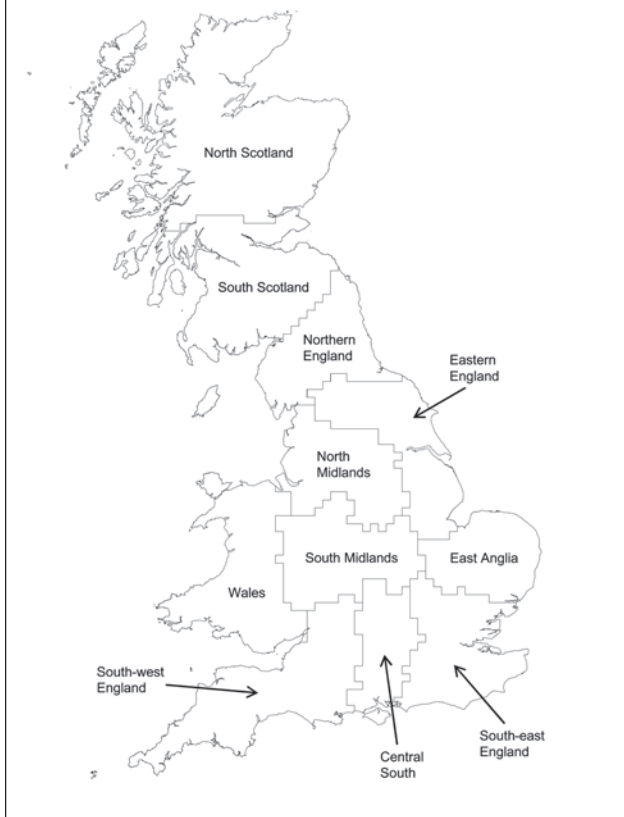
Statistical analysis

The effects of weather on the extensive surveys were examined using a generalised linear model (GLM) with Poisson errors and a logarithmic link function. The dependent variable was the number of registrations and the factors were site, time period (specified as ten-day periods, 1 = 1–10 May to 6 = 21–30 June), cloud, wind and rain. Overdispersion of data with respect to the Poisson distribution was corrected by specifying the dispersion parameter as the residual deviance divided by its degrees of freedom. The time between sunset and the first registration was analysed using a general linear mixed model (GLMM) with site specified as a random effect to examine the variation explained by latitude and longitude at the site level and by count date, cloud, wind and rain at the visit level. The dependent variable (minutes elapsed) was normally distributed. Sunset times were obtained from the website http://www.onlineweather.com/v4/uk/sun for Inverness, Oban, Perth, Newcastle, York, Sheffield, Worcester, Cambridge and Basingstoke for each of the survey dates.

The occurrence of Woodcock at sites in the national survey was examined using a GLM with binomial errors, the number of occupied woods being the dependent variable and the number of woods surveyed per region-wood class stratum the binomial denominator. The number of registrations per hour within occupied woods was analysed using a GLM, with Poisson errors and a logarithmic link function, with region and woodland size

class as factors. To examine the effects of habitat type, these analyses were repeated including habitat as a factor, which was classified as deciduous, mixed or conifer on the basis of the dominant tree species recorded at each site. GLMs and GLMM were performed in GENSTAT 7.2 (Lawes Agricultural Trust 2003) and all other statistics were calculated in SYSTAT 9 (SPSS Inc. 1999).

Results

Seasonal pattern of roding activity

The roding activity of Woodcock at Whitwell Wood followed a similar seasonal pattern in 1991 (20 visits) and 1992 (21 visits), with no difference between years in the number of registrations or duration of roding per night when controlling for month (registrations GLM year $F_{1,35}$ = 3.27, P = 0.079, month $F_{3,35}$ = 1.49, P = 0.233; duration ANOVA year $F_{1,33}$ = 0.00, P = 0.998, month $F_{3,33}$ = 7.26, P = 0.001 (duration of roding not recorded accurately on two occasions)). Numbers of registrations increased from a mean of eight per night in March to a peak count of 25 in early June (Figure 2). The mean duration of roding increased from 24±4 mins. in March to 66±5 mins. in June and the time of the start of roding advanced in relation to sunset as the breeding season progressed (March 18±6 mins. after sunset, June 18±3 mins. before sunset, Figure 3).

May and June appear to be the most appropriate months for surveying roding Woodcock and there was no difference in numbers of registrations or duration of roding between ten-day periods within these months at Whitwell Wood and Millden (registrations GLM period $F_{5,44}$ = 1.65, P = 0.166, site $F_{1,44}$ = 16.73, P < 0.001; duration ANOVA period $F_{5,43}$ = 0.83, P = 0.534, site $F_{2,43}$ = 1.93, P = 0.172). The number of registrations was significantly related to the duration of roding per evening at both sites (ANCOVA duration $F_{1,57}$ = 49.69, P < 0.001, site $F_{1,57}$ = 32.90, P < 0.001, duration x site $F_{1,57}$ = 0.00, P = 0.998). There was, however, appreciable variation in the number of

Figure 2. Numbers of registrations of roding Woodcock at Whitwell Wood, Derbyshire during March–June 1991 and 1992. Data for the two years are combined because there was no difference between years when controlling for the effect of month.
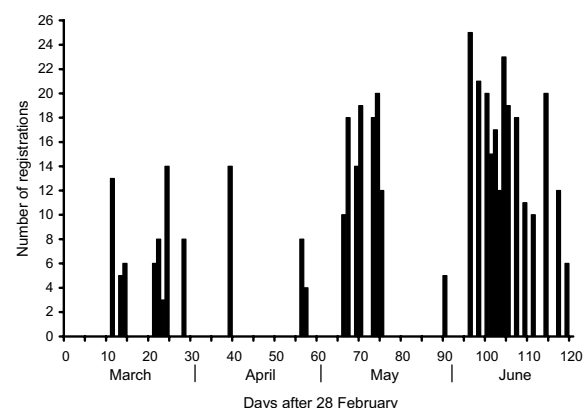
Figure 3. Duration of the evening roding period at Whitwell Wood, Derbyshire during March–June 1991 and 1992 in relation to sunset. Data for the two years are combined because there was no difference between years when controlling for the effect of month.
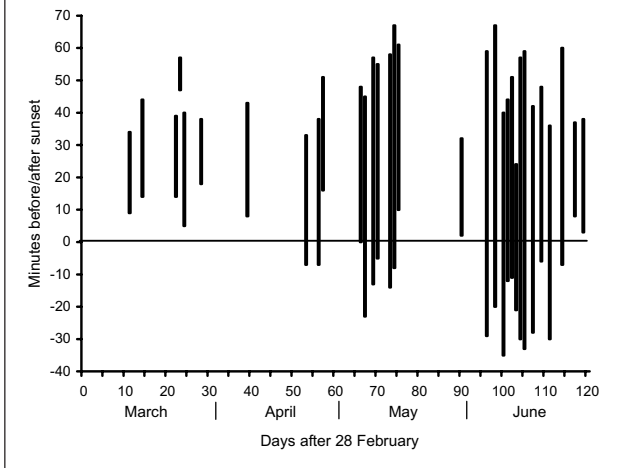
registrations and duration of roding between individual evenings. Coefficients of variation were 43%, 34% and 40% for the number of registrations at Whitwell Wood in 1991 ($n = 8$), in 1992 (n = 21) and at Millden (n = 22) respectively and were 31%, 26% and 21% for the duration of roding. This variation could not be explained by differences in evening temperature (temperature $F_{1,42} = 0.93$, $P = 0.341$, site-year $F_{2,42} = 0.26$, $P = 0.773$).

Evening roding activity and effects of weather

The 46 extensive sites represented a wide range of Woodcock abundance, with a mean of 8.6±0.9 registrations per site (range 0–34). The variation in counts made at the same site was appreciably smaller than that between sites (mean within-site deviance = 2.39, mean between-site deviance = 11.79 from a GLM with site as the only factor). Examination of the means and standard deviations of the number of contacts based on the first survey and means of two, three and four surveys indicated that the addition of the fourth survey altered the values very little.

Weather conditions had no significant effects on the number of Woodcock registrations made during a survey and the mean number of registrations was similar for each ten-day period during May and June (Table 1). The start of roding was influenced by rain, survey date and longitude of the site (Table 1). Roding commenced earlier on evenings with drizzle (1±5 mins. before sunset, $n = 6$) than on dry evenings (4±2 mins. after sunset, $n = 110$) and earlier still on evenings with light rain (15±6 mins. before sunset, $n = 5$). The start of roding advanced linearly by approximately one minute every four days after 1 May (slope -0.268±0.084 min./day), such that roding typically started 15 mins. after sunset in early May and 1 min. after sunset in late June. Roding commenced earlier in eastern Britain than in the west and the start time changed by approximately four minutes for every 100 km moved (slope -0.043±0.012 min./km).

Combining the data on times of Woodcock registrations for all visits to all sites indicates a main period of roding activity in May and June commencing 15 mins. before sunset and continuing for about 75 mins. A peak of activity occurred 20 mins. after sunset (Figure 4). A 75-min. survey commencing 15 mins. before sunset and ending 60 mins. after sunset should detect 94% of registrations. A 60-min. survey from 15 mins. before sunset to 45 mins. after sunset covers 83% of registrations.
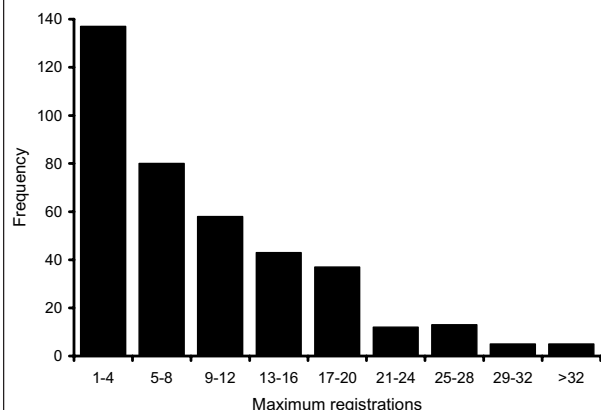
National survey results

Data were received for a total of 900 sites and Woodcock were present at 390 (43%). The maximum count of registrations at sites with Woodcock varied between one and 41 (mean 9.5±0.4), with low numbers of registrations at many sites and high numbers at a few sites (Figure 5). There was a significant difference between regions in the proportion of sites with Woodcock present (GLM controlling for woodland size class, $F_{10,30} = 3.40$, $P = 0.004$). The occupancy of woods was lowest in Wales, with birds recorded in just 18% of woods, and was highest in eastern England, where Woodcock were recorded in 69% of woods (Table 2). Numbers of registrations per hour

Table 1. (a) The effects of weather and ten-day period on the number of Woodcock registrations made during surveys at 46 sites across Britain in May–June 2002 (GLM controlling for site). (b) The effects of weather, survey date and site location on the start of roding (mins. before/after sunset) at 45 sites across Britain in May–June 2002 (GLMM).

(a) Registrations				(b) Start of roding			
Variable	df	F	P	Variable	df	Wald	P
Cloud	2	0.11	0.892	Cloud	2	3.34	0.188
Wind	2	1.14	0.324	Wind	2	2.13	0.344
Rain	2	0.69	0.504	Rain	2	10.08	0.006
Period	5	1.82	0.120	Survey date	1	11.82	<0.001
Site	45	4.31	<0.001	Latitude	1	0.10	0.754
Residual	73			Longitude	1	4.91	0.027

Figure 4. Percentage frequency of evening registrations of roding Woodcock in relation to the time of sunset during May–June 2002 (n = 1,325 registrations from 46 sites, mean survey date = 24 May ± 1 day).
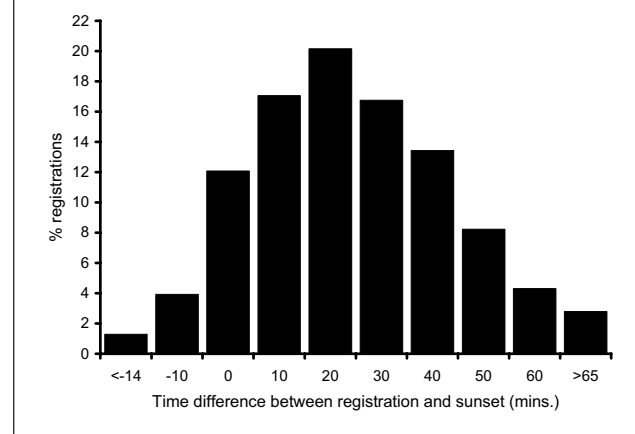
Figure 5. Frequency of maximum number of roding Woodcock registrations from 390 woods across Britain with Woodcock present in May–June 2003.

Table 2. Regional rates of occurrence of roding Woodcock and means of maximum counts of registrations at woods where Woodcock were present. Values are corrected for the effect of woodland density.

Region	Number of woods surveyed	% occurrence	Mean registrations ±SE at occupied woods
Eastern England	61	69	11.6±1.3
Northern England	62	56	11.1±1.5
East Anglia	83	54	9.9±1.2
Central South	125	50	10.0±0.9
North Midlands	136	49	12.0±1.3
Southern Scotland	46	43	11.0±2.5
Northern Scotland	32	37	6.0±1.4
South-east England	156	34	6.9±1.0
South Midlands	73	33	6.2±1.3
South-west England	76	31	7.4±1.4
Wales	50	18	2.3±1.3

within occupied woods varied between woodland size classes in a different manner between regions, such that in southern England numbers of registrations typically increased as woodland size increased, whereas in northern England and Scotland there was little difference in numbers of registrations between woodland size classes (GLM region $F_{10,346} = 3.21$, $P < 0.001$, woodland size class $F_{3,346} = 1.47$, $P = 0.222$, region x woodland size class $F_{30,346} = 1.51$, $P = 0.045$). The ranking of regions according to numbers of registrations at occupied woods differed slightly from the ranking based on the occupancy of woods, but the fewest registrations were made in Wales (Table 2).

There was no effect of habitat type (deciduous, conifer or mixed woodland) on the occurrence of Woodcock at a site (GLM controlling for region and woodland size class, $F_{2,103} = 1.93$, $P = 0.156$). However, numbers of registrations at sites where Woodcock were present differed between habitats, being highest in deciduous woods (deciduous 10.9±0.7, mixed 9.2±0.8, conifer 7.7±0.9, GLM controlling for the effects of region, woodland size class and the region x woodland size class interaction, $F_{2,322} = 3.81$, $P = 0.023$).

Discussion

Rationale for counting roding males

In order to clarify our understanding of the status of the UK breeding Woodcock population, a survey method was required which could easily be applied by amateur observers, but which yielded a true measure of Woodcock numbers and was sufficiently sensitive to enable the detection of future trends in abundance. In attempting to draw up a management plan for the Woodcock, Ferrand and Gossmann (2001) have advocated better monitoring across the species' European breeding range in order to facilitate sustainable harvesting and ensure a favourable status for this widely hunted species. Counts of roding males provide the only feasible way of monitoring breeding Woodcock populations at large scales, but they are difficult to

interpret for several reasons. Males do not maintain exclusive territories (Hirons 1980) and individuals cannot be distinguished visually. Males display over relatively large areas (43–134 ha) and some are more active than others (Hirons 1983). It is now clear that individual male Woodcock have distinctive calls that can be recognised with sonograms (Ferrand 1987) and that despite the different activity levels of individuals at a site, the number of registrations is linearly related to the number of males displaying (Hoodless 2004). Hence counting registrations of roding males is a valid approach to estimating the number of males displaying in a wood. However, it is still not clear whether there is a small proportion of males that do not rode at all (Ferrand 1983, Hirons 1983) and the relationship between numbers of males and females at a site is unknown. Further work to establish the relationship between the number of roding males and the total number of breeding Woodcock, perhaps by comparing roding counts with flush counts made with dogs, would be instructive. The value of roding surveys will be increased if they can be used to estimate densities of male Woodcock. The first step towards this has been achieved by the demonstration of a relationship between numbers of registrations and numbers of individual males. The next steps are to determine what proportion of all males rode during May and June and the effective survey area.

Number and timing of surveys

Little has been written about the precise timing of roding or variation in roding activity between nights. Woodcock roding in Britain typically commences in late February, reaches a peak in early June and finishes by mid-July (Hoodless pers. obs). This general seasonal pattern of activity is similar to that observed in France (Ferrand 1983), but differs from Sweden and Russia where roding does not commence until early April and activity tends to be more consistent throughout the breeding season, or less pronounced peaks may occur in early May and late June (Marcström 1988, Fokin and Blokhin 2000). The data collated in our study suggest that May and June are the most appropriate months for surveying breeding Woodcock in Britain, because roding activity was more variable early in the breeding season. Indeed, Hirons

(1983) has shown that activity in March is positively related to the maximum daytime temperature. It is also known that migrant Woodcock are present until mid-April (Hoodless and Coulson 1994), but it is currently unclear to what extent these birds rode prior to departing.

There was no seasonal trend in roding activity during May and June and no effect of evening temperature or cloud cover, wind speed or rain on surveys, provided that very windy or wet evenings were avoided. A complication with assessing Woodcock abundance from counts of roding males is that, even during May and June, there is appreciable unexplained variation in activity between evenings. Thus we advocate making several surveys to increase the chance of detecting the maximum activity at a site. Three surveys at each site are probably sufficient for a project where many sites are involved. For studies in which the aim is to assess annual changes in Woodcock abundance in relation to other variables at a small number of sites, it would be advisable to increase the number of surveys at each site.

The time that Woodcock start roding each evening is likely to be related to light intensity. While differences in cloud cover had no apparent effect on the start of roding in our study, it seems that the reduction in light level associated with precipitation is sufficient to produce an earlier start to roding. Roding commenced progressively earlier in relation to sunset during May and June. Presumably this was related to the fact that the sun takes longest to set at the summer solstice (21 June) and light levels change more slowly as this date is approached. This complicates specifying a time for observers to commence surveys, but the errors incurred by indicating a start time relative to sunset that is relevant for late May will be small.

It is often difficult for observers to judge when roding has finished and an attempt to record all registrations may result in observers waiting unnecessarily for 30 mins. or more after the last bird has been seen. We suggest that a preferable approach is to standardise survey effort by specifying a regionally-adjusted start time and a fixed survey length. A relatively short survey period of one hour is also likely to increase participation by volunteers in large-scale surveys.

National survey results

Roding Woodcock were present at a higher proportion of sites in Britain (43%) than typically found in France (24–28% occupancy 1990–1997, Ferrand and Gossmann 2000), despite the fact that the British breeding population is estimated to be smaller than that in France (UK 8,500–21,500, France 100,000–300,000, Stroud *et al.* 2004). In contrast, in Russia which is believed to be the main stronghold for the species in Europe, with a breeding population of 6–7 million birds (Stroud *et al.* 2004), Woodcock were present at 85–95% of 210–236 random sites surveyed during 2000–2004 (Fokin *et al.* 2004). Mean numbers of registrations at occupied sites were broadly comparable in all three countries.

Further analyses to examine differences in landscape factors and woodland habitat are planned to attempt to explain the large regional differences in Woodcock abundance observed in this study. Interestingly, breeding Woodcock were absent or only occurred in low numbers in the western, coastal areas of England and Wales, where they tend to be most abundant in winter. The situation appears to be similar in France (Yeatman-Berthelot and Jarry 1995). Our data suggest that Woodcock breed in conifers as frequently as in deciduous woods but that abundance is lower in conifers. Further work is needed to ascertain the suitability of different conifer species and stand ages for breeding Woodcock, as the first step in assessing how changes in management policy for commercial forests will affect Woodcock populations.

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Winter survival rates of Eurasian Woodcock in western France, with reference to hunting

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The Eurasian Woodcock (*Scolopax rusticola*) is a migratory bird of major importance for hunting, suffering many potential threats. We studied the causes of mortality and survival rates of 98 radio-tagged Woodcocks in a reserve with no hunting and in a hunting area in Brittany (France). Predation, occurring mostly in fields at night by terrestrial predators, was more important than expected (10 cases) and the rate was similar among adults and yearlings, while hunting mortality was greater for yearlings. Overall winter survival rates were 0.86 ± SE 0.07 for adults and 0.63 ± SE 0.07 for yearlings. For both ages, survival increased when the birds spent more time in the reserve. With equal rates of predation in both the reserve and hunting area, hunting mortality seemed to be additive over the winter. Population matrix models predicted that these low survival rates were not sufficient to sustain viable populations in the long term. These results suggest the need for caution in the harvesting of populations wintering in western European countries and could be a forewarning of a decline. Limitation of hunting by the introduction of a bag limit or by creation of reserves might ensure sustainable management of Woodcock populations.

Introduction

Eurasian Woodcocks (*Scolopax rusticola*) are solitary, migratory waders with a very wide breeding range across the Eurasian continent, but with populations concentrated along the Atlantic and Mediterranean coasts in winter (Cramp and Simmons 1983). Their conservation status is uncertain and was established as 'vulnerable in winter' (Tucker and Heath 1994; Heath *et al.* 2000) but recently revised as 'stable' (Wetlands International 2002). However, the sizes and trends of Woodcock populations are difficult to estimate in Europe, except in France where the breeding and wintering population appear to have been stable during the last 15 years (Ferrand and Gossmann 2001), and in Switzerland where the breeding population is clearly declining (Estoppey 2001a; Estoppey 2001b). Moreover, important demographic parameters, such as survival and breeding success, remain poorly known. Among these parameters, mortality due to hunting is probably a major factor affecting Woodcock populations. Indeed the Woodcock is an important quarry species and is hunted in the majority of European countries (estimated annual bag between three and four million birds in Europe; Ferrand and Gossmann 2001). French hunters kill between 30 to 40% of the total bag in Europe (shooting about 1,200,000 Woodcocks every winter), and interest in Woodcock hunting has recently increased because of the scarcity of other wild small game species such as partridges (*Perdix perdix*) and rabbits (*Oryctolagus cuniculus*) (Ferrand and Gossmann 2000). On the other hand, the impact of natural mortality induced by predation is virtually unknown. In addition, Woodcock populations are threatened by the loss of their wintering habitats (a reduction in the surface areas of permanent meadows and hedges, an increase in less suitable coniferous forests; Pain and Pienkowski 1997). It

has also been demonstrated that Woodcocks are sensitive to dramatic climatic events, especially cold spells, because their main food, earthworms, becomes inaccessible when the ground is frozen.

To date, conservation measures have mostly focused on the regulation of hunting. In most European countries, hunting is limited by time period, and/or bag size (e.g. in western France, the bag limit is generally fixed to three birds per day and 30 birds in the season). However, these bag limits are often fixed arbitrarily and are not adjusted to the current population dynamics because of the lack of knowledge of demographic parameters. The role of reserves has rarely been quantified. Indeed, only a few reserves have been created specifically for Woodcock conservation. A classical result, described by Fadat (1995), was that when hunting was prohibited for several years in a forest the age ratio was biased toward adults when hunting was permitted again.

Estimation of survival rates in different parts of the breeding and wintering range is essential in order to determine sustainable management practices (bag limit, reserves). Most studies dealing with survival rates were based on ring recoveries (Hoodless and Coulson 1994; Tavecchia *et al.* 2002) or age ratios (Fadat 1993). These methods suffer biases towards hunting and under-estimation of other causes of mortality. An alternative method is the use of radio-telemetry that has the advantage of conferring upon individuals a recapture rate equal to one, allowing a simplification of survival parameter estimates (White and Garrott 1990). Moreover, radio-tagging enables the cause of death to be determined, and the impact of predation to be quantified, which has not been possible in the previous studies using data sets from rings recovered mainly by hunters. In this

paper we use data on radio-tagged Woodcocks living inside and outside a hunting-free reserve to investigate: (1) What are the causes of mortality and what is the impact of predation? (2) What are the survival rates of wintering Woodcocks? (3) What is the efficiency of reserves? (4) What proportion of a population can be protected by a reserve?

Methods

Study site

The study was carried out in Brittany (48° 30' N, 3° 28' W; western France) during three consecutive winters (1999–2000, 2000–2001, 2001–2002; hereafter called 2000, 2001 and 2002 winters respectively). The study was conducted from 1 December to 20 February, including a major part of the hunting period in France (1 October–28 February). The study area was c. 1,800 ha and encompassed a forest (the Beffou forest) and surrounding bocage (a characteristic landscape of northern France consisting of small irregular fields interspersed by hedges and copses). Meadows grazed by cattle prevailed (70% of fields) and the remaining fields were cereal stubbles and winter cereals. The Beffou forest was composed of three main habitat types: closed-canopy deciduous woodland (30–100 years old, including mainly beech (*Fagus sylvatica*) and oaks (*Quercus robur* and *Q. sessiliflora*), closed-canopy coniferous woodland (30–100 years old, including mainly sitka spruce (*Picea sitchensis*), common silver fir (*Abies alba*), Scots pine (*Pinus sylvestris*) and Maritime pine (*Pinus pinaster*)) and young beech-oak plantations (10–30 years, with a dense shrub layer). Woodcock hunting was prohibited in the Beffou forest since 1995. Hence, for further purposes, the forest will be called the "reserve" and the remaining area the "hunting area". Hunting occurred mainly at weekends but was legal six days per week. Woodcock hunters are generally solitary and work with a dog. The climate has an oceanic influence, and is characterised by rain, wind and mild temperatures in winter (January, mean rainfall: 100 mm; mean temperature: 4.5°C; source Météo France).

Data collection

Woodcocks were captured on feeding sites between 18:00 and 24:00 with a spotlight and a landing net (Gossmann *et al.* 1988). Birds were fitted with a metal ring and aged (first-year vs. adult) according to wing feather characteristics and moult status (Clausager 1973; Fadat 1994). A total of 105 Woodcocks were captured and monitored. Each bird was fitted with a radio-transmitter (Biotrack® TW3), weighing 7–12 g (2–4% of body mass) according to the battery size. All the birds in 2000 and seven in 2001 were fitted with radio-tags attached to the back with a Teflon ribbon two-loop backpack harness (Kenward 1987). Seven Woodcocks died of starvation because the bill was jammed in the upper loop of the harness (probably when preening) and were removed for further analyses. Consequently, during winters 2001 and 2002, the radio-tags were glued on the back and maintained with a single-loop harness (passing across the belly and behind the wings [Figure 1]). The single-loop harness did not provoke any mortality. Hence, after excluding the seven birds that died, data from 98 individuals were available for analyses.

Birds were located by night and day two to five times per week until their departure on migration, which started at the end of February until early April. Locations were plotted on a 1/10,000 map to the nearest 10 m by day and 50 m by night. The status of the bird (alive or dead) was assessed according to its behaviour. When no movement was recorded for two consecutive days and nights, the bird was flushed to check if it was still alive. Otherwise, we searched for the radio-tag. Mortality was classed as due to hunting when hunters brought back the radio-tag, or when the radio-tag was found with obvious signs of knife-cutting on the harness. Mortality was
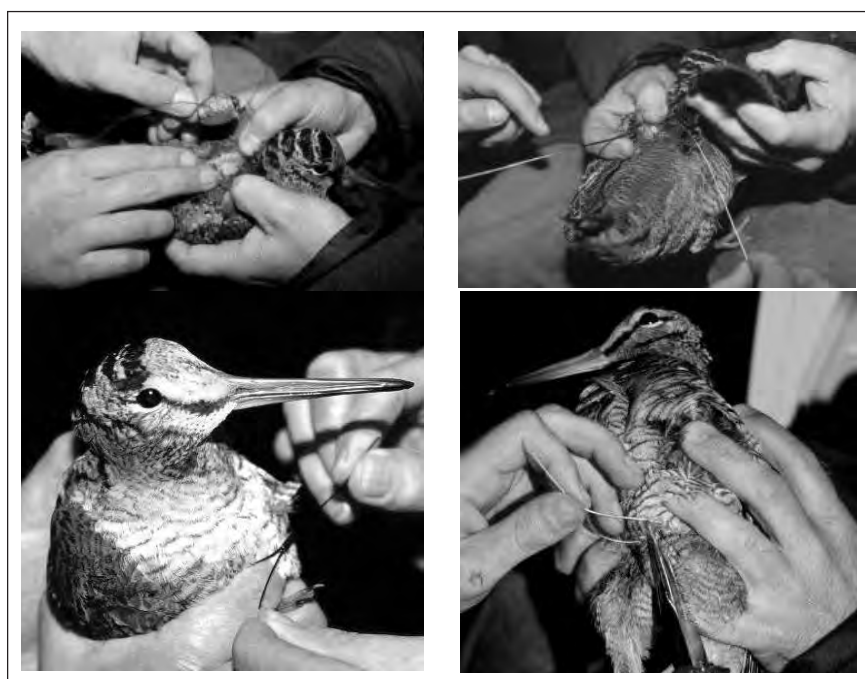
Figure 1. Details of radio-tag attachment. The radio-tag is glued to the back, on a part of skin naturally naked (top left). Both wires of the harness are then passed behind the wings (top right) and in front of the legs (bottom left), to form a belt, and secured in a sleeve with pliers (bottom right).

classed as predation when the radio-tag was found with the remains of the body, was buried, or had tooth marks and a chewed antenna [fox (*Vulpes vulpes*)] or was found with feathers with scissor-like cuts (mustelids or feral cats). When cues were lacking, the source of mortality was defined as unknown. From late February, lost signals were attributed to migration departure.

The pattern of site use in Woodcocks was such that many individuals changed their diurnal site several times during the study period and could switch from the reserve to hunting areas (Duriez *et al.*, this issue, pp. 26–35). Therefore, for each individual the pattern of site use was assessed from the proportions of radio-tracking locations in the reserve and the hunting area.

Survival analyses

Survival probabilities of radio-tagged Woodcocks throughout the study period were assessed by using "known fates" models implemented in the software MARK (White and Burnham 1999). For analyses, we considered the "week" as the time unit and each bird as an independent sample unit. We assumed that survival was constant over time because our sample size was not sufficient for analyses including a time effect. We tested whether survival rate was related to age, year, pattern of site use, mass and date of capture, including additive and interaction terms. Age and year were introduced in the models as factors and, site use, mass (in g.) and date of capture (for each year, day 1=1 December) as standardised covariates. The pattern of site use was defined as the proportion of locations in the reserve area. We used the Akaike Information Criteria (AIC_c) to select the most parsimonious model (Anderson and Burnham 1999): AIC_c = -2log Dev + 2K + 2K(K + 1)/(n - K - 1), where Dev is the deviance of the model, K the number of parameters and n the effective sample size. We assumed equal fit of two models when the difference in AIC_c values (ΔAIC_c) between the models was < 2. Model selection was performed in two steps. Firstly, we used a step-down approach (Lebreton *et al.* 1992) to select the most parsimonious factorial model that fitted the data, starting with the model Age*Year as the global model. Secondly, the effect of each covariate was tested when separately added to the previous selected model.

Population matrix model

Modelling of population trajectories was conducted using a Leslie matrix using the software ULM (Legendre and Clobert 1995). The matrix structure followed Tavecchia *et al.* (2002) and considered a female-based model with two age-classes (yearlings and adults) and a post-breeding census. The initial population size was n_1 = 100 yearlings + n_2 = 100 adults. We assumed a constant 1:1 sex-ratio σ at fledging and an equal female fecundity in both age classes (two fledglings; Hoodless and Coulson 1998). In species with first breeding attempts occurring when individuals are one year old, such as the Woodcock, the population growth rate is highly sensitive to post-fledging survival. Because post-fledging survival s_0 is an unknown parameter (Hoodless and Coulson 1998), models were fitted with several values of s_0, ranging from 0.5 to 0.9. The transition matrix was the following:

$$\begin{bmatrix} s_{ew}S_{lw}S0\sigma f & s_{ew}S_{lw}S0\sigma f \\ S & V \end{bmatrix}$$

where s and v were annual survival rates for yearlings and adults respectively. Annual survival rate was a product of summer survival s_s (from 1 March to 30 September: 0.590±SE 0.041; Tavecchia *et al.* 2002), early winter survival s_{ew} (from 1 October to 30 November: derived from the monthly survival s_1 0.918±SE 0.024 in yearlings and s_2 0.959±SE 0.012 in adults; Tavecchia *et al.* 2002) and late winter survival s_{lw} (from 1 December to 28 February; s_3 for yearlings and s_4 for adults estimated in the present study). The model was deterministic (age structure, survival probability and breeding success constant over time) and assumed full reproduction at one year. We ran models for 100 generations. The sensitivity of the population growth rate (λ) to survival predicts the change in growth rate in response to a very small change in survival ($d\lambda/dsurvival$), all other demographic parameters being constant. The elasticity of the population growth rate to survival is the sensitivity multiplied by the ratio (survival/growth rate), i.e. the proportional change in growth rate to a small change in survival. Here a value is given for each parameter (adult survival, adult fecundity, yearling survival and yearling fecundity) for a varying amount of time spent in the reserve. The most important parameter has the highest value.

Results

Causes of mortality and site use

Over the three seasons, 59 Woodcocks (71% of adults and 54% of yearlings) survived to the hunting season and went on migration (loss of signal in spring) (Figure 2). The hunting mortality concerned mostly yearlings (91% of cases) and but the predation rate was similar between both ages (Figure 2). Predation was only caused by terrestrial predators: four cases were attributed to foxes (*Vulpes vulpes*) and six cases to feral cats or mustelids (stone marten (*Martes foina*) or marten (*Martes martes*)). Seven carcases attributed to martens, cats or foxes were found in the fields or hedges. Only one carcase attributed to fox and two attributed to Marten were found in the forest.

Figure 2. Causes of the end of monitoring (mortality or migration) for each age class (35 adults and 63 yearlings). To aid comparison between age classes, causes are expressed as percentages.
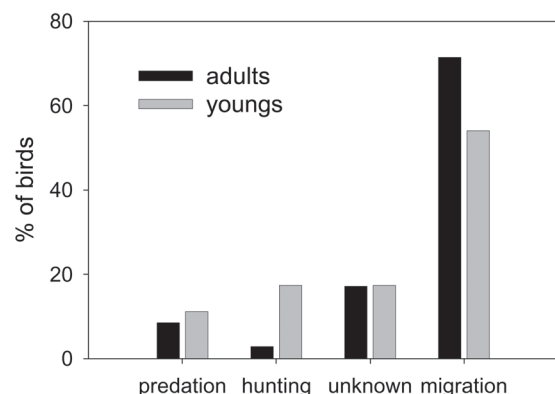
To investigate the effect of hunting on survival and the efficiency of the reserve, we looked at the percentage of diurnal locations in the reserve (Figure 3). More than half of the birds spent all their winter in the reserve, but the remaining half was at risk from hunting for a variable amount of time, and 30% of birds spent >50% of their time in the hunting area (woodlands or hedges). There was no difference between adults and yearlings in the percentage of locations in the reserve (GLM with binomial error: $F_{1,96} = 1.31$, $P = 0.255$; Figure 2).

Survival rates

Model selection indicated that the model S{Age + Reserve} had the lowest AICc (Table 1). When deriving survival parameters ((weekly survival) [12 intervals] over the 12 weeks of the study period) for age only, the model S{Age + Reserve} gives a mean winter survival rate of 0.863 ± SE 0.066 in adults and 0.627 ± SE 0.073 in yearlings. For both ages, survival increased when the birds spent more
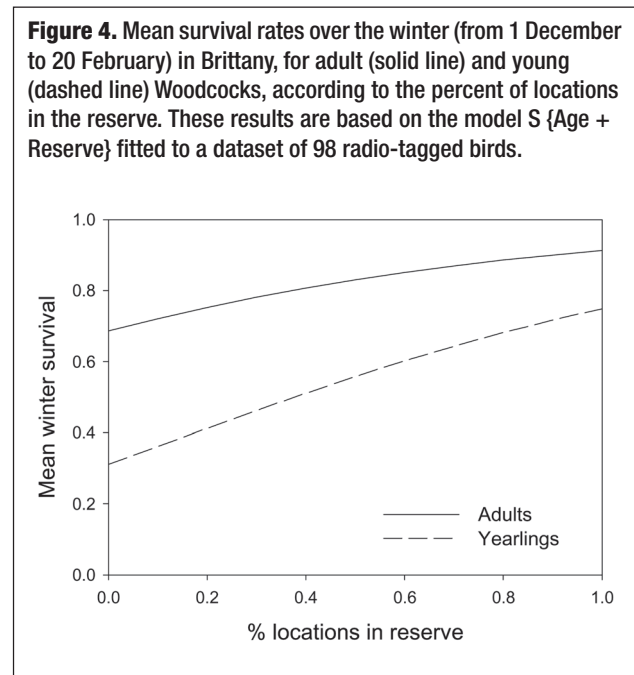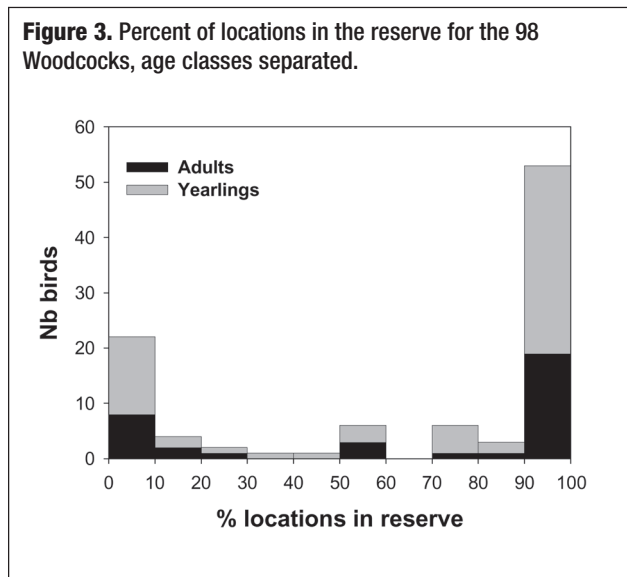
locations in the reserve (Figure 4; slope = 0.596 ± SE 0.209, P < 0.05). In the model S{Age * Reserve}, the slopes for adults and yearlings are respectively 0.150 ± SE 0.348 (ns) and 0.776 ± SE 0.249 (P < 0.05). When increasing the over-dispersion factor up to 2, the two best models remain the same and include the effects age and reserve.

Population matrix model

The population matrix model was adjusted to include the effects of age and the percentage of locations in the reserve on winter survival. Therefore, in yearlings, winter survival was $s_{ew}.s_3$ with $s_{ew} = s_1^2$ (to account for the two months of October and November) and we calculated different values for s_3 [(weekly survival)^{12} to account for the 12 weeks of study from 1 December to 22 February] according to the proportion of locations in the reserve (from 0 to 1). Similarly, in adults, winter survival was $s_{ew}.s_4$ with $s_{ew} = s_2^2$ and different values for s_4 were calculated

Table 1. Results of model selection investigating effects of age, year, date of ringing, mass at ringing and percent of locations in reserve on survival rates, based on 98 radio-tagged Woodcocks wintering in Brittany. K is the number of parameters and Dev is the Deviance of the model. The three columns on the right represent the ranking of the first four models for three values of the overdispersion factor C-hat.

Model	AICc	Δ AICc	AICc weight	K	Dev	C-hat = 1	C-hat = 1.5	C-hat = 2
S { Age + Reserve }	190.749	0	0.73418	3	184.715	1	1	1
S { Age * Reserve }	193.560	2.81	0.18005	3	187.526	2	2	2
S { Age }	196.693	5.94	0.03759	2	192.676	3	3	4
S { Age * Year }	198.541	7.79	0.01492	6	186.423	4		
S {.}	198.684	7.94	0.01389	1	196.678		4	3
S { Year }	199.990	9.24	0.00723	3	193.656			
S { Age * Date of ringing }	200.152	9.40	0.00667	3	194.119			
S { Age * Mass }	200.547	9.80	0.00547	3	194.513			

Figure 3. Percent of locations in the reserve for the 98 Woodcocks, age classes separated.

Figure 4. Mean survival rates over the winter (from 1 December to 20 February) in Brittany, for adult (solid line) and young (dashed line) Woodcocks, according to the percent of locations in the reserve. These results are based on the model S {Age + Reserve} fitted to a dataset of 98 radio-tagged birds.

according to the percentage of locations in the reserve. Figure 5 shows the variation of population growth rates λ for different values of percentage locations in the reserve and s_0. A reserve can help to maintain a population stable ($\lambda = 1$) only if $s_0 > 0.6$. An elasticity analysis for $s_0 = 0.6$ shows that the most important factor influencing Woodcock population dynamics was the adult survival, followed by yearling survival, adult fecundity and yearling fecundity (Figure 6). Results were similar and adult survival was still the most important parameter for values of s_0 of 0.5 and 0.7.

Discussion

Causes of mortality

Predation was an important cause of mortality in wintering Woodcocks (10.2% of birds, Figure 2). Predation has not been quantified in previous studies because the datasets were mostly built on hunting recoveries (Hoodless and Coulson 1994). The probability of recovering a predated Woodcock marked only with a leg ring must be very low owing to the bird's cryptic plumage and use of woodland habitat. Predation mostly occurred in the fields outside the forest. Because the predators involved (foxes, cats and mustelids) are mainly nocturnal, this predation probably occurred mostly at night, when the majority of Woodcocks were in the fields. For some birds living in hedges, the predation possibly occurred in the diurnal site, because predators are also known to follow hedges (Harris and Woollard 1990). Therefore, we believe that, under usual climatic conditions, the forest is the safer habitat for Woodcocks from a predation point of view and that it is risky for Woodcocks to frequent fields at night. Thus it is unlikely that Woodcocks frequent fields at night to lower predation risk, as suggested for the American Woodcock (*Scolopax minor*) by Connors and Doerr (1982). The benefit to use the fields at night is likely to be food-related (Granval and Bouché 1993; Duriez 2003). The absence of predation by raptors could be explained by the absence of potential predators (goshawks

(*Accipiter gentilis*), peregrine (*Falco peregrinus*), eagle-owl (*Bubo bubo*)) and of the nocturnal raptors present, barn owl (*Tyto alba*) and long-eared owl (*Asio otus*) both specialise in small mammal predation, leaving just tawny owl (*Strix aluco*) which occasionally kills Woodcocks (A. Hoodless pers comm.).

In our study, hunting and predation rates were similar. However, the relatively low hunting pressure in our study zone thanks to the presence of the reserve, which represented one-third of the study area, and the effect of hunting on survival rates, suggest that in areas without reserves, hunting rates might be higher than predation rates. The hunting mortality in yearlings was high compared to adults despite no difference in the proportion of individuals frequenting the reserve. This probably reflected greater knowledge of the study area by adults. Owing to the great fidelity to their wintering quarter (Wilson 1983; Fadat 1993; Hoodless and Coulson 1994), Woodcocks which spend their first winter in an area free from hunting are more likely to survive and visit the same place in following winters. This difference between adult and yearling hunting mortality suggests that population dynamics estimates based on age-ratio bag statistics (Fadat 1993) are not valid in the wintering period. According to our dataset, the commonly observed ratio of 70% of yearlings shot in France does not mean that 70% of the wintering Woodcocks are yearlings.

Population dynamics

Our survival rates calculated from a radio-tracking dataset and the values calculated on hunting recoveries for Woodcocks wintering in the French Atlantic coast by Tavecchia *et al.* (2002) were similar for adults (0.86 and 0.88 respectively, for a three-month survival) but were 14% lower for yearlings (0.63 and 0.77 respectively). In the closely related American Woodcock, an age-specific difference was found in annual survival (Krementz *et al.* 2003) but not in winter survival (Krementz *et al.* 1994; Krementz and Berdeen 1997). The low winter survival rates in American Woodcocks (0.65 to 0.72) are

Figure 5. Simulation of population growth rate of Woodcocks wintering in western France according to the percent of time they spent in reserve areas and for different values of post-fledging survival (s0).
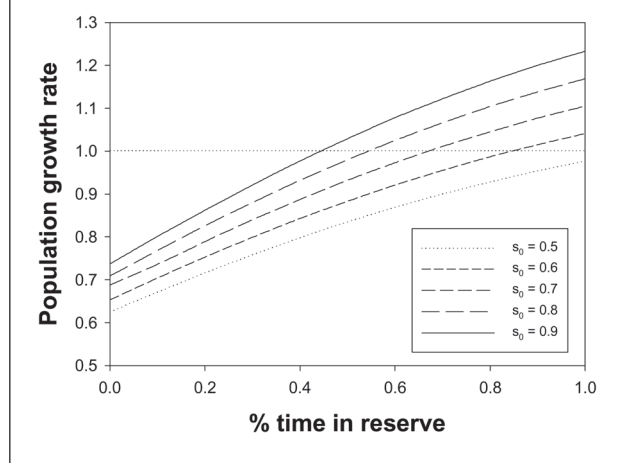
Figure 6. Elasticity of population matrix models according to the percent of time spent in the reserve, for post-juvenile survival $s_0 = 0.6$. Results are given for adult survival (solid line), adult fecundity (long-dashed line) and yearling fecundity (short-dashed line).
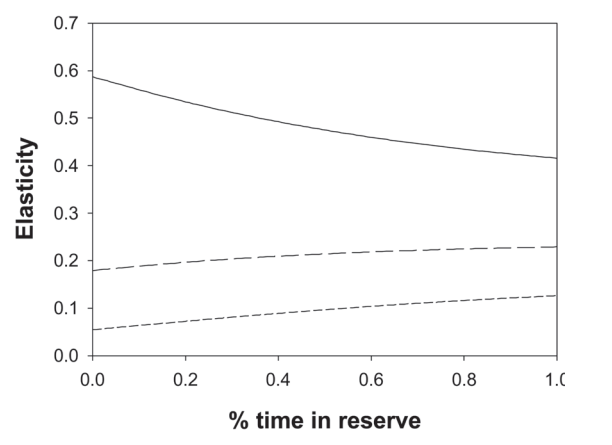
considered to be one cause of the general decline of this species, in addition to suitable habitat loss (Krementz *et al.* 1994; Krementz and Berdeen 1997; Pace 2000). The similar winter survival rates found in yearling Eurasian Woodcock, even near a hunting-free reserve, could be a forewarning of a similar population decline.

The mortality rate increased by 23% in adults and 44% in yearlings if they spent all the winter in the hunting area compared to the reserve. This confirms the efficiency of reserves for protecting Woodcocks, as already suspected from the high ratio of adult birds shot in a forest that was a reserve for several years (Fadat 1995). The best selected model S {Age + Reserve} suggests an additive effect of hunting mortality over the winter period considered. If the hunting mortality was compensatory, we would not expect such a difference in survival between the reserve and the hunting area (Newton 1998).

The population matrix model shows that the population growth rate λ increases with the percent of time that the birds in the population spend in the reserve. For populations subjected to hunting on their wintering grounds, post-fledging survival s_0 should be above 0.6 to maintain a constant population level. Post-fledging survival should be a critical demographic parameter in Woodcocks because they breed in their first year and the average life expectancy of the birds wintering in France is only 1.25 years (Tavecchia *et al.* 2002). Even the prohibition of hunting and the creation of numerous reserves cannot stabilise populations if $s_0 < 0.6$. In the case of a total absence of reserves in France, the population would decline even if $s_0 = 1$. Moreover, the elasticity analysis suggests that adult survival is the most important parameter to consider for sustainable management of Woodcock populations. The more time that individuals spend outside reserves, the quicker population growth rate decreases and the more important adult survival becomes.

We do not suggest that our results are definitive, since our sample size was small and we need further studies on winter and summer survival in other regions or countries with less intensive hunting. Our demographic simulations considered that Woodcocks only produced one clutch per year, but if a fraction of the population produced two clutches (not proved but theoretically possible), population trends could be different. Future work must focus on breeding biology, breeding success and juvenile survival in the main breeding range (Russia, Fenno-Scandia, Central Europe).

Implications for management

The low annual survival rates of Woodcocks (0.44 for adults and 0.34 for yearlings, Tavecchia *et al.* 2002) compared to other shorebirds (usually between 0.60 and 0.90; Figure 7), and the possible additive effect of hunting in winter, found in this study, suggest caution in the harvesting of populations wintering in France and possibly other western European countries. Implications for management would be the limitation of hunting and/or the creation of reserves. This study showed that reserves are efficient tools to protect wintering Woodcocks but their efficiency could be increased by the integration of the movements occurring between the reserve (forest), the

Figure 7. Comparison of adult annual survival rates estimated in Woodcocks (framed) and 26 other wader species (data from Piersma *et al.* 1996). Black dots indicate species hunted in France and other European countries and white dots are protected species. The value for the American Woodcock (*Scolopax minor*) is a mean of several studies (Krementz *et al.* 1994; Krementz and Berdeen 1997; Pace 2000; Krementz *et al.* 2003).
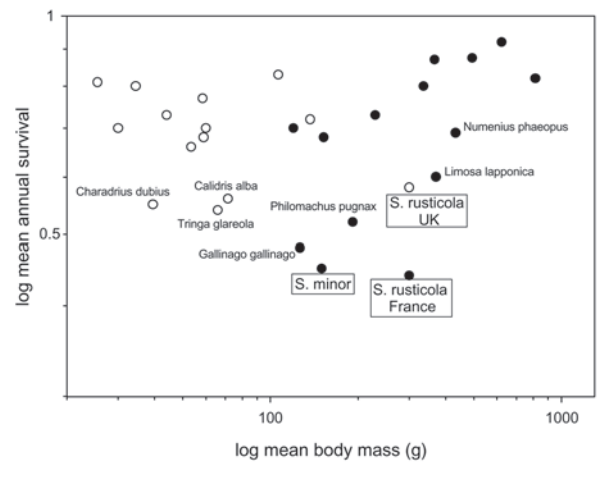
hunting area (woods and hedges), and the nocturnal feeding meadows. These movements usually did not exceed 1 km around the forest (Duriez *et al.*, this issue, pp 26–35). Because hunters were often patrolling very close to the reserve boundaries in our study zone, reserves in bocage landscape should include a buffer zone of at least 1 km wide with low and controlled hunting pressure in the surrounding woods and hedges, to be truly efficient.

Acknowledgements

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