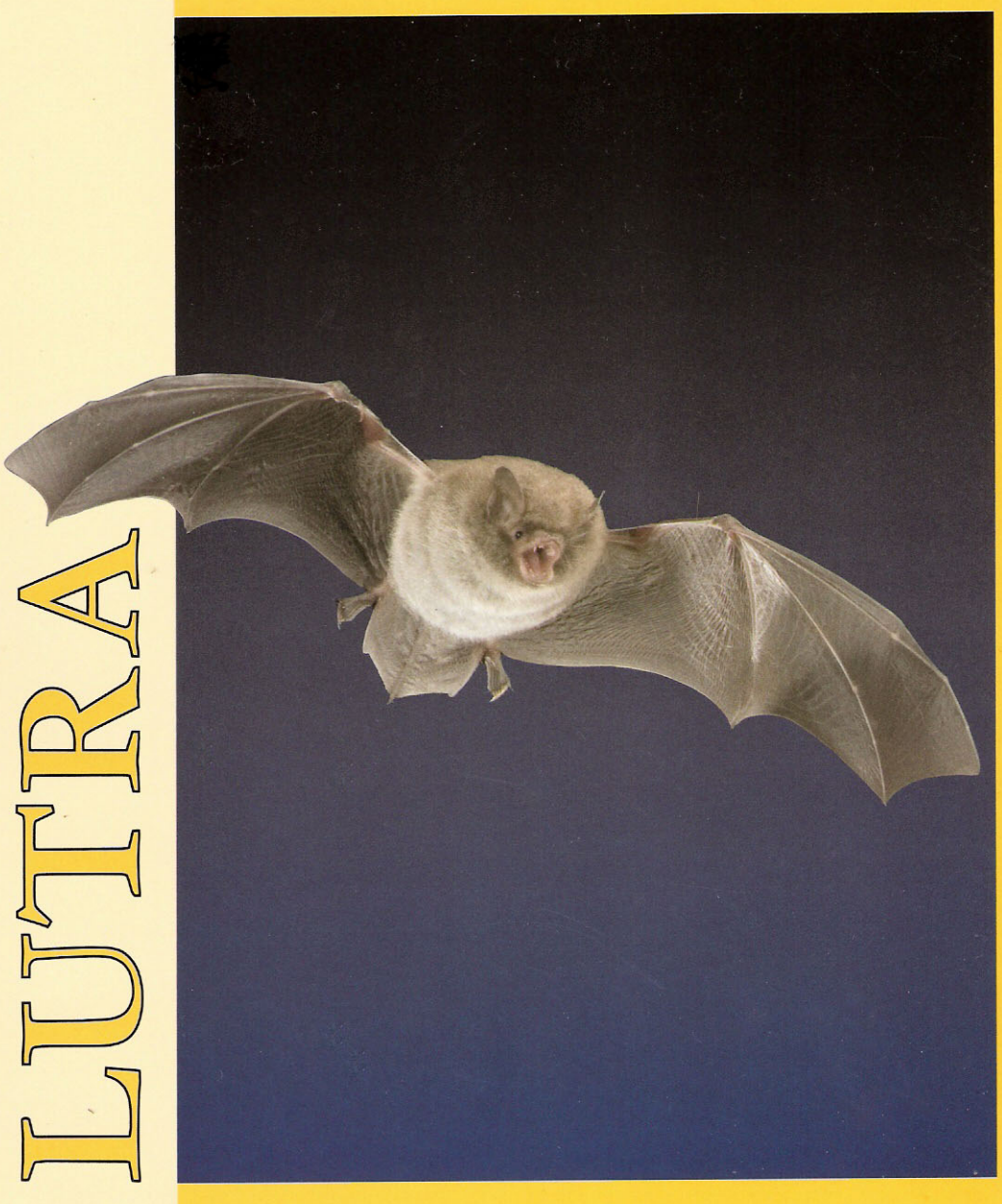
Journal of the Society for the Study
and Conservation of Mammals

LUTRA



Volume 50 – Number 1 – October 2007

50 Volumes of Lutra (1)

The Society for the Study and Conservation of Mammals (VZZ) was founded on February 15, 1952 and issued its first newsletter in the same year. Nineteen more newsletters (with consecutive page numbering) followed over the next seven years, the last two of these were called 'Lutra'. The last was not exactly what the editor, dr. Arie Scheygrond, had in mind for the launching of a new scientific journal. But a long lasting illness prevented his involvement in these developments. After this misunderstanding, it was decided to combine all these newsletters to form volume 1 of Lutra. This first volume contained all 20 issues published between 1952 and 1959. In 1960, the first 'real' Lutra was published as volume 2, issue 1.

This year Lutra is celebrating its 50th Volume, although it and its publisher, the Society for the Study and Conservation of Mammals, have existed for 55 years. Time for a retrospective. This editorial describes the history of the organisation and working process of Lutra. In the second issue of this volume, we will review developments in the papers contributed to Lutra.

From the very start, Scheygrond was the initiator to launching a VZZ publication dedicated to developments in mammal research and conservation. The first chairman of the VZZ was F.H. van den Brink, who would afterwards author the popular mammal guide 'Zoogdierengids' (first printed in 1955), which had a structure similar to R.T. Peterson's field guides. In his introduction to the first newsletter, he mentions the reasons for founding the VZZ, but does not explain the aspirations of the newsletter itself. The two men jointly contributed much to both the content and organization of the first newsletter. But over the years, Scheygrond took more responsibility.

At first, the newsletter was a simple, stencilled society bulletin, on average 16 pages long. It contained short scientific contributions, news reports about mammals and the Society, literature overviews, and book reviews. Most Society messages were written by Scheygrond, as were the extensive overviews of mammal literature. Later, these growing lists were carefully maintained by dr. Eric Van der Straeten (1970-1997) and Bauke Hoekstra (1974-2003), who covered Belgium and the Netherlands respectively.

Initially, the newsletter was bilingual, with contributions in both Dutch and French (see also figure 1). The VZZ aimed to be the mammal society for the Benelux countries, Belgium, the Netherlands, and Luxemburg. These aspirations, however, proved too ambitious since the newsletter attracted very little interest from the Walloon part of Belgium and from Luxemburg. There were attempts to include French contributions in the early newsletters, but this only happened occasionally and was not convincing. This led to a somewhat forced orientation towards the French mammal research community, during the first years, which was particularly encouraged by Van den Brink. VZZ members were also offered the opportunity to publish their scientific articles in a special section in Mammalia, the journal of the

VZZ's sister society, the 'Société Française pour l'Etude et la Protection des Mammifères'. Part of the arrangement was the exchange of reprints between the members, a service certainly used in the beginning but this became increasingly redundant after the release of Lutra. Nevertheless, it was only in the late 1980s that the agreement with Mammalia officially ended.

When the VZZ decided to publish its own scientific journal, it appointed an editorial board which defined the aspirations of the journal (in newsletter 18 - 1959): "As requested by several of our members, we will aim for a journal in which research about mammals in the Netherlands and, in broader sense, western Europe as well as in New Guinea and the West Indies is to be published. As circumstances allow it will also include announcements, reports, and short notes concerning our society. As a first step, the editorial board introduces a shorter journal name, to simplify reference to its articles. The name 'Lutra' was chosen. [...] the board encourages authors to submit only type-written manuscripts, including an English summary to outline the contents of the paper." Despite this admonition, one regular contributor and editor too, Vincent van Laar has persevered to this day in submitting, at least partly, hand-written texts. Van Laar was editor of Lutra for over forty years (1959-2000) and was renowned for his slightly ironic but always positive comments, and for providing stimulating suggestions on content, based on his extensive experience and the comprehensive amount of field data that he had collected himself. These attributes greatly helped many authors to improve their manuscripts. In 1988, in a retrospective of the first 25 years of the VZZ (Lutra 31-2: 153-161) Scheygrond noted that early editions also carried "As far as space was available, book reviews and until 1974 reports of the society's meetings and excursions."

Scheygrond (1907-1996) successfully defended a PhD thesis on a plant sociological subject, and worked as a biology teacher in Gouda, his birthplace. He was a passionate nature conservationist with a special interest in mammals. The otter was one of his favourite species. The cover of his book 'Zoogdieren van Nederland' (first printed in 1943; co-authored with dr. M.A. IJsseling) had an elegant illustration of an otter, provided by P.L. Scholten, the Gouda graphic artist who illustrated the book throughout. The drawing shows a front view of an otter, drawn from above, a perspective which emphasises the animals' litheness and muscularity. The VZZ adopted this design as its logo at its inception and it can always be found (in differing forms) on the cover of the journal. Scheygrond took on many responsibilities – he was already the editor of the 'Mededelingenblad' before he became editor of Lutra and was also the secretary and treasurer of the VZZ. He was a friendly, charismatic man, who knew what he wanted, had a very clear viewpoint and unequivocal standpoints. He decided what was published in Lutra, and how it was published. However, the choice was never difficult, as only a limited number of papers were submitted in the 1970s. Overall his involvement with Lutra spans 40 years. Ten years as sole editor (1952-1959), managing editor for a further fourteen (1960-1974) and from 1975 to 1991 as editor.

Scheygrond was completely responsible for publishing the first ten volumes of Lutra. Although the aim was to publish three issues each year in the 1970s, two or more issues were often combined, due to a lack of manuscripts. The opening article of the first copy of Lutra was curious but characteristic of an era: an obituary of Henri J.V. Sody, a zoologist who had worked at the Zoological Museum of 's Lands Plantentuin in Buitenzorg at Java, Indonesia. This shows the range of other types of articles that were published in Lutra. Aside from research articles they included minutes from meetings, excursion reports and literature and book reviews. In the 1960s and 1970s, Lutra became *the* medium for research papers on indigenous mammals and the possibility of extinction faced by some of them. Yet it is still questionable how much this research influenced government policy. It was twenty years until policy makers paid significant attention to

LUTRA

ORGAAN VAN DE VERENIGING VOOR ZOOGDIERKUNDE EN ZOOGDIERBESCHERMING
BULLETIN DE LA SOCIÉTÉ POUR L'ÉTUDE ET LA PROTECTION DES MAMMIFÈRES
Adres der redactie: Van Itersonlaan 7, Gouda
Tel. 01820-4021
Uitgever: E. J. BRILL — Leiden

VOLUME 2 MEI 1960 No. 1

IN MEMORIAM H. J. V. SODY

door

A. C. V. VAN BEMMEL

Op 16 januari 1959 overleed te Amsterdam HENRI JACOB VICTOR SODY. Daarmede is een uitstekend en toegewijd zoogdierspecialist van ons heengegaan.

SODY werd op 31 augustus 1892 te 's-Gravenhage geboren. In 1917 studeerde hij af aan de Rijks Hogere Landbouwschool te Wageningen en vertrok in 1918 naar het toenmalige Nederlands-Indië. Aanvankelijk werkte hij daar als employé op de thee-onderneming Tjikadjang bij Garoet (Java). In 1920 werd hij aangesteld als leraar bij de Middelbare Landbouwschool te Buitenzorg. Deze functie heeft hij tot 1941 vervuld, enkele malen onderbroken door Europees verlof in 1926 en 1933 en door enkele jaren non-actief in Nederland (1934-1937).

In 1941 werd SODY gedetacheerd bij het Zoölogisch Museum van 's Lands Plantentuin te Buitenzorg met de opdracht het rattenmateriaal van het Klapperproefstation te Menado (Celebes) te bewerken. Na het gereedkomen van deze opdracht werd de detachering verlengd en ook gedurende de Japanse bezetting bleef SODY, geïnterneerd in een speciaal kamp, zijn werk in het museum voortzetten. Daarop vertrok hij met verlof naar Nederland. In 1949 werd hij definitief voor de dienst in de tropen afgekeurd en gepensioneerd.

Hoewel geschoold op natuurwetenschappelijk gebied, was SODY toch geen zoöloog van professie. Hij pleegde zichzelf daarom dan ook een amateur te noemen. Maar in de vele jaren waarin hij zich met de studie van de vogels en zoogdieren bezig hield, had hij een ervaring en een feitenkennis verworven, die aan het ongelooflijke grensden. Zelf heb ik SODY pas in 1937, dus kort na zijn terugkeer op zijn post in Buitenzorg, leren kennen. Daarom heb ik ook niet kunnen nagaan of hij in zijn studietijd zich reeds met het onderzoek van vogels en zoogdieren bezig hield. Wel was hij lid van de redactie van „Ceres" en van het „Algemeen

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the plights of the otter and badger when their status as endangered species was beyond dispute. However, the 'old papers' in Lutra then still serve their purpose as source of reference for the past distribution.

Curiously for years Lutra did not contain any information about the publishing procedures and this information cannot be found in VZZ's archives. Not until 1975, in issue 19(1), was there a colophon explicitly stating the members of the editorial board, which at that time consisted of three members: Scheygrond, Van Laar and dr. A.C. van Bruggen, the latter of whom was editor-in-chief. Occasionally the minutes of the business meetings of the society of this time contain details about Lutra, such as those of the meeting of 12 February 1969: "The chair [...] gave words of thanks to the editorial board of Lutra, for the good care of said publication". We may, however, never know the exact meaning and background and the outcomes of the following item (meeting of 12-13 May 1972): "At the end of the meeting Mr. van Bree brought up the policy conducted by the editorial board. It was decided to examine this more closely in consultation with the board".

Between the Scheygrond era and that of dr. Chris Smeenk (see below), the tasks of editor were done by dr A.M. Husson SCJ (Conservator of Mammals at the State Museum of Natural History (RMNH) in Leiden; editor from 1960-1977) and later by Van Bruggen (also affiliated to this State Museum; editor from 1972-1998 and editor-in-chief from 1975-1980). Prior to becoming editor of Lutra Husson interested dr. W. Backhuys, then director of the international scientific publisher Brill, in Lutra and this resulted the company publishing Lutra from 1959 until 1985. After 1985, Lutra was published by the Society herself, whilst Brill printed the journal for years. Since 1996, Lutra has been printed by Ponsen & Looijen BV in Wageningen.

The 1970s were relatively calm: the Society was small with about 300 to 400 members, who often met at gatherings. In 1980, a new period started for Lutra, when Smeenk succeeded Husson, at the Museum. The cover became light blue, with the logo of the VZZ, giving Lutra more the feel of a 'real' journal. 'Guidelines for authors' (in Dutch) were included on the inside of the back cover, albeit in very condensed format. These instructions, now expanded are today available in both English and Dutch on the VZZ website (www.vzz.nl).

In the following years, the editorial procedures became much more explicit, but were mostly still carried out by one person, Smeenk. He considered himself the managing editor, but in practice, he did almost all the work of the editorial board: acquiring papers, editor-in-chief, editor, reviewer and managing editor. He and his wife even did most of the shipments of the journal to its readers! The other members of the editorial board did often receive a copy of all newly received manuscripts, together with a request to comment on them. Often, Smeenk had already added his own comments to these manuscripts, which he had sometimes already returned to the authors.

The curators of the mammal collections of the two major Natural History museums in the Netherlands, Smeenk of the RMNH and dr. Peter J.H. van Bree of the Zoological Museum in Amsterdam (ZMA), generated numerous papers in Lutra throughout the 1970s and 1980s. These publications were often produced by students whom they were supervising. Today many students still publish their work in Lutra, but many other papers are written by the applied scientific community, by conservationists and even by amateur naturalists with a completely different background and education.

VZZ membership more than doubled in the 1980s (from 374 members in 1981 to 815 in 1991) and then stabilised in the next decade (to 821 in 2001). The larger membership in the 1980s led to more activities, such as the formation of working groups, a new phenomenon for the VZZ. Thematic symposia were organised

more frequently and these new activities have contributed to an ever increasing number of submissions to our journal. Interesting and sometimes bulky special issues were produced from some of these symposia and, in contrast to his predecessor, Smeenk often 'suffered' from an abundant supply of material. Editing all these papers was a time-consuming activity, so much that his ordinary work had to wait at times. At the time it was normal to produce just two issues per volume, the production of special issues generated a considerable extra work load and often led to the publication of three issues in a year when two had been planned. Raising funds to produce special issues was easier then than it is today. Today, Lutra is nearly completely financed by membership revenues.

The editorials of the special issues show that scientifically soundness was not the editor's only concern but that he was also passionate about the conservation of mammals. Some editorials contain pleas for a better conservation and protection of, for example, the otter and the harbour porpoise. Interesting he was not afraid to name and shame the relevant authorities.

Smeenk's legendary linguistic skills, his knowledge of editorial rules and conventions (and, even more disconcerting of the reasoning behind these) continues to inspire the present editorial board to publish a high quality journal in every respect. Often Smeenk and Scheygrond would spend time discussing and arguing over tiniest details. For example they would greatly enjoy discussing the whys and wherefores over whether 'Zeeuws-Vlaamse' or 'Zeeuwsvlaamse' was proper written Dutch. There were many similarities between the two man, both were highly skilled, determined and involved editors. But there were also some differences. Smeenk could be furious with a submission of substandard quality, but was always keen to get the best out of it and would spend hours in improving poor texts. The editors Van Laar and dr. Sim Broekhuizen remembered that period in a previous edition (Lutra 41-1: 1-3, 1999): "Smeenk was a managing editor for so long, for 18 years [1981-1998], and as a result, the VZZ members came to take the regular, timely production of Lutra for granted, nobody felt responsible. Lutra was as regular as clockwork. In addition, authors found it no more than natural that any textual shortcomings were repaired by the editors. He could be so irritated by poor quality that we feared for his life at times. For one as determined as Smeenk being an editor was a dangerous business. But once he had vented his anger he would resume working energetically, making sure that everything was fine and that the paper could go to print."

In 1981 a very active (and at the time young) board member, G.H. Glas, initiated a new VZZ publication, 'Lutra-informatie'. This was a simple and highly informative, photocopied newsletter containing VZZ news and announcements of activities. This newsletter became the glossier and popular journal 'Zoogdier' in 1991 and from that year on contained short and popular articles about indigenous mammals as well as VZZ news, reports of sightings, and preliminary results of ongoing studies.

Between 1981 and 1991, Van Bruggen, Van Laar, Scheygrond, Smeenk and Van der Straeten formed a solid editorial team. This was great in terms of ensuring the continuity of production but it also scared away other potential editors, who were possibly afraid that their skills were not considered well enough for Lutra. In short Lutra had been in the hands of too few people for too long, and it seemed that nobody was prepared to come forward to pick up the ball.

In the 1990s it became increasingly difficult to produce two issues per annum. The excessive commitments of the editorial board may have been one explanation for this, but it may not just have been the shortage of skilled editors prepared to work on Lutra. The fact was that fewer and fewer professionals were engaged in fundamental scientific research on mammals in the Netherlands. In addition the pressure on those scientists

to publish in high level journals ("to publish or perish") meant that papers of potential interest to Lutra were now being submitted to higher ranking journals.

The journal nearly collapsed in the late 1990s. Fewer manuscripts were received. It was unclear if the VZZ members were sufficiently interested in Lutra, and given the huge workload of the editors, it was hard to form a new editorial board. Nevertheless, a new start was made in 2001, with a new team of editors, and new enthusiasm. The team presented itself in the editorial of Volume 44 (2001), with a *real* editorial, and since that volume, each issue is introduced by an editorial. These are meant to explain any changes that may have occurred, future plans and provide a thematic introduction to the issue. A new look was introduced and an attempt made to explain it "… Once in a while we discover that the way we did things for years, works no longer. The lay out of Lutra is one of these things […] Apart form this new look two other changes are worth mentioning. From now on Lutra publish only in English and Dutch, and English is preferred over Dutch. […] Another change is that Lutra now distinguish between full articles and short notes. While full articles describe the methods, results and conclusions of comprehensive mammal research, short notes may consist of remarkable observations, simple surveys, methodological aspects or other brief communications. …" To mark this new start Lutra's cover changed from pale blue with the otter logo on the front, to one that was bright yellow with a black and white photograph. And the colophon of the journal clearly states: "… Lutra publishes peer-reviewed scientific papers on mammals across all disciplines, but tends to focus on ecology, biogeography, behaviour and morphology. Although exceptions are made in some cases, Lutra generally publishes articles on mammal species native in Europe, including marine mammals. …" This new editorial introduction in fact represented a continuation of an editorial course developed since the early days of the journal. What is new is that this editorial plan is put to paper, so one can refer to the editorial conventions. In practise Lutra aims at publishing the results of studies that can be conducted with relatively simple means.

The other explicit choice, to publish either in English or in Dutch, was also a continuation of an existing trend, rather than a new policy. English has been the leading language in the scientific community since the Second World War, but it was not until the 1990s that most papers published in Lutra were written in English (figure 1). There have been complaints that the new editorial team has changed Lutra into a journal entirely written in English, but this has been a long established trend. In 1994 (still in the 'blue' period) the majority of papers published was in English rather than in Dutch (figure 2).

The board of the VZZ has never sought to influence the composition of the editorial board, or to interfere with editorial conventions and policies. This still holds true today, but there are certainly discussions with VZZ board members, and the board of VZZ is consulted over the more important decisions that have to be made. Editors have full editorial freedom and nobody but them is involved in the acquisition, review, and acceptation of manuscripts, in setting the editorial policies, or in designing the lay out of the journal. It is our opinion that this freedom is essential: the editors of a scientific journal should operate independent of the publisher.

The new editorial team has been operating for a number of years now and has made a start in building a new phase of Lutra's existence. The current editorial board is a skilled and determined team aiming to produce an attractive and interesting journal into the foreseeable future. Recently, a new section (Comments) was introduced which provides readers with a platform to respond to articles. Moreover, from now on we are also offering readers the possibility to start debates about new topics in the Forum section. For the benefit of our readers we also plan, at around the turn of the year, to publish all 50 volumes in a DVD/CD format. This will enable all our readers to track

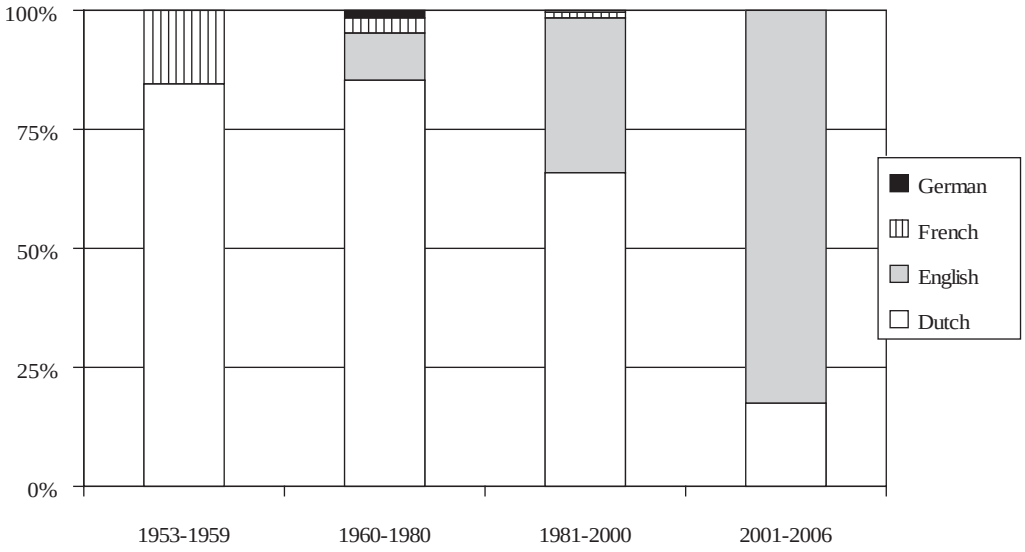

Figure 1. Language used in full papers and short notes published in Lutra since 1953.

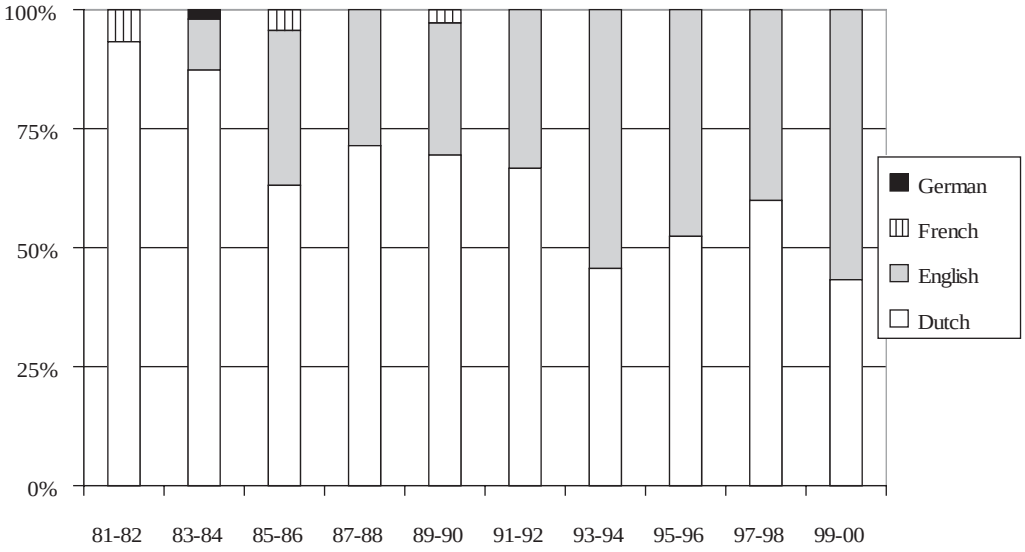

Figure 2. Language used in full papers and short notes in the 'blue period' (1981-2000).

back to past issues and articles. This endeavour is made possible thanks to a grant from the 'Stichting Publicatiefonds Lutra', a fund formed in 1993 to manage a legacy, one which Lutra has made use of several times in the recent past. The editors are very thankful for this grant.

With the production of this disk, we are definitively seeing the end of a phase when Lutra was only available in print. While subscribers continue to receive hard copies of Lutra through the post, PDF versions of articles have been freely available on the VZZ website (www.vzz.nl) from volume 48 (2006) onwards. For Lutra, as for so many other journals, the internet has made a huge difference. In addition to improved access to papers, the exchange of information and manuscripts between editors, authors and referees is now much quicker and easier.

Meanwhile, two new editors have been recruited to the team, Koen Van Den Berge and Kees Camphuysen. Koen is particularly well known from his work on indigenous carnivores and can be considered the leading specialist in Belgium. Kees is probably best known for his work on seabirds, but also for his studies and data collection of cetaceans in and around the North Sea and his interpretations of distribution patterns and trends. Several recent papers on marine mammals in Lutra were from him and his colleagues. We hope that we will be able to utilise the knowledge and skills of Koen and Kees in the years to come. Unfortunately, two editors had to resign. Kamiel Spoelstra has accepted a job in the United States of America and cannot combine that work with Lutra. We would like to take the opportunity to thank him for all his efforts, also as an author for Lutra, and to wish him the best of luck and success. Goedele Verbeylen has indicated that she needs to give priority to her many other activities in studying and conserving mammals and has to give up her editorial responsibilities. We would like to thank Goedele for her input over recent years, for her speedy replies and valuable input and accuracy as an editor.

Temporal variation in flight activity, foraging activity and social interactions by bats around a suburban pond

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Abstract: We investigated overnight and seasonal activity patterns of different bat species around a suburban pond between April and September 2003. Among the seven species identified, three (*Pipistrellus pipistrellus*, *Pipistrellus nathusii* and *Myotis daubentonii*) showed the highest level of occurrence and/or flight activity. Flight activity of *Pipistrellus pipistrellus* greatly varied over time, with the highest levels occurring just after sunset. The activity of *Pipistrellus nathusii* and *Myotis daubentonii* remained constant for at least the first few hours after sunset. Flight and foraging activities of all species changed with the reproductive period. Whereas flight activity increased from pregnancy to post-lactation in *Pipistrellus*, it decreased during post-lactation in *Myotis daubentonii*. We demonstrated an increase in social calls among *Pipistrellus pipistrellus* during the first hours of the night and, markedly so, during the post-lactation period. These results are discussed in relation to the species' ecology and behaviour.

Keywords: Chiroptera, flight activity, foraging activity, social calls.

Introduction

Unlike tropical bats, which can be separated into guilds based on diet (Aguirre 2002), all European bat species are insectivorous, although some representatives of the genus *Myotis* have found to partially feed on fish (Levin et al. 2006). In temperate regions, insect eating bats face ecological constraints such cold temperatures in winter and associated food shortages. Because most temperate bats hibernate, they devote a limited amount of time to breeding and fat accumulation (Ransome 1990). Monitoring bat activity during the active season can thus provide insights into bat behaviour and requirements during this critical period. For insectivorous species, activity patterns, i.e. changes in flight or foraging activities, may vary on a daily or seasonal basis in response to many factors, such as insect availability (Anthony et al. 1981, De Jong & Ahlén 1991) or weather conditions (Avery 1985, Ruedi 1993, Verboom & Spoelstra 1999). For example, 'aerial hawking' species depend on the evening peak in the abundance of flying insects, while 'gleaning' species can potentially emerge later from their roost, as they primarily feed on diurnal perched insects or moths that remain available throughout the night (Entwistle et al. 1996). Sex, age and reproductive status also influence activity patterns, as they affect energy demand (Swift 1980, Catto et al. 1995, Wilkinson & Barclay 1997).

Few studies have investigated the activity patterns of different bat species over the night and the season (Gaisler et al. 1998, Bartonicˇka & Zukal 2003), and these have generally focused on species distribution in different habitats. Analyses of temporal variations of bat communities at a single site are even scarcer (O'Farrell & Bradley 1970, Bartonicˇka 2002). Riparian habitats are important centres for bat activity (Grindal et al. 1999). Flying insects emerging from the surface of water bodies are likely to represent a plentiful and predictable supply of prey and calm water provide a suitable

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drinking site (e.g. Geggie & Fenton 1985, Brigham et al. 1992, Rautenbach et al. 1996). In addition, these highly frequented habitats may be chosen as mating grounds by males, to increase their chance of finding females (Gerell & Lundberg 1985). Riparian environments are therefore particularly interesting for investigating the coexistence of bat species throughout summer in temperate regions.

In this study, we investigated both overnight and seasonal activity patterns of a bat assemblage around a suburban pond based upon data collected in a standardised way. We determined the occurrence, flying and foraging activity patterns of different identified bat species. Because these parameters may be affected by reproductive status (Audet 1990, Barclay 1991), we analysed the data with regard to three reproductive periods: pregnancy, lactation and post-lactation. We also studied for any variations of social calls by common pipistrelles (*Pipistrellus pipistrellus*, Schreber, 1774) on both a nightly and seasonal basis.

Material and methods

Study area and sampling

Our study was conducted between April and September 2003 around the Silex pond, located in the south-east of Brussels, Belgium. This 1 ha pond is located 100 m from the nearest house and 150 m from the nearest illuminated road. It is surrounded by the Forêt de Soignes on one side and by more open habitats, including wet meadows, a pasture with a few hedgerows, and a few apple trees, on the other side.

We recorded bat activity over 50 nights ($\overline{x}$ ± SD: 8.7 ± 2.7 nights per month). Recordings were performed during the first hours following sunset, the time when bats display the highest activity (Anthony & Kunz 1977). Each night, bat activity was sampled 45, 90, and 135 minutes after sunset: these points in time are referred to as Round 1 (R1), Round 2 (R2) and Round 3 (R3), respectively. On each of these nightly sampling rounds, two-minute recordings were randomly taken at six points on the bank of the pond, separated by at least 50 m. Overall, our survey involved taking 870 two-minute recordings. Recordings were made during warm (t° > 10°C at starting point), calm and dry nights to minimize the influence of temperature, wind and rain on bat activity.

To determine the effect of reproductive status on activity patterns, data were separated into three periods: April to mid-June, mid-June to the end of July, and August-September (18, 14, and 18 recording nights respectively). These periods correspond to distinct phases of the reproductive cycle of most common European bat species: pregnancy, lactation and post-lactation (Swift 1980, Bogdanowicz 1994, Bartonicka & Zukal 2003). Occasional captures by mist-netting Daubenton's bats (*Myotis daubentonii*, Kuhl, 1817) over the pond confirmed that the selected periods were consistent with the reproductive status of females.

Recording and identification

Bat activity was monitored with a Pettersson D-980 (Pettersson Elektronik AB, Sweden) and signals were stored on a DAT recorder (Sony). Time expansion was chosen as the first recording mode, as it provides the most reliable means of species identification (Barataud 1996). Frequency division (FD, division factor 10) was selected as the second recording mode because of its broadband and real-time recording properties (Barataud 1996). FD recordings were used to measure bat activity patterns. Recordings were analysed with Bat Sound software (Pettersson Elektronik AB, Sweden) using spectrogram analyses. Parameters used for species identification were the shape of the signal, maximum energy peak frequency, and bandwidth (Barataud 1996).

Occurrence, flight and foraging activities

Occurrence is defined as the percentage of recording days in which a given species was found over the pond. For each species, flight activity (FA) was estimated by measuring activity dura-

tion, calculated as the accumulated duration of every bat pass per unit of time (i.e. during the two-minute recording time). Foraging activity was assessed by counting the number of feeding buzzes per unit of time. These were recognised by the high pulse repetition rates associated with attacks on prey (Griffin 1958). Capture time was assessed by estimating the number of seconds between two foraging attempts, i.e. by dividing the sum of flight activity levels by the sum of the feeding buzzes recorded during the same lapse of time.

Emission of social calls

Social calls are signals with low-frequency components that can occur between echolocation calls for the purpose of communication (Fenton 2003). Because the common pipistrelle was the most abundant in the study area, we focused our analysis of social calls solely on this species. Emission of social calls was assessed by counting the number of vocalisations registered per two-minute interval, through simultaneous recordings in time expansion and frequency division.

Statistical analysis

Data were compared by using nonparametric Kruskall-Wallis, Mann-Whitney and Dunn's post hoc tests using Statistica 6.0. For comparisons of activity levels, records where no bats were registered were excluded from the analyses, to move the median value from zero and to obtain clearer graphs.

Results

Occurrence, overall flight activity and foraging rate

The recordings allowed identification of seven species (figure 1): common pipistrelle, Nathusius' pipistrelle (*Pipistrellus nathusii*, Keyserling & Blasius, 1839), soprano pipistrelle (*Pipistrellus pygmaeus*, Leach, 1825), Dauben-

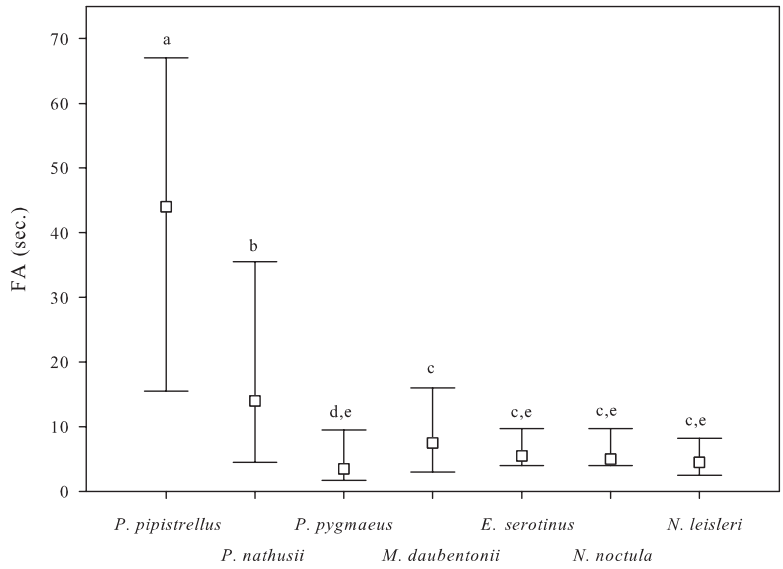

Figure 1. Overall flight activity (FA) (median, percentiles 25%, 75%), measured as the duration of bat passes per two-minute period, for the seven species identified around the pond. Equal lowercase letters indicate absence of significant differences (Dunn's tests, $P<0.05$).

Table 1. Overall flight and foraging activity medians (in brackets) and capture time (in italic) in each reproductive period and round for *Pipistrellus pipistrellus*, *Pipistrellus nathusii* and *Myotis daubentonii*.

	Pregnancy			Lactation			Post-lactation		
	R1	R2	R3	R1	R2	R3	R1	R2	R3
Pipistrellus pipistrellus	38.4	18.0	17.4	56.7	53.0	37.6	62.7	49.6	42.9
	(2)	(1)	(1)	(8)	(5)	(3)	(6)	(2)	(1)
	7.8	*11.3*	*15.2*	*6.0*	*9.4*	*11.3*	*10.2*	*20.2*	*25.0*
Pipistrellus nathusii	6.9	5.5	4.0	5.6	10.2	8.2	21.6	25.1	26.9
	(0)	(0)	(0)	(0)	(0)	(0)	(2)	(0)	(0)
	15.3	*39.2*	*27.6*	*18.2*	*13.1*	*16.1*	*13.2*	*29.8*	*49.6*
Myotis daubentonii	7.3	6.8	5.9	11.5	7.9	9.0	4.8	8.0	7.3
	(1)	(1)	(1)	(2)	(1)	(1)	(0)	(1)	(0)
	4.8	*5.8*	*5.3*	*4.7*	*6.6*	*7.7*	*6.1*	*8.8*	*7.2*

ton's bat, noctule (*Nyctalus noctula*, Schreber, 1774), Leisler's bat (*Nyctalus leisleri*, Kuhl, 1817) and serotine (*Eptesicus serotinus*, Schreber, 1774).

Flight activity levels differed significantly between species (Kruskall-Wallis test, H= 517.2, P<0.001; figure 1). Overall activity was higher among common pipistrelles (P<0.001); which was identified in 100% of the nightly samplings. Nathusius' pipistrelles were more active than Daubenton's bats (P<0.001), primarily because of the higher flight activity of Nathusius' pipistrelles during post-lactation (see below). However, whereas Nathusius' pipistrelles were identified on 76% of our recording nights, this value reached 96% for Daubenton's bats, indicating that this species regularly visits the study area. There were no significant differences in the activity levels of Soprano pipistrelles, serotines, Leisler's bats and noctules (P>0.05) and these species were excluded from further analyses due to their low activity levels and/or occurrence.

Capture time also varied according to the species (H=18.38, P< 0.001). Daubenton's bats captured insects more rapidly, with their feeding attempts occurring approximately every six seconds. By comparison common pipistrelles and Nathusius' pipistrelles captured insects every 13 and 24 seconds, respectively (P<0.05; table 1).

Flight and foraging activities after sunset during each reproductive period

The flight activity of common pipistrelles decreased after sunset throughout the successive reproductive periods **P** (pregnancy): H=19.8, P<0.001; **L** (lactation): H=32.5, P<0.001; **PL** (post-lactation): H=61.0, P<0.001). Activity in round R1 was significantly higher than in R3 (P<0.05). By contrast, the flight activities of Daubenton's bats and Nathusius' pipistrelles were relatively stable between these three rounds throughout all three periods (**P**: H=0.6, P=0.72; **L**: H=0.6, P=0.76; **PL**: H=5.2, P=0.07; and **P**: H=2.1, P=0.34; **L**: H=1.7, P=0.41; **PL**: H=0.4, P=0.83 respectively, table 1).

Consistent with flight activities, the pipistrelles showed a significant difference in the number of feeding buzzes recorded between the three rounds and for each period (**P**: H=19.8, P<0.001; **L**: H=32.5, P<0.001; **PL**: H=61.0, P<0.001; table 1). This species showed a decrease in foraging activity between R1 and R3 in each reproductive period (P<0.01). The after sunset foraging activity of Nathusius' pipistrelles did not vary during pregnancy and lactation (**P**: H=1.1, P=0.57; **L**: H=1.3, P=0.522; table 1); although more feeding buzzes were recorded in R1 during post-lactation (H=22.6, P<0.001; Dunn's test, P<0.01). Among Daubenton's bats, foraging activity remained constant during the three nightly intervals and for all three periods consid-

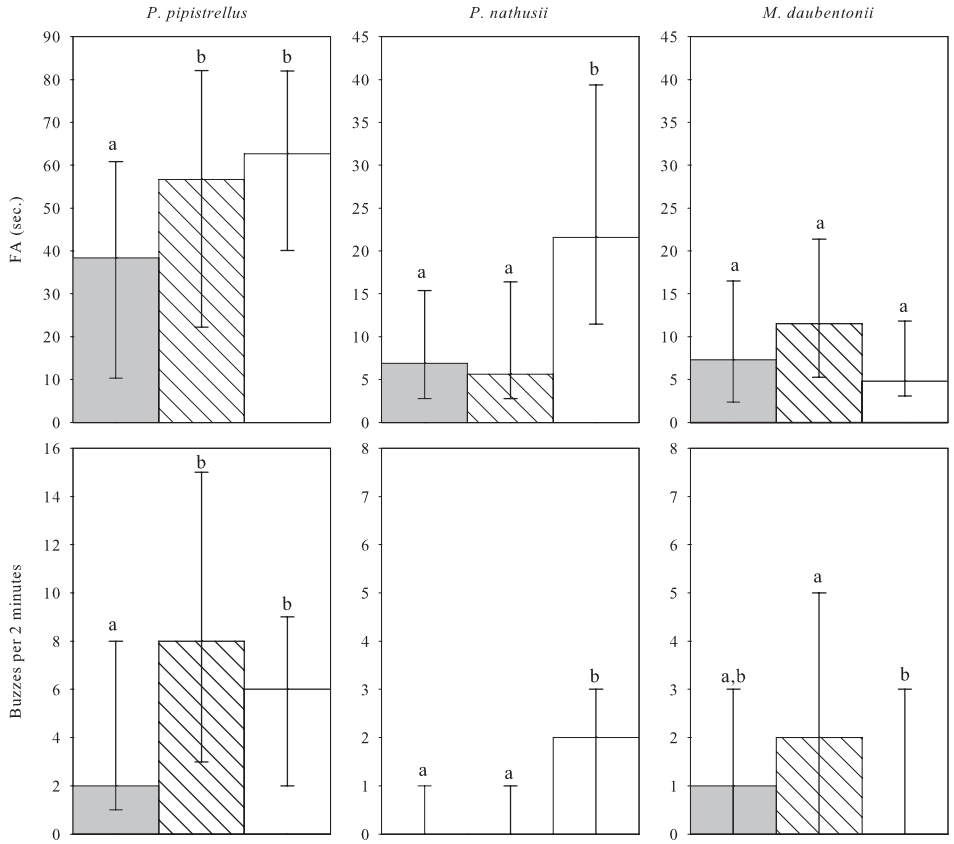

Figure 2. Flight activity (FA) and foraging activity (buzzes) (median, percentile 25% and 75%) of *Pipistrellus pipistrellus*, *Pipistrellus nathusii* and *Myotis daubentonii* during R1, according to three reproductive periods: pregnancy, lactation and post-lactation (respectively grey, hatched and white bars). Equal lowercase letters indicate absence of significant differences (Dunn's tests, $P<0.05$).

ered (**P**: $H=1.6$, $P=0.45$; **L**: $H=5.3$, $P=0.071$; **PL**: $H=0.7$, $P=0.69$), with medians being generally higher than for Nathusius' pipistrelles (table 1).

Seasonal variations in flight and foraging activities

Comparisons of flight and foraging activities between the periods of pregnancy, lactation and post-lactation were based on the data derived from round R1, which showed the highest overall activity values. Differences in activity between R1, R2 and R3 were independent of the season. Flight activity varied significantly with the reproductive period for all the three species studied ($H=25.9$, $P<0.001$ for common pipistrelles; $H=24.5$, $P<0.001$ for Nathusius' pipistrelles and $H=6.6$, $P<0.04$ for Daubenton's bats; figure 2a). The flight activity of common pipistrelles was significantly lower during pregnancy than during lactation and post-lactation ($P<0.01$). Nathusius' pipistrelles were more active during post-lactation than during the two other reproductive periods ($P<0.01$). Daubenton's bats showed lower, but non-significant levels, of flight activity during post-lactation ($P>0.05$). Foraging activity levels followed the same trend as flight activity among all three species (common pipistrelles $H= 24.6$, $P<0.001$; Nathusius' pipistrelles $H=17.9$, $P<0.001$; Daubenton's bats $H=9.5$,

P<0.009; figure 2b). In common pipistrelles and Daubenton's bats, foraging activity was significantly higher during lactation than during pregnancy and post-lactation (P<0.01).

Emission of social calls

The number of social calls emitted by common pipistrelles varied significantly between the three nightly sampling rounds (R1, R2 and R3) during the periods of pregnancy (H=7.9, P<0.02) and post-lactation (H=16.0, P<0.001). In both these periods bats produced less social calls during R1 than during R2 and R3 (P<0.05). The number of social calls also varied between reproductive periods (H=121.1, P<0.001), with more calls recorded during post-lactation (P<0.001; figure 3).

Discussion

Three species of the genus *Pipistrellus* are represented in our study area: common pipistrelles, Nathusius' pipistrelles and the soprano pipistrelles. However, their activity levels and presumably the total numbers of individuals of each species over the pond, varies considerably. Common pipistrelles are the most dominant species, being recorded on all the sampling occasions and having higher estimated levels of activity. The Nathusius' pipistrelle is the second most abundant species. This result must be considered against the background of a differential presence of the sexes for the two species in spring and summer. In Belgium, groups of common pipistrelles consist of both sexes, whereas groups of Nathusius' pipistrelles in spring and early summer consist mainly of males. At this period of the year, female Nathusius' pipistrelles move to the eastern part of their range and join harems on their migration routes to their hibernation sites (Lina 1990, Kapteyn & Lina 1994). The soprano pipistrelle occurs less regularly and activity levels are very low. This species was described for the first time in the Brussels Region in 2002 and is not widespread in Belgium (Kapfer, Van de Sijpe et al., in press). The Daubenton's bat was also commonly recorded over the pond and made very frequent capture attempts, demonstrating that the species is particularly efficient in catching prey in this environment. Finally, serotines, noctules and Leisler's bats were recorded with a relatively low frequency and activity levels. The results suggest that these species used the area as a feeding ground occasionally and for brief periods.

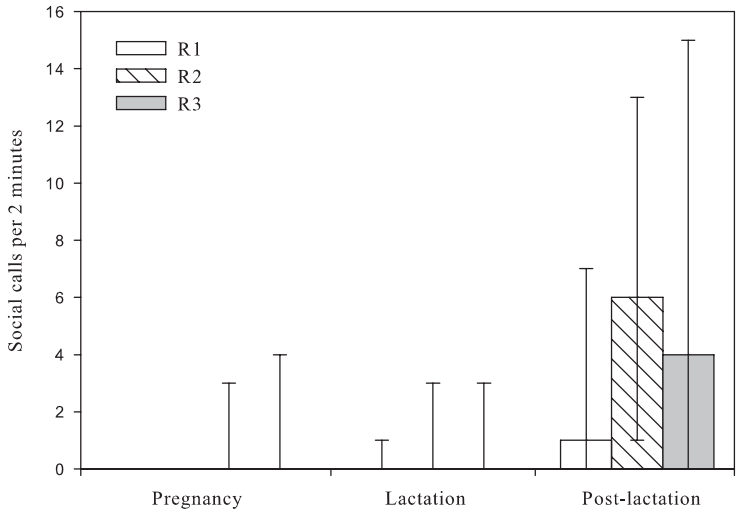

Figure 3. Social calls sampled per round (median, percentile 25% and 75%) as a function of the reproductive period in *Pipistrellus pipistrellus*.

Our data also show that the flight and foraging activities of common pipistrelles decrease throughout the hours following sunset. This might be due to a rapid fall in the number of flying insects, bought about by rapidly declining temperature after sunset (Anthony & Kunz 1977). When insect density rapidly decreases, aerial hawking bats stop hunting as the cost of prey detection may become too high (Rydell et al. 1996). We do not know whether the decrease in activity recorded over the night results from bats returning to their roost with a full stomachs, or from animals leaving the pond to move to other more rewarding hunting areas. The flight and foraging activities of Daubenton's bats remain relatively constant over at least the first hours after sunset. Similar data have been documented for this species in other study areas (i.e., Dietz 1993; Bartonicka & Zukal 2003). Daubenton's bats usually fly 10-30 cm above the water surface and prey on insects emerging from or standing on the water (Jones & Rayner 1988), or occasionally on small fishes (Brosset & Delmare 1966, Siemers et al. 2001). The emergence of aquatic insects follows a diurnal rhythm, closely linked with illumination levels and water temperature, but not correlated with air temperature (Morgan & Waddell 1961). Our results are consistent with this observation since Daubenton's bats continue to hunt with a constant and high capture rate, even when *Pipistrellus* species hunt less efficiently.

Variation in flight activity throughout the summer might be explained by bats hunting more or less over the pond according to their biological requirements (e.g., induced by the endogen cycle), or by bats coming to the site, or leaving it for better ones. Our study area was not a confined space, so all these explanations are possibilities. Previous studies (Kapfer, in prep.) suggest that food is not a limited resource in the area, at least during the time that we conducted the experiments. Kapfer, Rigot et al. (in press) have recently shown that female and juvenile Daubenton's bats are faithful to the same hunting places. This strongly supports the idea that fluctuations in flight activity are associated with the reproductive periods. Indeed, the arrival of juvenile common pipistrelles that start to fly around the end of June and beginning of July (Swift 1980, Whitaker 1998) and the higher activity of males during post-lactation (Gerell-Lundberg & Gerell 1994) may explain the increase in activity around the pond during lactation and post-lactation. Our results reveal a decrease in foraging activity associated with an increase in flight activity during post-lactation. This is consistent with the mating system of *Pipistrellus*, best characterised as a resource defence polygyny with males defending the roost containing their harems (Gerell-Lundberg & Gerell 1994). Males probably reduce their foraging activity and spend considerably more time flying in the immediate vicinity of their day roosts (Gerell & Lundberg 1985, Lundberg & Gerell 1986). As mentioned above, flight activity among Nathusius' pipistrelles is relatively low from spring to mid-summer, but increases during the post-lactation period. This may be primarily related to a higher flying activity of males but is also partly due to an influx of new individuals (e.g. migrating females) visiting the area (Kapteyn & Lina 1994, Peterson 2004). The low flight activity of Daubenton's bats recorded in August and September might be a result of changes in activity patterns, with males resting in the day roost to establish mating roosts (Encarnaçao et al. 2004). This period also corresponds to the timing of movement towards winter roosts (i.e. caves, forts) (Klawitter 1980, Lesiński 1986, Dietz & Fitzenräuter 1996).

Our data suggest that the emission of social calls by common pipistrelles varies in both during the course of the night and between different reproductive periods. Social calls are higher during the first hours after sunset, probably as a result of a decline in insect availability leading to increasingly territorial behaviour. Barlow & Jones (1997) used play-back experiments to demonstrate that social calls are used to warn off and drive away other pipistrelles of the same species when insect densities decrease. These calls are often combined with chases. Our investigations also reveal that the species emits more social calls during post-lactation than during the

two former reproductive periods. At the end of summer, males produce "songflights" apparently to deter male intruders but also to attract females to their roost (Gerell-Lundberg & Gerell 1994). Preliminary work suggests that the social calls of pipistrelle species emitted before and during the reproductive periods might have different structures (De Smet 2004). Further studies should be carried out to test this hypothesis and to investigate if both sexes emit social calls and/or if the message associated with the social call varies according to the reproductive status, the emission rate or associated behaviour.

Many studies have built up general pictures of the behaviour of bat assemblages over a pond. However, to the best of our knowledge, there is a shortage of field experiments, performed in a standardised manner, on temporal patterns of bat flights and foraging activities. The present study confirms that urban ponds are important habitats for bats, and can show a high species richness. Apart from being important as drinking sites, they are also used as foraging and mating grounds during different reproductive periods of the species considered.

Acknowledgements: This work is a part of the PhD carried out by the first named author under the supervision of S. Aron and P. Devillers. We are grateful to Prof. Gareth Jones, Dr. Victor van Cakenberghe, Dr. Lorraine Berry, and the two anonymous reviewers for their comments on the manuscript. We also thank Dr. Ludo Holsbeek and Alex Lefevre for the translation of our abstract in Dutch. We thank the Conservation Biology section of the RINSB for providing material, advice and laboratory supplies for our research. The study was supported by the FRIA (Fonds pour la Recherche dans l'Industrie et l'Agro-alimentaire) and several grants from the Belgian FNRS.

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Samenvatting

Temporele variatie in vliegactiviteit, jachtactiviteit en sociale interacties van vleermuizen boven een vijver in een buitengebied

Ons onderzoek spitste zich toe op nacht- en seizoensactiviteit van een vleermuispopulatie rond een voorstadvijver tussen april en september 2003. Van zeven gedetermineerde soorten, waren er drie (*Pipistrellus pipistrellus*, *Pipistrellus nathusii* en *Myotis daubentonii*) dominant wat betreft voorkomen en/of vliegactiviteit. De vliegactiviteit van *Pipistrellus pipistrellus* fluctueerde sterk in tijd, met een piek net na zonsondergang. De activiteit van *Pipistrellus nathusii* en *Myotis daubentonii* bleef vrij constant gedurende minstens twee uur na zonsondergang. De vlieg- en jachtactiviteit varieerden met het voortplantingsseizoen. Waar de vliegactiviteit toenam van drachtperiode tot de post-lactatieperiode bij het genus *Pipistrellus*, nam deze af gedurende de post-lactatie bij *Myotis daubentonii*. Een toename van sociale roepen werd aangetoond bij *Pipistrellus pipistrellus* gedurende de eerste uren van de nacht maar ook tijdens de post-lactatieperiode. Deze resultaten worden besproken in relatie met de ecologie en het gedrag van de soorten.

Received: 4 December 2006
Accepted: 5 April 2007

The summer distribution and occurrence of cetaceans in the coastal waters of the outer southern Moray Firth in northeast Scotland (UK)

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Abstract: Information on the distribution and occurrence of whales, dolphins and porpoises in the coastal waters of Scotland's Moray Firth, in the north-west North Sea, remains fairly sparse to date, with few detailed studies being conducted on species other than the bottlenose dolphin (*Tursiops truncatus*). Consequently, familiar coastal species such as the minke whale (*Balaenoptera acutorostrata*) and harbour porpoise (*Phocoena phocoena*) have received far less attention in these waters, and yet these and other species may be of considerable conservation priority. In the present study, an examination of the animals using the southern coastal waters of the outer Moray Firth was carried out between May and October 2001 to 2005 inclusive. During 9,663 km of dedicated boat survey effort, 751 encounters were recorded with eight different species (six species of toothed whale, and two species of baleen whale) in an 880 km square coastal study area between Fraserburgh and Lossiemouth. The most commonly sighted cetaceans were harbour porpoises (comprising 60% of all encounters) and minke whales (at 25%), but the two most abundant species were porpoises and bottlenose dolphins, jointly accounting for 89% of the total animals encountered. Considerable inter-annual and seasonal variation was observed in both the number of encounters and the diversity of species recorded, and a seasonal increase in harbour porpoises was noted, with inshore movements of females and their calves across the summer months. For each of the other species recorded, all were considered "pelagic", deeper water animals which only sporadically utilised the study site. The temporal and spatial occurrences of the principal coastal species are discussed with respect to the complex ecological, biological and anthropogenic determinants in this location. Recommendations for the subsequent monitoring of this cetacean community are considered to be particularly important for current and future conservation strategies. Further work integrating broader scale survey coverage is proposed, with more detailed studies in particular areas of focal interest or concern with respect to local management and/or conservation directives.

Keywords: Cetaceans, distribution, occurrence, species diversity, boat-based surveys, Moray Firth, Scotland, northern North Sea, conservation, local management.

Introduction

The distribution and occurrence of whales, dolphins and porpoises in the north western North Sea has primarily been described from opportunistic data collected during seabird surveys in the 1980s and 1990s (Mudge et al. 1984, Northridge et al. 1995) and by dedicated volunteer networks (Evans 1992). With the addition of the large-scale SCANS (Small Cetacean Abundance in the North Sea) surveys conducted in 1994 (Hammond et al. 2002), these datasets have been combined to produce a general atlas of distribution for northwest Europe by Reid et al. (2003), featuring 28 cetacean species over a 25 year period. The end result provides a useful illustration of regional trends in cetaceans in these northern, temperate waters. But, due to the patchy nature of the observational coverage compiled, these low-resolution datasets are found to be largely unsuitable for "local" management, where finer scale determinations are typically required (Weir et al. 2007).

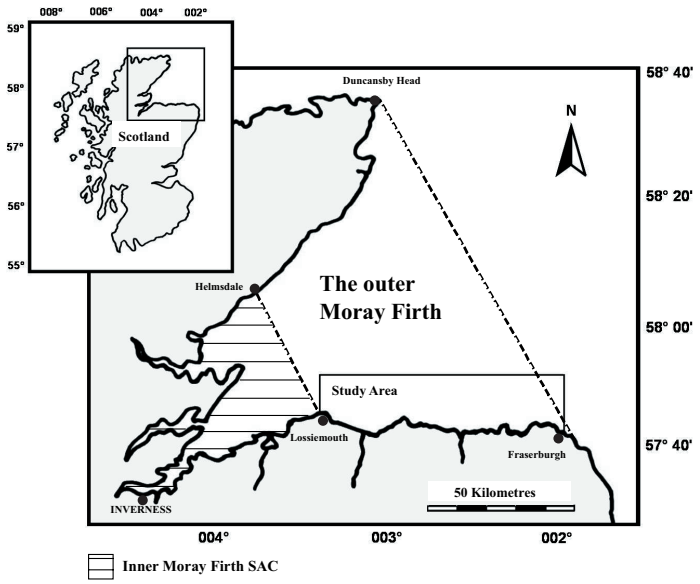

Figure 1. Map of the Moray Firth showing the position of the 880 km^2 study area along the southern coastline of the outer firth between Lossiemouth and Fraserburgh.

In the outer Moray Firth on the east coast of Scotland (57º41'N, 2º00'W), a number of fine and meso-scale studies have intimated the importance of this North Sea coastal embayment for a number of cetacean species (e.g. Hastie et al. 2003, Thompson et al. 2004, Weir et al. 2007). To date, however, the only detailed, year-round studies in the firth have been carried out on bottlenose dolphins (*Tursiops truncatus*) (Wilson et al. 1997, Wilson et al. 1999, Wilson et al. 2000, Grellier et al. 2003, Eisfeld & Robinson 2004, Hastie et al. 2004, Wilson et al. 2004, Durban et al. 2005, Bailey & Thompson 2006, Lusseau et al. 2006, Culloch & Robinson, in press), with few long-term investigations of other species known to occur here. Consequently, several familiar coastal species in this location, such as the minke whale (*Balaenoptera acutorostrata*) (Tetley 2004, Robinson & Tetley 2007) and harbour porpoise (*Phocoena phocoena*) (Whaley & Robinson 2004, Clark 2005), have received far less attention in these waters. Yet these and other inshore species arguably form a significant component of this marine ecosystem, and may be of considerable conservation priority in this respect (Clark et al. 2006).

The aim of this paper is to highlight the abundant cetacean community frequenting the southern outer Moray Firth and the respective importance of this area as a prime coastal habitat for these mammals during the summer and autumnal months. This objective is considered particularly relevant for the evaluation and improvement of existing management policies for the Moray Firth area as a whole – the recent shift in the distribution and range of the "resident" bottlenose dolphin population (see Wilson et al. 2004 and Stockin et al. 2006), for example, having raised questions as to the effectiveness of the current Special Area of Conservation (SAC) within the inner region of the firth. This presentation forms part of a larger, on-going project investigating changes in the spatio-temporal habitat use and site fidelity of the key cetacean species inhabiting this coastal North Sea location.

Materials and methods

The study area

Sharing large-scale environmental determinants, such as water circulation and climate patterns,

the Moray Firth in northeast Scotland is an integral part of the northwest North Sea and Atlantic Ocean beyond (Wright et al. 1998). Bound on two sides by land, it is generally defined as the area of sea from Duncansby Head in the north, to Inverness in the south-west, to Fraserburgh in the east (Harding-Hill 1993) (figure 1). The area to the west of a line drawn from Helmsdale to Lossiemouth is defined to as the "inner" Moray Firth, whilst the remaining sea to the east of this limit is the "outer" Moray Firth.

The characteristics of this large embayment (measuring some 5,230 km^2) vary greatly within its extent. In the inner firth, the seabed slopes gently from the shore to a depth of around 50 m approximately 15 km from the coast, whilst the outer firth more closely resembles the open North Sea (Holmes et al. 2004). The waters are a combination of mixed and coastal waters. Of the twelve major rivers which discharge freshwater into the firth, ten flow into the inner area substantially reducing the salinity here (Holmes et al. 2004). The main marine input is produced by the Dooley current which brings mixed cold waters down from the north that circulate in a clockwise direction (Wilson 1995). The resulting frontal zones are subsequently characterised by strong horizontal gradients in surface or bottom temperatures (Reid et al. 2003). The Moray Firth is internationally recognised as a site of outstanding biological importance and the inner firth was officially appointed a Special Area of Conservation in March 2005 (Scottish Natural Heritage 2006).

Data collection

Data used in the present study were collected from May to October 2001 to 2005 inclusive. Systematic boat surveys were conducted along an 83 km length of the southern Moray Firth coastline (lying between the ports of Lossiemouth and Fraserburgh) using four standardised routes positioned parallel to the shore – three outer routes, approximately 1.5 km apart in latitude, and an inner coastal route (where the probability of sighting bottlenose dolphins was highest) – covering a total survey area of approximately 880 km^2 (figure 2). The dedicated surveys were carried out using 5.4 m outboard boats with an observation frame giving an eye height of approximately 3.5 m above water. Surveys were conducted at mean vessel speeds of seven knots in visibility ≥1 km and Beaufort Sea States ≤3 with a crew of two experienced and up to four additional trained observers. The observers searched the area using a continuous scanning method (Mann 1999), from directly in front

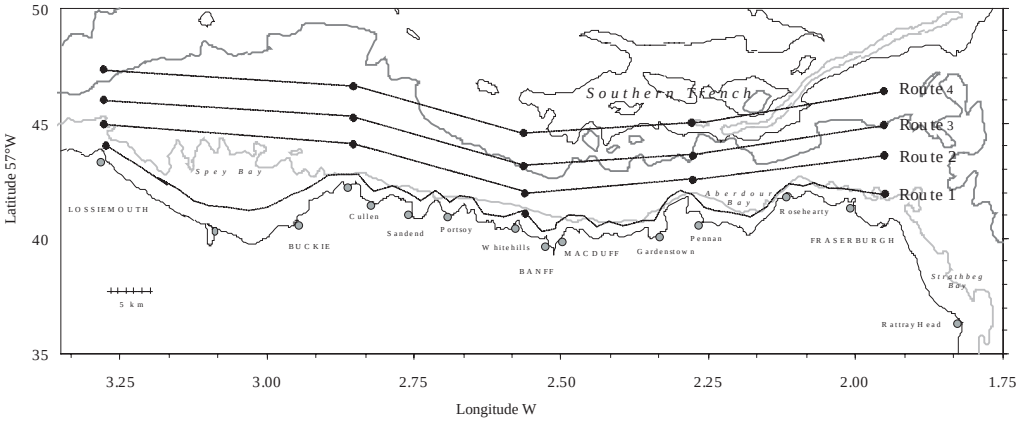

Figure 2. Showing the southern coastline of the outer Moray Firth and the survey routes used during systematic boat surveys. The routes were divided into three longitudinal outer transects (routes 2 to 4 respectively), each approximately one minute apart in latitude, plus an inner coastal transect (route 1) where bottlenose dolphin sightings were concentrated.

of the boat to 90 degrees left and right of the track line. To ensure animals were sighted before they reacted to the presence of the survey vessel, binoculars were used from the observation frame to scan far from the boat, while the remaining crew searched closer to the vessel with the naked eye. This scanning method and configuration of observers was found to minimise heterogeneity in detection probabilities between the different species and/or group sizes (after Palka 2005), as well as facilitating standardisation and comparability between the survey trips.

During survey trips, both the vessel position (using Global Positioning System) and respective environmental data were recorded. When cetaceans were spotted, the boat was gradually slowed (and circled back where necessary) to allow absolute identification of the species encountered. In addition, the number and position of animals were recorded and distances were corrected with respect to the survey vessel accordingly. With the exception of harbour porpoises, photography was used to validate identifications of all the cetacean species encountered.

Results

Across the 5-year survey period, 393 trips were made on 250 days, covering a total survey distance of 9,663 km (table 1). During this time, 751 encounters were recorded with eight different

Table 1. The survey effort for dedicated cetacean surveys conducted between May and October 2001 to 2005 inclusive.

Year	Number survey days	Total survey trips	Survey effort (km)	Total number encounters
2001	45	53	1514.2	63
2002	67	98	2518.6	226
2003	60	80	1946.0	211
2004	35	74	1886.8	62
2005	43	88	1797.6	189
Total	250	393	9663.1	751

Table 2. Showing the cetacean species encountered in the study area respective to the cumulative effort for each of the survey routes 1 to 4. The total number of animals encountered is given in parentheses.

Survey route	Route 1	Route 2	Route 3	Route 4	Total
Total effort (km)	5788.8	1872.9	1485.9	515.6	9663.1
Odontocete whales	248 (1756)	157 (452)	118 (339)	39 (147)	562 (2694)
1) *Phocoena phocoena*	142 (448)	156 (441)	117 (333)	37 (118)	452 (1340)
2) *Tursiops truncatus*	95 (1258)	0 (0)	0 (0)	0 (0)	95 (1258)
3) *Orcinus orca*	5 (13)	0 (0)	1 (6)	0 (0)	6 (19)
4) *Grampus griseus*	4 (19)	1 (11)	0 (0)	0 (0)	5 (30)
5) *Globicephala melas*	1 (6)	0 (0)	0 (0)	2 (29)	3 (35)
6) *Lagenorhynchus acutus*	1 (12)	0 (0)	0 (0)	0 (0)	1 (12)
Mysticete whales	42 (63)	73 (82)	53 (54)	21 (23)	189 (222)
7) *Balaenoptera acutorostrata*	41 (62)	73 (82)	53 (54)	20 (22)	187 (220)
8) *Megaptera novaengliae*	1 (1)	0 (0)	0 (0)	1 (1)	2 (2)
All cetaceans	290 (1819)	230 (534)	171 (393)	60 (170)	751 (2916)

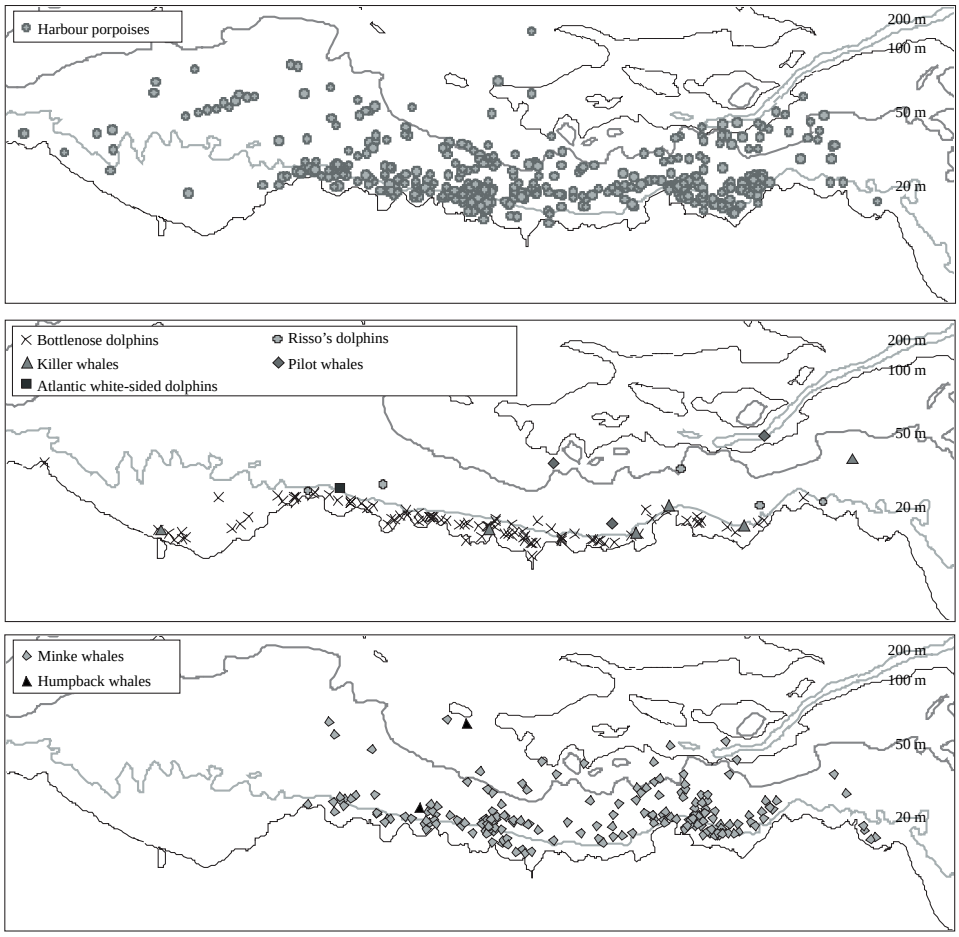

Figure 3. Sightings maps of the southern outer Moray Firth, showing the spatial distribution of cetacean species encountered across the 5-year survey period from May to October 2001 to 2005 inclusive.

species: six species of toothed (odontocete) whale [five delphinids and one phocoenid] and two species of baleen (mysticete) whale, both of which were rorqual whales (table 2). The respective distribution of these encounters is shown in figure 3.

The most commonly sighted species, comprising 60% of all encounters, was the harbour porpoise, followed thereafter by the minke whale at 25%, but the two most abundant species were the harbour porpoise and bottlenose dolphin, jointly accounting for 89% of the cumulative number of animals encountered (table 2). All three of these "coastal" species were recorded within the study area between May and October, with the exception of minke whales during May (figure 4a). Both harbour porpoises and minke whales were encountered throughout the study area on survey routes 1 to 4 respectively, but bottlenose dolphins were only recorded on the innermost survey route (route 1) in shallow waters rarely exceeding 25 m depth (median depth 16.3 m, n=95). Whilst minke whales and harbour porpoises were also recorded on this innermost route, corrections for survey effort revealed a considerably higher abundance of both species on each of the outer survey routes 2 to 4 respectively (table 3).

Throughout the study, considerable variation was observed in both the number of encounters and the diversity of species recorded from one survey year to the next (table 1 and figure 4b). In

Table 3. The encounter rates for harbour porpoises, minke whales and bottlenose dolphins in the outer southern Moray Firth (expressed as the number of encounters per km for each species on survey routes 1 to 4 respectively). The determination in parentheses denotes the total number of animals per km effort.

Species	Route 1	Route 2	Route 3	Route 4
Phocoena phocoena	0.025 (0.077)	0.083 (0.235)	0.079 (0.224)	0.072 (0.229)
Balaenoptera acutorostrata	0.007 (0.011)	0.039 (0.044)	0.036 (0.036)	0.039 (0.043)
Tursiops truncatus	0.016 (0.217)	-	-	-

2004, for example, only harbour porpoise (*n*=54) and a lesser number of bottlenose dolphin (*n*=9) encounters were recorded. In 2001, however, a total of seven different species were identified, although the total number of encounters per km was found to be very much lower than for 2002, 2003 and 2005, and only slightly higher than for 2004 (figure 4b).

A seasonal increase in the number of monthly cetacean encounters was also apparent in the pooled dataset (figure 4a), but this was directly attributed to a progressive increase in harbour porpoise encounters from May through to October. Whilst bottlenose dolphin encounters were highly variable across all months, minke whales were typically recorded in the study area from mid June onwards; with the number of minke whale encounters remaining fairly constant from July to October thereafter. For each of the additional cetacean species encountered, all were considered to be pelagic, deeper water animals that only sporadically utilised the coastal study site, as no obvious patterns of occurrence were determined. That saying, killer whales (*Orcinus orca*) were only sighted between the months of June and August (*n*=6), whilst Risso's dolphins (*Grampus griseus*) were exclusively recorded in September (*n*=5). Regardless of the number of encounters of each of the species recorded in this study, however, all of the species identified (both coastal and pelagic) showed spatial and temporal overlaps in their respective distributions.

Discussion and conclusions

The productive, coastal waters of the outer southern Moray Firth support an interesting diversity of cetaceans. In addition to the wide-scale occurrence of "coastal" bottlenose dolphins, minke whales and harbour porpoises, inshore movements of several other "pelagic" animals can be seen during the summer and autumnal months. Killer whales, pilot whales (*Globicephala melas*) and humpback whales (*Megaptera novaengliae*), for example, were all intermittently encountered in the study area between the months of July and August; Risso's dolphins were seen in increasing abundance during the latter years of the study; and a single sighting of twelve Atlantic white-sided dolphins (*Lagenorhynchus acutus*) was recorded in August 2005. However, at least eight additional species have been documented in the study area, from historical accounts (Smiles 1876, Harvie-Brown & Buckley 1895, Taylor 1899), opportunistic sightings (Mudge et al. 1984, Camphuysen & Winter 1995, Reid et al. 2003, Cave 2006, K.P. Robinson, personal observation) and from incidental strandings records (Baumgartner et al. 2006, R.J. Reid, unpublished data). In no particular order, these include: the white-beaked dolphin (*Lagenorhynchus albirostris*), striped dolphin (*Stenella coeruleoalba*), sperm whale (*Physeter macrocephalus*), northern bottlenose whale (*Hyperoodon ampullatus*), common dolphin (*Delphinus delphis*), Sowerby's beaked whale (*Mesoplodon bidens*), fin whale (*Balaenoptera physalus*) and the sei whale (*Balaenoptera borealis*).

The majority of species encountered during the surveys varied widely in their distribution, but bottlenose dolphins showed a clear preference for shallow, coastal waters less than 25 m in depth. Long-term studies of *Tursiops truncatus* suggest their occurrence in inshore waters is directly related to the distribution of near-shore prey (Defran & Weller 1999), and along the southern coastline of the Moray Firth, migratory salmonids

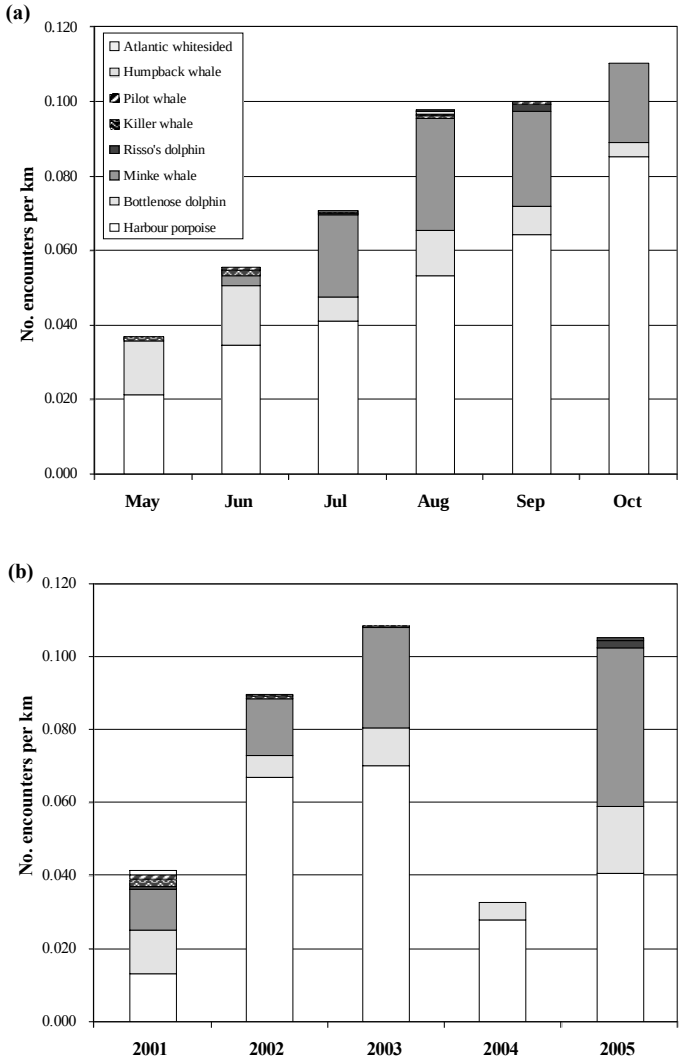

Figure 4. Stack histograms showing (a) the cumulative number of cetacean species per km of survey effort area recorded between May and Oct, and (b) the interannual variability in the number and diversity of cetacean encounters from 2001 to 2005 with respect to the annual survey effort undertaken.

– thought to be highly significant in the diet and the seasonal movements of this dolphin community (Santos et al. 2001, Stockin et al. 2006) – were commonly targeted by the species during the summer and autumnal months (K.P. Robinson, personal observation). Minke whales and harbour porpoises, on the other hand, were more usually abundant in deeper waters further from shore, with mixed species sightings typically occurring along the 20-50 m isobaths. In Scottish waters, sandeels (*Ammodytes* spp.) comprise the principal quarry for both minkes and porpoises (Pierce et al. 2004, Santos et al. 2004), and their comparable distribution in the present study was almost certainly linked to the availability of sandeel prey and the profitability of selected areas for mutual foraging. The relationships between predators and their prey, however, remain inherently complex and dynamic. For example, many species of pelagic fish also targeted by cetaceans

in these waters, including whiting (*Merlangius merlangus*), haddock (*Gadus morhua*) and pelagic mackerel (*Scomber scombrus*) (Santos et al. 1994), are ultimately dependent on sandeel prey themselves (Greenstreet et al. 1998, Robinson & Tetley 2007). Consequently, respective variations in the presence or absence of these key mid-trophic species in the study area, both as predators and as prey, would be further significant to the distributions of the cetacean species observed.

In addition to ecological parameters such as water depth and prey distribution, however, the seasonal and inter-annual variations recorded for cetaceans in the present study area might also be explained by a combination of other factors, including: reactions to anthropogenic impacts (Thompson 1992, Evans 1996), requirements for suitable calving conditions (Yasui & Gaskin 1986, Weir et al. 2007) and even inter-specific competition with other cetacean species (Ross & Wilson 1996), notably the avoidance by porpoises of areas used by bottlenose dolphins. In 2004, for example, the low number of cetacean sightings and the complete absence of minke whales in the study area were believed to be the direct result of regional sandeel depletions due to over-fishing, as corroborated by North Sea fisheries data (FRS 2004, Greenstreet et al. 2006) and the reported breeding failures of many seabirds around the Scottish coastline at this time (Proffitt 2004). In addition, record numbers of large, demersal squid trawlers were recorded in the study area between June and September 2004 (K.P. Robinson, personal observation) – in response to exceptionally high landings of *Loligo forbesi* in the firth the previous summer by the usually small, local fishery (Young et al. 2006) – which may have further resulted in the disturbance or direct displacement of the animals occupying the targeted fishing areas. This conjecture was supported by the low numbers of porpoise and bottlenose dolphin sightings recorded on inshore survey routes between Cullen Bay and Pennan where and when the larger trawlers were most concentrated. Furthermore, post-trawling observations by divers in Cullen Bay and Banff (B. Jamieson & C. Hollingdale, personal communication) revealed deep scarring of the sea floor and extensive damage to the shallow and shelf sedimentary habitats predictably populated by sandeels in this location (Tetley 2004, Clark et al. 2006). Since intensive demersal trawling is known to cause widespread physical and biological changes to marine habitats and their fauna (Lindegarth et al. 2000, Rosenberg et al. 2003), the loss of local sandeel communities and other prey species in affected areas (through associated bycatch and the degradation of critical habitat) would be assumed to impact upon those predatory cetacean species as well.

The absence of white-beaked dolphin encounters in this investigation was also particularly interesting given the high abundance of animals described for the region from earlier datasets (e.g. Northridge et al. 1995, Hammond et al. 2002, C.J. Camphuysen, unpublished data). However, an examination of strandings data for the area (Baumgartner et al. 2006, R.J. Reid, personal communication) suggests that the species may in fact be present here during the colder winter months – incidentally at a time when inter-specific competition from bottlenose dolphins is less prevalent. In harbour porpoises, for example, the avoidance of areas occupied by the larger bottlenose dolphins evidently results in spatial and/or temporal habitat segregation between the species (Thompson et al. 2004). And whilst there are no published cases of directed aggression towards white-beaks by bottlenoses in Scottish waters (the two species being ecologically very different, i.e. near-shore versus pelagic), where sympatric populations exist along the coast of Aberdeen, an inverse relationship has been observed between the temporal occurrences of the two species (C.D. MacLeod, unpublished data), with white-beaks occupying a higher ranking in the community only when the temporal occurrence of bottlenoses is lowest. In the present study area, however, since bottlenoses are seen to be ubiquitous along the coastline for the full duration of the study period (May to October), no such temporal switch over would be possible.

The seasonal differences in the occurrence of the principal cetacean species recorded may further be explained in terms of their reproductive and/or calving requirements. In contrast to minke whales, for example, it appears that harbour porpoises and bottlenose dolphins utilise the sheltered inshore waters of the firth across the warmer summer months to give birth (Grellier et al. 2003, Clark 2005, Culloch & Robinson, in press). Indeed, calves were recorded in 84% of all bottlenose encounters in the present study, with newborn animals being produced from July to October inclusive. For harbour porpoises, however, neonatal calves were typically observed between May and July, consistent with known calving periods for the species throughout the North Sea (Lockyer 1995), and the seasonal increase in porpoises was believed to result from the inshore movements of lactating females with their calves (followed thereafter by the males). Since the consumption rates of female porpoises are known to increase to 80% of their body weight during lactation (Yasui & Gaskin 1986), the energetic demands of calving and nursing may subsequently be a driving factor in the seasonal migrations of the principal species observed.

In conclusion, the distribution data presented here suggest that the spatial and temporal occurrence of cetaceans in the study area is variable and complex. The spatial data indicate that some species restrict their movements and activities to particular areas and depths, whilst others are more widespread and responsive in their distribution. Continued warming of the local waters, however, is predicted to result in further changes to this cetacean community (MacLeod et al. 2005, Learmonth et al. 2006), with probable additions and expected increases in existing warmer-water cetaceans, such as Risso's and common dolphins, and the disappearance or change in the relative and absolute abundances of others, such as pilot whales and killer whales, for example. In this respect, further monitoring of this cetacean community is considered to be particularly important for present and future conservation strategies. On going spatio-temporal analyses of the "priority" coastal species identified in this study will allow us to focus conservation measures in relation to human activities in this area (e.g. bycatch reduction, disturbance by shipping, tourism etc); to identify times and areas of special significance in the life cycle, such as breeding periods and nursery areas; and to measure the effectiveness of current management and action plans, assisting in their future development. Further work should aim to achieve additional coverage of the outer Moray Firth region, integrating broader scale survey data and directing more detailed work in focal areas of particular interest or concern. Such a multi-scale approach should ultimately lead to the identification of oceanographic, biological and anthropogenic determinants that underlie the distinctive patterns of distribution seen in this coastal North Sea area, and these objectives are believed to be fundamental to local management directives for the protection of this and other coastal cetacean communities in UK and European waters.

Acknowledgements: Many thanks to the numerous volunteers and staff of the CRRU who spent long hours in the field assisting with data collection. Boat-based surveys were carried-out with support from the British Ecological Society, Care for the Wild International, The Miller Foundation, Ecocorps Scotland and, more recently, the Earthwatch Institute. We also thank Colin MacLeod for his comments on an early draft of this paper and Graham Pierce for input and assistance with fisheries data and discussion of cetacean diets. Finally, many thanks to the two anonymous reviewers who provided constructive comments on this manuscript that contributed to a very much improved final version.

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Samenvatting

De verdeling en het voorkomen van walvisachtigen gedurende de zomer langs de zuidkust van het buitenste deel van de Moray Firth in noordoostelijk Schotland

Gegevens over het voorkomen en de ruimtelijke verdeling van walvissen, dolfijnen en bruinvissen in de kustwateren van de Moray Firth (Schotland), in het noordwestelijke deel van de Noordzee, zijn tot op heden schaars. Zo zijn er slechts enkele gedetailleerde onderzoekingen aan andere soorten dan de tuimelaar verricht (*Tursiops truncatus*). Daardoor hebben regelmatig aan de kust voorkomende soorten als de dwergvinvis (*Balaenoptera acutorostrata*) en de bruinvis (*Phocoena phocoena*) veel minder aandacht gekregen, ondanks het feit dat maatregelen tot bescherming van deze en andere soorten van groot belang kan zijn. Het hier gepresenteerde onderzoek geeft een beeld van de dieren die in de zomers van 2001 tot en met 2005 gebruik maakten van de kustwateren in het buitenste deel van de Moray Firth. In een kustgebied van 880 km^2 tussen Fraserburgh en Lossiemouth werd een traject van in totaal 9.663 km op systematische wijze geteld, waarbij 751 waarnemingen werden verricht. Er werden acht soorten walvisachtigen waargenomen: zes soorten tandwalvissen en twee soorten baleinwalvissen. De bruinvis en de dwergvinvis werden het vaakst waargenomen (respectievelijk 60% en 25% van alle waarnemingen); de twee in aantal meest voorkomende soorten waren de bruinvis en de tuimelaar, tesamen goed voor 89% van het totaal aantal waargenomen dieren. Van jaar tot jaar en in de loop van de zomer treden er aanzienlijke verschuivingen op in de waargenomen aantallen en de aantallen soorten. Daarnaast treedt er in de loop van het seizoen een toename op van de aantallen bruinvissen, waarbij de verplaatsingen van vrouwtjes met jongen richting kust toenamen. Alle andere waargenomen soorten, die als 'pelagisch', in dieper water levend worden beschouwd, werden slechts incidenteel in de kustwateren waargenomen Het voorkomen in tijd en ruimte van de belangrijkste soorten wordt besproken in relatie tot de complexe ecologische, biologische en antropogene factoren die een rol spelen in het onderzoeksgebied. Aanbevelingen voor het voortzetten van de tellingen van de walvisachtigen in dit gebied zijn van groot belang voor de huidige en toekomstige beschermingsmaatregelen. Verdergaand, grootschaliger monitoringsonderzoek wordt voorgesteld, waarbij meer gedetailleerd gekeken wordt in juist die gebieden die van cruciaal belang zijn voor lokaal beheer en/of beschermingsmaatregelen.

Received: 14 August 2006
Accepted: 11 April 2007

Foraging humpback whale *(Megaptera novaeangliae)* in the Marsdiep area (Wadden Sea), May 2007 and a review of sightings and strandings in the southern North Sea, 2003-2007

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Abstract: A humpback whale (Megaptera novaeangliae) was observed in the Marsdiep area (western Wadden Sea, The Netherlands), 10-13 May 2007, triggering great media interest and attracting large crowds of spectators to the shore. The animal was foraging in strong tidal currents in a deep gully very close to the dike of Den Helder and in shallow areas of the sandy beach of the island of Texel. Unique characteristics of its dorsal fin are described to facilitate future individual identification of this animal. The feeding techniques, the foraging conditions, feeding areas and the possible prey targeted in the Marsdiep area are described. Humpback whales are very rare in the southern North Sea and have never been before encountered in the Wadden Sea. Recent strandings and sightings along the Dutch and Belgian coasts are summarized. These suggest an increase in numbers frequenting these waters. Historical material suggests that humpback whales have always been very rare and that the recent occurrences are unprecedented.

Keywords: humpback whale, Megaptera novaeangliae, sightings, behaviour, habitat, Wadden Sea, strandings, North Sea.

Introduction

A solitary humpback whale (*Megaptera novaeangliae*) was observed and briefly studied while foraging in tidal currents of the Marsdiep area (western Wadden Sea) during 10-13 May 2007. Humpback whales are rare in the southern North Sea and there have been no previous reports of large whales foraging in the Wadden Sea. This, plus the fact that four other individuals were reported in The Netherlands over the last four years following a period of ca. 250 years without a single documented sighting or stranding anywhere near this coastal area, formed the inspiration for this contribution. Individual characteristics of the animal are documented to facilitate future reports and sightings of the same whale elsewhere and the foraging behaviour and feeding habitats in the Marsdiep area are described. The paper includes a summary of recent sightings and strandings in the southern North Sea. A wider context is provided by adding a brief discussion on recent sightings elsewhere within the North Sea and population developments in the north eastern Atlantic.

Observations, May 2007

On 10 May 2007, coastguard reports were received by the author, as co-ordinator of the Dutch Seabird Group (NZG) Marine Mammal Database, suggesting that between one and three large whales were seen in the Marsdiep area, between Den Helder and the island Texel (western Wadden Sea; figure 1). Initial descriptions were vague, but a photo by Hans Verdaat, taken on 11 May showed the presence of at least one humpback whale. On 12 May 2007, a small boat ('*Het Sop*') was put on standby. When seawatchers, stationed at Huisduinen, relocated the

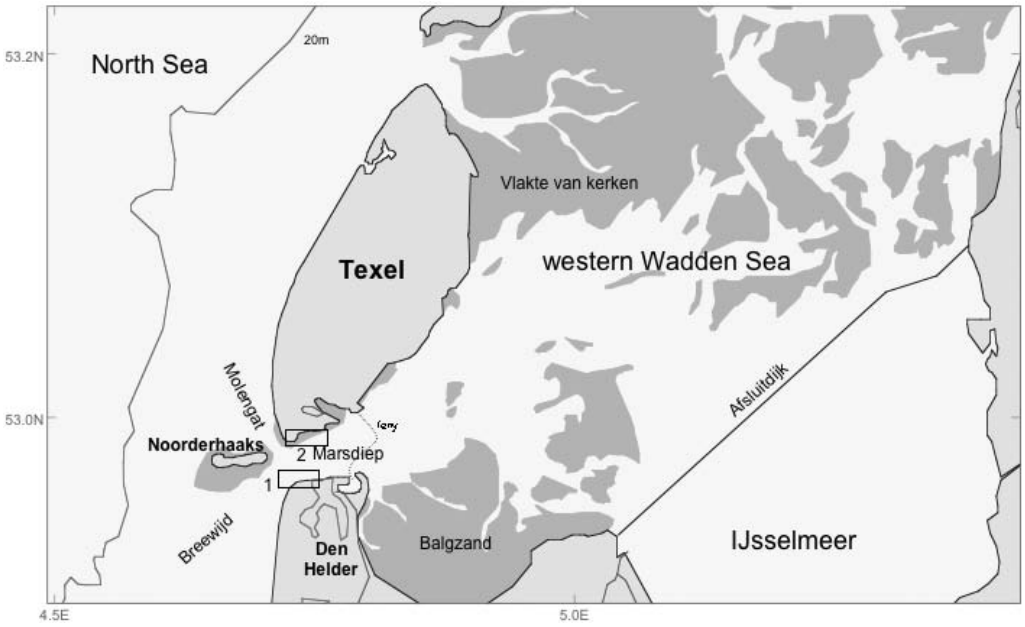

Figure 1. The Marsdiep area and locations mentioned in this article. Dark shadings around Noorderhaaks, in the Balgzand area and off Texel are intertidal mudflat areas, exposed during low tide. Two boxes indicate the main feeding sites: (1) Helsdeur off Kaap Hoofd near Den Helder and (2) the shallow zone off the southern tip of Texel.

whale during their daily systematic watches, at around 10:00 in the morning, the standby team from Texel was called out to assess the condition of the whale, confirm the identification, document its characteristics for identification and study its behaviour. The whale was followed at close range for three quarters of an hour. It appeared to be feeding and showed no signs of discomfort. It was trailed from the side and behind to avoid disturbance and seemed completely unconcerned about the present of the small boat. When the animal stopped feeding and swam towards the centre of the sound, the trailing was abandoned and the ship returned to Texel. A subsequent trip later that afternoon did not provide a sighting.

In the course of the next morning (13 May), the whale was spotted in the Breewijd area, off Huisduinen. At that time, it was performing rather deep dives, submerging for 5-10 minutes at a time. After just over half an hour of diving in that area, it suddenly moved towards the coast and started surface skimming close to the shore, as on the previous day. Three small boats were present in the area, keeping a fair distance so as not to hinder the animal in any sense. It was clearly the same animal, characterised by a partly whitish dorsal fin. Later that afternoon, the same whale was reported swimming off the south coast of Texel, bottom-feeding in very shallow waters and slowly working its way westwards. After having obtained sufficient photographic evidence of the identity of this animal, the whale was left alone, undisturbed. These were the last views obtained of the animal which has not been seen in the area since.

Individual identification

The whale's dorsal fin (figure 2) was broad-based but sickle shaped with a rather sharp tip and a fairly gentle hump in front. The ventral side of the dorsal fin was yellowish-white over the entire length, as was the tip. The right side of the dorsal fin was dark grey, with a fairly extensive whitish area along the front of the fin

Figure 2. Right (a) and left side (b) of the dorsal fin of the humpback whale in the Marsdiep area, showing a characteristic yellowish-white area over the entire top of the fin, which is more extensive on the left side. The other whitish scratches and scars around the dorsal fin may be of additional use for the individual recognition of this individual during future close encounters. *Photographs: Kees Camphuysen.*

and a distinct whitish scar pointing down/backwards at the front near the fin base. On the back and right side of the animal, just ahead of the bump, two whitish scars were visible at a distance of twice the finbase length in front of the fin (figure 2a). When seen from the left, much of the dorsal fin was whitish, even near the tip of the fin, with a distinct pattern of scars in the dark part of the fin. At the hump in front of the fin two clear white spot markings were visible. Slightly behind and below the dorsal, at the tailstock, a clear white scar pointed upwards

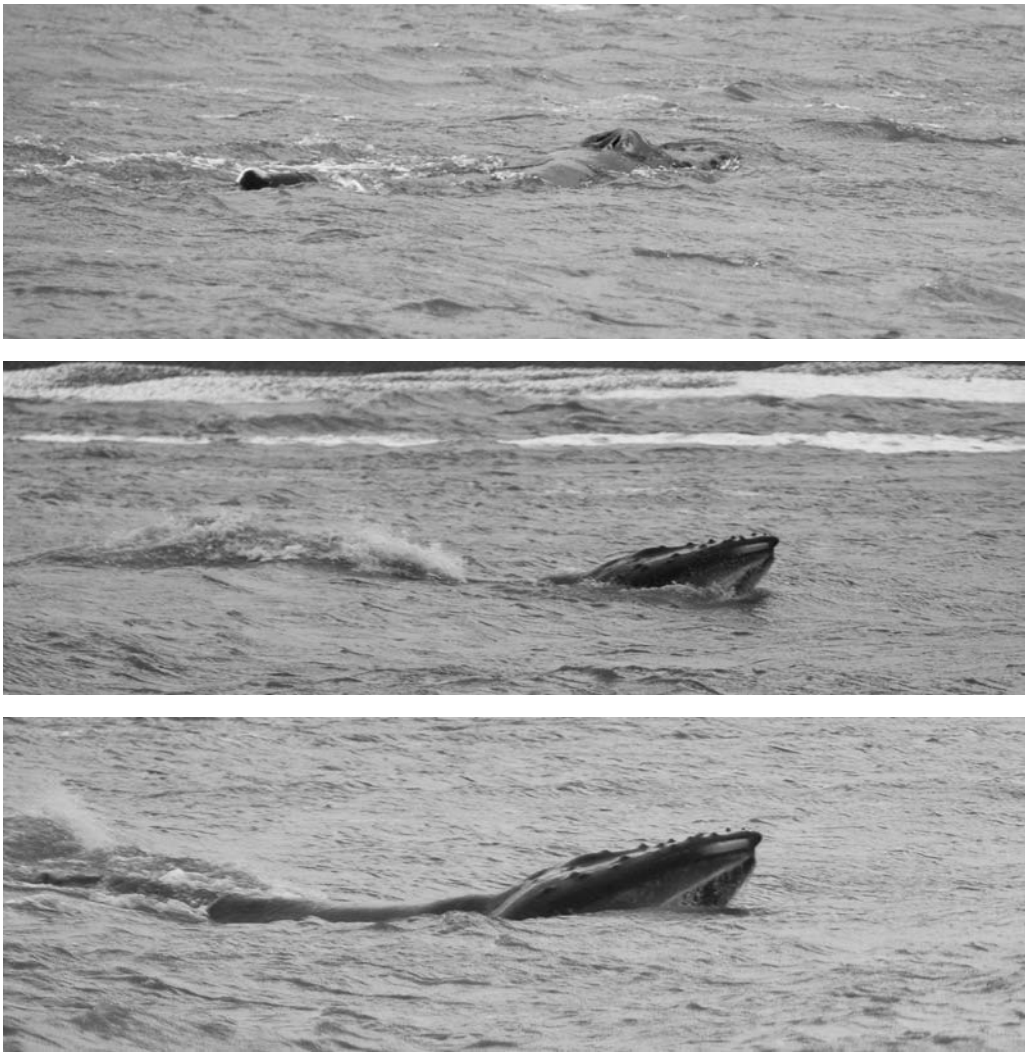

Figure 3. Surface skimming humpback whale. Swimming at the surface, with open mouth against the four knots flood current in an area later identified as a frontal zone between murky Wadden Sea water (background area) and clearer North Sea water (foreground area). The top photo shows the animal from behind, with the blowholes prominently visible and with the upper jaw fully level with the water surface. *Photographs: Kees Camphuysen.*

(figure 2b). The whitish area was clearly visible from the front, but even from behind the whitish pattern could be noted. The flukes of this whale were never seen above the surface.

Behaviour

Four different types of behaviour were observed, apart from travelling between areas: surface skimming, engulfment feeding, deep diving, and bottom feeding in shallow waters. Along the dike of Den Helder, the animal was *surface skimming* (figure 3): slowly swimming at the surface, with its mouth open against the four knots flood current. These feeding bouts lasted about 10-20 seconds, after which the throat was greatly expanded and water filtered out through the baleens. The animal followed a

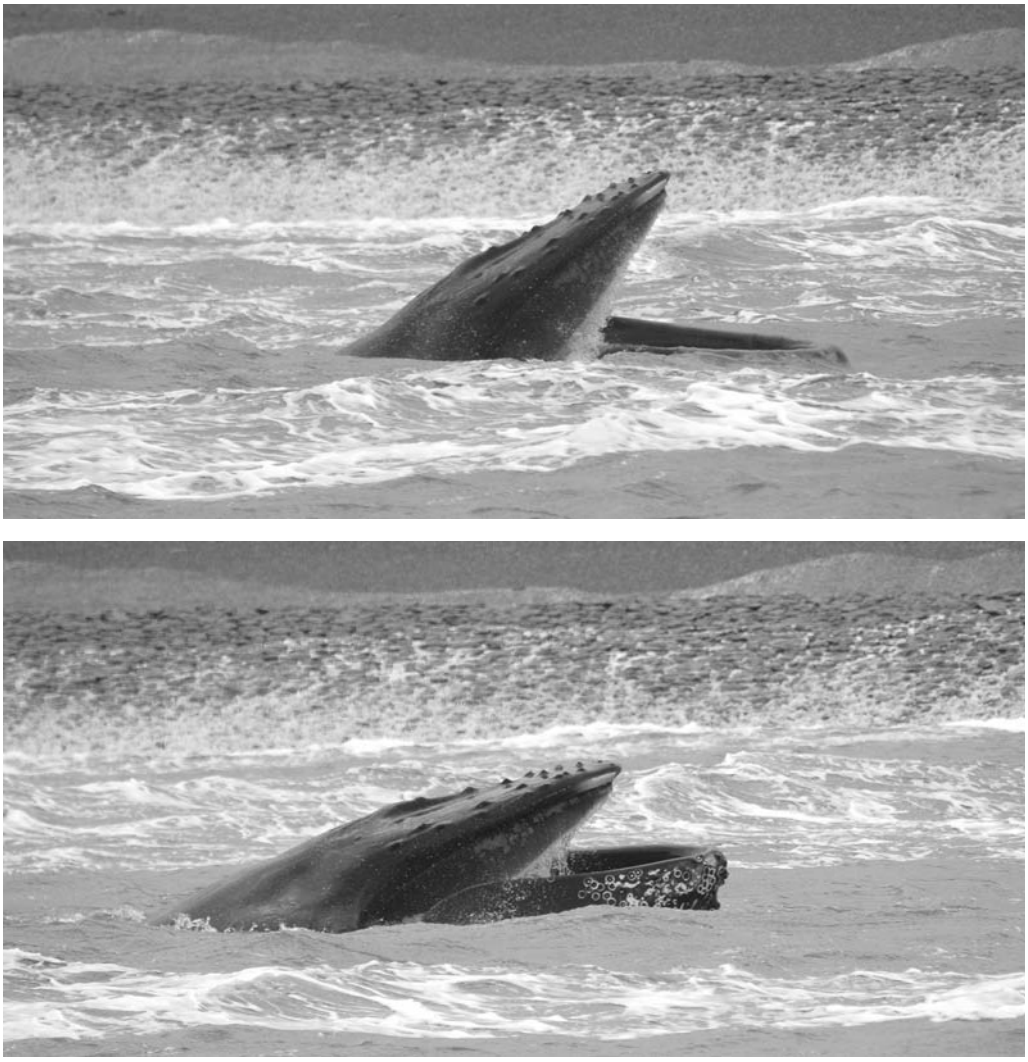

Figure 4. Rising higher out of the water, the humpback whale is surface feeding. With a water-filled mouth it is preparing to filter. *Photographs: Kees Camphuysen.*

zig-zag course, frequently returning to its starting position from where it would resume swimming slowly against the current.

Secondly, and partly as a variant on the surface skimming behaviour, the upper jaw appeared much more prominently above the surface (with the mouth wide open) and the lower jaw became visible as the mouth filled with water (figure 4). This followed a fairly steep upward move of the whale after a dive to some depth, behaviour that can be described as *engulfment feeding* which is typical for the rorquals (fin whales), although it is normally performed while swimming quickly towards a shoal of fish (Berta & Sumich 1999). This behaviour was commonly seen on 12 May, but rarely on the next day, when the whale was feeding in the same area but under calmer conditions. Both feeding techniques, surface skimming and engulfment feeding, aimed at

sampling the surface water. The animal worked a frontal zone of two water types, leaving and entering each zone in a regular fashion by following a zig-zag course that ran against the current.

The third technique was much less visible. The animal worked a very shallow (<5 m water depth), sloping area off a sandy beach at the southern tip of Texel, following a frontal zone indicated by accumulated flotsam and jellyfish. It dived frequently and fairly rapidly given the shallow water probably to the bottom to feed. The area was rich in surface feeding common terns (*Sterna hirundo*), sandwich terns (*Sterna Sandvicensis*), black-headed gulls (*Larus ridibundus*), common gulls (*Larus canus*) and some herring gulls (*Larus argentatus*), dipping for small sand eel (*Ammodytes* sp.). Local fisherman on board the trailing boat knew the area as a sand eel area (A. Vonk, personal communication).

In the fourth technique the whale conducted deeper dives in the central sound, which lasted many minutes at a time (following a period of 3-4 surfacings at a time). It is unclear what the animal was doing in this area, but it was probably either searching for prey at depth, or was awaiting another near shore foraging opportunity.

Feeding success and prey availability

There is no doubt that the animal was actively foraging, but there are no indications that this feeding was very profitable. When surface skimming the animal virtually failed to attract gulls and terns, and there were no visible prey leaping out of the water or the whale's mouth when the water was gulped through the baleen. It was obviously impossible to evaluate foraging success (if any) in the deep diving or bottom feeding whale, but while working that sandy bottom, (successful) foraging seabirds in the area at least indicated the presence of sandeels as prey in the top layers of the water column. Fish fyke catches in the Mokbaai area (a fish catching constant effort monitoring site of the Royal Netherlands Institute for Sea Research at Texel) revealed very low fish biomass during the whale visit (NIOZ, unpublished data).

Feeding habitat

The surface skimming behaviour was observed during (early) flood along the dike near Kaap Hoofd (Helsdeur, Den Helder). This nearshore area borders a gully of up to 50 m deep and the tidal current is particularly strong in that area. The Helsdeur is by far the deepest part of the Marsdiep area, which is otherwise between 12 and 30 m deep in the main shipping lanes. Later during flood, the animal worked waters off Texel between the TESO ferry terminal and the Molengat sea strait to the North Sea. This area is very shallow and the whale mostly frequented an area of 5-7 m water depth, apparently targeting sandeels as prey. The flood is two hours later in that area than the Helsdeur region as a result of water entering the Wadden Sea through the Molengat strait. Thus concentration of prey by tidal currents would occur at different times in the two regions.

The animal disappeared for considerable lengths of time. It should be noted that its presence in Molengat would easily go unnoticed as only few people frequent the southernmost tip of Texel and vantage points are few and far between in that area. Behind the sandy island of Noorderhaaks, the whale would be missed by coastal observers. Seawatchers at Huisduinen observed the animal at Schulpengat and Breewijd, Marsdiep, and Helsdeur. The humpback whale travelled some distance into the Wadden Sea (given the encounters with the Texel ferry), but not very far and probably not for very long.

Humpback whales in the Netherlands and Belgium

In Belgium, there is a single historical stranding of what is currently believed to have been a humpback whale (Blankenberge 1751, from a painting made in 1755; Camphuysen

Table 1. Recent sightings and strandings in the southern North Sea

Year	Month	Where	Event
2003	September	Nieuwe Waterweg-Maasvlakte (NL)	Carcass floating in Nieuwe Waterweg, misidentified and dragged back into the sea, stranded 7 October 2003 at Maasvlakte
2003-4	Dec-Jan	Katwijk-Scheveningen (NL)	Adult female and calf foraging in near shore waters; calf died presumably from drowning in fishing gear and washed ashore
2004	June	Vlieland (NL)	Stranding of dead immature female, total length 8 m, killed by strangulation from a line around the neck
2006	March	Lombardsijde, Nieuwpoort (B)	Stranding of dead female, total length 10.5 m, probably killed after being hit by a ship's propeller
2007	May	Marsdiep-western Wadden Sea (NL)	Subadult foraging in tidal inlet for a period of at least 3

& Peet 2006), but that was previously listed as a northern right whale (*Balaena glacialis*) (DeSmet 1974). This is the only likely historical case of a humpback whale known to have stranded along the coast of The Netherlands and Belgium, despite a long record of documented large whale strandings dating back to about 1250 (van Deinse 1931, Sliggers & Wertheim 1992).

The first humpback whale record in the Netherlands dates back to just September 2003 (table 1), when a whale corpse floating in Nieuwe Waterweg (the entry to Rotterdam harbour) was originally misidentified as a minke whale (*Balaenoptera acutorostrata*). It was dragged back into the North Sea but the corpse washed ashore at Maasvlakte one week later, but was too decomposed to be of much use for a museum collection (Smeenk et al. 2003).

It took only a few months before the next two humpback whales turned up. A mother and calf were seen off the mainland coast near Scheveningen, on the 18th of December 2003. Given the diet and exceptional abundance of foraging piscivorous seabirds in that area they were possibly attracted to these near shore waters because of rich stocks of small clupeids and other fish.. Unfortunately, the calf got caught in fishing gear and drowned before being cut loose by a fisherman. It washed ashore the next day, with the flukes and part of a flipper chopped off (C. Smeenk, personal communication; Camphuysen & Peet 2006). The adult female continued to utilise the coastal waters at least during January 2004, through was seldom seen and not hindered by anyone.

Within half a year, the fourth humpback whale was recorded. A freshly dead young female, about eight metres in length, was found washed ashore at Vlieland, with a rope around her head that had grown into the vital organs (death through strangulation). Goose barnacles on the rope suggested its oceanic origin and the material of the line suggested the rope had served to retrieve lobster pods (A. Vonk, personal communication; this type is not in use anywhere in the southern North Sea). There were reasons to believe that this whale had been swimming around with the loop around the body for a long time during maturation and growth, probably long before in entered the North Sea (van der Meij & Camphuysen 2006).

The most recent animal to wash ashore, in March 2006, was a 10.5 m long female humpback whale, at Lombardsijde, close to Nieuwpoort (Belgium). This had bled to death after a hit, presumably by a ship's propeller, although the corpse was in an otherwise good condition (Haelters 2006).

Discussion

Individual identification

Whale catalogues usually focus on the ventral side of the flukes when documenting the indi-

vidual characteristics of humpback whales (Katona & Whitehead 1981). Even although the individually unique markings may change during a whale's lifetime (Blackmer et al. 2000), the colour patterns and contours are usually sufficiently robust and consistent to facilitate subsequent individual re-identifications with a high degree of certainty, sometimes even on the basis of rather poor photographs. Unfortunately, no fluke shots were obtained during any of the observations in the Marsdiep area. Kaufman et al. (1990) have used lateral body markings of humpback whales and tail fluke markings to document the movements of individual whales around Australia. Many other studies (in other cetaceans) have used the unique characteristics of dorsal fins to describe individuals and to facilitate recognition during re-sightings of the same individual whale or dolphin (e.g. Similä et al. 1995, Mazzoil et al. 2004). There is no doubt that the dorsal fin of this particular individual is peculiar and that that future sightings and positive identifications can be expected from this.

There were witness reports, also made by skilled observers, of at least two individuals seen simultaneously but not together. However there is no evidence of a second animal from the accumulated photographic material. This might be because most pictures were taken from Den Helder, and that a second animal may not have frequented this specific part of the Marsdiep. However, in the absence of any proof, it seems sensible to log the event as a single, solitary (immature) whale working the Marsdiep area for a period of four days (10-13 May 2007).

Foraging behaviour

The foraging behaviour observed may be considered typical for humpback whales in their more traditional areas. Even though surface skimming is characteristic for right whales *Balaena* spp., is also a well known technique among humpback whales (Croll & Tershy 2002). Zonfrillo (1996) described a similar encounter with an extra-limital young humpback whale patrolling an area of the upper Clyde (west Scotland), which on occasion approached within 20m of the public esplanade of the small town of Greenock. This individual was bubble netting and shoals of small fish, probably young herring, could be seen showering from its open mouth as the humpback surfaced. Unusually large numbers of auks, grebes and divers were also present in the Clyde estuary during the same period, suggesting an abundant food supply. The Marsdiep humpback entered the estuary when food was far from abundant. No prey was seen to escape from its mouth when it was surface feeding and there were few foraging seabirds in the area. It is estimated that the individuals require around one tonne of small fish as a daily requirement (Zonfrillo 1996) so it is no surprise that the individual quickly abandoned the area. Only four weeks after the whale had left the area, small herring became overabundant in the Marsdiep area and feeding frenzies of seabirds could be seen everywhere. Had the visiting whale arrived late May or early June, there would have been plenty of profitable feeding opportunities, and the whale might have stayed longer.

Humpback whales in the North Sea

With this most recent sighting, there have now been six occurrences of humpback whales in the south eastern North Sea within four years, following a period of centuries during which not a single case could be documented. Three of these arrived dead, three were seen alive and one of those drowned in fishing gear. Most sightings from the North Sea were until recently from the Shetland Islands, where the first humpback whale since 1929 was sighted in June 1992 (Osborn 1993), with subsequent sightings in May and September 1993, and up to three individuals seen annually throughout the summers of 1994-98 (Evans 2006). Most of the summering individuals were seen around Sumburgh Head (south Mainland,

Shetland Islands) and were presumably feeding on sand eels (Harrop 1995). Since the mid 1990s, scattered sightings and strandings of humpback whales have occurred in various locations around the North Sea, including off of Aberdeen (summer 1997), the Moray Firth (July 2001 and July 2002), in the Danish coast (2002), the Firth of Forth (February 2003), and several other sightings off the east coast of Scotland in recent years (Camphuysen 1998, Anonymous 2003, Kinze et al. 2003, MacDonald 2007, Cetacean Research and Rescue Unit (Banff), unpublished data). Many, but not all, humpbacks in the North Sea were rather young immatures. The six reports in the Southern Bight in the early 21st century fit quite well with the apparent increase in sightings in the North Sea at large in recent years. The explanation for this should be sought for in the Atlantic Ocean, where the humpback whale naturally occurs.

Humpback whales in the North Atlantic

Humpback whales are highly migratory, spending spring through to autumn in their feeding areas in the mid- to high latitude waters and winter at calving grounds in the tropics (Clapham 2002). In the eastern part of the north Atlantic humpback whales are common in summer in the waters off Iceland and in the Norwegian and Barents Seas (Christensen et al. 1992, Smith et al. 1999, Stevick et al. 2006). Very few are seen farther south but they are occasionally sighted in the northern North Sea, to the west of the UK, to the south and southwest of Ireland and in the Bay of Biscay. The frequency of sightings involving small numbers around the UK and Ireland has increased since the 1980s (Evans et al. 2003, Evans 2006). Sightings from around the British Isles occur in three main areas: (1) Northern Isles, south to eastern Scotland, (2) northern Irish Sea to South-west Scotland; and Celtic Sea between southern Ireland, South Wales and South-west England. In UK shelf waters, the species occurs mainly from May-September, with some sightings in winter (November-March) and this is supported by acoustic recordings from hydrophone arrays in the north and west of Scotland and Ireland (Clark & Charif 1998, Charif & Clark 2000, Charif et al. 2001). Sightings in Ireland (mainly from the south coast) increase through the summer, reach a peak in September with a rapid decline thereafter (Evans et al. 2003).

Migratory destinations of humpback whales in the eastern part of the north Atlantic were investigated using natural markings. In the winter the whales migrate to areas around the West Indies (Stevick et al. 2003a) or the Cape Verde Islands (Jann et al. 2003). The southern North Sea is not on a migration route and most migration appears to occur further offshore (Charif et al. 2001). Long-distance foraging movements appear to be more prevalent in the eastern rather than the western north Atlantic, reflecting the abundance and predictability of prey and this may influence occasional longer movements (Stevick et al. 2006). The recent presence of humpbacks in the southern part of the North Sea may thus be a response to recent changes in preferred prey elsewhere. Small numbers, particularly of young animals, have been reported as occurring outside of traditional feeding or breeding areas. It is also possible, indeed likely, that the increase in the population of humpback whales in the Atlantic Ocean (a rate of increase of 0.031 is presented by Stevick et al. 2003b) has led to an expansion to new habitats.

Conclusions

An immature humpback whale visited the Marsdiep area (western Wadden Sea) for a period of four days in May 2007. This represented the sixth case of strandings and sightings in the Netherlands and Belgium since 2003, following a 250 year period without a single occurrence. This visit was also the first documented case of a foraging baleen whale in the Wadden

Sea area. Feeding conditions were poor and the whale soon abandoned the area. The sighting follows an increase in sighting frequency in the North Sea at large since 1992, which is presumably due to a general increase in stocks in the Atlantic Ocean, leading to expansion to new habitats.

Acknowledgements: Numerous people contributed in one way or the other to this article, mainly by supplying information during the brief visit of the humpback whale in the Marsdiep area. Rutgert Oosterhuis, skipper of *Het Sop*, has to be thanked in particular for his enthusiasm and willingness to drive scientists around at short notice. G. Tijsma and R. Stekelbos (coastguard), Dominiek de Jong (VC Brandaris), and Oscar Bos (Ecomare) were among the first to report the whale. My thanks also go to the personnel from the 'Verkeerstoren Den Helder' (coastguard), workers at Animedics (Den Helder), Adrie Vonk, Arnoud van den Berg, Ben Schrieken, Ben Wielstra, Chris van der Vliet, Frank van Duivenvoorde, Hans Verdaat, Ineke Vonk, Jan Haelters, Kees de Graaf, Kees Rebel, Mardik Leopold, Rinse van der Vliet, Sytske Dijksen, teh TESO ferry bridge personnel and Tim van de Nus. Jan Boon was a great help in handling the excessive media attention. Two anonymous referees and Kees Canters kindly and extensively commented on an earlier version of this text, as a result of which substantial improvements were made.

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Samenvatting

Foeragerende bultrug (*Megaptera novaeangliae)* in het Marsdiep (Waddenzee), mei 2007, en een overzicht van waarnemingen en strandingen in de zuidelijke Noordzee, 2003-2007

Een bultrug (*Megaptera novaeangliae*) werd waargenomen in het Marsdiep (westelijke Waddenzee), van 10 tot en met 13 mei 2007. Het dier foerageerde in sterke getijdestromen op de rand van een bijzonder diepe plek in het Marsdiep voor de Helderse zeewering en langs het strand van Texel in uitgesproken ondiep water. De bijzondere kenmerken van de rugvin zijn gedetailleerd beschreven, om eventuele vervolgwaarnemingen elders in Europa van dit

individu mogelijk te maken. De wijze van foerageren, de omstandigheden waaronder naar voedsel werd gezocht, de bezochte gebieden en de mogelijke prooidieren in het Marsdiep worden beschreven. Bultruggen zijn buitengewoon zeldzaam in de zuidelijke Noordzee en werden tot dusverre nog nooit in de Waddenzee gezien. Het artikel besluit met een overzicht van de recente gevallen in Nederland en België en een overzicht van de klaarblijkelijke toename van meldingen in de Noordzee en Europa in de afgelopen tientallen jaren. Historische gegevens suggereren dat bultruggen hier altijd bijzonder schaars zijn geweest. De recente toename in de Noordzee zou kunnen zijn veroorzaakt door een zeker herstel van de Atlantische populatie.

Received: 17 May 2007
Accepted: 25 August 2007

Short Note

First records of *Plecotus auritus* (Linnaeus, 1758) and *Plecotus macrobullaris* Kuzjakin, 1965 in the Republic of Macedonia

Results of a mammal survey in Galicica National Park (II)

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This paper reports the first observation of brown long-eared bat (*Plecotus auritus* (Linnaeus, 1758)) and Alpine long-eared bat (*Plecotus macrobullaris* Kuzjakin, 1965) in the Republic of Macedonia. By the end of July 2006 the presence of five long-eared bats *Plecotus* spec. was established in the south western part of this country. Four of these bats were captured within the Galicica Mountains, between Lake Ohrid and Lake Prespa, while the fifth specimen was caught at Leva Reka, near the city of Resen (figure 1). Four of the *Plecotus* specimens were adults while the fifth, a male (specimen 4) was in his first year. The females, caught on 27, 29 and 31 July respectively, were all lactating.

Details of the long-eared bats, such as sex, forearm length, weight as well as details of the site of capture, such as date, name, altitude, and geographical position, are provided in table 1. From three of the long-eared bats the length of digit 1 was measured according to Schober & Grimmberger (2001). These measurements as well as other characters exclude *Plecotus austriacus* (Fischer, 1829) and *Plecotus kolombatovici* (Đulić, 1980) for specimens 1, 4 and 5, while for specimens 2 and 4 these measurements also exclude *Plecotus macrobullaris*. The tragus length of specimen 1 (14.2 mm) confirms the identification of *Plecotus auritus*, while the tragus length of specimen 5 (16.2 mm) as well as the tragus width (5.7 mm) indicates *Plecotus macrobullaris*; despite the relatively short digit 1 (6.5 mm) not corresponding with reference data for this species. Pictures were made of specimens 1, 2, 3 and 5. The shape of the tragus of specimen 3, and of the big supraorbital gland, indicate *Plecotus auritus* according to Kiefer & Von Helversen (2004a) (photo 1 and 2).

DNA samples of wing membrane tissue were collected from all the bats and were processed by Andreas Kiefer at the University of Mainz. In a personal communication he confirmed the identification of *Plecotus auritus* (eastern lineage) in specimens 1-4, with specimen 5 turning out to be *Plecotus macrobullaris macrobullaris* (= eastern lineage) (photo 3).

All *Plecotus auritus* (specimens 1 to 4) were caught in mistnets stretched out horizontally over three artificial cattle pools: the "Walled Pond", the "Campsite Pond" and the "Grebenine Valley Pond", respectively (table 1). The geographical positions, according to the Universal Transverse Mercator (UTM) co-ordinate system, of these three mistnet sites are situated in two adjacent km UTM squares, denoted (dots) in figure 1. *Plecotus macrobullaris* (specimen 5) was caught in an 18 m mistnet over the Leva Reka stream: a small stream, outside the Galicica National Park, shown in the km UTM square asterisk, north of Resen in figure 1.

On the night of July 27 the sky was partly clouded with temperatures between 14° and 10° C in the mountains. Two days later (July 29) the night-sky was clear and the temperatures dropped to 6.5°C. On July 31 the sky was again partly clouded and

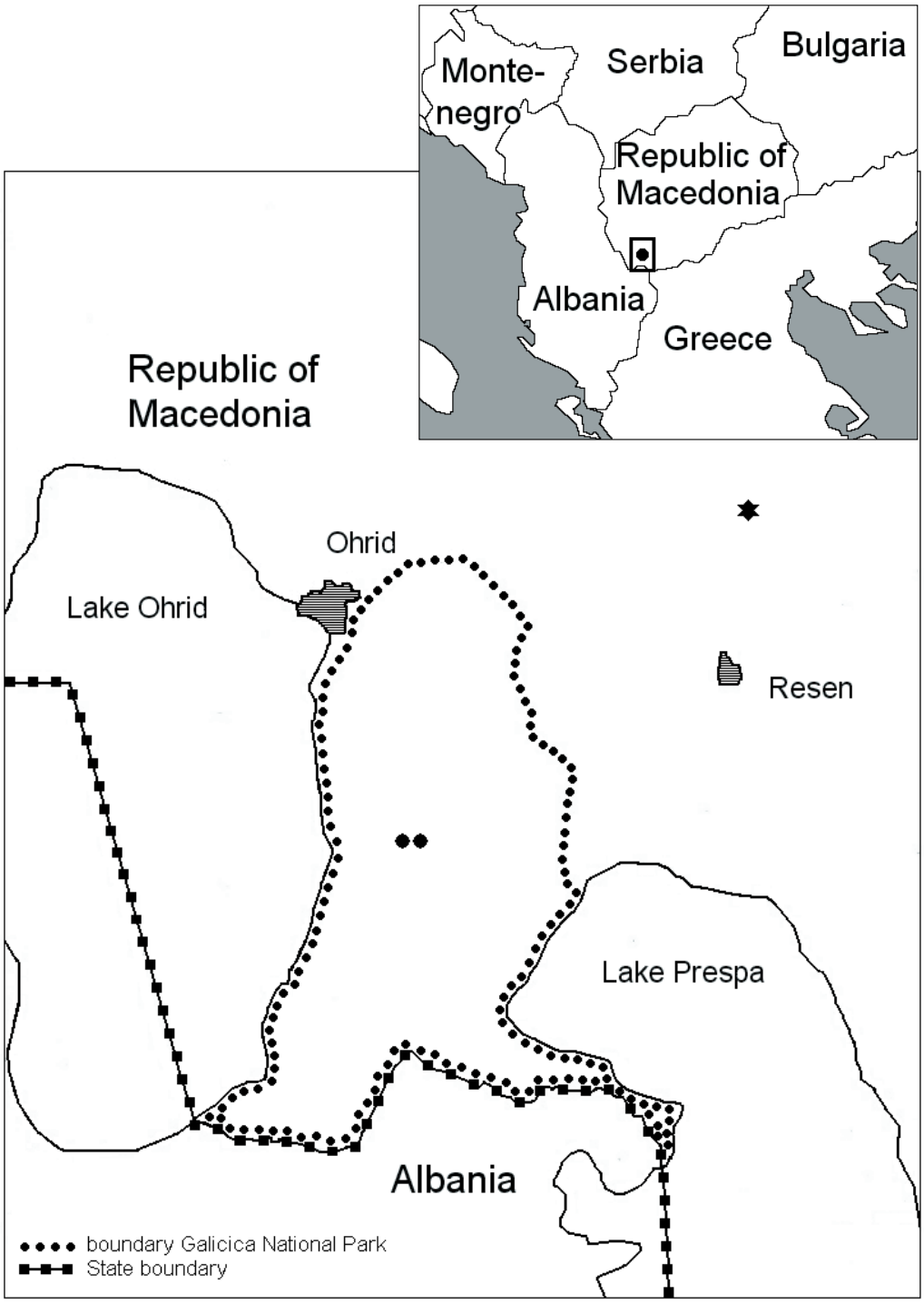

Figure 1. The recorded locations of brown long-eared bat *Plecotus auritus* (dot) in Galicica National Park and of Alpine long-eared bat *Plecotus macrobullaris* (asterisk) near Resen, Republic of Macedonia, Southeast Europe.

Photo 1. Brown long-eared bat (*Plecotus auritus*); female, Macedonia, July 28, 2006. The pointed shape of the tragus is clearly visible. *Photograph: Rollin Verlinde*.

Photo 2. Brown long-eared bat (*Plecotus auritus*); female, Macedonia, July 28, 2006. The big supraorbital glands are clearly visible. *Photograph: Rollin Verlinde*.

Photo 3. Alpine long-eared bat (*Plecotus macrobullaris*); female, Macedonia, July 31, 2006, showing the lancet-shaped tragus. *Photograph: Jeroen van der Kooij*.

Photo 4. Mistnetting near Leva Reka. *Photograph: Jeroen Willemsen*.

Table 1. Details of captured long-eared bats (*Plecotus* spec.) and weather conditions; FA: fore-arm, dig1: length of digit 1, W: weight, trl: tragus length, trb: tragus breadth, n.r.: not recorded.

Date / Site	Specimen	Altitude	Geographical position	Sex	FA	dig1	W	trl	trb
27-7-2006 / Campsite Pond	# 1	1473	N: 41° 01' 38'' E: 020° 51' 28''	F	41.2	7.3	8.4	14.2	n.r
28-7-2006 / Grebenine Valley Pond	# 2	1400	N: 41° 01' 50'' E: 020° 50' 35''	M	38.0	n.r.	6.3	n.r.	n.r.
28-7-2006 / Grebenine Valley Pond	# 3	1400	N: 41° 01' 50'' E: 020° 50' 35''	F	40.0	n.r.	7.5	n.r.	n.r.
29-7-2006 / Walled Pond	# 4	1481	N: 41° 01' 50'' E: 020° 51' 07''	F	39.8	8.0	7.9	n.r.	n.r.
31-7-2006 / Leva Reka stream	# 5	963	N: 41° 09' 10'' E: 020° 00' 24''	F	40.7	6.5	9.5	16.2	5.7

temperatures remained between 17.5° and 16°C. On July 31 in the plains near Leva Reka the night temperatures ranged from 25° to 20°C (table 1). No weather recordings were made on July 28.

A total of 52 bats were caught in mistnets over eight nights at ten different locations in 14 sessions (Buys 2006). The captures of three serotines (*Eptesicus serotinus*) were published earlier in this journal (Boshamer & Bekker 2006).

Kiefer (2004) recently described the rather complex status of the genus *Plecotus* in Europe and we follow him in our recognition of *Plecotus macrobullaris*, based on morphological and DNA (ndI) criteria, as well as *Plecotus sardus*, *Plecotus kolombatovici*, along with undisputed species such as *Plecotus auritus* and *Plecotus austriacus*. This would lead to a redrawing of the distribution of *Plecotus auritus* in southeast Europe. Von Horáček & Đulić (2004) accept this, categorising specimens from Crete and Sardinia as *Plecotus kolombatovici* or *Plecotus alpinus* (= *Plecotus macrobullaris*) and *Plecotus sardus* respectively.

The distribution map of *Plecotus auritus* in *The atlas of European mammals* (Entwistle 1999) shows that this species has been observed in the eastern 50 km UTM square (Greece), adjacent to the area where we did our fieldwork. Kryštufek & Petkovski (2003) mention the presence of the *Plecotus austriacus* in the Republic of Macedonia. *Plecotus auritus* has not previously been recorded in this country and this is the first observation of the brown long-eared bat in the Republic of Macedonia.

To date records of *Plecotus macrobullaris* are mostly restricted to the Alps; with single observations from the isles of Sardinia and Crete, the Pyrenean Mountains and two locations in the north of Greece (Kiefer & Helversen 2004b). The presence of *Plecotus macrobullaris*, in this area, establishes a third location, clustered around northern Greece and southwest Macedonia.

Acknowledgements: We would like to thank all the participants of the Field Study Group of the Dutch Society for the Study and Conservation of Mammals (VZZ) who voluntarily helped in 2006 with the "Results of a mammal survey in Galicica National Park I and II". We are grateful to Andreas Kiefer (University of Mainz) for processing the DNA samples. We also would like to thank Dr. Svetosar Petkovski and Dr. Vesna Sidorovska, President and Vice-President of Bioeco, for permits and Mr. Andon Bojdan, Director of the Galicica National Park, for permission to carry out the survey.

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Samenvatting

Eerste waarneming van Plecotus auritus (Linnaeus, 1758) en Plecotus macrobullaris Kuzjakin, 1965 in de Republiek Macedonië – Resultaten van een zoogdierinventarisatie in Galicica Nationaal Park (II)

Tijdens vangacties met mistnetten in het Galicicagebergte, tussen het Ohridmeer en het Prespameer in de Republiek Macedonië, werden eind juli 2006 vijf grootoorvleermuizen in mistnetten gevangen. DNA-analyse bracht aan het licht dat het vier gewone grootoorvleermuizen (*Plecotus auritus* (Linnaeus, 1758)) betrof en een Alpen-grootoorvleermuis (*Plecotus macrobullaris* Kuzjakin, 1965). Hiermee werden deze twee soorten voor het Macedonische faunagebied vastgesteld.

Received: 4 April 2007
Accepted: 16 May 2007

Short Note

European mink (*Mustela lutreola*) still surviving in Ukrainian deltas of the Danube and Dniester

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The Ukrainian part of the Danube delta was surveyed between 26 February and 3 March 2007 to determine if the European mink (*Mustela lutreola*) (photo 1) still occurs in that area. trap two European mink in three trapping nights (1 ♀ and 1 ♂ near 45°18' N, 29°44' E; figure1). A hair sample was taken for genetic analysis after which the animals were released. Due to

Photo 1. The European mink (*Mustela lutreola*) has a conspicuous white coloration on its upper lip and around its nose. This is absent in the American mink (*Mustela vison*). *Photograph: Addy de Jongh.*

Live traps were built (photo 2), similar to those used by Kranz et al. (2004) in 2003 and 2004 in the Romanian part of the Danube delta. With a nightly average of 18 traps set, we were able to bad weather conditions (e.g. high water, frost) no tracks of European mink could be found in the area. The trapping was negatively influenced by the frequent capture of brown rats (*Rattus norvegicus*) and the overturning and dragging away of traps by the abundant raccoon dog (*Nyctereutes procyonoides*). During a visit to the Dniester delta on the border of Moldova and the

Photo 2. The second European mink in the live trap. *Photograph: Addy de Jongh.*

Photo 3. The frozen road victim from the Dniester delta. *Photograph: Tjibbe de Jong.*

Ukraine a European mink road victim was found (photo 3), indicating that a population of mink exists in that area as well.

Recent introductions of the American mink (*Mustela vison*) in the Danube delta are believed to have caused population declines and local extinctions of European mink. Males of the American mink are able to mate early with European mink females producing resorbed hybrid offspring and could prevent successful reproduction in European mink (Ternovskij & Ternovskaya 1994). American mink is more aggressive and produces more offspring in a single season. Studies with radio telemetry on both mink species have indicated that European mink may be chased away from its home range by invading American mink (Sidorovich 1997). The combination of these two factors has been suggested to have contributed to the decline of European mink populations (Maran 2007) (figure 2).

To assess the risk for European mink in the Ukrainian part of the Danube delta, we questioned trained foresters in the area. In the Soviet time, there was an American mink fur farm in the neighbouring city Izmail. After the collapse of the Soviet system the fur farm was dismantled.

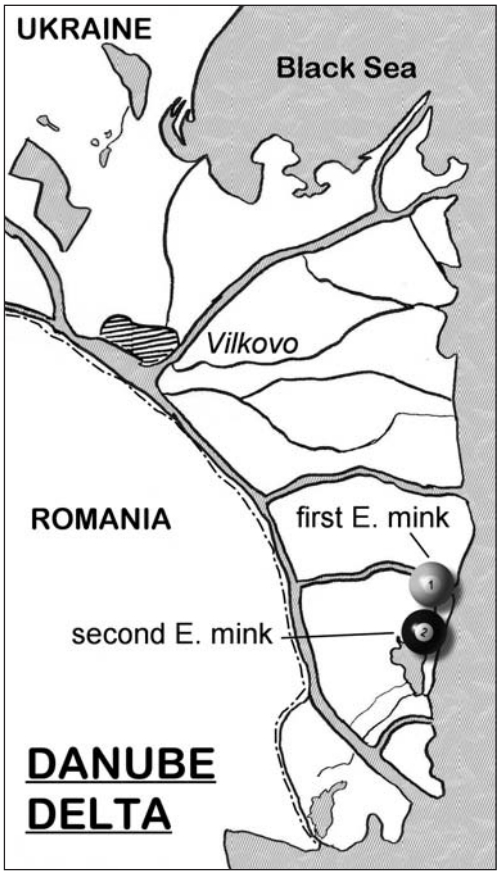

Figure 1. Locations in the Danube delta where both European mink were trapped.

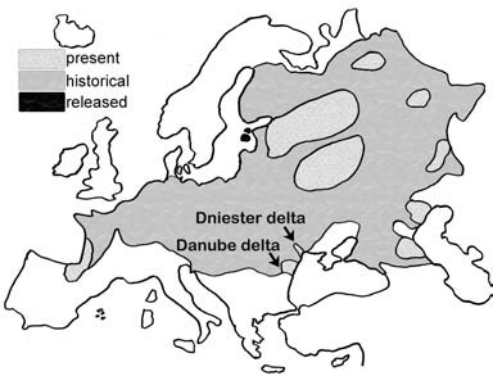

Figure 2. The historical and present geographic distribution of the European mink. Note the released populations on the large Estonian islands of Saaremaa and Hiiumaa.

The foresters suggested that it was unlikely that any of these animals survived, and could show that only European mink were seen in the area.

A biologist specialised in the Dniester ecosystem also confirmed that European mink were living in this delta, but very low numbers were thought to occur (N.V. Rozhenko, personal communication). The pelt of a European mink caught here at the end of the 20th century indicated that European mink occurred in this delta around ten years ago. There were no indications of American mink in this area. A decline in the European mink population was thought to be the result of a newly constructed dam on the river Dniester (further north in Moldova) which regulates the water level and negatively influences the mink's habitat. The dam mainly reduced fluctuations in water levels of the river, negatively affecting the food resources of the European mink (N.V. Rozhenko, personal communication).

We will continue research in both deltas, with the aim of enhancing our understanding of the occurrence and population size of European mink. Depending on our findings, a telemetry study will be set up to improve our knowledge about home ranges and daily activities of this species. A rescue plan for the survival of the European mink in this region needs to be developed urgently.

Acknowledgements: We thank Alexander Voloshkevych, director of the Ukrainian Danube Delta Biosphere Reserve, for his hospitality, help and advice. We also thank the foresters of the reserve for their company, friendship and willingness to cooperate. We are grateful for the important input of Mr. Tokar senior, the father of one of the authors, for his rapid and professional construction of the live traps. Last but not least, we are grateful for the equipment and advice provided by our Irish colleague Lughaidh Ó Néill.

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Samenvatting

Europese nerts *(Mustela lutreola)* overleeft nog steeds in Oekraïense delta's van Donau en Dnjestr

In de periode tussen 26 februari en 3 maart 2007 slaagden de auteurs er in twee Europese nertsen te vangen in het Oekraïense deel van de Donau delta. Hiermee is aangetoond dat de Europese nerts zich hier nog weet te handhaven. De dieren zijn na de vangst gelijk weer vrijgelaten. De boswachters van het Oekraïense Donau Biosfeer Reservaat gaven aan dat zij in het reservaat alleen Europese nertsen hebben waargenomen. De Amerikaanse nerts, die in andere delen van Europa de Europese nerts heeft verdrongen, werd niet aangetroffen. Vanwege de vroegere aanwezigheid van een pelsdierfokkerij in de nabijheid werd gevreesd dat de Amerikaanse nerts zich in het gebied kon vestigen. Dat bleek niet het geval te zijn. In de Dnjestr delta ten oosten van de Donau delta toonde een verkeerslachtoffer aan dat ook hier de Europese nerts zich wist te handhaven. Ook hier worden geen Amerikaanse nertsen aangetroffen. Door de aanleg van een dam in de rivier de Dnjestr is volgens een plaatselijke deskundige de locale populatie sterk achteruitgegaan. De auteurs gaan in samenwerking met Tsjechische en Oostenrijkse collega's door met het onderzoek. Er zijn sterke aanwijzingen dat er verder naar het oosten langs de Zwarte Zee kust nog meer populaties van de Europese nerts voorkomen. Een internationaal onderzoeksprogramma is in voorbereiding om de Europese nerts in deze regio te behouden. Het onderzoek moet uiteindelijk uitmonden in een betere bescherming en overleving van de soort in deze regio.

Received: 27 April 2007
Accepted: 30 May 2007

Book Reviews

Rabbits, refuges and resources

Rabbits, refuges and resources. How foraging of herbivores is affected by living in burrows. J.J.A. Dekker 2007. PhD thesis. Wageningen University, Wageningen, The Netherlands. 144 pp. ISBN 90-8504-611-4.

When walking in the dunes or other areas with a lot of rabbits you will probably notice variations in rabbit grazing intensity: closer to the rabbit burrows there are very short lawns with abundant rabbit droppings, whereas further away the vegetation gets taller with only a few droppings. This is a typical pattern found for herbivores which forage from burrows: a group referred to as "central-place foragers". European rabbits are a good example of this category of, mostly smaller, herbivores. Such species occur all over the world and include: American pikas living in the Rocky Mountains, Daurian pikas on the Asian steppes, hoary marmots in the alpine zone of North-America, rock hyraxes on African savannas and prairie dogs on the North-American prairie. These herbivores share the common feature of living in refuges, mostly burrows, from which they forage.

Jasja Dekker's thesis explores the factors that shape the spatial patterns of foraging activity amongst central-place foraging herbivores. It tests several factors that may explain the gradient of foraging intensity which decreases with distance from burrows. These factors include: vigilance against predators (Chapter 2), variation in food quantity and quality (Chapter 3), seasonal variation in plant growth (Chapter 4), interactions with larger, free-ranging, herbivores (Chapter 5 and 7) and social interactions between rabbits (Chapter 6). To test the importance of these factors he uses a combination of creative experiments and modelling. The experiments used domestic rabbits, as newly caught wild rabbits often experience great stress when kept in experimental conditions.

To test the effect of vigilance on spatial foraging patterns in rabbits (Chapter 2), domestic rabbits were enclosed on uniform grassland and their foraging behaviour was monitored for five weeks. The rabbits first depleted the vegetation close to their artificial refuges. As they moved further from the burrow more time was spent on vigilance in relation to foraging time. Under increased perceived predation risk (induced by playing buzzard sounds) spatial foraging behaviour did not change but the time spent on both foraging and vigilance increased. In a subsequent experiment the effect of food quantity and quality was tested using pellets containing low and high quality grass (Chapter 3). In an indoor setting rabbits were offered trays of pellets of differing quantity and quality, positioned at different distances from their artificial burrows. The rabbits first depleted the nearest trays before moving to the more distant trays. The order of tray visits was determined by both the quantity and quality of the pellets.

Whereas the second and third chapters mostly tested separate mechanisms under artificial conditions, Chapter 4 focuses on the seasonal dynamics of the food source of rabbits. This is a novel approach, and the chapter that I found the most interesting. Seasonally grasses grow at different rates and the interaction between these rates and grazing pressure means that food availability and quality is constantly changing. In an outdoor experiment three pairs of rabbits were each introduced onto an enclosed strip of grassland. After one growing season the rabbits had created a gradient in grass quantity and quality: quantity increased with distance from the burrows, whereas quality declined. The rabbits foraged close to the burrows early in the season, but expanded their foraging area when growth declined and the vegetation close to the burrows became depleted. This experiment illustrates well the dilemma of central-place foragers: when food availability declines they have to go further afield, resulting in more risk and less rewards per unit time spent foraging. Free-ranging

herbivores do not have this problem as they can move to areas where more food is available.

The central-place foragers' dilemma can be resolved when free-ranging large herbivores lower the vegetation height, resulting in a higher intake by rabbits, creating a facilitative effect (Chapter 5). Dekker models this relationship in space, i.e. he predicts that facilitation only occurs in areas which sustain a high plant production. When production is too low central-place foragers do not benefit from the presence of free-ranging large herbivores as they are competing for the same limited food source.

In the synthesis (Chapter 8), Dekker expands on this facilitation effect. Facilitation of small herbivores by large ones has been shown to occur in the field, but only in the sense of increased patch use by rabbits or other small herbivores. However, it would be very interesting to know whether this increased patch use eventually leads to increased numbers of rabbits, i.e. facilitation at the population level. Dekker's model addresses and predicts this issue, which is a highly relevant question for nature conservation. With the decline of rabbit numbers in Western Europe due to the RHD virus, it is useful to know whether the return of rabbits could be facilitated by introducing large herbivores (such as cattle or horses) for nature management purposes. In this case this has to be population facilitation. However, to restore rabbit numbers by introducing large herbivores, facilitation has to occur at the population level. Currently the outcome is unknown, as population facilitation has never been proven. This does not mean that it does not exist; although it is very difficult to prove, doing so involves having replicate populations where the conditions, apart from grazing by large herbivores, are standardized or at least similar. Dekker attempted to create an experimental setting for this, but the difficulties of getting a small founder population of wild-type domestic rabbits to reproduce, combined with problems with predators meant that no useful results could be obtained.

Despite this, the thesis gives a comprehensive overview of the factors affecting the foraging behaviour of central-place foragers. Even though European rabbits have been intensively studied, especially with relation to social interactions and disease ecology little was known about their foraging behaviour. This is even more the case for almost all other species of central-place foraging herbivores. This thesis therefore represents an important contribution in understanding the ecology of this group of mammals.

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Pollutants and hedgehogs

Non-destructive exposure and risk assessment of persistent pollutants in the European hedgehog (*Erinaceus europaeus*). H. d'Havé 2006. PhD thesis. University of Antwerp, Antwerp, Belgium. 231 pp. ISBN 90-5728-064-7.

At the end of 2006 Helga d'Havé successfully defended her thesis "Non-destructive exposure and risk assessment of persistent pollutants in the European hedgehog (*Erinaceus europaeus*)" at the University of Antwerp. The research was initiated to analyse levels of contaminants in hedgehogs in Flanders, and to assess whether they might be at risk due to exposure to these contaminants. The hedgehog is a good choice for this kind of study because they forage heavily on earthworms, which are very efficient in transferring contaminants from soil to predators. In this way, vermivore predators are generally exposed to rather high levels of contaminants, and are more likely to be at risk.

Hedgehogs are widespread in Flanders, and are often the victims of road kills. These Corpses were used to assess levels of contaminants among hedgehogs. However, the risk assessment had to

done using free-ranging living animals and one of the main goals of this research was to perform this assessment on living hedgehogs in a non-destructive way. This is a very important issue from both an ethical and a scientific perspective, and this research is an excellent example of ethics directing and driving research, rather than constraining it.

The thesis is well structured, with an extensive introduction on contaminants in insectivore animals, chapters on the development and validation of the non-destructive methods, and an assessment of using hedgehogs for monitoring purposes. Another chapter discusses the effects of exposure to contaminants in living animals, and the thesis concludes with an in-depth discussion of the results.

This research developed and validated new methods to assess contaminant levels in individual animals, based on samples of hairs and spines. Hair has been previously used to assess metal levels, but this method has not previously been used for organic contaminants especially brominated flame retardants. The use of spines is also a novel approach, which does not appear to have been used before. D'Havé critically discusses the suitability of hair and spines as indicators, and concludes that for some, but not all contaminants these provide suitable samples for monitoring individual animals. The overall conclusion is that hair and spines are suitable indicators for monitoring most contaminant levels among the hedgehog population. This is a big step forward in assessing general risks for hedgehog populations, but it limits the use of these methods to monitor individual animals, for instance in time.

Another goal of the research was to assess the effects of exposure to contaminants on hedgehogs in Flanders. This part of the thesis is an important piece of work from an ecotoxicological point of view. Besides the chemical analyses, and the physiological effect parameters, the study included demographic parameters. The latter were not only included as effect parameters, but are also considered as explanatory factors to describe differences between populations. This turned to be crucial, as it prevented the wrong conclusions being drawn. For instance, the study shows that levels of HCH were positively related to testo-

Hedgehogs show high individual variation in contaminant concentrations. *Photograph: Edgar van der Grift*

sterone levels in hedgehogs, which contrasts to most other literature data. In a limited ecotoxicological study the conclusion would have been that "HCH affects testosterone levels in hedgehogs, although in a different way than in other species". The study shows that the populations with highest HCH levels contained significantly more males than females, and that HCH levels were highest in those populations with best recruitment and highest population densities. The study was therefore able to conclude that it was unlikely that HCH affects testosterone levels, and that demographic factors are probably of more importance. This is quite different to the conclusion that would have been drawn from a more limited study, and clearly shows the importance of including demography in ecotoxicological studies when seeking to explain differences between populations.

The chapter on risk assessment concludes that hedgehogs are generally unlikely to be affected by contaminants. However, it illustrated that individual animals showed concentrations that exceeded critical levels. This raises the question of why hedgehogs, and also other species, show such high individual variation when it comes to contaminant exposure. In this light it is good to see that a follow up to this project is currently underway at the University of Antwerp to investigate the relationships between individual foraging behaviour and contaminant exposure.

To conclude, D'Havé's thesis describes a coherent and scientifically sound study, which is reflected in the fact that most chapters have been published in high quality peer reviewed journals. Besides the scientific quality, it shows that ethical considerations may direct research away from more familiar paths, and this may increase the applicability of the results.

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