LUTRA

Volume *Deel* 59 - Numbers *Nummers* 1/2 – December 2016

Contents *Inhoud*

Editorial *Redactioneel*

1 **A mammal atlas for the Anthropocene**
Johan B.M. Thissen & Jan Piet Bekker

Research Papers *Artikelen*

5 **Migration phenology and behaviour of bats at a research platform in the south-eastern North Sea**
Ommo Hüppop & Reinhold Hill

23 **The first proof of the recent presence of wolves in the Netherlands**
Glenn Lelieveld, Bart Beekers, Julia Kamp, Dick Klees, Leo Linnartz, Ellen van Norren, Elze Polman & Roeland Vermeulen

33 **Muskusrattenbestrijding tijdens de MKZ-crisis in 2001**
Daan Bos, Ferdy Timmerman & Ron C. Ydenberg

49 **One of the last wild brown bears (*Ursus arctos*) in the Netherlands (Noordwijk)**
Wim J. Kuijper, Ivo K.A. Verheijen, André Ramcharan, Hans van der Plicht & Thijs van Kolfschoten

65 **Supposedly lost syntype of the rough-toothed dolphin (*Steno bredanensis* (Lesson, 1828)) traced back at the Ghent University Museum**
Jan Piet Bekker, Mark E.J. Bosselaers & Gerard R. Heerebout

75 **Cetaceans stranded in the Netherlands in 2008-2014**
Guido O. Keijl, Lineke Begeman, Sjoukje Hiemstra, Lonneke L. IJsseldijk, Pepijn Kamminga & Seal Centre Pieterburen

109 **Tail defects in two Daubenton's bats (*Myotis daubentonii*)**
John Mulder & René Janssen

115 **Diurnal activity of juvenile Russian flying squirrels recorded by camera trapping**
Kei K. Suzuki, Tatsuki Shimamoto, Ryuji G. Furukawa & Hisashi Yanagawa

Book Reviews *Boekbesprekingen*

121 **De derde atlas van de Nederlandse zoogdieren – een nieuwe mijlpaal in de zoogdierkundige geschiedenis**
Jeroen van der Kooij

131 **Eat and be eaten**
Steve C.V. Geelhoed

133 **'De Wolf terug' - antwoorden op vragen**
Johan B.M. Thissen

Index

135 **Contents of Volume 59 (2016)**

Printed by Drukkerij Wilco, Amersfoort
Layout by Image Realize, New Zealand

ISSN 0024-7634

LUTRA

Journal of the Dutch Mammal Society
Volume 59 – Numbers 1/2 – December 2016

A mammal atlas for the Anthropocene

This issue of Lutra is arriving somewhat late. This year the editorial board decided to issue only one, extra-large, volume. Over the last two years many people in our pool of contributors have invested much of their time and energy in preparing the third Dutch mammal atlas. Half of Lutra's editorial board has also been involved in this endeavour and we are proud to see this project has finally come to fruition.

This issue of Lutra offers a thorough review of the mammal atlas, written in Dutch by Jeroen van der Kooij. This is not the only Dutch language paper in this issue. Last year the editor-in-chief announced a change in our policy, established in 2011, to only accept papers written in English. Since then we have started accepting papers in Dutch again. The paper by Bos et al. in this issue, about the claimed influence of foot-and-mouth-disease on the control of muskrat, was the first recent contribution in Dutch to be accepted.

The already mentioned third Atlas of the Mammals of the Netherlands (Broekhuizen et al. 2016) was published in April this year and covers the period 1989-2012. For the first time, the Atlas includes whales and dolphins, bringing the total number of species included in the book up to 106. In his preface Johan van de Gronden, philosopher and former director of the Dutch branch of the WWF, refers to the national Living Planet Index which shows that the populations of Dutch mammal species have increased by an average of 15% since 1990. The Atlas also shows that, in general, mammals are doing well in the Netherlands: 40 species have a larger range than in earlier atlases, which cover the periods 1946-1969 and 1970-1988, just six species have decreased and nine are more or less stable. For the other species, mainly whales and dolphins, the trend is unknown. There is a marked increase in the population and range of several large or medium-sized species such as harbour seal, grey seal, wolf, red fox, beech marten, pine marten, badger, otter, beaver, roe deer, red deer and wild boar. Several of those species hit an all-time low at some point in the twentieth century, the otter even became extinct in the Netherlands in 1988. While all of these species, except the fox, have been legally protected in the Netherlands since 1942 at the latest, relentless illegal persecution continued into the 1960s. The persecution came more or less to an end after a generation of 'overenthusiastic' gamekeepers and their allies retired. What we see now is a gradual and steady recovery, due to less persecution and less exposure to persistent and very poisonous organochlorines, especially the post-war generation of pesticides and PCBs. Generally, the lowest level of diversity of mammals in our country as a whole occurred around 1960, which seems to be true for the whole of Europe (Deinet et al. 2013). Rachel Carson's book *Silent Spring* (1962) was a landmark and

a game changer in this respect, although the EU Habitats Directive, climate change and the end of the 'cold war' have all positively influenced the populations of large and medium-sized mammals.

Two years ago the same Johan van de Gronden (2014) wrote an essay entitled 'The Wilderness and Us'. In 2015 he included a translation of the essay into Dutch in his new book '*Wijsgeer in het wild'* (Philosopher in the wild) and added the subtitle '*Natuur in het Antropoceen'* to the title of the essay (van de Gronden 2015). Since the 1980s the term 'Anthropocene' has been proposed to describe a new post-Holocene geological epoch. The term has been widely popularised by the Dutch atmospheric chemist and Nobel Prize laureate Paul J. Crutzen, who agrees that the influence of human behavior on the Earth's atmosphere in recent centuries is so significant as to constitute a new geological epoch for its lithosphere. It may well be that in a few years the Anthropocene will be formally adopted by International Union of Geological Sciences. There are currently several proposals for the designation of the starting year, 1784 as the year of invention of the steam engine is a good candidate. From that point onwards the burning of fossil fuels and the emission of carbon dioxide started to increase rapidly.

The term Anthropocene is an acknowledgement of the tremendous impact that mankind has on the natural environment. In a very densely populated country, such as the Netherlands, this is self-evident. In a sense we 'allow' mammals to also live here. Large and medium-sized mammals can co-exist with man, so long as we 'tolerate' them. They are mobile and intelligent generalists. In the Atlas there is an analysis of the changes (and their causes), threats to, and conservation status of, nearly every mammal. In almost every case changes in habitat, pollution or persecution are contributing to changes in the populations and ranges of mammal species, with eradication and introduction being the two extremes in the spectrum of human involvement in shaping fauna in the Anthropocene.

The new mammal atlas describes some spectacular developments. In March 2015 a young male wolf wandered through the northeast of the Netherlands. Wolf advocates had predicted that the first wolves arriving from Germany would be shy and timid creatures, but this young wolf walked through villages in broad daylight. After several days wandering around in the Provinces of Drenthe and Groningen, the wolf, already known as the 'Wanderwolf' in German, returned back to Germany. A few months later it was run over by a car near Hannover. Another surprising, but much less visible, development was the recent establishment of a small, reproducing, population of wildcats in the woods where the Netherlands, Belgium and Germany meet (Janssen 2015). Wolves and wildcats are part of the historical fauna of the Netherlands and were expected to arrive back with us at some point. The wolf became extinct in the Netherlands in 1869 (cf. Flaton 1989) and the last records of the wildcat are archaeozoological finds from Roman times (cf. Canters et al. 2005). Wild carnivores are steadily recovering from persecution all over Europe. However, in February of this year there was a rather unexpected record of a golden jackal in the Netherlands, just when the new mammal atlas was at its final proof stage. One of the editors asked the publisher if it would be possible to include an addendum about the golden jackal, but the process of printing the Atlas was already too far advanced. So, alas, the golden jackal is not mentioned in the new Dutch mammal atlas.

For decades the yellow-necked mouse was restricted to the same region in the Netherlands where recently the wildcat has established itself. But the new atlas shows that the yellow-necked mouse is invading the Netherlands in several areas all along the Dutch-German border. This is probably due to climate

change which is also having a positive effect on species such as pine marten and wild boar. As late spring frosts are becoming extremely rare, mast of beech and oak is becoming more abundant and reliable. This allows the mice to increase their reproduction success and pine marten to predate more mice.

Not all mammals are doing well in the Netherlands, however. The garden dormouse and the hamster are critically endangered. Decades ago both small species were not uncommon in agricultural landscapes in the far southeast of the Netherlands. In contrast to larger and medium-sized mammals they may have had an all-time population high at around 1960, just before agriculture became heavily intensified. Nowadays, there is only one known population of garden dormouse, living in a woodland near Maastricht, and numbering no more than a few dozen. The hamster only survives in the Netherlands because of special areas that are managed in a hamster-friendly way. These two species cannot survive in the modern agricultural landscape without help. In the hamster reserves predation is the main cause of death and survival is problematic as these areas are too small to cope with massive predation from the surrounding area. Hamster and garden dormouse are two examples of mammals that are not doing well in the current agricultural landscape, not just in the Netherlands, but in most of Europe. Since farmland covers about two thirds of the Netherlands, this should temper any high hopes about the future of mammals in the Netherlands in general. Mammals are recovering in waters, urban areas, woods and nature areas, but in farmland the prospects are still bleak. When the Netherlands held the Presidency of the European Union in the first half of this year, the Dutch Secretary of State for Agriculture, Mr. Martijn van Dam, advocated that the subsidies for agriculture should change from income support to making a more ambitious contribution to the protection and the recovery of natural resources. Unfortunately, this proposal was not endorsed by the majority of the Member States.

Some mammal species that have long been extinct in the Netherlands are making a comeback. However, we are not holding our breath waiting for a return of brown bears. In this issue Kuijpers et al. describe the find of subfossil remains of one of the last brown bears known from the Netherlands that lived in a remote part of the dunes about a thousand years ago.

In another paper, Mulder & Janssen studied the tail defects they found in two Daubenton's bats caught in the same night. The authors discuss the possible origin of these, and other, tail defects, which are rarely reported. Suzuki et al. used nest boxes to study the diurnal rhythm of, supposedly exclusively nocturnal, flying squirrels. Elsewhere, Geelhoed reviews Leopold's (2015) thesis on diets of porpoise: an interesting work, entitled 'Eat and be eaten', which also discusses the recently discovered role of grey seals as a predator of porpoise.

This issue of Lutra contains several contributions that directly relate to earlier Lutra papers. One long standing theme has been a series of articles on stranded whales, which are described in this issue by Keijl et al. in 'Cetaceans stranded in the Netherlands in 2008-2014'. This valuable overview of stranded whales and dolphins on the Dutch coast dates back to 1933, when the topic first appeared in several other magazines on natural history. Since 1955 stranding overviews were published in the direct predecessor of *Lutra* and from 1959 in *Lutra* itself. Another perennial topic to re-emerge in this issue of *Lutra* is off-shore bat sightings. Lagerveld et al. (2012) studied bats in Dutch offshore windfarms during a pilot study, and Boshamer & Bekker (2008) described as incidental observations of bats on oil and gas production platforms. In this issue a long term study, carried out over more than ten years is presented by Hüppop &

Hill on the migration phenology and behaviour of bats at a research platform in the south-eastern North Sea. In the past *Lutra* has also covered reports of stray wolves from the East, the first of which probably originated from the Carpathians and was shot there before being illegally transported to the Netherlands (Gravendeel, de Groot, Kik et al. 2013). In this issue these reports are now described as solid observations by Lelieveld et al. and evidence of a real comeback of wolves in the Netherlands. On a similar theme this issue also has a review by Thissen of a recently issued Dutch book, entitled '*De wolf terug - eng of enerverend?*' (The wolf is back - creepy or exciting?). Finally, in this issue, the rejection of the possible syntype of the rough-toothed dolphin described by Heerebout et al. (2014) is continued by Bekker et al., who traced back the supposedly lost syntype of the rough-toothed dolphin at the Ghent University Museum.

One of our editors is leaving the board. Meike Scheidat has been working with us as a specialist on marine mammals and did a wonderful job as an editor. Unfortunately in her years as a member of the editorial board we received very few manuscripts on marine mammals. We nonetheless thank her very much for her contribution.

References

Boshamer, J.P.C. & J.P. Bekker 2008. Nathusius' pipistrelles (*Pipistrellus nathusii*) and other species of bats on offshore platforms in the Dutch sector of the North Sea. Lutra 51 (1): 17-36.

Canters K.J., J.B.M. Thissen, M.A.J. van Diepenbeek, H.A.H. Jansman & K. Goutbeek 2005. The wildcat (*Felis silvestris*) finally recorded in the Netherlands. Lutra 48 (2): 67-90.

Carson, R. 1962. Silent spring. Houghton Mifflin, Boston, MA, USA.

Deinet, S., C. Ieronymidou, L. McRae, I.J. Burfield, R.P. Foppen, B. Collen & M. Böhm 2013. Wildlife comeback in Europe: The recovery of selected mammal and bird species. Final report to Rewilding Europe by ZSL, BirdLife International and the European Bird Census Council. London, UK.

Flaton, G.T. 1989. Limburgs laatste wolf 1845 of toch 1869? Natuurhistorisch Maandblad 78: 167-168.

Gravendeel, B., A. de Groot & M. Kik, K.K. Beentjes, H. Bergman, R. Caniglia, H. Cremers, E. Fabbri, D. Groenenberg, A. Grone, G. Groot Bruinderink, L. Font, J. Hakhof, V. Harms, H. Jansman, R. Janssen, D. Lammertsma, I. Laros, L. Linnartz, D. van der Marel, J.L. Mulder, S. van der Mije, A.M. Nieman, C. Nowak, E. Randi, M. Rijks, A. Speksnijder & H.B. Vonhof 2013. The first wolf found in the Netherlands in 150 years was the victim of a wildlife crime. Lutra 56 (2): 93-109.

Heerebout, G.R., M.E.J. Bosselaers & J.P. Bekker 2014. On two specimens of rough toothed dolphin (*Steno bredanensis* Lesson, 1828) in a zoological collection in the (southern) Netherlands. Lutra 57 (1): 38-42.

Janssen, C. 2015. De terugkeer van de wilde kat. Roots, November 2015: 24-27.

Lagerveld, S., B.J. Poerink, R. Haselager & H. Verdaat 2014. Bats in Dutch offshore wind farms in autumn 2012. Lutra 57 (2): 61-69.

van de Gronden, J. 2014. The wilderness and us. In: G. Brugmans & J. Strien (eds.). IABR 2014. Urban by Nature: 41-45. International Architecture Biennale Rotterdam, Rotterdam, the Netherlands.

van de Gronden, J. 2015. Wijsgeer in het wild. Essays over mens en natuur. Atheneum-Polak & Van Gennep, Amsterdam, the Netherlands.

Johan B.M. Thissen & Jan Piet Bekker

Migration phenology and behaviour of bats at a research platform in the south-eastern North Sea

Ommo Hüppop & Reinhold Hill*

Institute of Avian Research "Vogelwarte Helgoland", An der Vogelwarte 21,
D-26386 Wilhelmshaven, Germany, email: ommo.hueppop@ifv-vogelwarte.de

Abstract: More than ten years of autonomous acoustic recording of bats' echolocation calls at an unmanned offshore research platform 45 km north of the island of Borkum (North Sea) were analysed in relation to season, time of day and weather. To our knowledge this is the longest systematic dataset on offshore bat migration worldwide. Three-hundred and seventeen call sequences were recorded during typical migration times in spring and autumn and assigned to at least 23 Nathusius' pipistrelles (*Pipistrellus nathusius*), 3 northern bats (*Eptesicus nilssonii*) and 2 Leisler's bats (*Nyctalus leisleri*). Compared to the prevailing wind conditions, more bats than expected were recorded at lower wind speeds and southerly winds. Bats occurred under supporting tailwinds, but also under strong headwinds. In both seasons most bats occurred under winds from the south (i.e. crosswinds), which indicates offshore wind drift. We neither found effects of air pressure, nor of change in air pressure. Most registrations coincided with a dense cover of clouds, fog/low stratus and/or rain. From the structure of echolocation calls it can be concluded that most bats explored the platform rather than just passed it on transfer flights, some even foraged there. We conclude that most of the bats were on migration and attracted by the brightly lit platform and/or sought refuge there. This involves the risk of collisions with offshore wind turbines (which need to be brighter lit at sea than onshore). We assume that a great part of offshore bat migration takes place beyond the range of currently available techniques at greater altitudes than known so far.

Keywords: bats, acoustic monitoring, migration, North Sea, offshore, light, weather, wind, behaviour, conservation.

Introduction

Not too long ago, bats observed far offshore in the open North Sea were regarded as vagrants, regular offshore migration was virtually unknown (Vauk 1974, Vauk & Clemens 1982). Older notes on regular passage of bats at the remote island of Helgoland (Gätke in von Dalla Torre 1889) were even put into question (Vauk 1974, Skiba 2007). There are numerous records of several bat species from platforms, ships and islands far offshore, mainly from Europe but also from North America (e.g. Cryan & Brown 2007, Skiba 2007, Walter et al. 2007, Boshamer & Bekker 2008, Ahlén et al. 2009, Hüppop 2009, Hatch et al. 2013, Lagerveld et al. 2014, Petersen et al. 2014, Sjollema et al. 2014, Smith & McWilliams 2016) indicating that regular but cryptic migration over sea, which is long known for terrestrial birds (e.g. Gätke 1895, Clark 1912), is also more common than formerly expected in bats. The seasonal appearance of bats in Bermuda emphasises their ability to travel even distances of more than 1000 km over open ocean (Hatch et al. 2013).

Studies on the offshore migration phenology of bats are nevertheless still almost exclu-

* Present address: Avitec Research, Sachsenring 11, D-27711 Osterholz-Scharmbeck, Germany

sively restricted to coastal areas (recent overview in Rydell et al. 2014, Ciechanowski et al. 2016). Several studies compiled accidental observations or data from standardised studies covering shorter periods: Boshamer & Bekker (2008) reported 34 records of five species of bats (26 Nathusius' pipistrelles (*Pipistrellus nathusii*), 2 noctules (*Nyctalus noctula*), 2 northern bats (*Eptesicus nilssonii*), 1 serotine (*Eptesicus serotinus*) and 3 parti-coloured bats (*Vespertilio murinus*)) from platforms in the the Dutch sector of the North Sea from 1988 to 2007. Skiba (2007) observed on Helgoland, 50 km off the next coastal islands (figure 1), 105 bats in 36 nights from 2000 to 2006, mainly Nathusius' pipistrelles (*n*=84), but also 8 common pipistrelles (*Pipistrellus pipistrellus*), 12 noctules and 1 Leisler's bat (*Nyctalus leisleri*). Walther et al. (2007) and Petersen et al. (2014) compiled further observations of bats on ships and platforms in the North Sea and Baltic Sea, and on islands and installations in the North East Atlantic, respectively. In a pilot study at two offshore wind farms located 15 and 23 km off the Dutch coast in autumn 2012, virtually all of the 216 recordings of bat echolocation calls concerned Nathusius' pipistrelle, while noctule was noted only a few times (Lagerveld et al. 2014). Surprisingly, besides the data presented here, there is only one standardised study at an offshore site that covers several years: during 1200 nights of year-round autonomous recording on the island of Helgoland in 2004 and 2006 to 2008 (Hüppop 2009, Hüppop, unpublished data) the main species were Nathusius' pipistrelle (*n*=ca. 160), common pipistrelle (*n*= ca. 80) and *Eptesicus*/*Nyctalus* species (*n*=ca. 30).

Due to technical limitations associated with tracking the movements of small, cryptic and highly mobile animals over long distances, very little is known of the migratory pathways of bats (Cryan & Diehl 2009, Holland & Wikelski 2009, Weller et al. 2016). Systematic studies on the spatial and temporal occurrence of migrating bats (e.g. Rydell et al. 2014) are indispensable both for a better understanding of bat migration systems in general and for assessing anthropogenic threats to migrating bats, namely by wind turbines (Voigt et al. 2015, Arnett et al. 2016, O'Shea et al. 2016). It seems likely that offshore wind facilities will also kill bats, but it is difficult or impossible to find bat fatalities at sea and no attempts to assess such fatalities have been made so far (Arnett et al. 2016). Under adverse weather conditions lit offshore structures such as platforms, lighthouses and lightvessels may attract and kill large numbers of nocturnally migrating birds (Ballasus et al. 2009, Hüppop et al. 2016). Collisions of bats with lighthouses, lit buildings and communication towers have also been reported (Saunders 1930, Terres 1956, Crawford & Baker 1981, O'Shea et al. 2016). Hence, it can be predicted that those bat species that are attracted by lights (Rydell 1991, 1992, Blake et al. 1994, Stone et al. 2015) will also collide with lit offshore wind turbines and other manmade structures. Whereas onshore turbines in Germany have, depending on their height, either no red lights, flashing red lights, or flashing and

Figure 1. Locations of the research platform FINO 1 and the island of Helgoland.

Figure 2. The research platform FINO 1. *Photo: Reinhold Hill.*

steady red lights for aviation safety, offshore turbines and working platforms in addition to the red lights must have bright steady lights for shipping and/or working safety. Ahlén et al. (2009) observed bats hunting insects at wind power turbines near the blades and on the vertical tower sides.

Here, we present the results of more than ten years of autonomous acoustic recording of bats' echolocation calls at an unmanned offshore research platform in the south-eastern North Sea in relation to season, time of day and weather. To our knowledge this is the longest systematically collected dataset on offshore bat migration worldwide. Signals used by echolocating bats are not only highly variable among species, there are also intraspecific variations. Bats vary signal structure and repetition rate of calls to suit their information acquisition tasks (Simmons et al 1979, Kalko & Schitzler 1993, Schnitzler & Kalko 2001, Parsons & Szewczak 2009, Fenton 2013). We hence also tried to deduce the bats' behaviour at the platform from the recordings (e.g. transit vs. exploring or foraging) to get an idea of why bats occur at anthropogenic offshore structures.

Material & methods

Study site

The unmanned offshore research platform FINO 1 (54° 01' N, 06° 35' E) is located in the south-eastern North Sea, 45 km north of the island of Borkum (figures 1 and 2). It is founded on four pilings with a 256 m^2 working deck 20 m above sea level (a.s.l.) and has an 81 m lattice tower in its southern corner and a 164 m^2 helicopter deck at 25 m a.s.l. (Fischer 2006, for further details see www.fino1.de).

The flight safety lighting consists of two continuous red lights (10 cd) each at 101.5 m, 75 m and 55 m a.s.l., respectively. These lights were replaced in November 2007 and again in late autumn 2014 and spring 2015 by red

LED-lights of the same intensity. Further, four continuous white halogen flood lights (400 W) installed at 19.5 m a.s.l. illuminate the foundation underneath the platform deck. In summer 2012 the floodlights were equipped with energy-saving lamps (100 W) instead of the halogen bulbs. Four white lights (50 W) at 21.6 m a.s.l., blinking with Morse code "U", serve for shipping safety. A replacement to LED-lanterns of the same light intensity was made at the end of 2014. The name inscription at all four sides of the platform is continuously illuminated by two 200 W halogen lamps each, which were replaced by single energy-saving lamps (80 W) at each side in summer 2012 (G. Fischer and S. Howorek, personal communication).

Acoustic monitoring

Because access to the platform was only possible by irregular helicopter flights (see Fischer 2006, Hüppop et al. 2016) a recording system with the possibility of vast remote control was essential. Hence, we decided to setup a computer based system remotely accessible via the platforms computer network (Fischer 2006) rather than one of the autonomous bat recorders (e.g. Adams et al. 2013, Britzke et al. 2013) that were commercially available in 2004.

We installed a Pettersson D-230 bat detector at the platform's working deck and replaced the battery by a 9 V power supply. This detector combines a divide-by-ten and a heterodyne detector (fixed at 45 kHz; for technical background of the different detector types see e.g. Skiba 2003, Parsons & Szewczak 2009 or Barataud 2015). In contrast to time expansion systems, which keep most details of the ultrasound calls, both heterodyning and frequency division can operate in real time. The latter is broadband and thus not limited to a narrow frequency range. It retains much of the signal's time and frequency information (e.g. Miller & Degn 1981, Parsons & Szewczak 2009, Britzke et al. 2013). The bat detector was sheltered from wind, water and gull excrements by a basket windshield with long-haired polyester fleece cover, and a stainless steel roof. Both output channels of the bat detector (frequency divider and heterodyne) were continuously sampled by the on board soundcard of a computer with "RecAll 2.4" (www.sagebrush.com). When the level of the incoming signals of the frequency divider exceeded a predefined threshold they were stored on the computer for later analysis as two channel WAVE-files (44 kHz, 16 bit).

From 12 August 2004 to 21 December 2015 the system was operational throughout the year in ca. 3530 out of 4148 nights from sunset to sunrise. Due to computer problems several major gaps were unavoidable (figure 3). Additionally we cannot exclude occasional failures of the system that may have occurred for a few hours. The bat recorder itself and the sound card were checked for effects of humidity, corrosion or possible other technical issues but have been functioning properly during the whole period.

All acoustical analyses were made with "Praat" versions 4.6.12 to 5.3.69 (www.praat.org). Because of the harsh and noisy "technical" environment several millions of files were recorded making an automatic search for ultrasonic bat calls afterwards necessary. These were detected by pitch analysis with "Praat" (Hill & Hüppop 2008). Bat species were identified by frequencies of highest amplitude, signal structure, length of intervals between single calls and rhythm (mainly after Skiba 2009 and Barataud 2015, but also after Rydell 1993, Waters et al. 1995, Jensen & Miller 1999 and others). We checked all files with echolocation calls for feeding buzzes or other indicators of the bats' behaviour (Parsons & Szewczak 2009, Ratcliffe et al. 2013, Rydell & Wickman 2015).

Weather data

At the platform, wind speed and direction at 90 m above sea level were measured every

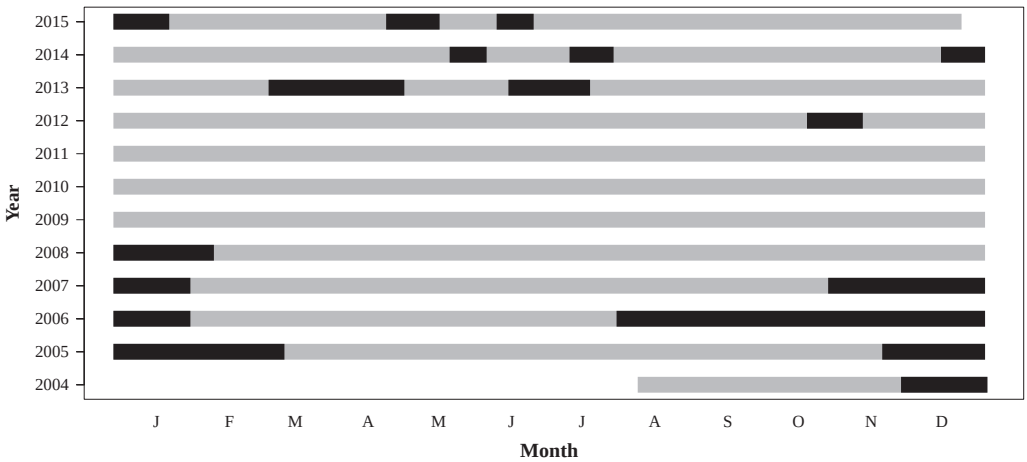


Figure 3. Functioning (grey) and not-functioning (black) of the recording system versus time.

10 minutes (kindly provided by the Federal Maritime and Hydrographic Agency, http://fino.bsh.de). For statistical analyses we averaged these values over the last 60 min before the first registration of a bat. To assess the influence of winds on migrating bats flying over the sea we calculated tailwind components (TWC) and crosswind components (CWC) from the wind data (see also Hüppop & Hilgerloh 2012):

TWC = cos (observed wind direction - presumed direction of migration) × wind speed

CWC = sin (observed wind direction - presumed direction of migration) × wind speed

Positive TWC values mean tailwind assistance, negative ones mean headwinds. Crosswinds from the left of the bat migrating into the presumably preferred direction are expressed by positive CWC values, winds from the right by negative ones. Presumed directions of migration (WSW in autumn and ENE in spring) were estimated from recoveries of marked Nathusius' pipistrelles in the larger region of the southern North Sea (Pētersons 2004, Vierhaus 2004, http://fledermauszug-deutschland.de).

For air pressure and change in air pressure over the last three hours before a registration we used data for the nearest full hour from a weather station on the island of Norderney (50 km south-east; 53° 43' N; 07° 09' E; Deutscher Wetterdienst).

Information on cloud types and precipitation were derived from scan data of the Spinning Enhanced Visible and InfraRed Imager (SEVIRI) on board METEOSAT Second Generation (MSG), the European geostationary satellite operated by EUMETSAT (Schmetz et al. 2002, Lensky & Rosenfeld 2008). The multichannel MSG data were purchased from www.eumetsat.int. They were analysed with the "MSG Native image reader" and interpreted according to the features in the EUMETSAT MSG interpretation guide (http://eumetrain.org/IntGuide/) and with the software "CAPSAT" (Lensky & Rosenfeld 2008, latest version kindly provided by I. Lensky).

To address fog/low stratus and precipitation detection at night we made use of the particular emissive properties of droplets at different infrared wavelengths: the small droplets found in fog or low stratus are less emissive at 3.9 µm than at 10.8 µm and 12.0 µm, whereas the emissivities are roughly the same for larger droplets (Lensky & Rosenfeld 2003, 2008, Cermak & Bendix 2008). In this technique, the Brightness Temperature Difference (BTD) of 12.0 µm - 10.8 µm is a measure for the clouds' opaqueness (higher values mean more opaque clouds), whereas the

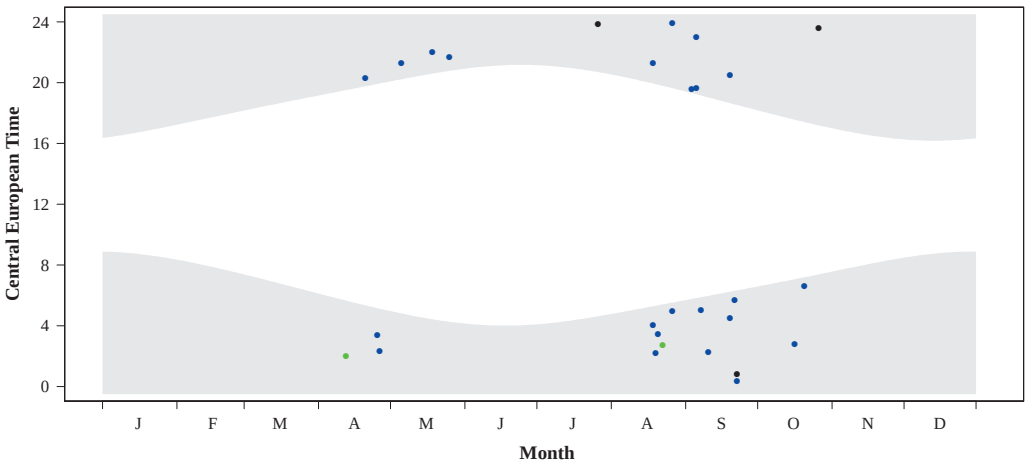


Figure 4. Acoustic recordings of Nathusius' pipistrelle (blue, *n*=23), northern bat (black, *n*=3) and Leisler's bat (green, *n*=2) at FINO 1. Grey areas: times between sunset and sunrise at FINO 1.

BTD of 10.8 - 3.9 µm is sensitive to particle size (higher values mean smaller droplets). Cloud top height was categorised according to the brightness temperature at 10.8 µm (Lensky & Rosenfeld 2008, http://eumetrain.org/IntGuide/). Weather radar data (since 2006) are available at http://meteox.com. They were used to validate precipitation as predicted from satellite images.

Statistical analyses

All statistics were carried out in R 3.2.4 (R Core Team 2016). We checked for the preference or avoidance of certain weather situations by comparing observed with expected frequencies for all weather parameters based on all available measurements at midnight over the years 2004 to 2015 (spring: April to May, *nwind*=635, *npressure*=732; autumn: August to October, *nwind*=1022, *npressure*=1103). We tested whether observed frequency distributions of bat observations fitted frequencies as expected from the distribution of several weather parameters by exact multinomial tests with log-likelihood-ratios as a measure for goodness-of-fit (see https://cran.r-project.org/web/packages/XNomial/vignettes/XNomial.html). The null hypothesis for this test is that the observed frequency is equal to an expected count in each category. The low number of bat detections at the platform excluded any multivariate statistical approaches.

Results

In total, 317 call sequences were recorded and analysed. They were assigned to a minimum of 28 individual bats (table 1). The recordings covered two distinct periods: 13 April to 26 May and 26 July to 26 October (table 1, figure 4). Three times more bats were observed during autumn (*n*=21) than during spring migration (*n*=7). Bats were recorded from immediately after sunset to shortly before sunrise, 16 before and 12 after midnight (figure 4). With at least 23 recorded individuals Nathusius' bat was the most numerous species. It was detected from 20 April to 26 May (median: 2 May) and from 19 August to 20 October (median: 9 September). Three individuals were identified as northern bat and two as Leisler's bat.

Bats occurred at the platform at winds with mostly southern directions between 98° (E)

Table 1. Observations of bats at the offshore research platform FINO 1 in the southeastern North Sea from 2004 to 2015. Δ air pressure = change in air pressure over the last three hours. Cloud, fog and presumed rain are derived from satellite and weather radar images (see Methods).

Date	Time (CET)	Species	Wind-direction	Windspeed (m/s)	Air pressure (hPa)	Δ air pressure (hPa)	Clouds, fog and rain	Remarks
16.10.2004	02:53 to 04:27	Nathusius' pipistrelle	104°	1.4	998.2	-1.1	low-level clouds, some rain	hunting
26.10.2004	23:37 to 23:53	Northern bat	231°	2.1	1012.4	-0.2	low- to high-level clouds, rain	
27.04.2005	02:23	Nathusius' pipistrelle	167°	5.5	1011.5	-1.4	mid-level clouds, rain	
26.05.2005	21:45 to 22:04	Nathusius' pipistrelle	308°	5.1	1017.1	1.3	mid-level clouds, rain	
19.08.2005	21:20 to 21:26	Nathusius' pipistrelle	261°	8.1	1013.1	1.1	mid- to high-level clouds, rain	hunting
20.08.2005	02:16 to 03:24	Nathusius' pipistrelle	181°	2.5	1013.9	0.7	mid-level clouds, rain	
06.05.2007	21:21	Nathusius' pipistrelle	271°	12.5	1012.5	-0.2	low- to mid-level clouds, rain	
23.09.2007	00:24 to 00:49	Nathusius' pipistrelle	168°	3.7	1022.2	-0.1	fog/low stratus	hunting
23.09.2007	00:52 to 00:54	Northern bat	174°	6.5	1022.4	0.2	fog/low stratus	
26.07.2008	23:54 to 00:21	Northern bat	161°	10.0	1017.6	1.6	high-level clouds, rain	hunting
07.09.2008	05:06 to 05:12	Nathusius' pipistrelle	164°	9.4	1005.1	-0.3	mid-level clouds, rain	
10.09.2008	02:20	Nathusius' pipistrelle	192°	10.9	1011.7	-0.6	mid- to high-level clouds, rain	
19.09.2008	04:36	Nathusius' pipistrelle	147°	4.2	1025.6	-0.5	low-level clouds	
19.09.2008	20:35 to 20:43	Nathusius' pipistrelle	268°	1.4	1030.5	1.2	fog/low stratus	
13.04.2009	02:05	Leisler's bat	98°	7.3	1010.3	-0.8	low-level clouds	
26.04.2009	03:26 to 04:05	Nathusius' pipistrelle	197°	5.4	1013.4	-0.2	high cumulonimbus, rain	
19.05.2009	22:06	Nathusius' pipistrelle	185°	3.5	1020.4	0.7	low-level clouds after passage of fog/low stratus	
22.09.2010	05:46	Nathusius' pipistrelle	151°	6.0	1021.7	-0.8	low-level clouds	
04.09.2011	19:37 to 19:48	Nathusius' pipistrelle	212°	4.3	1008.7	0.2	mid-level clouds, rain showers	
20.04.2012	20:20 to 20:21	Nathusius' pipistrelle	182°	2.4	997.1	1.4	extended fog/low stratus, rain	
20.10.2012	06:41	Nathusius' pipistrelle	194°	11.1	1012.4	0.6	mid-level clouds, cumulonimbus approaching	
27.08.2013	05:03 to 06:26	Nathusius' pipistrelle	111°	4.7	1018.7	-0.5	clear sky	
06.09.2014	19:42	Nathusius' pipistrelle	272°	3.9	1012.5	0.4	mid- to high-level cumulonimbus, rain	
06.09.2014	23:03	Nathusius' pipistrelle	234°	5.1	1012.9	0.4	after high-level cumulonimbus with rain	transfer
19.08.2015	04:07 to 04:15	Nathusius' pipistrelle	173°	5.8	1017.7	0.3	mid- to high-level clouds, rain	
21.08.2015	03:29 to 03:46	Nathusius' pipistrelle	144°	6.1	1024.0	-0.3	clear sky	hunting
23.08.2015	02:49	Leisler's bat?	98°	6.9	1016.6	-1.4	clear sky	
27.08.2015	23:59 to 00:29	Nathusius' pipistrelle	256°	7.3	1009.9	1.4	few low-level clouds, light showers	

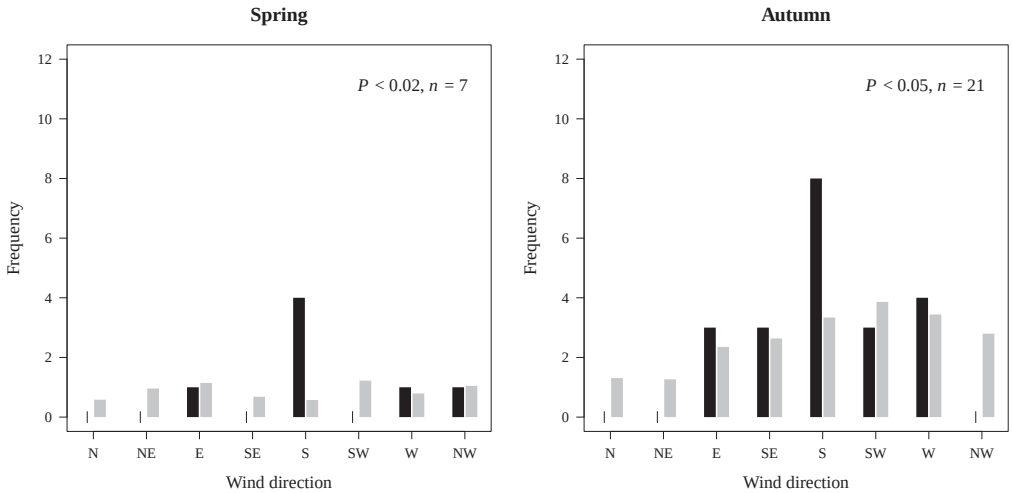


Figure 5. Observed (black) and expected (grey) frequencies of bat recordings at FINO 1 in relation to wind direction.

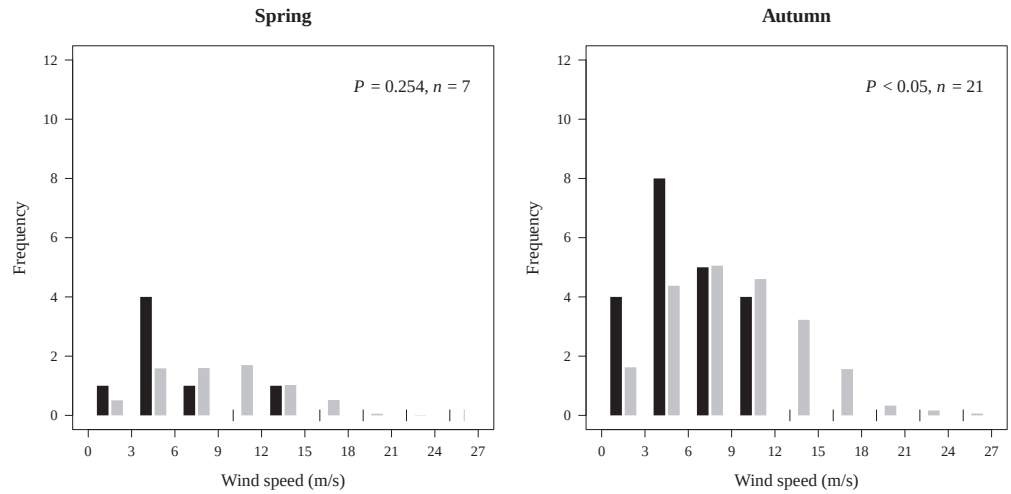


Figure 6. Observed (black) and expected (grey) frequencies of bat recordings at FINO 1 in relation to wind speed.

and 308° (NW) and with speeds up to 12.5 m/s (figures 5 and 6). Compared to the prevailing wind conditions, more bats than expected from the prevailing wind conditions were recorded at lower wind speeds (significantly in autumn) and southerly winds (significantly in spring and autumn). Bats occurred under supporting tailwinds (high positive TWC values in figure 7), but also under strong headwinds (high negative TWC values). In accordance with the preference of lower wind speeds, more bats were observed under low TWC values than could have been expected from the prevailing TWC conditions (significantly in autumn). In both seasons most bats occurred under winds from the south and accordingly CWC values (again significantly in autumn) which indicate offshore wind drift (figure 8). We neither found effects of air pressure (figure 9), nor of change in air pressure

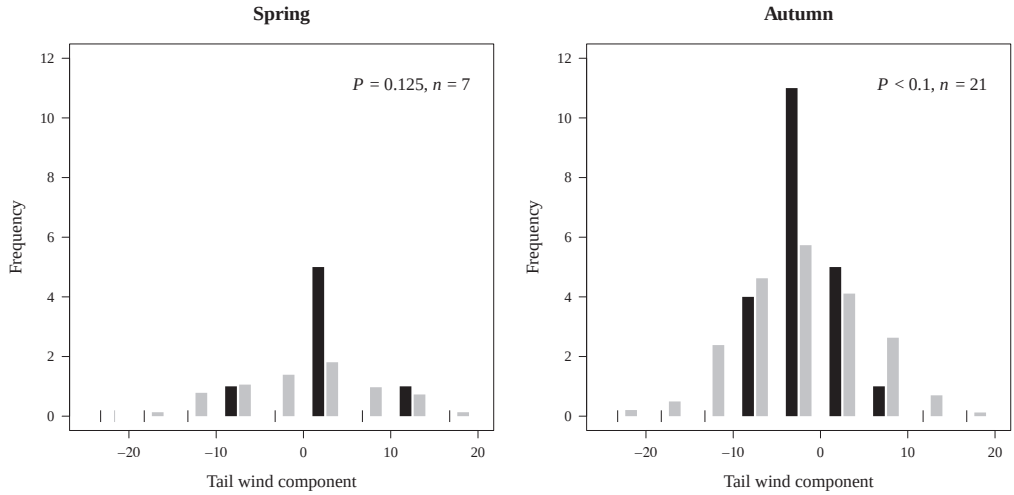


Figure 7. Observed (black) and expected (grey) frequencies of bat recordings at FINO 1 in relation to the tailwind component. Positive values mean tailwinds, negative ones headwinds.

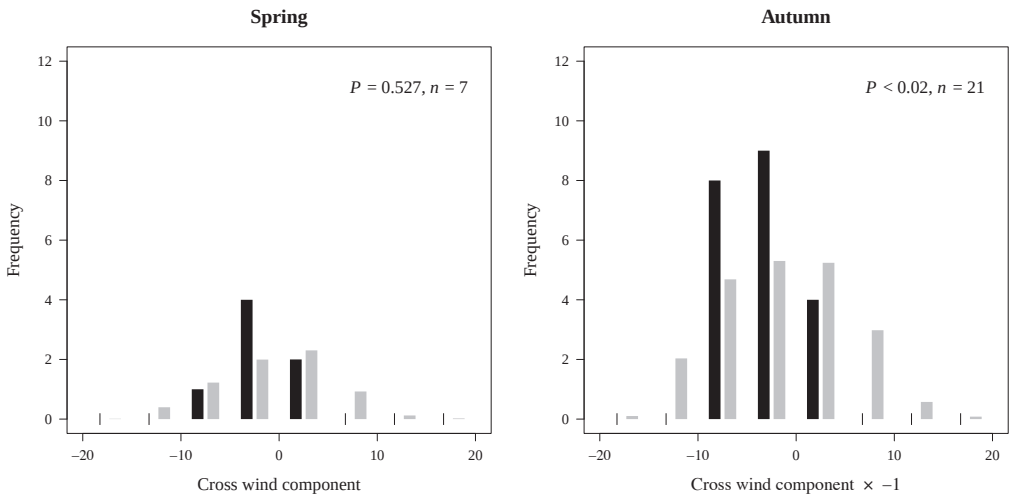


Figure 8. Observed (black) and expected (grey) frequencies of bat recordings at FINO 1 in relation to the cross-wind component. In both seasons, negative values mean offshore winds (from southerly directions)

(figure 10). Most registrations coincided with a dense cover of clouds, fog/low stratus and/or rain while only three bats were detected under clear sky conditions (table 1).

Individual bats were recorded over merely a few seconds up to more than one and a half hours (mean: 14 min; table 1), but there was only one Nathusius' pipistrelle that presumably just passed the platform (intervals between calls regular and > 200 ms, frequency of calls comparatively low and almost constant). Since all other bats had fairly irregular call intervals and a high proportion of calls with considerable frequency modulation it can be concluded that these bats were exploring the platform (see Kalko & Schnitzler 1993, Schnitzler & Kalko 2001, Fenton 2013). Feeding buzzes indicate that some also foraged there (table 1).

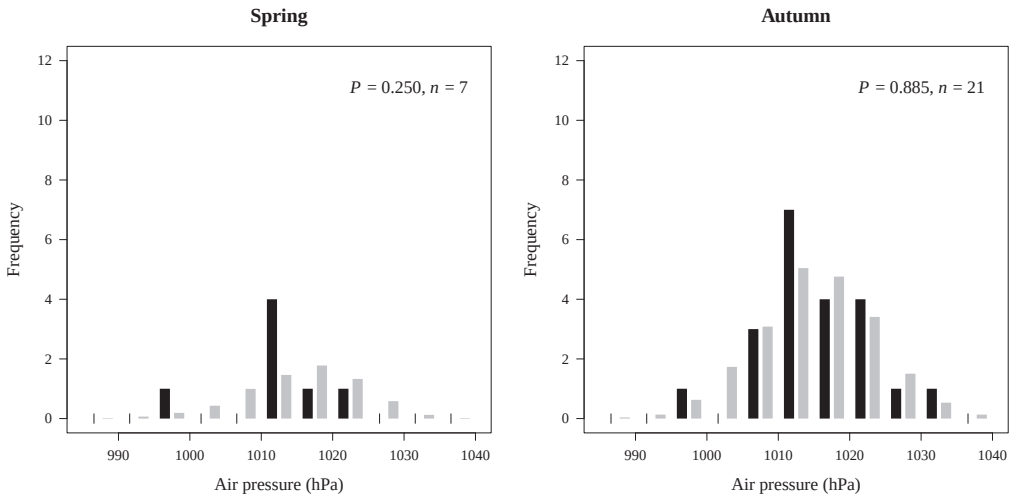


Figure 9. Observed (black) and expected (grey) frequencies of bat recordings at FINO 1 in relation to air pressure.

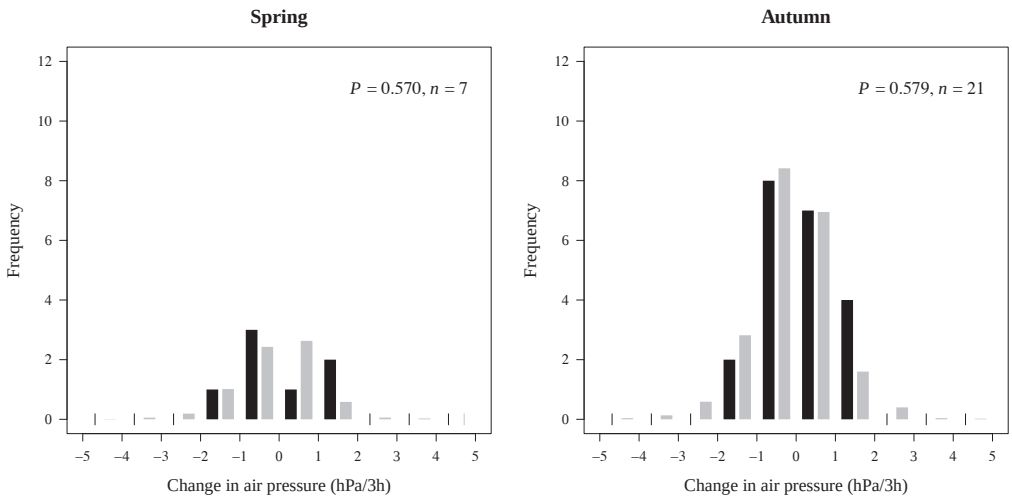


Figure 10. Observed (black) and expected (grey) frequencies of bat recordings at FINO 1 in relation to change in air pressure.

Discussion

All but one of the bat observations were restricted to the typical migration periods of the observed species in central Europe (e.g. Pētersons 2004, Rydell et al. 2014 and Ciechanowski et al. 2016 for coastal areas of the North Sea and the southern Baltic Sea or Meineke 2012 for Nathusius' pipistrelle inland passage in the Harz mountains, 249 km south-east), emphasising that the bats were on migration rather than on extended foraging flights from the mainland. Also, the distance from the platform to the coast is far beyond what has been reported for foraging distances or home ranges of the observed or closely related bat species (see e.g. Shiel et al. 1999 and Waters et al. 1999 for Leisler's bat, Nicholls & Racey

2006 for *Pipistrellus* species or Frafjord 2013 for northern bat). However, the only bat that was registered outside the migration periods (a Nathusius' bat on 26 June 2008) might have been blown offshore from its summer area by strong south-easterly wind.

While Nathusius' bat and Leisler's bat are well known as long distance migrants (Skiba 2003, Pētersons 2004, Vierhaus 2004), the northern bat is regarded as a resident species with only occasional migrations (Skiba 2003, Gerell & Rydell 2004, Ahlén et al. 2009). However, as already suggested by Tress (1994), our observations at FINO 1, and those made by others at oil rigs and on remote islands (Gerell & Rydell 2004, Boshamer & Bekker 2008, Petersen et al. 2014, Hüppop unpublished data) indicate that this species might be more migratory than the low number of recoveries of marked individuals and the few observations imply. Actually, numbers of marked northern bats are so far still small. In accordance with the compilation of findings of bats at offshore platforms in the Dutch sector of the North Sea by Boshamer & Bekker (2008) and the recordings of Lagerveld et al. (2014) at two wind farms off the Dutch coast in autumn 2012, we did not detect a single common pipistrelle. This is surprising since this species occurs as a regular migrant on the island of Helgoland (figure 1), 85 km ENE, at a comparable distance to the coast (Skiba 2007, Hüppop 2009).

The extensive exploratory behaviour of bats at the platform causes some uncertainty in the identification of northern bat and Leisler's bat. These two species, serotine (which can be expected at the platform, too; Boshamer & Bekker 2009, Hüppop 2009) and other bat species may considerably change and adapt the characteristics of their echolocation calls. Especially serotine and Leisler's bat, but also northern bat reduce the length and increase both the frequencies and the bandwidth of their calls when e.g. approaching obstacles or flying close to the ground or in dense vegetation (Rydell 1993, Waters et al. 1995, Jensen & Miller 1999, Skiba 2003, Gerell & Rydell 2004, Ahlén et al. 2009). The result is an extensive overlap of echolocation call structure between all three species which necessitates the use of other features such as "left out" single calls in the sequences of serotine, the "waltz-like rhythm" in northern bat or the "plip-plops" in Leisler's bat (Skiba 2003, Barataud 2015). Regrettably, individuals may omit these species specific characteristics in their call sequences. In conclusion, our identification of bat species other than Nathusius' pipistrelle has to be regarded with some caution.

At FINO 1, only 317 sequences of echolocation calls were recorded in a period of eleven years, while Lagerveld et al. (2014) recorded 189 and 25 bat call sequences at two Dutch offshore wind farms from 29 August until 20 October 2012 and from 4 to 23 September 2012, respectively. These wind farms, however, are only 15 and 23 km offshore, while the distance from the FINO 1 to the next coastal island is 45 km. This might suggest that bat migration is more coastal as proposed by Bach et al. (2009), Frey et al. (2012) and Rydell et al. (2014). But somehow it stands in contrast to the high number of bat recordings at the island of Helgoland (Skiba 2007, Hüppop 2009) where bats might stay for longer than on a platform without vegetation and presumably less insects. Also technical differences between the studies that influence the detectability of echolocation calls cannot be excluded, e.g. by the deviating sensitivity of the systems used (e.g. Adams et al. 2009, own observations) but also due to orientation and weatherproofing (Britzke et al. 2010). Our knowledge on the detection range of bat recording systems is very limited, but from handheld bat detectors it is known that e.g. *Pipistrellus* species can be detected up to only 25 m, northern bat up to 50 m and Leisler's bat up to 80 m (Barataud 2015). Hence, depending on the species, typically only altitudes up to considerably less than 50 to 100 m a.s.l. were covered and only bats flying close to the platform could be detected.

Bats likely use vision and their magnetic sense rather than echolocation to migrate (Holland 2007) and offshore wind turbines and other offshore structures attract bats (Ahlén et al. 2009). Many bat species, including those of the genera *Pipistrellus*, *Nyctalus* and *Eptesicus* seek lights because of the higher numbers of insects attracted to street lights, especially those emitting short wavelengths (see e.g. Rydell 1991, 1992, Blake et al. 1994, Stone et al. 2015, Shoeman 2016). Insects move over the North Sea (and other marine areas) in huge numbers (e.g. Chapman et al. 2004, Drake & Reynolds 2012) and sometimes masses also occur at the FINO 1 (own observations of flies, flying beetles and moths) or other offshore installations (Heydemann 1967). Bats presumably forage during their migration flight as do aerial feeding birds, such as swallows or swifts (Ahlén et al. 2009, Cryan & Diehl 2009, Šuba et al. 2012, Voigt et al. 2012). We hence assume that at least some of the observed bats were attracted by the (white) lamps of the FINO 1 platform signalling a possible chance for a "quick snack" or a suited daytime stopover to them.

Our results concerning bat registrations at FINO 1 in relation to weather are difficult to interpret and somehow contradict previous findings. In accordance with former offshore studies (Baltic Sea: Ahlén et al. 2009, North America: Cryan & Brown 2007, Sjollema et al. 2014, Dutch North Sea: Boshamer & Bekker 2008, Lagerveld et al. 2014) we found that bats were mainly recorded at low to moderate wind speeds. But in contrast to the findings at other offshore installations in the southern North Sea (Boshamer & Bekker 2008), we found a considerable effect of off land crosswinds. On the one hand, this might actually reflect drift (cf. Petersen et al. 2014) and suggest a preference of a more coastal migration as suggested by Bach et al. (2009), Frey et al. (2012), Lagerveld et al. (2014) and Rydell et al. (2014). On the other hand, it cannot be excluded that our registrations are only partly representative for the overall offshore bat migration, missing possibly stronger migration at altitudes which were beyond the coverage by our equipment (see above). Nevertheless we tried to distinguish between bats migrating on their intended routes and those deviating from these routes by wind drift. For this purpose, we separately investigated the wind direction according to seasons and halves of the night. In the first half of the night, bat calls were registered in both seasons only at southerly to westerly winds (161° to 308°, table 1). In spring, this means tailwind support for animals that set off from the coast of Lower Saxony or the eastern Netherlands and destinations in southern Scandinavia or Schleswig-Holstein, while in autumn, it means headwinds for bats coming from there. Within just a few hours after sunset bats coming from Scandinavia under headwinds can hardly reach the platform within the first half of the night. Therefore bats recorded at this time and with offshore wind directions are more likely drifted from the coastal islands or the mainland in the south or may have been individuals that spent the day at the platform without being recorded on their arrival. In the second half of the night, on the other hand, bat calls were recorded in both seasons exclusively during winds from easterly and southerly directions (98° to 197°, table 1). In spring we would expect mainly drifted bats at FINO 1 after midnight, whereas in autumn animals arriving from southern Scandinavia under head- or crosswind conditions are to be expected.

Mainly due to technical reasons our knowledge on flight altitudes of migrating bats is very limited. According to Ahlén et al. (2009) bats migrating close to the coast over the Baltic Sea fly at relatively low altitudes (<10 m, a few >40 m, altitudes of more than 100 m not covered). Further offshore, bats probably use supporting winds (Hatch et al. 2013, Smith & McWilliams 2016) on a larger scale and correspondingly fly much higher as found in eastern red bats (*Lasiurus borealis*), a medium-sized Vespertilionid, off the North

American east coast (at least five out of eleven bats > 200 m a.s.l.; Hatch et al. 2013). Onshore, McCracken et al. (2008) observed feeding Brazilian free-tailed bats (*Tadarida brasiliensis*) in large numbers up to 1118 m above ground level with peak activity at 400-500 m. When recorded at the FINO 1 platform, many bats probably sought refuge during periods of adverse weather (offshore platforms or vessels are the only available options at sea), food or for daytime resting.

Birds predominantly occur at FINO 1 when previous, favourable migration conditions (low wind speeds or tailwinds, clear sky) turn into unfavourable winds, heavy clouds, rain or drizzle and they accordingly get disoriented or seek refuge (Hüppop & Hilgerloh 2012, Hüppop et al. 2016). This also seems to hold for migrating bats: Normally bats accumulate in coastal areas during poor weather (e.g. strong winds or rain; Ahlén et al. 2009). But when they take off in good conditions they might come into worse weather on prolonged overseas flights. Especially rain is a problem since it can roughly double a bat's flight costs when the fur gets wet (Voigt et al. 2011). For a small bat flying at 4 to 9 m/s (Holderied & Jones 2007) it will take one and a half to over three hours of direct flight to reach the mainland from FINO 1, under adverse headwinds even longer. Since offshore wind turbines, platforms and vessels are the only available structures at sea it is likely that bats seek refuge there when flight conditions suddenly deteriorate. This could explain why – quite in contrast to the Dutch sites much closer to the coast (Lagerveld et al. 2014) – so many bats occurred at FINO 1 under rainy or at least overcast conditions. In accordance with this, Cryan & Brown (2007) recorded bats at an island 48 km west of San Francisco mainly under cloudy conditions.

The assumption that bats seek refuge at offshore structures is further supported by the temporal distribution of records throughout the night (in contrast to Lagerveld et al. 2014 numbers were lowest around midnight) and by the fact that the body masses of Nathusius' bat from platforms in the Dutch sector of the North Sea (many of them far away from the coast) were on average considerably lower than those from bat boxes in mainland North Holland (Boshamer & Bekker 2008).

Conclusions

With our long-term acoustic recording at a research platform we confirmed that there are regular movements of bats over the open North Sea as suggested by earlier accidental offshore observations on islands, ships, platforms or other man-made structures and by systematic but much shorter monitoring closer to the coast. The temporal restriction to the known migration times and the distance to the next islands or coast make it likely that these bats were on migration. However, the relation to adverse weather conditions (unfavourable winds, rain or at least more or less thick cloud layers), the exploring behaviour and some accumulation of recordings shortly after sunset and before sunrise, suggest that the bats rather sought refuge at the brightly lit platform than just were on transfer flights.

There is good reason for us to assume that the majority of migration takes place under better conditions (clear sky, tailwinds, e.g. Ahlén et al. 2009) but was missed in this and other offshore studies because bats flew beyond the range covered by the recording systems, presumably even at altitudes above 100 m under tailwind conditions. Currently there is no technology at hand to investigate bat migration over the North Sea or the Baltic Sea at higher altitudes, mainly because discrimination of migrating bats from birds e.g. in radar is not yet possible (Drake & Reynolds 2012, Aschwanden et al. 2015). Of course, bat detectors could be installed at 100 m a.s.l. at FINO 1. But since bats are attracted by lit structures (see above) and change their altitude rapidly when they are near tall vertical obstacles such as ships, bridges, and wind

turbines (Ahlén et al. 2009) this would provide little information on migratory transfer flights. In the near future, miniature GPS tags and data loggers (Weller et al. 2016) might give a closer insight into the migration and flight behaviour of the larger European bat species. The coastal flight behaviour of smaller bats could be studied with the help of tiny radio tags and a system of automatic receiving stations (see http://ifv-vogelwarte.de/das-institut/forschung/vogelzug/ag-hueppop/birdmove.html for a project on small songbirds).

Onshore, collisions with wind turbines are nowadays the leading cause of reported mortality in bats (O'Shea et al. 2016). But despite this and earlier evidence of bats migrating or foraging offshore in the North and Baltic Seas, there have been no studies to date to document collision mortality of bats with offshore wind turbines (or other artificial structures) even though they have been operational in Europe since 1991 (Hatch et al. 2013). Compared to onshore ones, offshore wind turbines require more and steadier lights with, in total, a higher light intensity in accordance with shipping safety regulations. Therefore, we see an increased risk of wind turbines attracting not only birds under deteriorating weather conditions (Hüppop & Hilgerloh 2012, Hüppop et al. 2016) but also considerable numbers of bats, with an unknown collision risk. We recommend bat monitoring as being part of the standardised "Investigation of the Impacts of Offshore Wind Turbines on the Marine Environment (BSH 2013)", also in the German exclusive economic zone of the North Sea. Regarding the rapid development of offshore wind farms, not only in Europe, there is an urgent need for further studies including the development of adequate technologies for offshore use.

Based on their compilation of migratory bat activity across the Baltic Sea and the southeastern North Sea coasts and islands, Rydell et al. (2014) concluded that the entire coastline and islands around the Baltic Sea are of potential importance to migrating bats in spring (April-May) and autumn (August-September) and should achieve relevant protection according to EU legislation and its implementations. This recommendation possibly needs to be extended to parts of the North Sea area. However, because of their cryptic migration behaviour, we have only a rough clue on the quantitative spatial distribution of bat migration. Fortunately, a new research project called "BatMove" is on the way that will hopefully shed new light on bat migration issues with regard to offshore wind farms.

Acknowledgements: Data collection was partly financed by the German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (Support codes 0327526 and 0329983). Data between 2008 and 2015 were collected by Avitec Research GbR without financial support. G. Fischer and S. Howorek kindly provided technical details on the illumination of the platform FINO 1. We are grateful to EUMETSAT, Meteox and the Deutscher Wetterdienst for making images and data freely accessible via the internet. I. Lensky's help was indispensable for analysing METEOSAT images with a recent Version of CAPSAT. We furthermore thank the Federal Maritime and Hydrographic Agency (Hamburg, particularly K. Herklotz) for providing weather data from the platform and appreciate the useful comments by Lothar Bach, Franz Bairlein and two anonymous referees on an earlier version. Kees Canters kindly translated the summary into a Dutch samenvatting.

References

Adams, A.M., M.K. Jantzen, R.M. Hamilton & M.B. Fenton 2013. Do you hear what I hear? Implications of detector selection for acoustic monitoring of bats. Methods in Ecology and Evolution 3: 992-998.

Ahlén, I., H.J. Baagøe & L. Bach 2009. Behavior of Scandinavian bats during migration and foraging at sea. Journal of Mammalogy 90: 1318-1323.

Arnett, E.B., E.F. Baerwald, F. Mathews, L. Rodrigues, A. Rodríguez-Durán, J. Rydell, R. Villegas-Patraca & C.C. Voigt 2016. Impacts of wind

energy development on bats: A global perspective. In: C.C. Voigt & T. Kingston (eds.). Bats in the Anthropocene: Conservation of bats in a changing world: 295-323. Springer International Publishing, Cham, Switzerland.

Aschwanden, J., S. Wanner, & F. Liechti 2015. Investigation on the effectivity of bat and bird detection at a wind turbine: Final Report Bird Detection. Schweizerische Vogelwarte, Sempach, Schweiz. URL: http://www.batsandwind.org/pdf/Hanagasioglu%20et%20al.%202015_Investigation%20of%20effectiveness%20of%20DTBat%20and%20DTBird.pdf; viewed 3 December 2016.

Bach, L., P. Bach, A. Helge, K. Maatz, V. Schwartz, M. Teuscher & J. Zöller 2009. Fledermauszug auf Wangerooge – erste Ergebnisse aus dem Jahr 2008. Natur- und Umweltschutz (Zeitschrift Mellumrat) 8: 10-12.

Ballasus, H., K. Hill & O. Hüppop 2009. Gefahren künstlicher Beleuchtung für ziehende Vögel und Fledermäuse. Berichte zum Vogelschutz 46: 127-157.

Barataud, M. 2015. Acoustic ecology of European bats. Species, identification, study of their habitats and foraging behaviour. Biotope, Mèze; Muséum nationale d'Histoire naturelle (Inventaires et biodiversité series), Paris, France.

Blake, D., A.M. Hutson, P.A. Racey, J. Rydell & J.R. Speakman 1994. Use of lamplit roads by foraging bats in southern England. Journal of Zoology 234: 453-462.

Boshamer, J.P.C. & J.P. Bekker 2008. Nathusius' pipistrelles (*Pipistrellus nathusii*) and other species of bats on offshore platforms in the Dutch sector of the North Sea. Lutra 51: 17-36.

Britzke, E.R., E.H. Gillam & K.L. Murray 2013. Current state of understanding of ultrasonic detectors for the study of bat ecology. Acta Theriologica 58: 109-117.

Britzke, E.R., B. Slack, M. Armstrong & S.C. Loeb 2010. Effects of orientation and weatherproofing on the detection of bat echolocation calls. Journal of Fish and Wildlife Management 1: 136-141.

BSH 2013. Investigation of the impacts of offshore wind turbines on the marine environment (StUK4). URL: http://www.bsh.de/en/Products/Books/Standard/7003eng.pdf; viewed 3 December 2016

Cermak, J. & J. Bendix 2008. A novel approach to fog/low stratus detection using Meteosat 8 data. Atmospheric Research 87: 279-292.

Chapman, J.W., D.R. Reynolds, A.D. Smith, E.T. Smith & I.P. Woiwod 2004. An aerial netting study of insects migrating at high altitude over England. Bulletin of Entomological Research 94: 123-136.

Ciechanowski, M., A. Jakusz-Gostomska & M. Żmihorski 2015. Empty in summer, crowded during migration? Structure of assemblage, distribution pattern and habitat use by bats (Chiroptera: Vespertilionidae) in a narrow, marine peninsula. Mammal Research 61: 45-55.

Clarke, W.E. 1912. Studies in bird migration. Vol. I and II. Gurney and Jackson, London, UK.

Crawford, R.L. & W.W. Baker 1981. Bats killed at a north Florida television tower: a 25-year record. Journal of Mammalogy 62: 651-652.

Cryan, P.M. & A.C. Brown 2007. Migration of bats past a remote island offers clues toward the problem of bat fatalities at wind turbines. Biological Conservation 139: 1-11.

Cryan, P.M. & R.H. Diehl RH 2009. Analyzing bat migration. In: T.H. Kunz & S. Parsons (eds.). Ecological and behavioral methods for the study of bats: 476-488. The Johns Hopkins University Press, Baltimore, USA.

Drake, V.A. & D.R. Reynolds 2012. Radar entomology: observing insect flight and migration. Cabi, Wallingford, UK.

Fenton, M.B. 2013. Questions, ideas and tools: lessons from bat echolocation. Animal Behaviour 85: 869-879.

Fischer, G. 2006. Installation and operation of the research platform FINO 1 in the North Sea. In: J. Köller, J. Köppel & W. Peters (eds.). Offshore wind energy: research on environmental impacts: 237-253. Springer, Berlin, Germany.

Frafjord, K. 2013. Influence of night length on home range size in the northern bat *Eptesicus nilssonii*. Mammalian Biology – Zeitschrift für Säugetierkunde 78: 205-211.

Frey, K., L. Bach, P. Bach & H. Brunken 2012. Fledermauszug entlang der südlichen Nordseeküste. Naturschutz und Biologische Vielfalt 128: 185-204.

Gätke, H. 1895. Heligoland as an ornithological observatory. David Douglas, Edinburgh, UK.

Gerell, R. & J. Rydell 2004. *Eptesicus nilssonii* (Key-

serling et Blasius, 1839) – Nordfledermaus. In: F. Krapp (ed.). Handbuch der Säugetiere Europas. Band 4: Fledertiere, Teil I: 561-581. Aula, Wiebelsheim, Germany.

Hatch, S.K., E.E. Connelly, T.J. Divoll, I.J. Stenhouse & K.A. Williams 2013. Offshore observations of Eastern red bats (*Lasiurus borealis*) in the Mid-Atlantic United States using multiple survey methods. PLoSOne 8 (12): e83803.

Heydemann, B. 1967. Überflug von Insekten über Nord- und Ostsee. Deutsche Entomologische Zeitschrift (Neue Folge) 14: 185-216.

Hill, R. & O. Hüppop 2008. Birds & bats: Automatic recording of flight calls and their values for the study of migration. In: K.-H. Frommolt, R. Bardeli & M. Clausen (eds.). Computational bioacoustics for assessing biodiversity. BfN-Skripten 234: 135-141. Bundesamt für Naturschutz (BfN), Bonn, Germany.

Holderied, M.W. & G. Jones 2009. Flight dynamics of bats. In: T.H. Kunz & S. Parsons (eds.). Ecological and behavioral methods for the study of bats: 459-475. The Johns Hopkins University Press, Baltimore, USA.

Holland, R.A. 2007. Orientation and navigation in bats: known unknowns or unknown unknowns? Behavioral Ecology and Sociobiology 61: 653-660.

Holland, R.A. & M. Wikelski 2009. Studying the migratory behaviour of individual bats: current techniques and future directions. Journal of Mammalogy 90: 1324-1329.

Hüppop, O. 2009. Bat migration at Helgoland, a remote island in the North Sea: wind assisted or wind drifted? Poster presentation. Proceedings of the 1st International Symposium on Bat Migration: 55. Leibniz Institute for Zoo and Wildlife Research (IZF), Berlin, Germany.

Hüppop, O. & G. Hilgerloh 2012. Flight call rates of migrating thrushes: effects of wind conditions, humidity and time of day at an illuminated offshore platform. Journal of Avian Biology 43: 85-90.

Hüppop, O., K. Hüppop, J. Dierschke & R. Hill 2016. Bird collisions at an offshore platform in the North Sea. Bird Study 63: 73-82.

Jensen, M.E. & L.A. Miller 1999. Echolocation signals of the bat *Eptesicus serotinus* recorded using a vertical microphone array: effect of flight altitude on searching signals. Behavioral Ecology and Sociobiology 47: 60-69.

Kalko, E.K.V. & H.-U. Schnitzler 1993. Plasticity in echolocation signals of European pipistrelle bats in search flight: implications for habitat use and prey detection. Behavioral Ecology and Sociobiology 33: 415-428.

Lagerveld, S., B.J. Poerink, R. Haselager & H. Verdaat 2014. Bats in Dutch offshore wind farms in autumn 2012. Lutra 57: 61-69.

Lensky, I.M. & D. Rosenfeld 2003. Satellite-based insights into precipitation formation processes in continental and maritime convective clouds at nighttime. Journal of Applied Meteorology 42: 1227-1233.

Lensky, I.M. & D. Rosenfeld 2008. Clouds-aerosols-precipitation satellite analysis tool (CAPSAT). Atmospheric Chemistry and Physics 8: 6739-6753.

McCracken, G.F., E.H. Gillam, J.K. Westbrook, Y.F. Lee, M.L. Jensen & B.B. Balsley 2008. Brazilian free-tailed bats (*Tadarida brasiliensis*: Molossidae, Chiroptera) at high altitude: links to migratory insect populations. Integrative and Comparative Biology 48: 107-118.

Meineke, T. 2012. Fledermäuse über dem Brocken im Harz. Nyctalus (Neue Folge) 17: 338-352.

Miller, L.A. & H.J. Degn 1981. The acoustic behavior of four species of vespertilionid bats studied in the field. Journal of Comparative Physiology 142: 67-74.

Nicholls, B. & P-A. Racey 2006. Contrasting home-range size and spatial partitioning in cryptic and sympatric pipistrelle bats. Behavioral Ecology and Sociobiology 61: 131-142.

O'Shea, T.J., P.M. Cryan, D.T.S. Hayman, R.K. Plowright & D.G. Streicker 2016. Multiple mortality events in bats: a global review. Mammal Review 46: 175-190.

Parsons, S. & J.M. Szewczak 2009. Detecting, recording, and analyzing the vocalizations of bats. In: T.H. Kunz & S. Parsons (eds.). Ecological and behavioral methods for the study of bats: 91-111. The Johns Hopkins University Press, Baltimore, USA.

Petersen, A., J.K. Jensen, P. Jenkins, P., D. Bloch & F. Ingimarsson 2014. A review of the occurrence of bats (Chiroptera) on islands in the North East Atlantic and on North Sea installations. Acta Chi-

ropterologica 16: 169-195.

Pētersons, G. 2004. Seasonal migrations of north-eastern populations of Nathusius' bat *Pipistrellus nathusii* (Chiroptera). Myotis 41-42: 29-56.

R Core Team 2016. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL: https://www.R-project.org/; viewed 3 December 2016.

Ratcliffe, J.M., C.P.H. Elemans, L. Jakobsen & A. Surlykke 2013. How the bat got its buzz. Biology Letters 9 20121031. DOI: 10.1098/rsbl.2012.1031.

Rydell, J. 1991. Seasonal use of illuminated areas by foraging northern bats *Eptesicus nilssoni*. Ecography 14: 203-207.

Rydell, J. 1992. Exploitation of insects around streetlamps by bats in Sweden. Functional Ecology 6: 744-750.

Rydell, J. 1993. Variation in the sonar of an aerial-hawking bat (*Eptesicus nilssonii*). Ethology 93: 275-284.

Rydell, J. & A. Wickman 2015. Bat activity at a small wind turbine in the Baltic Sea. Acta Chiropterologica 17: 359-364.

Rydell, J., L. Bach, P. Bach, L.G. Diaz, J. Furmankiewicz, N. Hagner-Wahlsten, E.-M. Kyheröinen, T. Lilley, M. Masing, M.M. Meyer, G. Pētersons, J. Šuba, V. Vasko, V. Vintulis, A. Hedenström 2014. Phenology of migratory bat activity across the Baltic Sea and the south-eastern North Sea. Acta Chiropterologica 16: 139-147.

Saunders, W.E. 1930. Bats in migration. Journal of Mammalogy 11: 225-225.

Schmetz, J., P. Pili, S. Tjemkes, D. Just, J. Kerkmann, S. Rota & A. Ratier 2002. An introduction to Meteosat second generation (MSG). Bulletin of the American Meteorological Society 83: 977-992.

Schnitzler, H. U. & E.K. Kalko 2001. Echolocation by insect-eating bats. Bioscience 51: 557-569.

Schoeman, M.C. 2016. Light pollution at stadiums favors urban exploiter bats. Animal Conservation 19: 120-130.

Shiel, C.B., R.E. Shiel & J.S. Fairley 1999. Seasonal changes in the foraging behaviour of Leisler's bats (*Nyctalus leisleri*) in Ireland as revealed by radiotelemetry. Journal of Zoology 249: 347-358.

Simmons, J.A., M.B. Fenton & M.J. O'Farrell 1979. Echolocation and pursuit of prey by bats. Science 203: 16-21.

Sjollema, A.L., J.E. Gates, R.H. Hilderbrand & J. Sherwell 2014. Offshore activity of bats along the Mid-Atlantic Coast. Northeastern Naturalist 21: 154-163.

Skiba, R. 2003. Europäische Fledermäuse. Neue Brehm-Bücherei 648. Westarp Wissenschaften, Hohenwarsleben, Germany.

Skiba, R. 2007. Die Fledermäuse im Bereich der Deutschen Nordsee unter Berücksichtigung der Gefährdungen durch Windenergieanlagen (WEA). Nyctalus (Neue Folge) 12: 199-220.

Smith, A.D. & S.R. McWilliams 2016. Bat activity during autumn relates to atmospheric conditions: implications for coastal wind energy development. Journal of Mammalogy, gyw116. DOI: dx.doi.org/10.1093/jmammal/gyw116.

Stone, E.L., S. Harris & G. Jones 2015. Impacts of artificial lighting on bats: a review of challenges and solutions. Mammalian Biology – Zeitschrift für Säugetierkunde 80: 213-219.

Šuba, J., G. Pētersons & J. Rydell 2012. Fly-and-forage strategy in the bat *Pipistrellus nathusii* during autumn migration. Acta Chiropterologica 14: 379-385.

Terres, J.K. 1956. Migration records of the Red bat, *Lasiurus borealis*. Journal of Mammalogy 37: 442-442.

Tress C. 1994. Zum Wanderverhalten der Nordfledermaus (*Eptesicus nilssoni*, Keyserling u. Blasius 1839). Naturschutzreport 7: 367-372.

Vauk, G. 1974. Fledermausbeobachtungen auf der Insel Helgoland. Zeitschrift für Säugetierkunde 39: 133-135.

Vauk, G. & T. Clemens 1982. Ein zweiter Nachweis der Zwergfledermaus (*Pipistrellus pipistrellus*) auf Helgoland. Myotis 20: 72-73.

Vierhaus, H. 2004. *Pipistrellus nathusii* (Keyserling und Blasius, 1839) – Rauhhautfledermaus. In: F. Krapp (ed.). Handbuch der Säugetiere Europas. Band 4: Fledertiere, Teil II: 825-873. Aula, Wiebelsheim, Germany.

Voigt, C.C., L.S. Lehnert, G. Pētersons, F. Adorf & L. Bach 2015. Wildlife and renewable energy: German politics cross migratory bats. European Journal of Wildlife Research 61: 213-219.

Voigt, C.C., K. Schneeberger, S.L. Voigt-Heucke & D. Lewanzik 2011. Rain increases the energy cost of

bat flight. Biology letters: rsbl20110313.
Voigt, C.C., K. Sörgel, J. Šuba , O. Keišs & G. Pētersons 2012. The insectivorous bat *Pipistrellus nathusii* uses a mixed-fuel strategy to power autumn migration. Proceedings of the Royal Society B: Biological Sciences 279: 3772-3778.
von Dalla Torre, K.W. 1889. Die Fauna von Helgoland. Zoologisches Jahrbuch 4, Supplement 11.
Walter, G., H. Matthes & M. Joost 2007. Fledermauszug über Nord- und Ostsee – Ergebnisse aus Offshore-Untersuchungen und deren Einordnung in das bisher bekannte Bild zum Zuggeschehen. Nyctalus (Neue Folge) 12: 221-223.
Waters, D.A., J. Rydell & G. Jones 1995. Echolocation call design and limits on prey size: a case study using the aerial-hawking bat *Nyctalus leisleri*. Behavioral Ecology and Sociobiology 37: 321-328.
Waters, D., G. Jones & M. Furlong 1999. Foraging ecology of Leisler's bat (*Nyctalus leisleri*) at two sites in southern Britain. Journal of Zoology 249: 173-180.
Weller, T.J., K.T. Castle, F. Liechti, C.D. Hein, M.R. Schirmacher & P.M. Cryan 2016. First direct evidence of long-distance seasonal movements and hibernation in a migratory bat. Scientific Reports 6: 34585.

Samenvatting

De fenologie van migrerende vleermuizen en hun gedrag bij een onderzoeksplatform in de zuidoostelijke Noordzee

Wij analyseerden de waarnemingen van echogeluiden van vleermuizen, die gedurende meer dan tien jaar werden opgenomen op een onbemand onderzoeksplatform in de Noordzee, 45 kilometer ten noorden van het waddeneiland Borkum. Daarbij keken we specifiek naar de relatie tussen deze waarnemingen en het seizoen, het moment van de dag en de weersomstandigheden, met name de windrichting en de windkracht.

Voor zover wij weten betreft het hier de langstlopende, systematisch verzamelde dataset betreffende overzeese trek van vleermuizen. In totaal werden 317 echogeluiden geregistreerd, uitsluitend gedurende de typische migratieperiode van vleermuizen in voorjaar en najaar. Daarvan konden er tenminste 23 worden toegerekend aan de ruige dwergvleermuis (*Pipistrellus nathusius*), drie aan de noordse vleermuis (*Eptesicus nilssonii*) en twee aan de bosvleermuis (*Nyctalus leisleri*).

Bij lagere windsnelheden en bij wind uit zuidelijke richtingen worden er meer vleermuizen waargenomen dan op basis van toeval mag worden verwacht. Zowel bij wind mee als bij sterke tegenwind zijn er vleermuizen waargenomen. In beide trekseizoenen kwamen de meeste vleermuizen voor bij zuidelijke winden, dat wil zeggen steeds bij zijwind. Dit laatste wijst erop dat er sprake moet zijn van verdrifting vanaf de kust. We konden geen effect aantonen van de algemene luchtdruk en ook niet van veranderingen in deze luchtdruk. Het merendeel van de waarnemingen vond plaats onder zwaarbewolkte omstandigheden, bij mist of laaghangende bewolking en/of bij regen.

Uit de duur en de eigenschappen van de geregistreerde echogeluiden kan worden afgeleid dat de meeste vleermuizen rond het platform verkenningsvluchten uitvoerden en er dus gedurende de trek niet alleen langs het platform vlogen. Sommige dieren voerden zelfs foerageervluchten uit.

Wij concluderen dat de meeste waargenomen vleermuizen op trek zijn en worden aangetrokken door het helder verlichte platform en/of daar een veilige plek zochten. Deze conclusie maakt duidelijk dat het risico van botsingen met offshore windturbines reëel is. Deze turbines zouden dan ook meer moeten worden aangelicht dan turbines op het vaste land. We nemen aan dat een groot deel van de overzeese trek van vleermuizen op grotere hoogten met de op dit moment beschikbare apparatuur niet kan worden waargenomen.

Received: 2 November 2016
Accepted: 18 November 2016

The first proof of the recent presence of wolves in the Netherlands

Glenn Lelieveld[1,2], Bart Beekers[1,3], Julia Kamp[1], Dick Klees[1,4], Leo Linnartz[1,3], Ellen van Norren[1,5], Elze Polman[1] & Roeland Vermeulen[1,6]

[1] Wolven in Nederland (www.wolveninnederland.nl), e-mail: info@wolveninnederland.nl
[2] Averti Ecologie, Acacialaan 21, NL-6721 CN Bennekom, the Netherlands
[3] ARK Natuurontwikkeling, Molenveldlaan 43, NL-6523 RJ Nijmegen, the Netherlands
[4] Studio Wolverine, Legstraat 2a, NL-4861 RK Chaam, the Netherlands
[5] Landschap Overijssel, Poppenallee 39, NL-7722 KW Dalfsen, the Netherlands
[6] FREE Nature, Augustuslaan 36, NL-6642 AB Beuningen, the Netherlands

Abstract: During the second half of the 20th century, wolves (*Canis lupus* L. 1758) have greatly expanded their range in Europe. Experts believe that wolves will ultimately recolonise the Netherlands. In March 2015, a German wolf (named 'Wanderwolf') visited the Netherlands, leaving a trail of sightings and several attacked sheep. This raised a lot of media interest and public discussion. In this article, we summarise the spread of the wolf across north-western Europe in the 21st century, often into habitats previously considered too small for viable populations, track Wanderwolf's background and journey across the north-east of the Netherlands and discuss other possible sightings of wolves in the Netherlands since 1990.

Keywords: Canis lupus, Europe, habituation, Netherlands, wolf, management, dispersion, recolonisation, habitat, expansion.

Introduction

During the second half of the 20th century, wolves (*Canis lupus*) have greatly expanded their historical range in Europe. The most important reasons for this expansion seem to be European-wide legal protection, especially since the fall of the Iron Curtain (the wolf was not a protected species in the former German Democratic Republic (DDR) until 1990), and increased populations of prey species, which allowed wolf populations to recover from their last refuges in Spain, Italy and Eastern Europe and to recolonise France, Switzerland and Germany. It is estimated that there are currently 46 wolf packs, 15 wolf pairs and 4 territorial individuals in France and 40 wolf packs or pairs in Germany (Kontaktbüro Wolfsregion Lausitz 2016, ONCFS 2016).

The first wolves to come back into Germany were sighted in the Lausitz region close to the Polish border. In 2000, for the first time in approximately 150 years, wolf pups were born in Germany, at a military training area (Kontaktbüro Wolfsregion Lausitz 2016, NABU 2016). From 2002/2003 wolves began to spread mostly in a north-westerly direction, occasionally visiting Denmark by 2012 (Jensen et al. 2015).

Wolves have also been heading back to the Netherlands. In March 2013, a camera captured a territorial female wolf in a military training area near the city of Meppen in Lower Saxony (Germany), some 50 kilometres from the Dutch border. The same wolf

was sighted a year later in March/April 2014 at military areas near Meppen and Nordhorn (through camera trapping and photos by passers-by). DNA analyses showed that the female wolf came from the Gartower pack in the Wendland region, Germany (B. Habbe, personal communication).

The wolves' rapid colonisation of densely populated western European countries surprised many since most of the older literature describes suitable wolf habitat as large areas (up to thousands of square kilometres) with minimal human disturbance (Mech & Boitani 2003, Kaartinen et al. 2005). Others suggested that these were refuge areas instead of being a preferred habitat of wolves (Llaneza, Lopez-Bao & Sazatornil 2012). A 2013 German study showed that European wolves are highly adaptive to cultivation and can deal with human population densities of up to 80 people per km^2 (Fechter & Storch 2014). A Dutch study suggested that the Netherlands may provide enough suitable habitats for at least 40 wolf packs (Lelieveld 2012), despite the country's high average population density of 500 people per km^2 (CBS 2014) and the intensive cultivation of its rural areas. Fechter and Storch (2014) argue that wolves can deal with even more densely populated areas than suggested by Lelieveld's study (2012).

Nonetheless, wolves tend to colonise areas with relatively little human disturbance, such as military areas or former open-cast coal mining areas. German wolves are known to have occupied territories of 200 km^2 on average, sometimes even as small as 80 km^2, indicating that the need for large territories is not, in itself, an obstacle for the settlement of wolves. It is likely that territory size is highly depending on the availability of prey (Fechter & Storch 2014).

In light of the expansion of wolves from the Polish border to the northwest of Germany and the sightings in Denmark, the appearance of the wolf in the Netherlands was no surprise to most experts. In March 2015, this expectation was fulfilled when, after generations without resident wolves, a single wolf wandered through the Dutch provinces of Drenthe and Groningen in broad daylight. From 7 to 10 March 2015, the Netherlands witnessed the comeback of an iconic species. In this article we describe the appearance of this wolf, its history and the response by the general public and others.

'Wanderwolf'

'Wanderwolf' had caught the eye of German wolf experts long before it reached the Netherlands. The first noticeable and documented incident with this young wolf, was in February 2015 when he attacked a sheep flock in Schleswig-Holstein. What was conspicuous about this incident was that he attacked them in broad daylight and did not seem to be as timid as its conspecifics. The wolf did not show any aggressive behaviour towards humans (Kabel 2015a), but kept returning to the flock for about an hour despite humans being just a few metres away, trying to protect the flock. A few weeks later, he was identified to be a yearling from the Munster pack in Lower Saxony, a pack known for its indifference towards humans. Such unusual behaviour has only been reported in this particular wolf pack in Germany. Experts began to discuss the possibility that humans had made a contribution to this conspicuous behaviour through feeding them (Kabel 2015b).

The authorities in Lower Saxony decided to make Wanderwolf more wary of human presence. The first step in this process was to permit a wolf advisor to startle the wolf by shooting at it with rubber bullets. The authorities also permitted the killing of the wolf if it were to actively threaten humans. These actions caused much debate among wolf experts and conservationists, who argued that startling a wolf with rubber bullets fired from a short distance could cause injuries and this should only be done by experts. After a meeting, all the stakeholders agreed it would be best

to capture the wolf and study its health and behaviour. If the wolf proved to be healthy and wild, it should be released back into its parents' territory and startled during release by experts to make the wolf more wary of humans. To follow its movements, it should be tagged with a GPS transmitter. However, Wanderwolf took matters into its own hands and entered the Netherlands before German experts were able to capture it.

Wanderwolf wandering through the Netherlands

In the afternoon of 6 March 2015 a German wolf expert contacted the platform organization 'Wolven in Nederland' ('Wolves in the Netherlands') to inform them that Wanderwolf was heading towards the Dutch border and was expected to enter the Netherlands soon. The information was forwarded to the relevant Dutch authorities: the Ministry of Economic Affairs, the Province of Drenthe, Faunafonds and other nature organisations. The authorities from Lower Saxony also made contact with the Province of Drenthe.

On the evening of 6 March 2015, a local resident witnessed the wolf near to the Dutch border at the Bargerveen Nature Reserve, (see figure 1). The observer was not able to make a photograph, so the sighting remained an unverifiable C3 classification under the SCALP criteria (Kaczensky et al. 2009, Reinhardt et al 2015).

In the night between 6 and 7 March 2015, Wanderwolf left the first evidence of his presence in the Netherlands when a sheep carcass was found near Nieuw Amsterdam (see figure 2). News about this was reported to Faunafonds (the responsible authority) which sanctioned the dissection of the sheep to research institute Alterra Wageningen UR to carry out DNA analysis of the saliva in the bite marks (see figure 3). Their findings confirmed that the sheep had been killed by a wolf (Alterra 2015).

The first sighting that could be validated with photos verified by experts (C1 under the SCALP criteria) was at 7 March around 8 a.m. near Erm, approximately 17 km from the German border. Other validated sightings showed that the wolf continued in a north-westerly direction, through Sleen and Wezuperbrug. A man driving with his daughter on the N381, between Zweeloo and Noord-Sleen, not far from Emmen, stopped their car for a wolf crossing the road in front of them. He took photos and sent them to various media outlets.

Between the first and last C1 sighting, at Wezuperbrug on 7 March, the wolf walked a distance of 17 km. The next morning, the animal was reported to be nearby Amen, 15 km further northwest (P. Venema, personal communication). On the same day, two observers photographed the wolf crossing a road in Wezuperbrug. According to their description, the wolf was wandering slowly and jumping at a bird. Shortly after these first sightings were reported in the news.

On 8 March, Wanderwolf was photographed many times during daylight hours in the Drentse Aa National Park. The next morning it was photographed (C1) close to Annen, approximately 16 kilometres from where it had been seen the day before. The wolf continued to follow a northerly direction, travelling through the villages of Hoogezand and Kolham between 8:30 and 10:30, which resulted in almost a live feed of verifiable sightings. Once outside the villages, Wanderwolf seemed to take a rest in the afternoon and continued northwards in the evening where he was photographed near Woudsbloem. At 10 March, the wolf travelled further north and reached the most northerly mainland point of the province of Groningen, the Eemshaven. He was seen and photographed by several people near this industrial harbour. A sheep farmer near Holwierde reported a panic amongst his sheep late in the evening of 10 March and the next morning found a dead sheep that had been attacked by a wolf. On that same morning (11 March), a farmer near Termunten drove away a 'wolf-like' animal

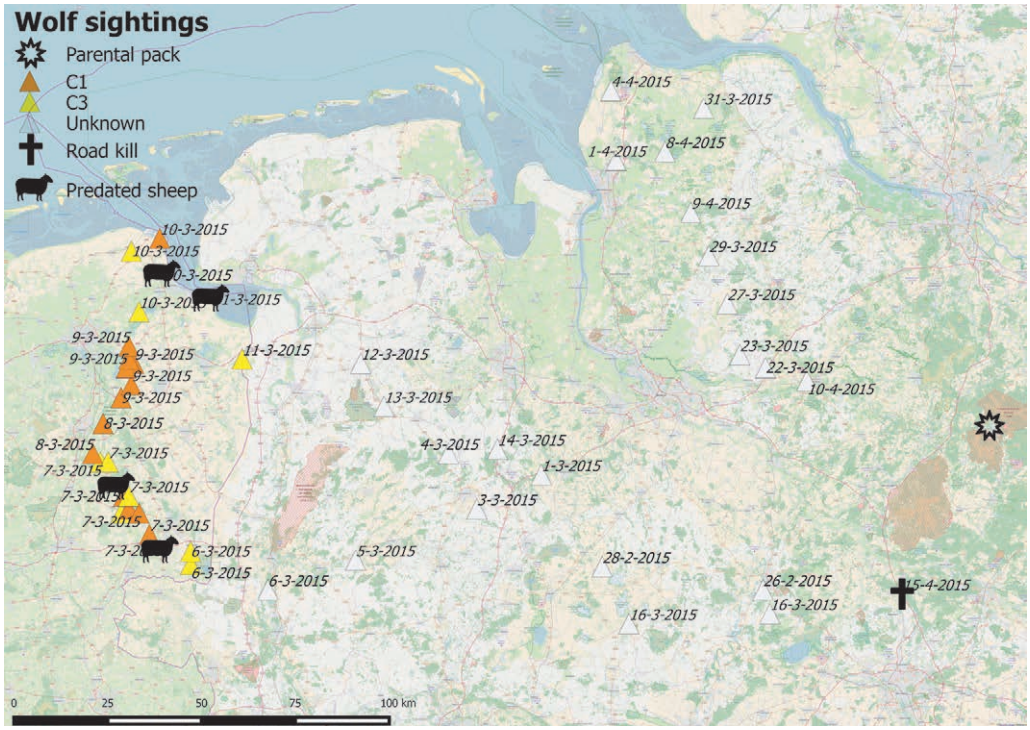


Figure 1. Map showing the locations of key life events of the Wanderwolf; the natal pack, locations of his juvenile dispersion in Germany and the Netherlands, locations in the Netherlands of predated livestock and the location where the Wanderwolf was hit by a truck. The sightings in the Netherlands were classified by SCALP criteria (Kaczensky et al. 2009 and Reinhardt et al. 2015) into verifiable and validated sightings (C1) and non-verifiable sightings (C3). On this map, from the C3 classification only C3a (unverifiable, but 'most likely a wolf') are shown. The authors do not have geographical information on validated sightings in Germany, and so sightings reported in the media have been classified as 'unknown' on the map.

from his flock, one of which had already been killed. Samples taken from the teeth marks on both sheep tested positive for wolf DNA.

The last verified sighting in the Netherlands was on 11 March around 9:30 in the morning when the wolf was photographed near Bad Nieuweschans. One hour later, around 10:50, the wolf was sighted near Bunde in Germany, 6 kilometres from Bad Nieuweschans.

Crisis management: media hype and governance

The short visit of the wolf to the Netherlands sparked a media frenzy about how to deal with the situation. The provincial authorities and Wolven in Nederland were regularly contacted for updates about sightings and questions that ranged from the potential danger to pets to safety while walking in the forest. Experts were interviewed in live media; Leo Linnartz of Wolven in Nederland featured in a popular television talk show.

Because of the urgency of the situation, the Province of Drenthe called in a crisis team in close cooperation with the authorities from Lower Saxony during the weekend Wanderwolf was in the Netherlands. The team consisted of members of several Dutch authorities and Wolven in Nederland, and decided to follow the advice of German wolf experts of

Figure 2. One of the predated sheep, Nieuw-Amsterdam, the Netherlands, 07-03-2015. *Photo: Bart Beekers.*

the Lupus Institute and the policy of Lower Saxony. Preparations were made for keeping the animal temporarily in an enclosure while planning on what to do with the wolf after having determined its wildness and origins. However, in the end it was decided to tranquilise the animal, collar it with a GPS transmitter and to immediately release the animal back into the wild. During the following day, the team started searching for the wolf in an attempt to sedate it. On 11 March the wolf had returned to Germany, before the team got a chance to capture it.

Returning to Germany

After Wanderwolf left the Netherlands and returned to Germany, it disappeared out of sight for some time and media attention on it decreased. However, on 15 April 2015 it was killed in an accident with a truck on the A7 highway nearby Berkhof close to Hannover, Germany (although this was not announced until 23 July) (NLWKN 2016). At that time it was not known whether the wolf had been examined or where its carcass was. Research by Wolven in Nederland, later (in January 2016) revealed that the wolf was stored at the Lower Saxony Ministry for Environmental, Energy and Climate Protection in Hanover. The authorities there agreed to donate the wolf to the Netherlands for education and research purposes. The carcass of Wanderwolf was picked up at Friday 29 January 2016 by Wolven in Nederland and handed over to the Naturalis Biodiversity Center in Leiden to be incorporated in its collection.

Revealing the background of Wanderwolf

Examination of Wanderwolf by autopsy and the analysis of its DNA revealed a lot of information on its background. The DNA analysis traced the wolf back to the Munster pack in Germany. The territory of this pack is sit-

Figure 3. Research by Dennis Lammertsma and Hugh Jansman on one of the sheep killed by Wanderwolf at Alterra Wageningen UR. *Photo: Wendy Bos.*

uated in a large military training area and was established when a female wolf from the Nochten pack in Saxony settled in the area in 2011 (Landesjägerschaft Niedersachsen 2016). The pups of the Munster pack that were born in 2014 made a stir in the beginning of 2015 when they showed less timid behaviour towards humans than usual. One of them eventually became known as 'Wanderwolf'. This wolf travelled along roads, through villages, towns and industrial zones. The remarkable daytime activity caused different reactions amongst the general public. Some people concluded that the animal must have been of captive origin, or even intentionally released. Some were afraid for their children, others for their dogs, cats and horses, or asked if they still could walk safely with or without their dog in nature areas. Experts continued to advise that wild wolves do not avoid human structures, such as roads and buildings, but do mostly avoid the risks that humans may impose, although this behaviour can be changed by habituation as a result of (un)intentionally feeding. Habituated wolves themselves form no danger, but can spread the effect by not teaching their offspring to fear humans. The wolves of the Munster pack never showed an interest in people and clearly backed off whenever they were closely approached. Nonetheless, in reaction to the unusual behaviour of this pack of wolves, the government of Lower Saxony decided to tag two young wolves with GPS transmitters. In June 2015, the authorities tagged one male and one female from the Munster pack, both born in 2014. The male of this pack was culled later, on 27 April 2016, because of its lack of shyness towards humans, even though he never showed any aggressive behaviour.

Previous sightings of wolves in the Netherlands

Before Wanderwolf in March 2015, the Netherlands may have been visited by other wild wolves. However, none of these earlier potential visits could be verified as wild wolves dispersing to the Netherlands in a natural way.
Fifteen years earlier, in 2000, a first wolf-like animal was sighted in the southernmost part of the province of Zeeland, close to the Belgian border. The animal was first sighted on

14 October and had reportedly been killing sheep on a regular basis. Local people claimed that the animal was a wolf, but the only evidence was a short video of a wolf-like creature taken from far away, which was regarded insufficient evidence for validation. The animal was reported to have been around until at least 22 December, but disappeared afterwards. Rumours say the animal was shot, but this is not proven (Calle 2010).

The next sighting of a wolf-like animal was on a Saturday afternoon on 27 August 2011 when people stopping at a gas station along the A12 near Duiven, a town east of Arnhem, saw a wolf-like animal crossing this busy motorway. Pictures were taken with mobile phones, but none of these pictures were of sufficient quality to become evidence for a C1 sighting. However, German wolf expert Ilka Reinhardt gave this sighting a C2 classification, making it a near-certain sighting of a wolf in the Netherlands.

Two years later, on 4 July 2013, a dead wolf was found along a road near Luttelgeest in Flevoland. This wolf most likely originated from the Carpathian region (Gravendeel, de Groot, Kik et al. 2013). Although at first it was thought that the wolf had arrived in Luttelgeest by itself, researchers later concluded that the most plausible explanation was that the animal had been shot abroad (as bullet impacts and shattered fragments were found inside the body) and dumped by the roadside to make it look like as if it had been hit by a car or truck (Gravendeel, de Groot, Kik et al. 2013).

Between April and July 2014, several possible wolf sightings were made on the Dutch side of the Dutch-German border near Meppen and Nordhorn (Anonymous 2015). The sightings were independent of each other and occurred before local media gave attention to these sightings. All the sightings and findings of tracks and excrement (without proper DNA tests) were recorded as C3 sightings as there was no verifiable evidence.

The wolf today in Dutch society

The road trip of Wanderwolf through the Netherlands proved to be a highly successful PR event for this species. In the 15 years between the first supposed wolf sightings in the Netherlands and Wanderwolf, a lot has changed in peoples' attitudes towards the expected return of wolves to the Netherlands (Anonymous, 2012). Disbelief, aggression, misinformation and fear were the main initial reactions. Education and awareness-raising work have much to better inform public opinion. One of people's main initial concerns has been to do with the protection of livestock. Committed farmers in Germany have shown that it is possible to prevent livestock predation by working together with other stakeholders to keep livestock safe and ensure that wolves stick to their natural prey.

The Dutch government has taken up its responsibility concerning this iconic though controversial species. It has developed a wolf management plan (BIJ12 2015; cf. Groot Bruinderink & Lammertsma 2013), and financially supported studies to determine the best damage-prevention measures for different kinds of livestock in the Netherlands. Any damage to livestock will be compensated completely by the authorities. Normally the Faunafonds charges a handling fee and a deductible excess for any claims of damage by wildlife. Neither will apply in case of damage by wolves.

Acknowledgements: We wish to thank all those who helped to put the wolf on the political agenda in a positive, realistic and constructive way. Two of them, Peter Venema and Hugh Jansman, have particularly helped to raise political awareness about the wolf and have helped this article by their solid advice. We also wish to thank two anonymous reviewers for their constructive feedback.

References

Alterra 2015. Het was een wolf, afkomstig uit een roedel wilde wolven in Duitsland. Press release published on 2 April 2015. URL: http://www.wur.nl/nl/nieuws/Het-was-een-wolf-afkomstig-uit-een-roedel-wilde-wolven-in-Duitsland.htm; viewed 14 November 2016.

Anonymous 2012. Appreciatie-onderzoek naar de komst van de wolf. Kwalitatief en kwantitatief onderzoek onder de Nederlandse bevolking. Intomart GfK, Hilversum, the Netherlands.

Anonymous 2015. De wolf van Twente. Zoogdier 26 (2): 21.

BIJ12 2015. Operationeel Draaiboek Wolf Fase 1. Published on 29 January 2015 by Unit Faunafonds of BIJ12. URL: http://www.wolveninnederland.nl/nieuws/wolvendraaiboek; viewed 14 November 2016.

Calle, L. 2010. Wolf *Canis lupus*. In: J.P. Bekker, L. Calle, S. Dobbelaar, A. Fortuin, C. Jacobusse & K. de Kraker (eds.) 2010. Zoogdieren in Zeeland. Fauna Zeelandica Deel 6: 156-157. Zoogdierwerkgroep Zeeland & Het Zeeuwse Landschap, Wilhelminadorp, the Netherlands.

CBS [Centraal Bureau voor de Statistiek] 2014. Demografische kerncijfers per gemeente 2014. Centraal Bureau voor de Statistiek, Den Haag/Heerlen, the Netherlands. https://www.cbs.nl/nl-nl/publicatie/2014/50/demografische-kerncijfers-per-gemeente-2014; viewed 14 November 2016.

Fechter, D. & I. Storch 2014. How many wolves (*Canis lupus*) can fit in Germany? The role of assumptions in predictive rule-based habitat models for habitat generalists. Plos One 9 (7): e101798.

Gravendeel, B., A. de Groot, M. Kik, K.K. Beentjes, H. Bergman, R. Caniglia, H. Cremers, E. Fabbri, D. Groenenberg, A. Grone, G. Groot Bruinderink, L. Font, J. Hakhof, V. Harms, H. Jansman, R. Janssen, D. Lammertsma, I. Laros, L. Linnartz, D. van der Marel, J.L. Mulder, S. van der Mije, A.M. Nieman, C. Nowak, E. Randi, M. Rijks, A. Speksnijder & H.B. Vonhof 2015. The first wolf found in the Netherlands in 150 years was the victim of a wildlife crime. Lutra 56 (2): 93-109.

Groot Bruinderink, G.W.T.A. & D.R. Lammertsma 2013. Voorstel voor een wolvenplan voor Nederland; versie 2.0. Rapport 2486. Alterra WUR, Wageningen, the Netherlands.

Jensen, T.S., K. Olsen, P. Sunde, C. Vedel-Smith, A.B. Madsen & L.W. Andersen 2015. Genindvandring af ulven (*Canis lupus*) i Danmark. Flora og Fauna 121 (1+2): 48-54.

Kabel, N. 2015a. Gen-Untersuchungen zu auffälligem Wolf abgeschlossen: Tier stammt aus Rudel in Niedersachsen. Pressetext. Ministerium für Energiewende, Landwirtschaft, Umwelt und ländliche Räume des Landes Schleswig-Holstein, Kiel, Germany. URL: http://www.gdi-sh.de/DE/Landesregierung/V/Presse/PI/2015/0315/MELUR_150330_Wolf_Lauenburg.html; viewed 14 November 2016.

Kabel, N. 2015b. Wolf in Ortschaft nahe Mölln gesichtet. Ministerium für Energiewende, Landwirtschaft, Umwelt und ländliche Räume des Landes Schleswig- Holstein, Kiel, Germany. URL: http://www.schleswig-holstein.de/DE/Landesregierung/V/Presse/PI/2015/0315/MELUR_150307_Wolf.html; viewed 14 November 2016.

Kaczensky, P., G. Kluth, F. Knauer, G. Rauer, I. Reinhardt & U. Wotschikowksy 2009. Monitoring von Großraubtieren in Deutschland. Skripten 251. Bundesamt für Naturschutz, Bonn, Germany.

Kaartinen, S., I. Kojola, & A. Colpaert 2005. Finnish wolves avoid roads and settlements. Annales Zoologici Fennici 42: 523-532.

Kontaktbüro Wolfsregion Lausitz 2016. Verbreitung in Deutschland. Monitoringjahr 2015/2016. URL: http://wolfsregion-lausitz.de/index.php/verbreitung-in-deutschland; viewed 15 November 2016.

Landesjägerschaft Niedersachsen 2016. Rudel Munster. Wildtier Management Niedersachsen. URL: http://www.wildtiermanagement.com/wildtiere/haarwild/wolf/wolfsnachweise_in_niedersachsen/rudel_munster/; viewed 23 November 2016.

Llaneza, L., J.V. Lopez-Bao & V. Sazatornil 2012. Insights into wolf presence in human-dominated landscapes: the relative role of food availability, humans and landscape attributes. Diversity and Distributions Volume 18 (5): 459-469.

Lelieveld, G. 2012. Room for wolf comeback in the Netherlands. MSc thesis. Department of Ecology, Vrije Universiteit, Amsterdam, the Netherlands.

Mech, L.D. & L. Boitani 2003. Wolves: behaviour, ecology and conservation. University of Chicago Press, Chicago, USA.

NABU [Naturschutzbund Deutschland] 2016. Karte Wolf (*Canis lupus*). Mitteleuropäische Tieflandpopulation. Stand 15.04.2016. URL: https://www.nabu.de/tiere-und-pflanzen/saeugetiere/wolf/deutschland/index.html; viewed 14 November 2016.

NLWKN [Niedersächsischer Landesbetrieb für Wasserwirtschaft, Küsten- und Naturschutz] 2016. Rätsel um den Wanderwolf gelöst. URL: http://www.nlwkn.niedersachsen.de/aktuelles/pressemitteilungen/raetsel-um-den-wanderwolf-geloest-135690.html; viewed 14 November 2016.

ONCFS [Office National de la Chasse et de la Faune Sauvage] 2015. Bulletin loup du réseau. N° 35 - 2016, Période du 01.01.2016 au 01.06.2016. URL: http://www.oncfs.gouv.fr/IMG/pdf/bulletin_loup_35.pdf; viewed 14 November 2016.

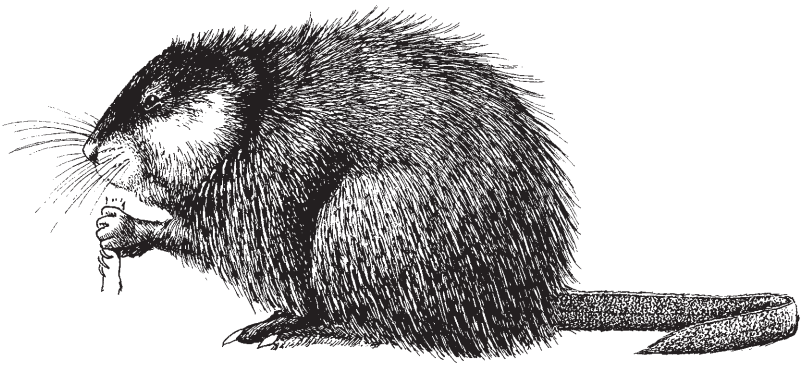
Reinharts, I., G. Kluth, S. Nowak and R.W. Mysłajek 2015. Standards for the monitoring of the Central European wolf population in Germany and Poland. Skripten 398. Bundesamt für Naturschutz, Bonn, Germany.

Samenvatting

Eerste bewijzen van de terugkeer van de wolf in Nederland

In de tweede helft van de 20ste eeuw hebben wolven (*Canis lupus*) hun verspreiding in Europa flink uitgebreid. Experts menen dat wolven uiteindelijk ook Nederland weer zullen koloniseren. In maart 2015 liet een wolf afkomstig uit Duitsland, die daar reeds de naam 'Wanderwolf' had gekregen, een spoor van waarnemingen door Nederland achter. Deze wolf heeft een aantal schapen aangevallen. Zijn aanwezigheid kreeg veel media-aandacht en riep veel discussie op. In dit artikel presenteren we de meest essentiële informatie over dit bezoek en over de herkomst en verdere achtergrond van Wanderwolf. Daarnaast presenteren we een overzicht van een andere in Nederland (mogelijk) waargenomen wolven in de periode 1990-2015.

Received: 27 October 2016
Accepted: 16 November 2016



Muskusrattenbestrijding tijdens de MKZ-crisis in 2001

Daan Bos [1,2], Ferdy Timmerman [1] & Ron C. Ydenberg [3,4]

[1] Altenburg & Wymenga ecologisch onderzoek, Suderwei 2, NL-9269 TZ Veenwouden, the Netherlands, e-mail: d.bos@altwym.nl

[2] Groningen Institute for Evolutionary Life Sciences, Rijksuniversiteit Groningen, P.O. Box 11103, NL-9700 CC Groningen, the Netherlands

[3] Wageningen Universiteit, Resource Ecology Group, P.O. Box 47, NL-6700 AA Wageningen, the Netherlands

[4] Centre for Wildlife Ecology, Department of Biological Sciences, Simon Fraser University, Burnaby, BC, Canada V5A 1S6

Abstract: *Muskrat control during the outbreak of Foot-and-Mouth Disease in 2001.*

The muskrat populations in much of the low lying parts of northwestern Europe are subject to control programmes, in order to prevent damage by digging. Control is mainly implemented by trapping. As yet there is, however, no rigorous evidence that trapping actually affects the population size. In search for experimental evidence, we hypothesised that a temporary reduction in trapping effort during the outbreak of Foot-and-Mouth Disease (FMD) in the Netherlands in 2001 could be used for this purpose. The FMD epidemic hit the Netherlands when numbers of muskrat catches were rising in nine out of twelve provinces. During three months in spring, 16,000 field hours (15%) have been spent less than the five-year spring average until then. The reduction in effort was not absolute and also not homogeneously distributed in space. On average, there was a decline in effort and catches in agricultural areas, but an increase in urban areas. The variation and the range of the differences with the five-year average effort were not larger than in previous years. The outbreak of FMD, and the associated reduction in effort, is confounded with an autonomous development in effort and catches. We therefore tested whether changes in catch rate in summer, autumn and spring, were related to differences in effort spent in spring. The developments in the polder area Krimpenerwaard have been summarised separately, because it was especially there that extreme numbers of muskrat had been caught in the years after FMD. The high levels of catches in the Krimpenerwaard in the period 1999 -2006 cannot be attributed to limitations caused by the FMD epidemic. This is because the number of hours spent in the Krimpenerwaard was not significantly decreased during the FMD period as compared to the five-year average until then, and secondly because the catch rates had already sharply increased before the FMD crisis erupted. Our basic assumption, i.e. that the developments during and after the FMD period could be used to illustrate the effectiveness of the control programme in limiting muskrat populations, cannot be sustained. It is, however, justifiable to say that the FMD crisis may have strengthened existing negative developments. We conclude that the FMD period has limited value as a spontaneous experiment. The impact of the FMD crisis is small relative to other sources of variation and the increase in catches around the FMD must therefore primarily be seen as an autonomous development.

Trefwoorden / keywords: bestrijding, control, Mond- en Klauwzeer, Foot-and-Mouth Disease, experiment, *Ondatra zibethicus*, pestsoort, pest species.

Inleiding

Achtergrond

Al sinds 1941 worden in Nederland muskusratten (*Ondatra zibethicus)* bestreden, om schade door graverij te voorkomen (Doude van Troostwijk 1976, Barends 2002). Sinds 2005 is de bestrijding van deze pestsoort geregeld op grond van artikel 67 van de Flora- en faunawet en sinds 2009 via de Waterwet toegewezen aan de Waterschappen. Het is aan hen om te voorkomen dat muskus- en beverratten door middel van graverij schade veroorzaken aan waterstaatswerken, zoals oevers, dammen en andere structuren.

Tot op de huidige dag gebeurt dat door de muskusratten jaarrond en vlakdekkend te bestrijden. Het gaat daarbij jaarlijks om grote aantallen van deze pestsoort, en een grote inzet van mensen en middelen. Op grond van de literatuur, theoretische modellen en praktijkervaring is aannemelijk te maken dat bestrijding leidt tot lagere aantallen (Doude van Troostwijk 1976, Bos & Ydenberg 2011), maar er bestaat niettemin een uitdrukkelijke roep om goede veldgegevens uit Nederland te verzamelen. De Unie van Waterschappen voert daarom momenteel een veldproef uit waarin op praktisch vlak kennis over de populatieontwikkeling wordt verzameld bij verschillende strategieën van bestrijden. De proef heeft vooral tot doel om de relatie tussen de inzet van bestrijding en het optreden van schade aan waterkeringen te meten, waarbij het effect van bestrijding op de populatie één van de deelvragen is. Bij het presenteren van de proef aan de bestrijders in Nederland is vanuit de bestrijding regelmatig geopperd dat het voor dat onderdeel zou volstaan om de ontwikkelingen rond de Mond- en Klauwzeer (MKZ) crisis goed te bestuderen. Die periode in 2001 zou daarbij beschouwd kunnen worden als een groot, maar kortdurend experiment.

De MKZ-crisis

Nadat in Engeland in februari 2001 MKZ werd geconstateerd, ging op 7 maart 2001 in Nederland een verbod in op pluimvee- en evenhoevigen-evenementen. Op 13 maart werd vervolgens een vervoersverbod voor MKZ-gevoelige dieren ingevoerd, maar een week later werd in Oene (Gld, zie figuur 1) een mogelijk MKZ-geval geconstateerd, en een dag later in Olst (Ov). In de daarop volgende periode vonden diverse uitbraken van MKZ plaats, waarvan het grootste deel (23) in de zone rondom Oene (de driehoek Zwolle - Deventer - Apeldoorn), één in Kootwijkerbroek en twee in noordoost Friesland (Ee en Anjum) (Bouma et al. 2003, Boender et al. 2010).

Vanwege het vervoersverbod en afsluiting van zones die verdacht werden van besmetting met het MKZ-virus, raakten opslagpunten van mest en melk vol, waardoor er een zorg ontstond dat melk illegaal geloosd zou worden in sloten of het riool. Besmette melk in oppervlaktewater zou het MKZ-virus op muskusratten kunnen overbrengen, waardoor bestrijders op hun beurt het virus verder zouden kunnen verspreiden. De bestrijders kregen te maken met beperkingen en konden volgens diverse bronnen hun werkgebied niet in (Landelijke Coördinatie Commissie Muskusrattenbestrijding (LCCM) 2001, Trouw 7/2/2004). Als gevolg hiervan vreesden sommige auteurs destijds al voor een toename van de muskusrattenpopulaties (van der Bie & van Duuren 2002). In latere jaren zijn grote aantallen muskusratvangsten meermaals met MKZ in verband gebracht, o.a. in de media (Algemeen Dagblad 15/2/2006, de Stentor 6/5/2006, De Boerderij 1/4/2009, mondelinge mededeling meerdere bestrijders). De ene bestrijdingsorganisatie werd harder door de beperkingen getroffen dan de andere. Volgens het landelijk jaarverslag betekende het over het algemeen dat er een aantal weken niet (of zeer beperkt) gewerkt kon worden (LCCM 2002). Voor de bestrijders waren er dan ook directe effecten voor wat betreft hun mogelijke uren inzet in agrarisch gebied in het voorjaar

van 2001. Op 18 mei 2001 werden veel preventieve maatregelen door de Minister weer ingetrokken. 26 Juni 2001 geldt als het officiële einde van de MKZ-crisis.

Context

Tijdens de uitbraak was de muskusrattenbestrijding in Nederland niet onder controle. De vangsten waren hoog, landelijk gingen ze van 0,9 vangsten per km watergang per jaar (vangsten/km/jaar) in 1998 naar 1,4 vangsten/km/jaar in 2004 (van Loon et al. 2016). In negen van de twaalf provincies stegen de vangsten in het jaar van de MKZ-crisis (LCCM 2002). De crisis brak uit in een seizoen dat voor de bestrijding van aanmerkelijk belang is, namelijk aan het einde van de voorjaarstrek. Deze voorjaarstrek levert normaliter veel vangsten op. Daarnaast was er in de jaren rond de MKZ-crisis onrust onder het personeel bij veel bestrijdingsorganisaties, door delegatie van Provincies naar Waterschappen en door interne reorganisaties (LCCM 2002). Dergelijke onrust heeft een nadelig effect op de arbeidsmotivatie van bestrijders en daarmee mogelijk op de doelmatigheid van hun inzet.

Factoren die muskusrattenpopulaties beïnvloeden

Factoren waarvan het aanwijsbaar of aannemelijk is dat ze invloed uitoefenen op muskusrattenpopulaties zijn weersomstandigheden, kwaliteit van het leefgebied, bestrijding (Verkaik 1991, van Loon et al. 2016), ziekte, predatoren, en interne populatieregulatie. In dit verband is de vraag relevant of de rol van bestrijding beter aannemelijk kan worden gemaakt. Bestrijding vindt plaats met mechanische middelen, door het al dan niet gericht plaatsen en regelmatig controleren van vangmiddelen. De hoeveelheid tijd besteed aan bestrijding is van groot belang (van Loon et al. 2016), maar ook de effectiviteit van de bestede tijd (cf. Lammertsma & Niewold 2005).

Vraagstelling

Door de beperkte toegang tot vangstgebieden is er tijdens de MKZ-periode mogelijk minder bestreden dan in een normaal jaar. Dit geldt niet voor bebouwd (stedelijk) gebied. Daar zou naar verwachting juist extra tijd besteed kunnen zijn, omdat de bestrijders de vrijgekomen uren daar wel in konden zetten. Bij een lagere bestrijdingsinzet ten opzichte van andere jaren zullen er minder muskusratten gevangen zijn. Als dit zo is, en aannemend dat bestrijding een belangrijke factor is in de populatieregulatie bij muskusratten, dan zal de populatie gegroeid zijn. Dat zou betekenen dat er in de daarop volgende maanden of jaren meer dieren (zowel absoluut als per tijdseenheid) gevangen kunnen worden.

De basale vraag is in hoeverre muskusrattenbestrijding effect heeft op de vangsten, en daarmee mogelijk op de populatie. In het jaar van de MKZ-crisis is er mogelijkerwijs meer spreiding in de vangstinspanning en is deze wellicht ook minder afhankelijk van de waargenomen ontwikkelingen in vangstresultaat. Dat maakt het kansrijker om een relatie tussen verschillen in vangstinspanning en vangstontwikkeling aan te tonen. De onderzoeksvragen luiden daarom:

1. Heeft de MKZ-crisis geleid tot beperkingen voor wat betreft de inzet, en zo ja in welke mate?
2. Zijn er tijdens de MKZ-crisis minder muskusratten gevangen dan in dezelfde periode in andere jaren?
3. Is er bij de beantwoording van de bovenstaande vragen verschil tussen bebouwd en agrarisch gebied?
4. Heeft een eventuele beperkte inzet tijdens de MKZ-periode geleid tot hogere vangstsnelheden na de MKZ-crisis?

Methode

De Nederlandse bestrijding registreert de vangsten en ingezette velduren op weekbasis en per uurhok (vakken van 5 bij 5 km) sinds 1987. Deze data zijn opgevraagd en ingedeeld in seizoenen, te weten de winter (december t/m februari), het voorjaar (maart t/m mei), de zomer (juni t/m augustus) en het najaar (september t/m november). Merk op dat een jaar hierbij tot en met november loopt en begint in december van het vorige jaar. In het voorjaar van 2001 golden er beperkingen in het veld als gevolg van de MKZ-crisis. Aldus zijn er drie categorieën van seizoenen vóór, tijdens (voorjaar 2001) en na de MKZ-crisis (de factor MKZ).

De vangstgegevens (aantal vangsten en uren) zijn opgeteld per uurhok, jaar en seizoen voor de jaren 1997-2005. We hebben ons beperkt tot de vier jaren vóór- en ná de MKZ-crisis. Deze beperking is arbitrair, maar een kortere referentieperiode werd gevoelig geacht voor fluctuaties tussen jaren. Op basis van de Landgebruikskaart van Nederland (LGN5) zijn de uurhokken vervolgens ingedeeld in drie categorieën (factor 'Dominant landgebruik'): 'Bebouwd gebied' (landgebruik gedomineerd door bebouwing; bedekking met bebouwing > 60%), 'Agrarisch gebied' (bedekking met agrarisch landgebruik > 60%) en 'Overig' (bos, natuur, water of gemengd).

De trend in tijdsbesteding over de jaren is bepaald aan de hand van een lineaire regressie over de som van de bestede uren. We hebben getoetst of het aantal uren per uurhok in het voorjaar van 2001 verschilt met het gemiddelde in het voorjaar van de vijf jaren 1997-2001, de referentieperiode. Daarbij is ook bekeken of dit verschilde tussen agrarisch en bebouwd gebied. De afwijking in het aantal bestede uren van dit gemiddelde is berekend voor elk van de uurhokken in elk van deze voorjaren. Dit is een variabele (de afwijking in gespendeerde uren, of delta_uren) voor de hieronder beschreven analyse.

Ten slotte is er getoetst of de mate waarin minder uren zijn ingezet tijdens de MKZ-periode ('het verschil in uren') gerelateerd is aan hogere vangstsnelheden direct volgend op de MKZ-crisis (ten opzichte van hetzelfde seizoen in het voorgaande jaar). Daarbij is beoordeeld of een dergelijke relatie er ook was in het jaar 2000, voorafgaand aan de MKZ-crisis. Om dit te kunnen doen is de vangstsnelheid (vangsten/uur) berekend door het aantal vangsten te delen door het aantal uren bestrijdingsinzet per uurhok per seizoen. Per jaar en per seizoen is het verschil in vangstsnelheid berekend met hetzelfde seizoen in het voorgaande jaar. Met lineaire regressie is getoetst of deze afhankelijk is van 'het verschil in uren', van de factor 'Dominant landgebruik' en de interactie daartussen. Dit is gedaan voor de zomers, de najaren en de winters van respectievelijk de jaren 2000 en 2001. Niet significante interacties en factoren zijn verwijderd uit het model. Er was geen aanleiding om datatransformatie toe te passen. Statistische analyses zijn uitgevoerd met SPSS 22.

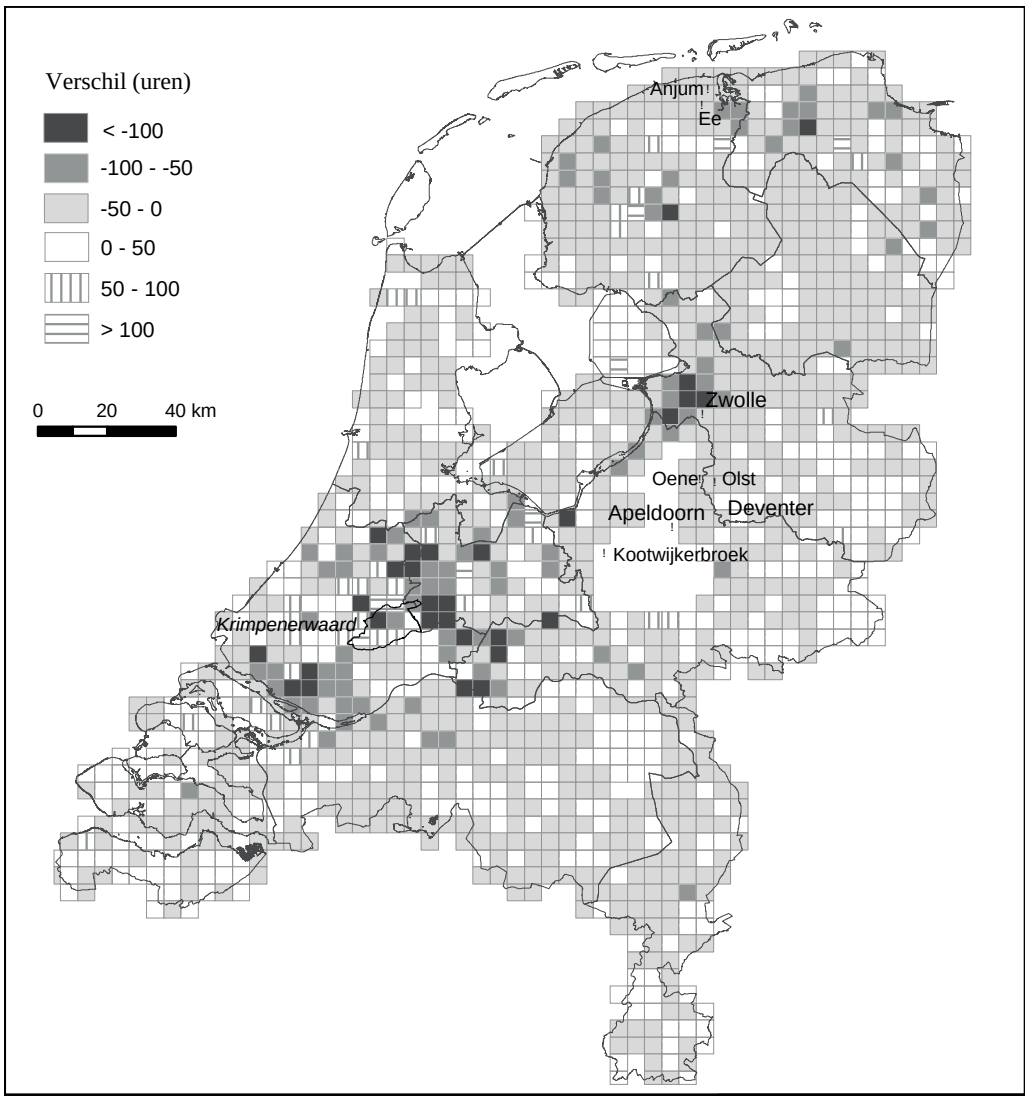
Studiegebied

De gegevens zijn samengevat op landelijke schaal. Van de ca 2.200 uurhokken die overlappen met Nederland zijn 1.442 uurhokken beschikbaar met vangstinformatie over de studieperiode en kennis over het grondgebruik. Daarnaast worden de uitkomsten van één enkele polder, de Krimpenerwaard (figuur 1), apart beschreven omdat daar in de jaren na 2001 zeer veel muskusratten zijn gevangen. De Krimpenerwaard is een veenweidepolder in Zuid-Holland van ca. 13.500 ha. De cijfers van de vijf centrale uurhokken daarin dekken gezamenlijk 90% van het oppervlak.

Resultaten

Bestrijdingsinzet

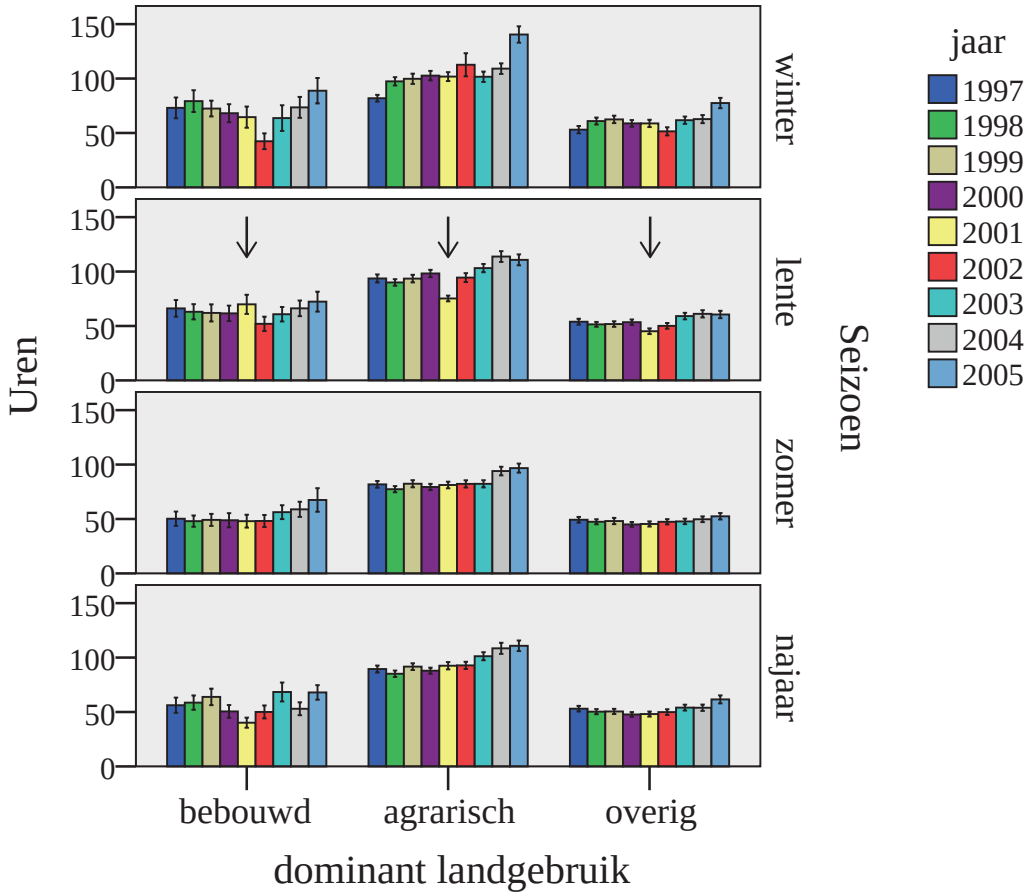
In de bestudeerde uurhokken nam het aantal gespendeerde velduren aan bestrijding toe



Figuur 1. De ruimtelijke verdeling van het verschil in ingezette uren tussen de MKZ-periode en het gemiddelde in het voorjaar van de jaren 1997-2001, per atlasblok in Nederland. De ligging van polder Krimpenerwaard is apart aangegeven omdat daar in de tekst speciaal op wordt ingegaan. Verder zijn belangrijke plaatsnamen in relatie tot de MKZ-uitbraak op de kaart aangegeven.

Figure 1. The spatial distribution of the difference in effort (field hours invested (h)) between the spring of 2001 (Foot-and-Mouth Disease-crisis or FMD-crisis) and the average in the spring of the years 1997-2001 per atlas square in the Netherlands. The location of the polder area Krimpenerwaard is shown separately, as it is addressed specifically in the text. Other important places in relation to the FMD outbreak are also indicated on the map.

(lineaire regressie, jaar effect $F_{1,7} = 15$, $P=0{,}06$). Dit is vooral goed zichtbaar in de zomer en het najaar vanaf 2002 (figuur 2). In agrarisch gebied worden in absolute zin de meeste uren gespendeerd. Dit komt vooral door het gegeven dat het aantal uurhokken dat valt onder

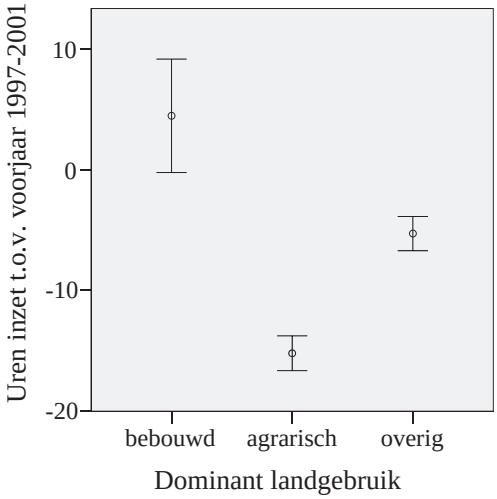


Figuur 2. De gemiddelde inzet van uren per atlasblok in Nederland voor drie categorieën van landgebruik. De foutbalken verwijzen naar de standaardfout. De inzet is in het voorjaar van 2001 (MKZ-crisis) in het agrarisch gebied lager dan in de referentieperiode 1997-2001. In het bebouwd gebied ligt het aantal uren dan juist hoger. Steekproefomvang: agrarisch gebied (*n*=818), bebouwd (*n*=48) en 'overig' (bos, natuur, water en gemengd (*n*=576). De pijl geeft de MKZ-periode aan.

Figure 2. Mean effort invested per atlas square in the Netherlands for three categories of land use. Error bars indicate the standard error of the mean. The effort in agricultural areas during the spring of 2001 (Foot-and-Mouth Disease-crisis or FMD-crisis) is lower than in the reference period 1997-2001, while this is the reverse in built-up areas. Sample size: agricultural area (n=818), built-up (n=48) and 'other' (forest, nature, water and mixed (n=576). The arrow indicates the season of the FMD-crisis.

agrarisch gebied (*n*=818) groter is dan de categorie 'overig' (*n*=576) en veel groter dan het bebouwd gebied (*n*=48).

Tijdens de MKZ-periode, in het voorjaar van 2001, zijn 10,6 ± 1,0 s.e. (14%) minder uren per uurhok gespendeerd dan gemiddeld in het voorjaar van 1997-2001. Dit is met name in het agrarisch gebied het geval; het gaat om een verschil van gemiddeld 15 uur ± 1,4 s.e. (20%) per atlasblok in agrarisch gebied (figuur 2 en 3). In totaal zijn in het gehele land 16.089 uren (15%) minder besteed dan gemiddeld in het voorjaar over de periode 1997-2001. Die uren zijn niet allemaal elders gespendeerd (figuur 2). In het bebouwd gebied ligt het aantal uren weliswaar 4 uur ± 4,7 s.e. (4%) hoger dan het



Figuur 3. Het gemiddelde verschil in ingezette uren per categorie van landgebruik tussen de MKZ-periode en het gemiddelde in het voorjaar van de jaren 1997-2001. Het gemiddelde verschil is negatief in agrarisch gebied en positief in bebouwd gebied. Steekproefomvang als in figuur 2. De foutbalken verwijzen naar de standaardfout.

Figure 3. Mean difference in number of field hours per category of land use between the FMD period and the average in the spring of the years 1997-2001. The mean difference is negative in agricultural areas and positive in built-up areas. Sample size as in figure *2. Error bars indicate the standard error.*

gemiddelde voorjaar van 1997-2001, maar in absolute zin betreft dat maar 214 uren.

Gedurende de MKZ-periode zijn er dus, ondanks de beperkingen, wel degelijk grote hoeveelheden velduren ingezet in alle landgebruikcategorieën. In de zomer en herfst na de MKZ-crisis wijkt het aantal gespendeerde uren in het agrarisch gebied niet belangrijk af; niet minder, maar ook niet veel meer. In de winter van 2002 is er een forse toename in velduren te zien.

De variatie in afwijking van het gemiddelde is niet extra groot geworden door de MKZ-crisis (tabel 1). Ook in de andere voorjaren kunnen er sterk meer of minder uren in een atlasblok bestreden zijn dan gemiddeld in de referentieperiode.

Tabel 1. De variatie in de afwijking van het aantal uren dat per atlasblok in het voorjaar is ingezet ten opzichte van de gemiddelde inzet in de referentieperiode (1997-2001, *n*=1442).

Table 1. Variation in the deviation of the number of trapping hours invested per atlas square in spring in comparison to the average amount spent in spring during the reference period (1997-2001, n=1442).

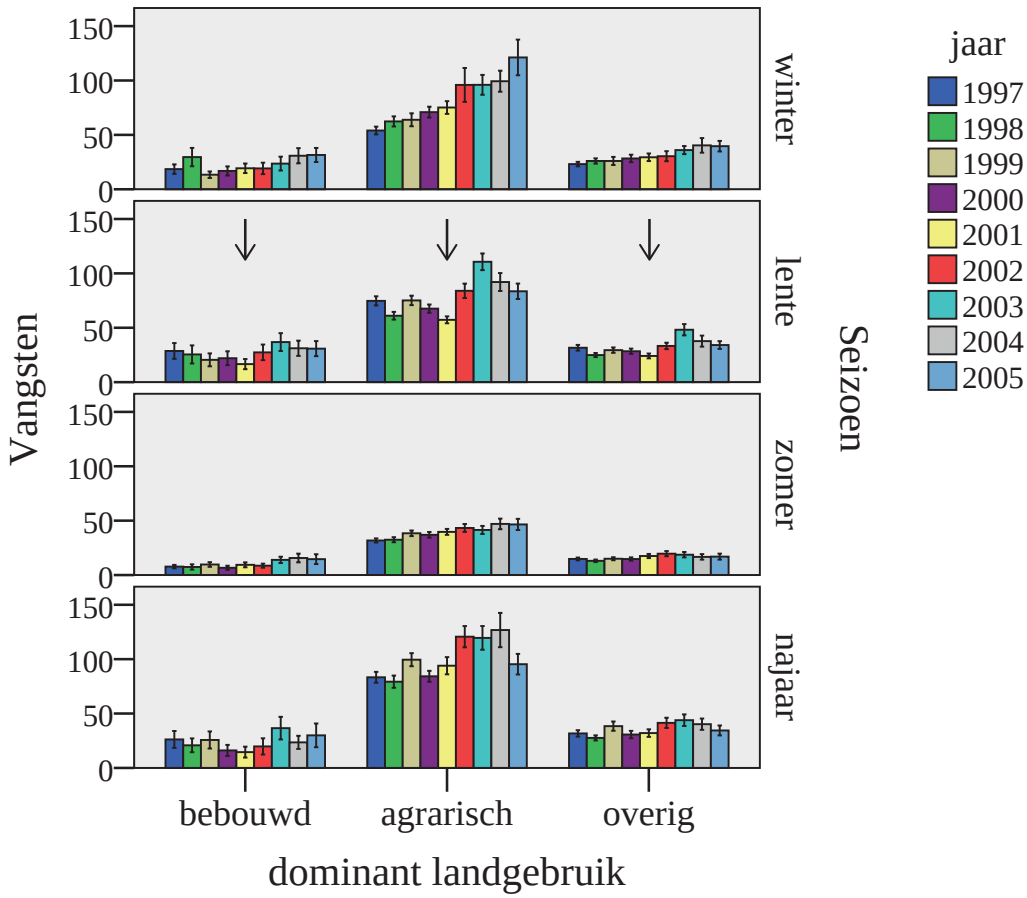
Jaar	Gemiddelde afwijking	Range	Variantie
1997	3,8	827	1676
1998	0,4	660	864
1999	2,4	727	1096
2000	5,6	370	893
2001	-10,6	819	1488

Ruimtelijk gezien zijn er hele delen van Nederland waar het verschil in ingezette uren niet bijzonder groot of zelfs positief is (figuur 1). De grote en negatieve verschillen zitten met name in de lage, waterrijke delen van Nederland.

Vangsten

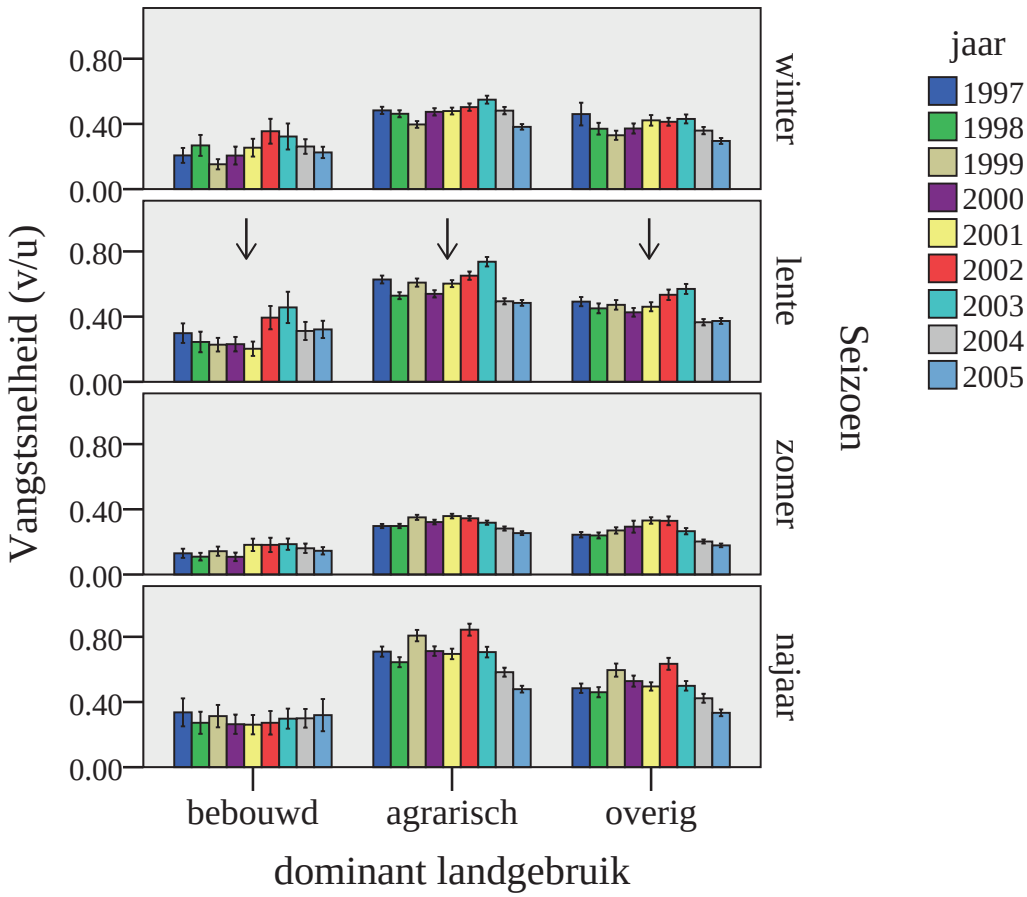
Op atlasblokniveau en in absolute zin worden de meeste vangsten in agrarisch gebied gemaakt (figuur 4). Het aantal vangsten in het MKZ-voorjaar was lager dan in eerdere en latere voorjaren (ANOVA, MKZ effect $F_{2, 5990}$ =39, P<0,001). In absolute zin zijn er toch nog 61.543 dieren gevangen in heel Nederland. Dit is ca 85% van het gemiddelde in de voorjaren van 1997-2001. In de zomer en het najaar na de MKZ-crisis was het aantal vangsten gemiddeld maar een fractie hoger dan de jaren ervoor. In de winter liepen de vangsten al op vóórdat er van MKZ sprake was en na de MKZ-crisis zet die trend zich door. In die zin is er geen trendbreuk zichtbaar ten opzichte van de vorige jaren. Het aantal vangsten in bebouwd gebied ligt vanaf de winter van 2003 op een wat hoger niveau.

De vangstsnelheid (vangsten/uur) varieert met de landgebruikscategorie en het seizoen (figuur 5). In agrarisch gebied ligt ze op een



Figuur 4. Het gemiddelde aantal vangsten per atlasblok in Nederland voor drie categorieën van landgebruik. De foutbalken verwijzen naar de standaardfout. Steekproefomvang als in figuur 2. De pijl geeft de MKZ-periode aan.
Figure 4. The mean number of catches per atlas square in the Netherlands for three categories of land use. Error bars indicate the standard error. Sample size as in figure *2. The arrow indicates the season of the FMD-crisis.*

hoger niveau dan elders, en in de zomer is de vangstsnelheid relatief laag. Belangrijk is dat in het agrarisch gebied, in de zomer en het najaar volgend op de MKZ-crisis, geen grote toename in vangsten of vangstsnelheid wordt geconstateerd op landelijke schaal, ondanks een normale ureninvestering. Over de winters van 1999 tot 2003 neemt de vangstsnelheid toe, en de winter van het seizoen 2002 (direct na de MKZ-crisis) past in die - mogelijk autonome - ontwikkeling. In statistische termen is de factor MKZ verward ('confounded') met jaar. Echter, omdat er niet alleen atlasblokken zijn waar mínder tijd is besteed, maar ook atlasblokken waar méér tijd is ingezet, zijn de twee factoren ten dele te ontwarren. Figuren 6 (najaar) en 7 (winter) laten de veranderingen in vangstsnelheid per atlasblok zien, vóór en ná MKZ, uitgezet tegen de afwijking in het aantal bestede uren ten opzichte van het gemiddelde in de referentieperiode 1997-2001 (delta_uren). Uit de figuren blijkt nogmaals dat er zowel atlasblokken zijn waar de vangstsnelheid is gestegen ten opzichte van het vorige jaar als waar zij is gedaald (variatie langs de y-as). Gemiddeld zijn er minder uren besteed in het voorjaar van de MKZ-crisis, maar ook daarin zit een enorme sprei-



Figuur 5. De ontwikkeling in vangstsnelheid per atlasblok in Nederland voor drie categorieën van landgebruik. De foutbalken verwijzen naar de standaardfout. Steekproefomvang als in figuur 4. De pijl geeft de MKZ-periode aan.
Figure 5. The development in catch rate per atlas square in the Netherlands for three categories of land use. Error bars indicate the standard error. Sample size as in figure *4. The arrow indicates the season of the FMD-crisis.*

ding (variatie langs de x-as). De verandering in vangstsnelheid t.o.v. het jaar ervoor is significant gerelateerd aan de hoeveelheid uren die er gemiddeld minder zijn besteed tijdens MKZ, in het najaar ($F_{1,1369}$=4,5, P<0,05) en de winter ($F_{1,1384}$ = 13,3, P<0,001) volgend op de MKZ-crisis (tabel 2). In de zomer is dat verband afwezig. De factor 'dominant landgebruik' speelt in geen van de testen een significante rol en is daarom uit de modellen weggelaten. De verklaarde variatie van het resulterende model is zeer gering (R^2_{adj} <0,01).

Het snijpunt van de regressielijnen met de y-as is in bijna alle jaren niet significant verschillend van nul. Gemiddeld genomen is er dus geen verandering in de vangstsnelheid bij een ureninzet zoals die in de vijf jaar ervoor gemiddeld was. De helling van de lijn is negatief in najaar en winter, wat betekent dat extra inspanning in het voorjaar de vangstsnelheid in het najaar en winter vermindert.

Een dergelijke relatie is er overigens ook in het jaar 2000 en ze zal er waarschijnlijk ook in andere jaren zijn. De MKZ-crisis heeft ons echter de aanleiding gegeven om dit te toetsen, omdat we meenden dat de verschillen relatief groot zouden zijn en de patronen dus gemakkelijker te ontdekken. De inspanning

Tabel 2. De parameterschattingen van de relaties tussen de verandering in vangstsnelheid en afwijking in gespendeerde uren. De verandering in vangstsnelheid betreft het verschil met hetzelfde seizoen in het jaar ervoor. De afwijking in gespendeerde uren betreft het verschil in uren met de gemiddelde ureninzet in de referentieperiode 1997-2001 (delta_uren). Betekenis van de gebruikte afkortingen en symbolen: n.s. = niet significant, * = significant (P<0,05), ** = significant (P< 0,01), *** = significant (P< 0,005).

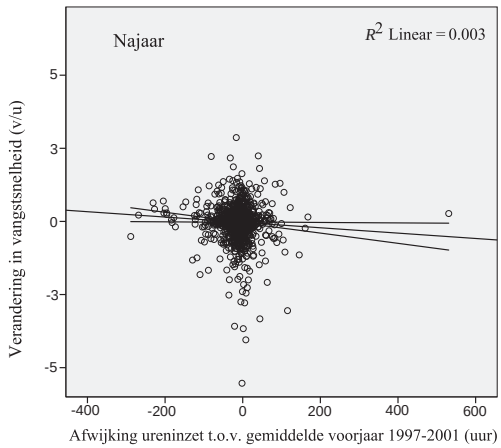
Table 2. Parameter estimates of the relationship between the change in catch rate and deviation in hours spent. The change in catch rate is the difference with the same season in the previous year. The deviation of hours spent is the difference in hours with the average hours invested during the reference period 1997-2001 (delta_uren). Abbreviations and symbols used: see above.

Jaar	Seizoen	Snijpunt met y-as	Helling
2000	Zomer	n.s.	n.s.
2000	Najaar	-0,071	-0,002**
2000	Winter	n.s.	-0,002***
2001	Zomer	n.s.	n.s.
2001	Najaar (figuur 6)	n.s.	-0,001*
2001	Winter (figuur 7)	n.s.	-0,002***

in het voorjaar heeft dus effect op de waargenomen vangstsnelheid in het najaar en de winter erop. En dat kan nog best veel zijn: iedere 100 uur extra vermindert de vangstsnelheid met 0,1 vangst per uur.

Focus op de Krimpenerwaard

Op landelijk niveau is er veel spreiding in de vangstsnelheid, zodat een eventueel patroon wellicht gemaskeerd kan worden in analyses of plaatjes waar al die spreiding in zit. Daarom leggen we in de onderhavige paragraaf de focus op een bijzondere polder, de Krimpenerwaard. De Krimpenerwaard krijgt speciale aandacht, omdat met name voor dit gebied onder bestrijders de gedachte bestond dat de MKZ-crisis tot een 'explosie' van muskusratten heeft geleid. Er zijn daar in de betreffende jaren op een relatief klein, maar homogeen



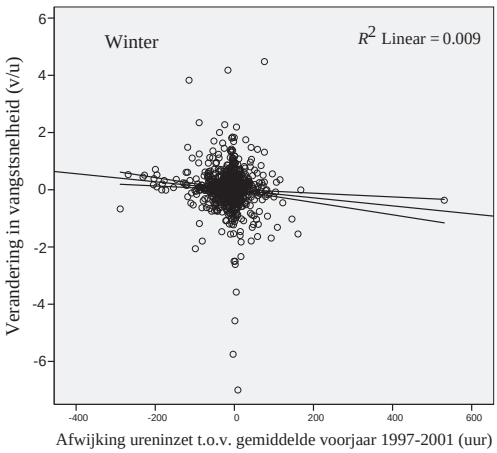
Figuur 6. De relatie tussen het verschil in vangstsnelheid in het najaar van 2001 ten opzichte van najaar 2000 per atlasblok, in relatie tot de afwijking in gespendeerde uren in het voorjaar (dit betreft de afwijking in het aantal uren van het gemiddelde in de referentieperiode 1997-2001; delta_uren). Er is een zwak, maar significant negatief verband (y=-0,034-0,001x, tabel 2).

Figure 6. The relationship between the difference in catch rate in the autumn of 2001 compared to autumn 2000 per atlas square in relation to the deviation in hours spent in spring (this is the difference in number of field hours between the FMD period and the average in the spring for the reference period 1997-2001; delta_uren). There is a weak but significant negative correlation (y=-0.034-0.001x, table *2).*

oppervlak extreem veel uren besteed en véél dieren gevangen.

In de Krimpenerwaard liggen de gemiddelde vangstsnelheden sinds het najaar van 1998 fors hoger dan de gewenste praktijknorm van 0,25 vangsten/uur (figuur 8). Dit wijst op een hoge populatiedichtheid van muskusratten. De vangsten liepen er op van 0,3 vangsten/km/jaar in 1998 naar 8,1 vangsten/km/jaar in 2004. Dat was in absolute aantallen bijna één derde van alle vangsten in Zuid-Holland en 11% van alle vangsten in Nederland in 2004.

Het aantal gespendeerde uren in de Krimpenerwaard liep in het MKZ-voorjaar terug met 392 uur (23%) ten opzichte van het jaar



Figuur 7. De relatie tussen het verschil in vangstsnelheid in de winter vóór en ná de MKZ-periode per atlasblok, in relatie tot de afwijking in gespendeerde uren (dit betreft de afwijking in het aantal uren van het gemiddelde in de referentieperiode 1997-2001; delta_uren). Er is een zwak, maar significant negatief verband, y=0,28-0,002x.

Figure 7. The relationship between the difference in catch rate in the winter before and after the FMD period per atlas square in relation to the deviation in hours spent in spring (this is the difference in number of field hours between the FMD period and the average in the spring for the reference period 1997-2001; delta_uren). There is a weak but significant negative correlation, y=0.28-0.002x.

ervoor, waarin de inspanning al een beetje was verhoogd, maar is 36 uur hoger ten opzichte van het gemiddelde over 1997-2001 (figuur 9). In het MKZ-voorjaar zijn er 2.129 muskusratten gevangen in de Krimpenerwaard, 2,5 keer zoveel als gemiddeld in het voorjaar van 1997-2001. Pas in het najaar en de winter erop is het aantal uren in de Krimpenerwaard echt flink opgevoerd. De vangstsnelheden waren al opgelopen van 0,27 in de winter van 1996 naar gemiddeld 2,2 vangsten/uur in de winter van 2001. Dat is dus vóórdat de MKZ-crisis uitbrak. Hieruit volgt dat de aanwezigheid van bijzonder hoge aantallen Muskusratten in de Krimpenerwaard, en de daarbij horende hoge gemiddelde vangstsnelheden in de periode 1999-2006 niet aan de MKZ-crisis mogen worden toegeschreven. Men kan hoogstens stellen dat beperkingen in ureninzet een zich zorgelijk ontwikkelende situatie hebben verslechterd. Door de beperkingen was het namelijk minder goed mogelijk om adequaat op de oplopende vangstaantallen te reageren.

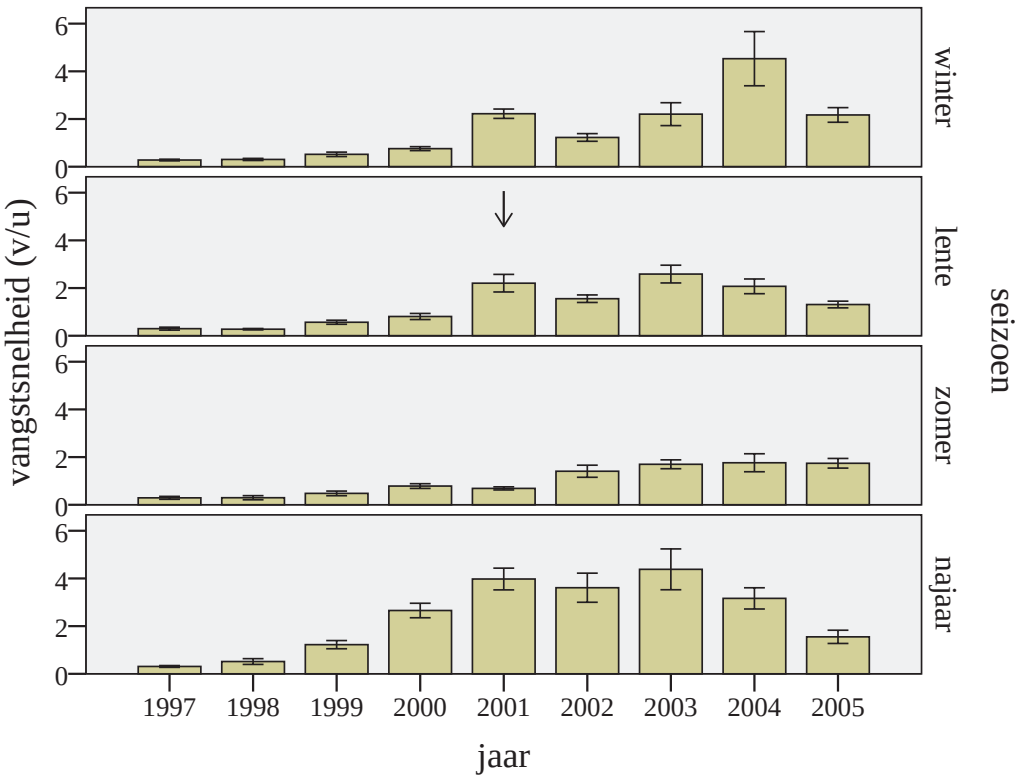
Discussie

De MKZ-crisis heeft geleid tot beperkingen wat betreft uren bestrijdingsinzet. Het aantal uren bestrijdingsinzet tijdens de MKZ-periode bedroeg in agrarisch gebied ca. 20% minder dan het aantal uren in het gemiddelde voorjaar van 1997 tot 2001. De toegang tot agrarisch gebied is echter nooit helemaal afgesloten geweest. De toegang tot bebouwd gebied kende geen beperkingen, en inderdaad is er een subtiele toename in het aantal uren dat in bebouwd gebied is gespendeerd in het MKZ-voorjaar in vergelijking met eerdere jaren.

Er zijn tijdens de MKZ-crisis landelijk minder muskusratten gevangen dan in dezelfde periode in andere jaren. Gedurende een korte periode van maart tot mei 2001, zijn er minder uren besteed en minder vangsten gemaakt. Ter relativering hiervan moet gezegd worden dat er in absolute aantallen echter maar weinig dieren minder gevangen zijn dan gemiddeld in de referentieperiode (8.511 dieren minder in agrarisch gebied, waar er gemiddeld in het voorjaar ruim 55.000 werden gevangen in de jaren 1997-2001; ofwel 10 dieren (= 15%) minder per atlasblok).

Er is in het aantal bestrijdingsuren en vangsten een stijging waar te nemen in de jaren vóór en ná de MKZ-crisis. We mogen stellen dat dit dus voornamelijk een autonome ontwikkeling is, omdat ze al vóór de MKZ-crisis is ingezet.

Er heeft tijdens de MKZ-crisis een minimale verschuiving plaatsgevonden van ureninzet van agrarisch gebied naar bebouwd gebied.

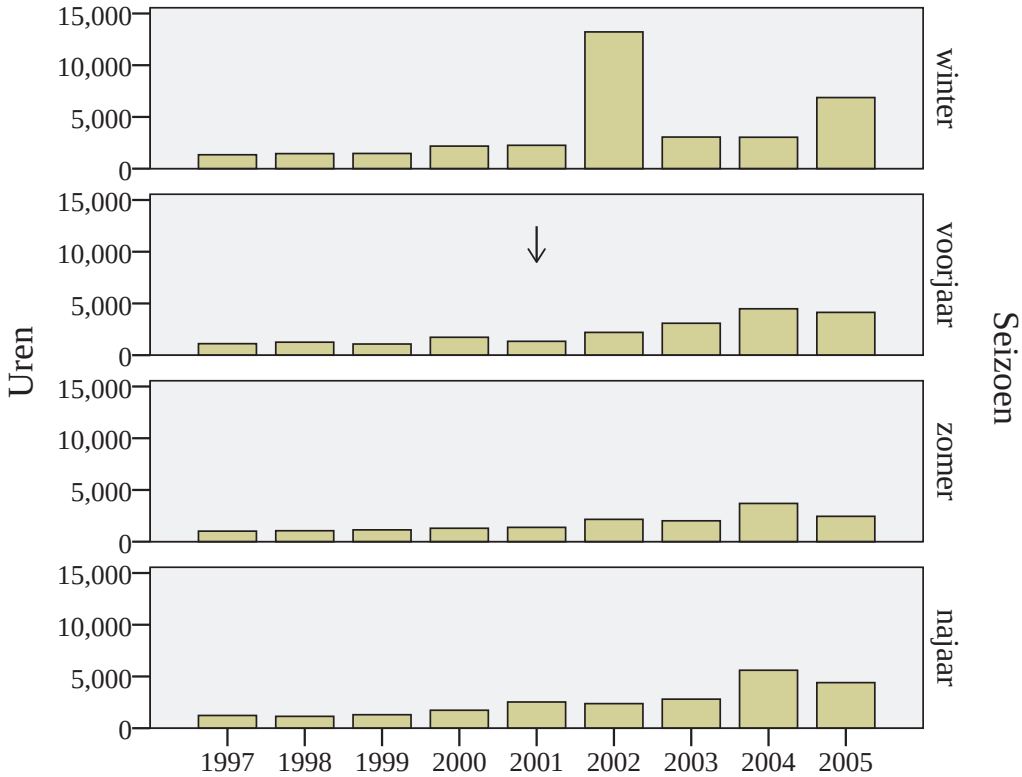


Figuur 8. De gemiddelde vangstsnelheid per atlasblok voor vijf atlasblokken in de Krimpenerwaard (atlasblok = 3823, 3824, 3832, 3833 en 3842) in Zuid-Holland (West-Nederland). De foutbalken verwijzen naar de standaardfout. Het landgebruik in deze atlasblokken is gedomineerd door agrarisch gebied. De pijl geeft de MKZ-periode aan.

Figure 8. The average catch rate (n/h) per atlas square for atlas squares in the polder area Krimpenerwaard (atlas squares = 3823, 3824, 3832, 3833 and 3842) in Zuid-Holland (western Netherlands). Error bars indicate the standard error. The land use in these atlas squares is dominated by agricultural area. The arrow indicates the season of the FMD-crisis.

De MKZ-crisis kan in bebouwd gebied dus geen negatieve invloed op de vangsten hebben gehad. Er is niettemin een toename in vangsten in het bebouwde gebied vanaf 2003. Deze toename lijkt ons een gevolg van een zich onafhankelijk van de MKZ-crisis ontwikkelende populatie aldaar. Omdat er zich ook in het omliggende gebied grotere populaties ontwikkelen, zal onder andere sprake zijn geweest van een hogere immigratie, in interactie met een bestrijdingsinzet die uiteindelijk te laag is gebleken om een toename van het aantal vangsten te kunnen voorkomen. Het voert te ver om er in dit artikel over te speculeren welke factoren daar het meest aan hebben bijgedragen.

De 'verandering in vangstsnelheid' ná de MKZ-periode, vergeleken met hetzelfde seizoen ervóór, is significant gerelateerd aan de hoeveelheid uren die er gemiddeld minder zijn besteed tijdens de MKZ-periode, in het najaar en in de winter volgend op de MKZ-periode. Deze relatie wordt ook gevonden in het jaar 2000. De inspanning in het voorjaar heeft dus effect op de waargenomen vangstsnelheid in het najaar en de winter erop. En dat kan nog best veel zijn: iedere 100 uur extra vermindert de vangstsnelheid met 0,1 vangsten/uur. Maar



Figuur 9. Het totaal aantal ingezette uren in de gehele Krimpenerwaard in Zuid-Holland (West-Nederland). Het landgebruik is gedomineerd door agrarisch gebied. De pijl geeft de MKZ-periode aan.

Figure 9. The total number of field hours invested throughout the polder area Krimpenerwaard in Zuid-Holland (western Netherlands). The land use is dominated by agricultural area. The arrow indicates the season of the FMD-crisis.

er is nog veel onverklaarde variatie, en het effect is relatief klein ten opzichte daarvan. Het is zinvol om die variatie verder te exploreren, maar niet in het kader van dit artikel. We hebben namelijk goede redenen om aan te nemen dat stijging of daling in vangstsnelheden te maken moet hebben met hoeveelheid ingezette uren in verhouding tot hoeveel dieren er zijn, en dat er daarnaast andere belangrijke factoren spelen, zoals immigratie en emigratie. Dat betekent dat complexere modellen moeten worden aangepast dan welke hier aan de orde kunnen zijn. In een separate modelstudie (van Loon et al., in prep.) wordt daar verder op ingegaan.

Nu representeren de hier bestudeerde atlasblokken bijna geheel Nederland. Omdat er regionale verschillen zullen zijn, en omdat zinvolle patronen misschien verborgen blijven in de spreiding die met een dergelijke landelijk verdeelde steekproef meekomt, hebben we ook de gegevens van een specifieke polder bestudeerd: de Krimpenerwaard. Daaruit volgden twee goede redenen om aan te nemen dat de aanwezigheid van bijzonder hoge aantallen muskusratten in de Krimpenerwaard in de periode 1999-2006 niet aan de MKZ-crisis mogen worden toegeschreven. Ten eerste is het aantal gespendeerde uren in de Krimpenerwaard niet noemenswaardig teruggelopen in de MKZ-periode ten opzichte van het gemiddelde voorjaar in de jaren 1997-2001 (figuur 9). Ten tweede waren de vangstsnelheden al sterk gestegen naar gemiddeld 2,2

vangsten/uur in de winter van 2001, dus vóórdat de MKZ-crisis uitbrak (figuur 8).

Op grond van deze cijfers valt te concluderen dat de invloed van de MKZ-crisis gering is ten opzichte van andere bronnen van variatie. Het is waarschijnlijker dat de stijging in absolute vangsten in de jaren volgend op de MKZ-periode grotendeels het gevolg is van een autonome ontwikkeling naar hoge aantallen, die zich ook zonder de MKZ zou hebben voorgedaan, en een groter aantal ingezette uren. Dit is consistent met het gegeven dat er eigenlijk helemaal niet zo heel veel dieren minder zijn gevangen in de MKZ-periode, dan in de vier voorgaande voorjaren gemiddeld. Het is wel meetbaar dat een lagere urenbesteding in het voorjaar leidt tot hogere vangsten in najaar en winter, dus is het verdedigbaar om te stellen dat de MKZ-periode mogelijk reeds bestaande negatieve ontwikkelingen heeft versterkt.

De hier gepresenteerde bevindingen stroken dus maar ten dele met de veelgehoorde praktijkgedachte in de bestrijding dat de MKZ-crisis een belangrijke invloed heeft gehad en als illustratie kan dienen voor de noodzaak tot bestrijding (de Stentor 6/5/2006, De Boerderij 1/4/2009). Maar ze zijn wel in overeenstemming met de visie van enkele hierover geïnterviewde bestrijders en teamleiders (persoonlijke mededeling J.P. Dijkstra, P. Blanker, A. van Veen, J. van den Bergs en S. Dol). In hun optiek is de MKZ-periode een kortdurende fase geweest waarin de werkzaamheden weliswaar enkele beperkingen kenden, maar in grote lijnen gewoon doorgang hebben kunnen vinden. Vaak was het nodig om bijvoorbeeld het erf van boerderijen te mijden, maar kon het werk doorgaan indien men op andere wijze toegang tot de watergangen zocht. Altijd was het mogelijk om het werk varend uit te voeren. Soms is de tijd binnen doorgebracht om vangmiddelen te maken die later massaal buiten zijn uitgezet. Vergelijkbaar relativerende opmerkingen staan ook in het provinciale jaarverslag van Overijssel en het landelijk jaarverslag van 2001 (LCCM 2002).

Om diverse redenen bevatten de gegevens uit vangstregistratie ongetwijfeld fouten en ruis. Verder is er een onbekende variatie in de kwaliteit van de ingezette velduren. Dit hangt af van de mate waarin bestrijders onderling verschillen en de mate waarin de organisatie bestrijders in staat stelt om met een gecoördineerde strategie, met de juiste middelen en met een goede motivatie te werken. Het is in onze optiek echter verdedigbaar om te stellen dat de aard van deze onnauwkeurigheden niet systematisch is veranderd na de MKZ-crisis, zodat dit onze analyse niet ongeldig kan maken. Het is overigens wel aannemelijk te maken dat tijdens de MKZ-crisis de uren minder efficiënt konden worden ingezet.

De resultaten zijn een belangrijke motivatie om op zoek te gaan naar meer systematische, meer langdurige, en wellicht wat extremere variatie in urenbesteding. Denk daarbij aan de grootschalige veldproef, zoals die in de afgelopen drie jaar door de Unie van Waterschappen is uitgevoerd.

Conclusies

De veelgehoorde praktijkgedachte in de bestrijding dat de ontwikkelingen tijdens en na de MKZ-crisis als illustratie kunnen dienen voor de noodzaak tot bestrijding is niet hard te maken. Wel is het verdedigbaar om te stellen dat de MKZ-crisis mogelijk reeds bestaande negatieve ontwikkelingen heeft versterkt.

Het aantal uren dat tijdens de MKZ-periode is bestreden lag ca. 20% lager dan het gemiddeld voorjaar van 1997-2001. Er zijn ca. 18% minder vangsten gemaakt. Voor beide parameters geldt dat dit vooral in het agrarisch gebied heeft gespeeld.

Er is een toename waargenomen in vangsten in het bebouwde gebied vanaf 2003. Deze toename kan niet een gevolg zijn van beperkingen tijdens de MKZ-crisis, omdat er gemiddeld alleen maar méér uren in bebouwd gebied zijn gespendeerd tijdens de MKZ-periode.

De aanwezigheid van bijzonder hoge aantal-

len Muskusratten in de Krimpenerwaard in de periode 1999-2006 mag niet aan de MKZ-crisis worden toegeschreven.

De verandering in vangstsnelheid in het najaar en de winter ten opzichte van vorige jaren is significant gerelateerd aan de urenbesteding in het voorjaar. Dit geldt voor het MKZ-jaar, maar ook voor het jaar ervoor. Extra bestrijdingsinspanning in het voorjaar vermindert de vangstsnelheid in het najaar.

De variatie in uren inzet, die door de MKZ-crisis is teweeggebracht, is in feite niet groter dan in de vijf voorgaande jaren. Buiten het verschil in agrarisch en bebouwd gebied, was de variatie verder ook niet systematisch verschillend in de ruimte. Als spontaan experiment heeft de MKZ-crisis daarom maar beperkte waarde. De invloed van de MKZ-crisis is gering ten opzichte van andere bronnen van variatie en de stijging in vangsten rond de MKZ-crisis moet daarom voornamelijk als een autonome ontwikkeling worden gezien.

De bevindingen rechtvaardigen de gemaakte keuze om een experiment uit te voeren met een grotere controle op spreiding in inzet van uren, een groter verschil in bestrijdingsinzet tussen de behandelingen en een langere duur van de proef, dan onder de omstandigheden tijdens de MKZ-periode hebben plaatsgehad.

Dankwoord: We bedanken graag de bestrijders en teamleiders van de muskusrattenbestrijding die ons op het spoor van deze analyse hebben gezet en hen die in latere fase inhoudelijk meegedacht hebben. Met name gaat het om J. van den Bergs, P. Blanker, A. Deelen, J.P. Dijkstra, S. Dol, H. de Groot, D. Moerkens, en A. van Veen. Daarnaast grote dank aan E. Klop en E.E. van Loon voor hulp bij het werk en de analyses. Tenslotte willen we ook Maurice LaHaye en twee anonieme referenten bedanken voor hun constructieve bijdrage aan de tekst.

Literatuur

Barends, F. 2002. The Muskrat (*Ondatra zibethicus*): expansion and control in the Netherlands. Lutra 45: 97-104.

Boender, G.J., H.J.W. van Roermund, M.C.M. de Jong & T.J. Hagenaars 2010. Transmission risks and control of foot-and-mouth disease in The Netherlands: Spatial patterns. Epidemics 2: 36–47.

Bos, D. & R. Ydenberg 2011. Evaluation of alternative management strategies of muskrat *Ondatra zibethicus* population control using a population model. Wildlife Biology 17: 143–155.

Bouma, A., A.R.W. Elbers, A. Dekker, A. de Koeijer, C. Bartels, P. Vellema, P. van der Wal, E.M.A. van Rooij, F.H. Pluimers & M.C.M. de Jong 2003. The foot-and-mouth disease epidemic in The Netherlands in 2001. Preventive Veterinary Medicine 57: 155–166.

Doude van Troostwijk, W.J. 1976. The Muskrat (*Ondatra zibethicus* L.) in the Netherlands, its ecological aspects and their consequences for man. Proefschrift Rijksuniversiteit Leiden, Leiden, Nederland.

Landelijke Coördinatie Commissie Muskusrattenbestrijding 2001. Landelijk jaarverslag 2000 Muskusrattenbestrijding. LCCM, Den Bosch, Nederland.

Landelijke Coördinatie Commissie Muskusrattenbestrijding 2002. Landelijk verslag muskusrattenbestrijding 2001. LCCM, Tiel, Nederland.

van der Bie, R. & L. van Duuren 2002. Klemmende zaken. INDEX 3: 28–29.

van Loon, E.E, D. Bos, C. van Hellenberg-Hubar & R.C. Ydenberg 2016. A historical perspective on the effects of trapping and controlling the muskrat (*Ondatra zibethicus*) in The Netherlands. Pest Management Science. DOI: 10.1002/ps.4270

Verkaik, A.J. 1991. Verspreidings- en verplaatsingspatronen van muskusratten *Ondatra zibethicus* in Flevoland. RIN-rapport 91/12. Rijksinstituut voor Natuurbeheer, Arnhem, Nederland.

Samenvatting

In deze studie worden de ontwikkelingen in vangsten en uren besteed aan muskusrattenbestrijding in Nederland rond de MKZ-periode samengevat, op zoek naar experimenteel bewijs voor invloed van deze bestrijding op de populaties van de doelsoort. Aanleiding voor de studie was de gedachte dat de MKZ-crisis

bezien zou kunnen worden als een groot, maar kortdurend experiment. De verwachting was dat verschillen in uren inzet in tijd of ruimte relatief groot zouden zijn en dat daarom relaties met vangstontwikkeling gemakkelijker zouden kunnen worden aangetoond.

Als de MKZ-crisis een groot effect zou hebben gehad op de populatieomvang, dan moet er òf een trendbreuk zichtbaar zijn in vangsten òf de vangstsnelheid sterk toenemen direct na de MKZ-crisis. Ook moeten er in gebieden waar relatief gezien minder uren aan de bestrijding zijn besteed de effecten groter zijn. Er is echter geen trendbreuk geconstateerd en de vangstsnelheden namen niet sterk toe. Wel is de verandering in vangstsnelheid in het najaar en de winter ten opzichte van vorige jaren gerelateerd aan de urenbesteding in het voorjaar, maar dat is ook zo in een ander jaar waarin naar dat verband is gezocht. Dit effect is echter klein, bovendien is er veel onverklaarde variatie. Niettemin concluderen we dat een extra bestrijdingsinspanning in het voorjaar de vangstsnelheid in het najaar vermindert.

De waargenomen toename in vangsten in het bebouwde gebied vanaf 2003 kan niet een gevolg zijn van beperkingen tijdens de MKZ-crisis, omdat er gemiddeld alleen maar méér uren zijn gespendeerd in bebouwd gebied tijdens de MKZ-crisis dan gemiddeld in het voorjaar in 1997-2001.

Speciaal is naar de gegevens van de Krimpenerwaard gekeken, omdat daar in de jaren na 2001 opvallend veel muskusratten zijn gevangen. De aanwezigheid van bijzonder hoge aantallen muskusratten in deze polder in de periode 1999-2006 kan om de volgende redenen niet aan MKZ worden toegeschreven: 1. Het aantal aan de bestrijding bestede uren nam in de MKZ-periode niet af ten opzichte van het gemiddelde in de voorgaande jaren en 2. De vangstsnelheden waren voor de MKZ-crisis uitbrak al sterk toegenomen.

De veelgehoorde praktijkgedachte in de bestrijding dat de ontwikkelingen tijdens en na de MKZ-crisis als illustratie kunnen dienen voor de noodzaak tot bestrijding, is op basis van de hier gebruikte gegevens niet hard te maken. Wel is het verdedigbaar om te stellen dat de MKZ-crisis mogelijk reeds bestaande negatieve ontwikkelingen in de vangsten heeft versterkt. De invloed van de MKZ-crisis is gering ten opzichte van andere bronnen van variatie. De stijging in vangsten rond de MKZ moet daarom voornamelijk als een autonome ontwikkeling worden gezien. Wil men het effect van muskusrattenbestrijding op de doelsoort zelf toch onderzoeken dan is een experiment van langere duur, systematischer van opzet en met grotere verschillen in ureninzet noodzakelijk.

Received: 21 March 2016
Accepted: 21 June 2016

One of the last wild brown bears (*Ursus arctos*) in the Netherlands (Noordwijk)

Wim J. Kuijper[1], Ivo K.A. Verheijen[1], André Ramcharan[1], Hans van der Plicht[1,2] & Thijs van Kolfschoten[1]

[1] Faculty of Archaeology, Leiden University, P.O. Box 9514, NL-2300 RA Leiden, the Netherlands, e-mail: w.j.kuijper@gmail.com

[2] Center for Isotope Research, Groningen University, Nijenborgh 4, NL-9747 AG Groningen, the Netherlands

Abstract: Early in 2016, bones of a left front leg of a brown bear (*Ursus arctos*) were found in the dunes between Noordwijk and Zandvoort (Amsterdamse Waterleidingduinen - Amsterdam Water Supply Dunes). The stratigraphical composition of the find horizon was identified as the old surface (palaeosoil) of the so-called 'Oude Duinen' (Old Dunes). The find horizon has yielded many shells and malacological research has indicated the former presence of a centuries-old, undisturbed, moist, deciduous forest. This forest was located at the border of Rijnland and Kennemerland, and remained unaffected by man for a long time. Shifting sand has since formed younger dunes on top of older ones. This process started around the year 1000 AD. The skeletal remains were ^{14}C dated to 1140 ± 30 BP, which calibrates to 880-970 calAD. This means that the remains are from the late Holocene age and belong to one of the last wild brown bears in the Netherlands, which was one of the largest mammals living in the Netherlands at this time. Zoological data and historical sources indicate that the last brown bear occurred in the Netherlands around the year 1000 AD. To contextualise the finding we also present an overview of all finds of the brown bear known from the Dutch Holocene.

Keywords: brown bear, *Ursus arctos*, Noordwijk, the Netherlands, Holocene.

Introduction

The brown bear (*Ursus arctos*) (figure 1) was one of the largest mammals found in the Netherlands during the Holocene but it disappeared around 1000 AD (Verhagen 1989). Since then, only occasionally individual brown bears have migrated from Germany to the eastern parts of the Netherlands, without forming a viable population. This paper reports on a find from the dunes north of Noordwijk (Province of Zuid-Holland), in the coastal area of the Netherlands. In addition we present an overview of all known Holocene brown bears finds in the Netherlands, as a follow-up to the publications of Verhagen (1989) and Ervynck (1993).

The site of the brown bear of Noordwijk

In the beginning of 2016 the skeletal remains of a brown bear were found in the dune area bordering the North Sea, north of Noordwijk, called the "Amsterdamse Waterleidingduinen" (Amsterdam Water Supply Dunes). A canal ("Van Limburg Stirumkanaal") was being infilled with sand from the surrounding area and this process uncovered soil profiles and old surface deposits from the Old Dunes, which dated back to medieval times and before. At several locations, geological and archaeological research was conducted

Figure 1. The brown bear (photo taken in Bayerischer Wald). *Photo: Paul van Hoof.*

(Vader 2007, Vossen 2007). After the construction work was completed, a bare stretch of sand, the "Van Limburg Stirumvallei" (figure 2) remained, with local exposures of palaeosoils.

The find horizon containing the brown bear remains was sampled for malacological purposes at 30 locations, distributed over an area of 2500 m². The total volume of the samples was 83.5 liters. The rich malacological fauna indicates that several hundred years this site was covered by a moist, deciduous forest. The soil would have been covered with a well-developed layer of leaf litter and decaying logs, and have contained a varied vegetation. The preserved remains of stubs of several birches (*Betula* sp.) and an alder (*Alnus* sp.) were found on the site (figure 2). Some water snails and plant seeds indicate local, wet conditions (Kuijper 2016). It is assumed that the sampled soil developed on the transition between a low (marshy) and a higher (moist) level.

In four samples, remains of mammals were present. One sample yielded some small bones and two molars of a wood mouse (*Apodemus sylvaticus*). The wood mouse lives in open country, wet pastures, woods, the edges of forests, dunes and heather fields and is common in the Netherlands (Pot 2016). In a second sample, a nearly complete skeleton of a root vole (*Microtus oeconomus*), containing dozens of small bones, nine molars and four incisor teeth was found. The root vole is a good swimmer and inhabits wet places (marsh, reed, wet forests, damp dune valleys) and dry grasslands. Its European population is mainly distributed throughout North-East Europe, although some relict populations persist in the Netherlands (Koelman & Bekker 2016). A third sample yielded seven ribs and a fragment of a pelvic bone. On the pelvic bone some gnawing marks, possibly of a fox, were present. These skeletal elements probably belong to a young deer, larger than a roe deer (*Capreolus capreolus*). On the surface of the old soil, a molar of a red deer (*Cervus elaphus*) was found. The find of several bones of a brown bear at one of the sampling locations was remarkable. All these skeletal remains were found in a natural setting and not, as with most other finds in the Netherlands,

Figure 2. The research area near Noordwijk, with stub remains (black) of birches (*Betula* sp.) and an alder (*Alnus* sp.). *Photo: Wim Kuijper.*

during archaeological excavations.

After the formation of the Older Dunes, shortly before the Roman era, there was a prolonged quiet phase in the formation of the dunes. Forests developed and the wet locations contained swamps and dune lakes. The pollen analysis of peat shows that between 175 BC and 900 AD the tree cover (birch, oak, alder, willow, beech) increased. Between the end of the 8th century and the end of the 9th century, the presence of beech increased remarkably (Jelgersma et al. 1970, Vossen 2007). At the same time, the water table rose and there was much open water present in the low-lying valleys. A virtually closed forest area formed in the whole dune area between Velsen and Noordwijk. Through archaeological research, we know that it contained large oaks and beeches. Part of this forest was the border of Rijnland and Kennemerland, and for that reason it remained unaffected by human influence for a long time. Around 1300 the area was still a ‘ wilderness ‘ and was (partly) known as Haarlemmerhout (van Til and Mourik 1999).

In the same area, near the site where the brown bear remains were recovered, skeletal remains of red deer, wild boar and roe deer have been found in recent years. These have not been dated, but probably originate from similar deposits. Thus it may be concluded, that the Old Dunes contained extensive deciduous forests that provide a suitable habitat for the brown bear.

About 1000 AD, a new phase of aeolian deposition started in the dunes: from the west and the Young Dunes developed. Swamps were filled-in, and forests were buried by sand. The sand drifts would not have taken part simultaneously all across the area: their extent would

have differed and the vegetation would have changed in response to this. Sand drift in the Young Dunes continued throughout the Middle Ages up to early modern times. There were probably not enough quiet phases during this period to allow for forests to become re-established. To help age our finds it is important to know the original altitude of the soils from where the samples were taken. They are estimated to have been deposited several metres above sea level (NAP). Some studies, including Blokzijl & Pruissers (1989), Jelgersma et al. (1970) and Vossen (2007), provide geological information on the immediate vicinity of the site of the brown bear find. Based on these studies we conclude that our materials (bones, molluscs, seeds) originated from the surface of the Old Dunes. The forest that grew here was overblown by the Young Dunes and its fauna and flora became covered. This is confirmed by the result of the ^{14}C date 880-970 calAD.

Description of the skeletal remains

The skeletal material is a large portion of a left front leg. All the skeletal elements are present except for one second phalanx, two third phalanges and most of the sesamoid bones (figures 3 and 4). Overall the bones are well-preserved: most of the skeletal elements are complete and they only show slight cracking due to dehydration. The proximal end of the humerus is fragmented and the ulna partly fragmented, but all the parts are still present. Two of the three third phalanges are fragmented distally. The good preservation is indicated by the high collagen yields, taken before dating the sample. The good preservation, the representation of skeletal elements and the location of the find supports the possibility that originally, a large part, possibly a complete skeleton was preserved. Unfortunately, it was not possible to study the overlying sediments as they were removed during the restructuring of the landscape.

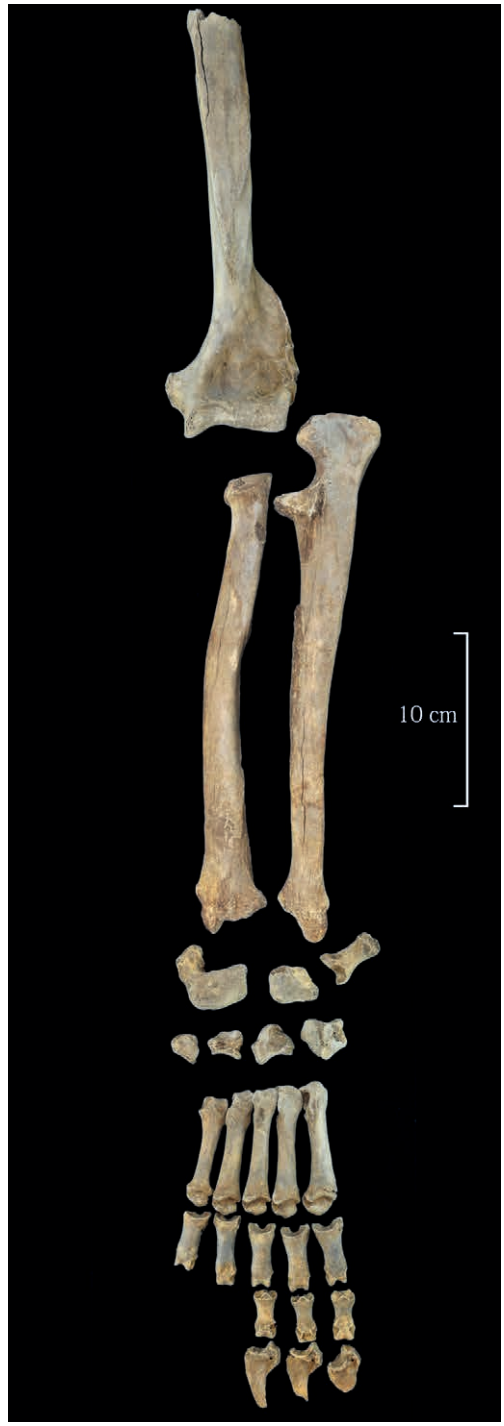


Figure 3. Left front leg of the brown bear from Noordwijk. *Photo: Ivo Verheijen.*

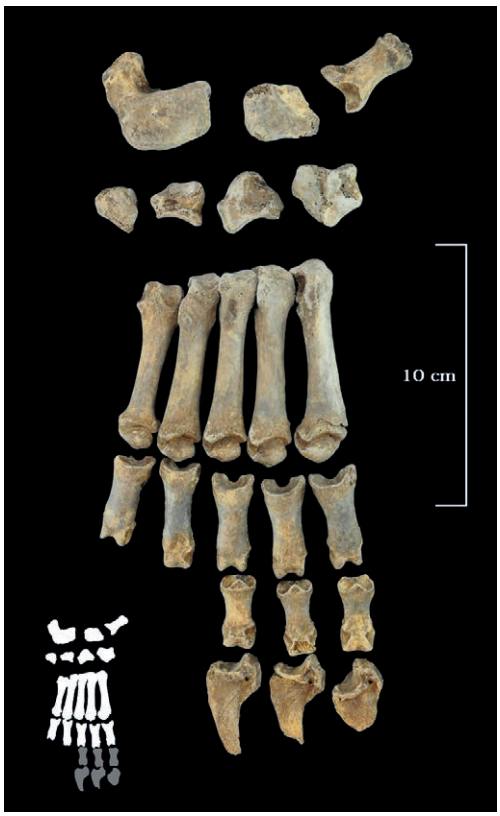


Figure 4. Left hand of the brown bear from Noordwijk (detail of figure 3). In the bottom left corner of the picture the grey fragments show the skeleton elements (distal phalanges) of which the position is uncertain. *Photo: Ivo Verheijen.*

The material was checked by A. Verbaas for macroscopic traces such as cut marks and traces of gnawing that could possibly provide insights into the taphonomic history of the find. No traces were found and this suggests an undisturbed deposition with little or no access by carnivore scavengers.

In order to compare the skeletal remains to other Holocene and Pleistocene brown bear remains from north-western Europe, measurements were taken using the standards provided by Von den Driesch (1976). Apart from providing a framework for comparison, these measurements can also give us an idea about the body size of one of the last brown bears in the Netherlands. All the measurements taken are shown in table 1. For measurements of less than 15 cm, a digital caliper was used. These measurements were rounded to a tenth of a millimetre. For larger measurements, a larger, analogue caliper was used, accurate to one millimetre. Skeletal elements with damage on the specific areas of the bone used for measuring, were excluded and recorded in the table with a dash (-). For the phalanges, the numbering by phalanx type (middle and end) was not done anatomically, since it is very hard to distinguish the exact position of each phalanx within the hand. The numbering was done in accordance with the position of the phalanges in figure 4, sequentially from left to right.

We could only find good references for comparing the size of the longbones and metacarpals. The largest radius from the Noordwijk fossils was 273 millimeters, which is in the top range of modern day brown bears that have dimensions of between 240 and 270 millimeters (Couturier 1954: 52). For European brown bear fossils from the Pleistocene, larger measurements have been found including a 334 mm radius from Maspino (Tuscany) (Koby 1945). The largest length of the ulna from our find is 309 millimeter. This is in accordance with modern-day specimens, where males measure between 315 and 321 millimeter and a female specimen has been recorded as having a length of 288 millimeter (Couturier 1954: 52). The ulna of the brown bear fossil from Masipino (Koby 1945) was 375 mm. The proximal end of the humerus from the Noordwijk fossils was damaged and no measurements could be taken. The distal epiphysis was complete; the maximal width of the epicondyles is 83.1 mm. In the bear remains from the North Sea, described by Bosscha Erdbrink (1982, 1983) these were generally larger. He concluded that the North Sea specimen belonged to a large and robust bear, but it is possible that it was of another species or subspecies. Finds from Jaurens (France) with an average metacarpal I length of 84 mm (Ballesio 1983) confirm that Pleis-

tocene bears might have been larger than the Holocene one from Noordwijk.

Dating and stable isotope composition

A sample of the humerus was radiocarbon (^{14}C) dated to 1140 ± 30 BP (before present) (laboratory number GrA-66477). The organic fraction of bone is best dated by collagen. This is extracted from the bone using a procedure originally developed by Longin (1971). The collagen is then combusted in an Elemental Analyser, which is coupled to an Isotope Ratio Mass Spectrometer (EA-IRMS). The IRMS determines the isotope ratios $^{13}C/^{12}C$ (for CO_2) and $^{15}N/^{14}N$ (for N_2) for the combustion products. Part of the CO_2 gas is reduced to graphite by a reaction with H_2 (Aerts et al. 2001). For this graphite, the isotope ratio $^{14}C/^{12}C$ is measured by Accelerator Mass Spectrometry (AMS) based on a 2.5 MV particle accelerator (van der Plicht et al. 2000).

The radiocarbon date is reported according to an internationally agreed convention (Mook & Streurman 1983, Mook & van der Plicht 1999). This convention takes complications, such as variations in the natural ^{14}C content, into account. This defines the ^{14}C timescale, which is relative. It differs from the calendar timescale, but the two timescales are related. They can be connected by calibration, which converts ^{14}C dates (in BP) into calendar ages. Only then does the ^{14}C timescale become absolute. Calibration curves are obtained by dating samples by both ^{14}C and an independent, preferably absolute method, most notably dendrochronology (Reimer et al. 2013). Note that, for ^{14}C, BP does not mean 'Before Present' in the literal sense.

The calibration is shown in figure 5. The blue curve is the calibration curve for the relevant timeframe. The vertical axis is the ^{14}C timescale and the red curve corresponds to the ^{14}C date 1140 ± 30 BP. The horizontal axis is the calendar timescale. The resulting probability distribution for the calendar dates (plotted in black) is 880-970 AD (or calAD, for "calibrated AD"). The ^{14}C measurement is a Gaussian probability distribution (the red curve); the calibrated distribution is not Gaussian due to irregularities in the calibration curve. The numbers quoted correspond to the 1-sigma range (68.2% probability).

In addition to the ^{14}C measurement, the stable isotopes ^{13}C and ^{15}N are also measured. They are a measure of bone collagen quality but also provide additional info about diet (Kohn 1999). They are reported as δ-values, the deviation of the rare to abundant isotope ratio from that of a reference material, expressed in permil:

$$\delta^{13}C = \left(\frac{\left(\frac{^{13}C}{^{12}C}\right)_{sample}}{\left(\frac{^{13}C}{^{12}C}\right)_{reference}} - 1 \right) x1000‰ \quad \text{and}$$

$$\delta^{15}N = \left(\frac{\left(\frac{^{15}N}{^{14}N}\right)_{sample}}{\left(\frac{^{15}N}{^{14}N}\right)_{reference}} - 1 \right) x1000‰$$

For ^{13}C, the reference is PDB which is a belemnite; for ^{15}N, it is ambient air (Mook 2006).

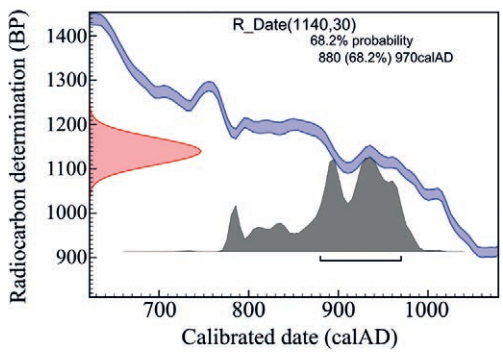


Figure 5. Calibration of the radiocarbon date. The blue curve is (part of) the calibration curve. The red curve corresponds to the 14C date of 1140 ± 30 BP. The black curve is the probability distribution for the calendar age. The 1-sigma (68.2% probability) confidence interval is 880-970 AD (or calAD, for "calibrated AD").

Table 1. Measurements of all skeletal elements of the left front leg of the brown bear from Noordwijk. All measurements were taken with use of the standard measurements established by von den Driesch (1976): GL = Greatest length; BP = (Greatest) breadth proximal end; BD = (Greatest) breadth distal end; SD = Smallest breadth of the diaphysis; HP = Height proximal end; HPC = Height proximal condyle; BPC = (Greatest) breadth across the coronoid process (= greatest breadth of the proximal articular surface); DPA = Depth across the *Processus anconaeus*.

Skeletal element	SubID	GL	BP	BD	SD	HP	HPC	BPC	DPA
Humerus		-	-	83.1	24.4				
Radius		273	34.9	49.1	21.9				
Ulna		309	45.4	19.5				46.8	50.9
Metacarpals	Metacarpal I	66.5	20.1	17.1	9.0				
	Metacarpal II	75.6	15.8	17.7	11.5				
	Metacarpal III	75.3	15.1	17.2	10.2				
	Metacarpal IV	78.3	15.5	16.9	10.8				
	Metacarpal V	78.9	20.0	19.2	10.9				
Phalanx I	1	38.9	17.0	13.7	11.5				
	2	39.5	17.8	14	11.7				
	3	43.7	16.2	13.4	10.5				
	4	39.4	19.1	14.6	12.0				
	5	37.8	-	14.3	11.9				
Phalanx II	1	29.5	14.3	13.9	10.3				
	2	30.2	14.5	-	10.0				
	3	28.9	14.5	14.0	10.3				
Phalanx III	1	-	13.2			21.8	14.1		
	2	-	12.5			22.1	16.9		
	3	-	12.9			-	14.9		

For the bear sample, the measured stable isotope ratios are $\delta^{13}C$ = -21.60 ‰, and $\delta^{15}N$ = 5.08 ‰. These are within the normal range for herbivore mammals.

The brown bear in the Netherlands, an overview of the Holocene finds

The Dutch fossil record includes several Pleistocene and Holocene brown bear finds. Pleistocene finds are known from the bottom of the North Sea and from sand/gravel pits on land. Several brown bear remains have been found in Eemian deposits from the sand/gravel pit at Hogebroek near Raalte (Province of Overijssel) (Brewer & Schouwenburg 2009). For the Holocene - the last ca. 10,000 years – the literature lists 50 locations with remains of brown bears. These are listed in table 2 and plotted on a map of the Netherlands (figure 6).

Most of the Holocene finds are from archaeological settings, except for the find from Noordwijk and possibly the one from Schouwen – Meeuwenduinen. The overview given in table 2 indicates that bear remains are generally rare. Usually they consist of a single tooth, bone or a skull fragment. Some bones show cutmarks or traces of gnawing. Perforated canine teeth were used as pendants or amulets. These teeth were possibly obtained through exchange and do not necessarily indicate the presence of bears in the area concerned. Table 2 and figure 6 show that the brown bear was present in the Netherlands during almost the entire Holocene. The oldest finds are from the Mesolithic and the most recent from the early Middle Ages. They indicate the presence of many forested areas in the Netherlands. The situation in Belgium

Table 2. Locations in the Netherlands with Holocene remains of brown bear.

		RD-coördinates						
Location	Site	X	Y	Archaeological period	Period	Part	Remarks	References
Aartswoud	t Hoog/Drie Bunders	126,600	528,820	Neolithic	2150-1950 BC	1 phalanx II		Gehasse 2001: 174
Aartswoud	During survey (surface)	c. 126.6	c. 528.8	Neolithic	2150-1950 BC	1 canine		Theunissen 2001: 112
Almere	Hoge Vaart - A27	151,520	481,000	Neolithic	c. 4050-3750 BC	1 canine, 1 molar, 1 phalanx, 1 scapula		Laarman 2001
Borgharen	Pasestraat	176,264	321,622	Early Medieval	6th-7th century AD	1 canine	artificial hole	van der Jagt et al. 2014
Bornwerd	Friese terpengebied	192,700	594,500	Early Medieval	5th-7th century AD	1 canine		Verhagen 1990
Brandwijk	Het Kerkhof	114,130	433,810	Neolithic	4900-4200 BC	1e max., 1 left metacarpal, 1 third phalanx posterior, 1 right astragalus, 2 left metacarpi	max. 3 individuals	Robeerst 1995, C. Cakirlar pers. comm. 2016
Broek in Waterland	Cleaning ditch	c. 128	c. 494	Neolithic	5300-2000 BC	1 root left lower canine	artificial hole	Bosscha Erdbrink 1982
Cornjum	Friese terpengebied	181	584,190	Early Medieval	5th-7th century AD	1 canine		Verhagen 1990
Den Ham	Vroomshoop (Linderbeek)	232,000	495,300	Neolithic (- Iron Age)	5300-2000 (-12) BC	2 scapulae (1 animal?)		Erdbrink 1953, Groenewoudt et al. 2007
Drechterland	Hoogkarspel (N23/Makerwaardweg)	139,070	523,320	Middle - Early Bronze Age	1800-800 BC	1 left pelvis, 1 lumbar vertebrae		L. Kootker & J. van Dijk pers. comm. 2016
Eenum	Groningse terpengebied	247/248	595/596	Early Medieval	5th-7th century AD	1 mandibula		Verhagen 1990
Emmeloord	J78	178,900	519,900	Bronze Age	2000-1800 BC	1 maxillary canine, 1 first molar mandibular, 1 humerus		Gehasse 1995
Enkhuizen	Kadijken	146,645	525,775	Bronze Age	1600-1000 cal BC	1 femur	cutmarks	Zeiler & Brinkhuizen 2011
Gennep	Stamelberg	194,800	412,600	Early Medieval	350-524 AD	1 mandibula		Verhagen 1990, van der Kamp 1995
Hekelingen	I	81,960	426,850	Neolithic	2900-2600 BC	1 right canine lower mandibula	artificial hole	Modderman 1953
Hekelingen	III - unit A1	82,210	426,750	Neolithic	3000 cal BC	2 maxillary/mandibular teeth		Prummel 1987
Hekelingen	III - unit B2	82,210	426,750	Neolithic	2600 cal BC	1 cranium, 1 maxillary tooth, 1 humerus	gnawing and butchering	Prummel 1987
Hellevoetsluis	Ossenhoek	68,983	429,048	Neolithic	c. 2900 BC	1 left ulna	gnawing of dog	van Dijk 2009
Hoogkarspel	Vindplaats F (HKL 1967)	139,800	522,500	Iron Age	c. 800 – 700 BC	1 neurocranium fragment		Suwijn 1981
Houten	Loerik	I4I.240	448,360	Early Medieval	725-900 AD	1 part ulna		de Vries & Laarman 2001

Table 2, continued

Houten	Schalkwijkseweg	141,200	446,880	Roman period	50 BC - 50 AD	2 fragments pelvic girdle		Buitenhuis 2001
Tjongerdal	Prandinga	c. 214	c. 558	Mesolithic - Roman period	8800 BC - 450 AD	1 canine		Prummel 2013
Tjongerdal	Jardinga (Johannahoeve)	c. 214	c. 559	Mesolithic - Roman period	8800 BC - 450 AD	2 canine		Prummel 2013
Tjongerdal	Makkinga (Lochtenrek)	c. 212.8	c. 556.6	Mesolithic - Roman period	8800 BC - 450 AD	1 cranium		Prummel 2013
Maasstricht	O.L. Vrouwebasiliek (pandhof)	176,578	317,578	Early Medieval	400-425 AD	1 mandibula		Ervynck 1997
Mijnsheeren-land	Hofweg	92,216	423,052	Bronze Age	1800-1100 BC	1 mandibula fragment		Lauwerier 1995, v. Heeringen & Lauwerier 1996
Molenaarsgraaf	Hazendonk	116,755	430,460	Neolithic	3400-2850 BC	1 second phalanx , 1 right patella, 1 lumbar vertebra	cutmarks	Zeiler 1997
Molenaarsgraaf	Polder Molenaarsgraaf	117,991	431,147	Neolithic - Bronze Age	1800-1500 BC	1 bone		Louwe Kooijmans 1974
Noordoost-polder	Schokland P14	181,580	518,000	Neolithic	4900-4100 calBC	1 metacarpus II		Gehasse 1995
Noordoost-polder	Schokland P14	181,580	518,000	Neolithic	2600-1900 calBC	1 tibia, 1 femur, 1 radius, 1 ulna		Gehasse 1995
Noordwijk	Amsterdamse Water-leidingduinen	95	482	Early Medieval	880-970 calAD	nearly complete frontleg		this article
Opmeer (Aartswoud)	Molenkolk I	127,260	528,840	Neolithic	2150-1950 BC	1 bone		Theunissen 2001
Schipluiden	Harnaschpolder	81,620	448,320	Neolithic	3550-3490 BC	9 cranium fragments, 2 phalanges, parts left and right maxilla, left incisor, right mandibula fragment, left M2 mandibula		Zeiler 2006
Schouwen	Meeuwenduinen	c. 37	c. 413	Roman period - Medieval	1th-2th? century AD	Parts frontleg young animal: humerus and radius		Nooren 2016
Schouwen	Beach			Holocene?	not dated	1 canine	artificial hole	AWN 2015
Swifterbant	S3	168,170	510,214	Neolithic	4100-4000 calBC	1 phalanx I, 2 phalanx II, 3 fragments metacarpals		Zeiler 1997
Tiel	Dominicuskwartier	158	433	Modern time	1500-2000 AD	1 distal articulation tibia		van Renswoude & Habermehl (eds.) 2014
Tiel	Passewaaij	156,121	430,988	Late Roman period	270-350 AD	1 canine		Groot 2008

Table 2, continued

Toornwerd	Groningse terpengebied	238	597	Early Medieval	5th-7th century AD	1 canine		Verhagen 1990
Uitgeest	Waldijk (Assum)	108,700	502,900	Bronze Age	950-750 BC	1 M3 mandibula		de Vries 2008
Utrecht	De Meern (LR 57)	131,000	455,850	Bronze Age	1400-1275 BC	1 maxilla fragment with canine- and incisors (premaxillare)		Meijer 2009
Valkenburg a.d. Rijn	Dorpsheuvel (castellum)	89,700	466,100	Roman period	40-240 AD	1 canine		Clason 1961
Valkenburg a.d. Rijn	De Woerd	90,300	465,230	Roman period/early Medieval	0-1000 AD	1 right mandibula, 1 cranium (2 individuals)		Verhagen 1990
Veldhoven (Oerle)	Touterfout - Halve Mijl	151,900	380,950	Bronze Age	1800-1100 BC	1 phalanx	cremation, in burial pit	Theunissen 1993 (1996)
Velsen (castellum)	N.Spaarndammer Polder	106,460	496,180	Roman period	15-55 AD	1 canine, 1 phalanx II		Verhagen 1990, Schnitger 1988
Vlaardingen	Arij Koplaan	81,390	435,650	Neolithic	c. 2300 BC	1 neurocranium, 1 upper frontal part rostrum (remains M2 on left side), 1 proximal part right mandibula, 1 proximal part right intermaxillare, 1 part right maxillare	artificial hole	van Bree 1961
Voorschoten	Boschgeest	89,710	459,610	Neolithic	3400-2000 BC	1 tooth	artificial hole	Groenman-van Waateringe et al. 1968
Westwoud	Noorderboekert	137,284	522,910	Neolithic (late)	2850-2000 BC ?	1 lunare	cutmark	J. Aal pers. com. 2016
Wieuwerd	Friese terpengebied	175	569	Early medieval	5th-7th century AD	1 canine		Verhagen 1990
Wijk bij Duurstede	De Geer	151,113	443,616	Roman period	270-450 AD	1 femur fragment		Bekkema et al. 2011
Wijk bij Duurstede	De Horden	151,228	443,018	Bronze Age	1800-1100 BC	2 metacarpals		Laarman 1996
Zeewijk (Winkel)		124.65	530.83	Neolithic	2450-2100 calBC	1 phalanx II		Zeiler & Brinkhuizen 2014
Zutphen	Ooijershoek	212,200	459,930	Mesolithic	7160-6870 BC	1 tooth	cutmarks	Groenewoudt et al. 2001, Peeters & Niekus 2005

Figure 6. Map of locations in the Netherlands where Holocene remains of brown bear were found. *Drawing*: *W. Laan (Archol)*.

and Luxembourg was more or less the same. It is possible that bears were still present in the southern and eastern parts in these countries until the 12th century (Ervynck 1993).

The origin and age of the finds from Tiel – Dominicuskwartier are uncertain. The authors report (translated from Dutch) that: "In this period, the brown bear was described to be almost certainly extinct in the Netherlands. Given the origin of the fragment, it is more likely that it dates from the early Middle Ages." (Renswoude & Habermehl (eds.) 2014). In addition, it is also possible that we are dealing with a dancing bear that died in Tiel.

Historical sources

A statement from 943 AD in the charters of the Bishop of Utrecht about the right to hunt for brown bears in the east of the country, can be taken as reliable since the brown bear still occurred frequently in the adjoining West-German area in the 10th century until 1650 (IJsseling & Scheygrond 1950: 119).

According to Liesenborghs (2007), the brown bear was already extinct in the Low Countries during the Roman occupation. The species then rather quickly disappeared from Western Europe, although a few relict populations remain even today.

The book 'Jacht-Bedryff', probably written by C.J. van Heenvliet and later edited by Swaen (1948) describes hunting practice and the animals hunted around 1600 AD. The writer was the forester of Holland and West-Friesland, including the dunes of Holland, exactly the area where the brown bear of Noordwijk was found. The book reports on the animals that could be hunted: deer, fallow deer, roe deer, hare, rabbit (and many bird species). Of wild boar, wolf and fox it is written: 'zijn daer eertijdts veel geweest, doch in lange jaren gene' (= in former times there were many, though for a long time there have been none). The cause of these animals disappearing was the conversion of forests to agricultural areas and marshes to pastures and hay meadows. This shows that the brown bear was not present in the dune forests around this time (1600 AD). Bears apparently disappeared from the dune area long before wild boar, wolf and fox and had even disappeared from the memory of man.

Discussion

The find of a brown bear in Noordwijk in the Netherlands is remarkable. It is the first time that so many bones (an almost complete left front leg) have been found in a natural setting in the Netherlands. The good state of preservation and the location both support the idea that originally, an entire skeleton might have been preserved. The dimensions of the Noordwijk brown bear are well within the current size range of the European brown bear, although it is much smaller than Pleistocene individuals from the Netherlands.

We also have information about the geological and botanical history of the site. The expected age of the find, based on the geological setting, was confirmed by the result of the ^{14}C date 880-970 calAD. After the formation of the Older Dunes there was a prolonged phase when deposition did not take place. Forests developed on the surface and swamps and dune lakes were present in the wetter locations. In the dune area between Velsen and Noordwijk a virtually closed forest area formed, estimated to be several hundred square kilometres in size. The area was large enough to support a viable population of brown bears. Around 1300 AD the area was still a 'wilderness' (van Til and Mourik 1999).

The finds of the brown bear in Late-Holocene deposits and the historical data about the disappearance (around 1000 AD) of the species in the Netherlands, fit well together, implying that the remains from Noordwijk belong to one of the last wild brown bears in the Netherlands.

Acknowledgements: H. Vader (Hillegom) reported the presence of a species of a land snail which no longer lives in this dune area. This was the reason to start research at the site which gave important malacological and zoological results. W.H. Nekkers (Noordwijk) drew our attention to the presence of the bear bones at a malacological sampling point. N. den Ouden (Naturalis, Leiden), W. Prummel and C. Cakirlar (GIA, Groningen), F. Laarman (RCE, Amersfoort), J.T. Zeiler (ArchaeoBone), K. Esser and A.L. van Gijn (Faculty of Archaeology, Leiden), J. Aal (Archol, Leiden), L. Kootker and J. van Dijk (Archeoplan Eco, Delft) were helpful in providing the information for table 2. A. Verbaas (Faculty of Archaeology, Leiden) examined the bones on possible traces (e.g. cutmarks, gnawing traces) and C.E. Vermeeren (BIAX, Zaandam) identified the trees that would have been present on the site. P. van Hoof took the photograph of a brown bear. Y.M. Haring and N. Parrott corrected the

English, C. Schouwenburg and J.P. Bekker corrected the information concerning Pleistocene bears. Two anonymous reviewers made valuable comments on an earlier version of the manuscript. Many thanks to all of you.

References

Aerts, A.T., J. van der Plicht, H.A.J. Meijer 2001. Automatic AMS sample combustion and CO_2 collection. Radiocarbon 43: 293-298.

AWN 2015. Botten bruine beer gevonden in Schouwen. URL: www.awn-archeologie.nl/2015/botten-bruine-beer-gevonden-in-schouwen/; viewed 21 November 2016.

Ballesio, R. 1983. Le gisement Pléistocène supérieur de la grotte de Jaurens à Nespouls, Corrèze, France: les carnivores: III Ursidae. Nouvelles Archives du Museum d'Histoire naturelle de Lyon 21: 9-43.

Bekkema, M., M. Groot, M. van Haasteren & K. Scharringhausen 2011. Dierlijk bot uit Wijk bij Duurstede – De Geer: midden-Romeinse tot en met Karolingische tijd. Zuidnederlandse Archeologische Notities 262. Hendrik Brunsting Stichting, Archeologisch Centrum, Vrije Universiteit Amsterdam, the Netherlands.

Blokzijl, J. & A.P. Pruissers 1989. Het voorkomen van veen- en humeuze lagen in en rondom het infiltratiegebied van Gemeentewaterleidingen Amsterdam. Rapport Rijks Geologische Dienst, Haarlem, the Netherlands.

Bosscha Erdbrink, D.P. 1982. More fossil bear remains in some Dutch collections. Scripta Geologica 66: 1-14.

Bosscha Erdbrink, D.P. 1983. Sundry fossil bones of terrestrial mammals from the bottom of the North Sea. Proceedings of the Koninklijke Nederlandse Akademie van Wetenschappen B 86 (4): 427-448.

Brewer, J.G. & C. Schouwenburg 2009. Carnivora from Salland. A last word from D.P. Bosscha Erdbrink. Cranium 26 (2): 13-18.

Buitenhuis, H. 2001. Archeozoölogie. In: J.S. Krist, J.B. de Voogd & J. Schoneveld (eds.). Een vindplaats uit de Late IJzertijd en Vroeg-Romeinse tijd aan de Schalkwijkseweg te Houten, terrein 14, Provincie Utrecht: 135-168. ARC-Publicatie 48. Groningen, the Netherlands.

Clason, A.T. 1961. Some remarks on the faunal remains from the Roman Castellum at Valkenburg, prov. of South Holland. Palaeohistoria VIII: 139-147.

Couturier, M.A.J. 1954. L'ours brun. M.A.J. Couturier, Grenoble, France.

de Vries, L.S. 2008. Het archeozoölogisch onderzoek. In: J. de Koning. 3000 jaar bewoning bij Assum. Nederzettingssporen uit de Late-Bronstijd/Vroege IJzertijd, Romeinse tijd en Late Middeleeuwen bij de Waldijk en de Assummervaart, gemeente Uitgeest: 205-249. Batenburg, Zaandijk, the Netherlands.

de Vries, L.S. & F.J. Laarman 2001. Archeozoölogie. In: W.K.Vos & J.J. Lanzing. Houten-Zuid 'Het Archeologisch onderzoek op terrein 2I': 89-95. Rapport. ADC ArcheoProjecten, Amersfoort, the Netherlands.

Erdbrink, D.P. 1953. A review of fossil and recent bears of the old world I & II. PhD thesis. Utrecht University, the Netherlands.

Ervynck, A. 1993. De bruine beer der Benelux. Zoogdier 4 (3): 5-11.

Ervynck, A. 1997. Maastricht en bruine beren: een eeuwenoud verhaal. Archeologie in Limburg 72: 25-27.

Gehasse, E.F. 1995. Ecologisch-archeologisch onderzoek van het Neolithicum en de Vroege Bronstijd in de Noordoostpolder met de nadruk op vindplaats P14. PhD thesis. Amsterdam University, the Netherlands.

Gehasse, E.F. 2001. Aartswoud: An environmental approach of a Late Neolitic site. In: R.M. van Heeringen & E.M. Theunissen (eds.). Kwaliteitsbepalend onderzoek ten behoeve van duurzaam behoud van neolithische terreinen in West-Friesland en de Kop van Noord-Holland. Deel 3. Archeologische onderzoeksverslagen. Nederlandse Archeologische Rapporten 21: 161-201.

Groenewoudt, B.J., J. Deeben, B. van Geel & R.C.G.M. Lauwerier 2001. An early Mesolithic assemblage with faunal remains in a stream valley near Zutphen, the Netherlands. Archaeologisches Korrespondenzblatt 31 (3): 329-348.

Groenewoudt, B., M. Kosian, F. Laarman & E. Rensink 2007. De 'fauna van de Linderbeek' opnieuw bekeken. Een analyse van de archeologische betekenis van prehistorische faunaresten uit een Twents beekdal. RACM Beknopte Rapportage Archeologische Monumentenzorg 7. Rijksdienst voor Archeologie, Cultuurlandschap en Monumen-

ten, Amersfoort, the Netherlands.

Groenman-van Waateringe, W., A. Voorrips & L.H. van Wijngaarden-Bakker 1968. Settlements of the Vlaardingen Culture at Voorschoten and Leidschendam (ecology). Helinium VIII: 105-130.

Groot, M. 2008. Animals in ritual and economy in a frontier community. Excavations in Tiel-Passewaaij. Amsterdam Archaeological Studies 12. Amsterdam University Press, Amsterdam, the Netherlands.

IJsseling, M.A. & A. Scheygrond 1950. De zoogdieren van Nederland. Thieme & Cie, Zutphen, the Netherlands.

Jelgersma, S., J. de Jong, W.H. Zagwijn & J.F. van Regteren Altena 1970. The coastal dunes of the western Netherlands; geology, vegetational history and archeology. Mededelingen Rijks Geologische Dienst, Nieuwe Serie 21: 93-167.

Koby, F. (ed.) 1945. Un Squelette d'ours brun du pléistocène italien. Verhandlungen der naturforschenden Gesellschaft in Basel 56 (1): 58-85.

Koelman, R.M. & D.L. Bekker 2016. Noordse woelmuis *Microtus oeconomus.* – In: S. Broekhuizen, K. Spoelstra, J.B.M. Thissen, K.J. Canters & J.C. Buys (eds). De Nederlandse zoogdieren: 127-129. Natuur van Nederland 12. Naturalis Biodiversity Center & EIS Kenniscentrum insecten en andere ongewervelden, Leiden, the Netherlands

Kohn, M.J. 1999. You are what you eat. Science 283: 335-336.

Kuijper, W.J. 2016. A late Holocene forest fauna with *Spermodea lamellata, Merdigera obscura* and *Cochlodina laminata* in the dunes of Noordwijk (province of South Holland), The Netherlands. Basteria 80: 195-200.

Laarman, F.J. 1996. Zoological material of the Bronze Age, Iron Age and Roman Period from Wijk bij Duurstede-De Horden: In: L.I. Kooistra. Borderland farming. ROB: 369-380. Van Gorcum, Assen, the Netherlands.

Laarman, F.J. 2001. Archeozoölogie: aard en betekenis van de dierlijke resten. In: J.W.H. Hogestijn & J.H.M. Peeters (eds.). De mesolithische en vroeg-neolithische vindplaats Hoge Vaart - A27 (Flevoland). Rapportage Archeologische Monumentenzorg 79-16. Rijksdienst voor het Cultureel Erfgoed, Amersfoort, the Netherlands.

Lauwerier, R.C.G.M. 1995. Binnenmaas - Mijnsheerenland/Hofweg 1995; Waarneming Midden Bronstijd. Report Archeozoölogie / ROB 22031995, Amersfoort, the Netherlands.

Liesenborghs, P. 2007. Het edele vermaak. De jacht in de Spaanse Nederlanden onder de Aartshertogen. PhD thesis Geschiedenis, Katholieke Universiteit Leuven, Belgium.

Longin, R. 1971. New method of collagen extraction for radiocarbon dating. Nature 230: 241-242.

Louwe Kooijmans, L.P. 1974. The Rhine/Meuse delta. Four studies on its prehistoric occupation and Holocene geology. Analecta Praehistorica Leidensia VII. Leiden University Press, Leiden, the Netherlands.

Meijer, Y. 2009. Gewei uit de geul. LR57: Onderzoek naar een bronstijdrestgeul en sporen uit de vroeg-Romeinse tijd aan de Burgemeester Middelweerdbaan in De Meern, Utrecht. Basisrapportage Archeologie 31. Gemeente Utrecht, the Netherlands.

Mook, W.G. 2006. Introduction to Isotope Hydrology. Taylor & Francis/Balkema, Leiden, the Netherlands.

Mook, W.G. & H.J. Streurman 1983. Physical and chemical aspects of radiocarbon dating. PACT publications 8: 31-55.

Mook, W.G. & J. van der Plicht 1999. Reporting ^{14}C activities and concentrations. Radiocarbon 41: 227-239.

Nooren, M.J. 2016. Bruine beer in Zeeland. Uit de gebieden van Staatsbosbeheer. De Levende Natuur 117: 72.

Modderman, P.J.R. 1953. Een neolithische woonplaats in de polder Vriesland onder Hekelingen (eiland Putten) (Zuid-Holland). Berichten van de Rijksdienst voor het Oudheidkundig Bodemonderzoek 4 (2): 1-26.

Peeters, H. & M.J.L.T. Niekus 2005. Het Mesolithicum in Noord-Nederland. In: J. Deeben, E. Drenth, M.-F. van Oorsouw, L. Verhart (eds.). De Steentijd van Nederland. Archeologie 11/12: 201-234.

Pot, A. 2016. Bosmuis *Apodemus sylvaticus.* – In: S. Broekhuizen, K. Spoelstra, J.B.M. Thissen, K.J. Canters & J.C. Buys (redactie). Atlas van de Nederlandse zoogdieren: 137-138. Natuur van Nederland 12. Naturalis Biodiversity Center & EIS Kenniscentrum insecten en andere ongewervelden, Leiden, the Netherlands.

Prummel, W. 1987. The faunal remains from the neolihtic site of Hekelingen III. Helinium 27: 190-258.

Prummel, W. 2013. Dieren uit de prehistorie in het

Tjongerdal. Twirre 23 (1): 16-21.

Reimer, P.J., E. Bard, A. Bayliss, J.W. Beck, P.G. Blackwell, C. Bronk Ramsey, C.E. Buck, R.L. Edwards, M. Friedrich, P.M. Grootes, T.P. Guilderson, H. Haflidason, I. Hajdas, C. Hatté, T.J. Heaton, D.L. Hoffmann, A.G. Hogg, K.A. Hughen, K.F. Kaiser, B. Kromer, S.W. Manning, M. Niu, R.W. Reimer, D.A. Richards, E. M. Scott, J.R. Southon, R.A. Staff, C.S.M. Turney & J. van der Plicht 2013. IntCal13 and Marine13 Radiocarbon age calibration curves 0-50,000 years cal BP. Radiocarbon 55: 1869-1887.

Robeerst, J.M.M. 1995. De Neolithische fauna van de Donk Het Kerkhof bij Brandwijk, Alblasserwaard. Verslag Keuzevak Zoöarcheologie. Projectgroep Brandwijk, Leiden University, the Netherlands.

Schnitger, F.W. 1988. Kleine huisdieren en wild van het Romeinse castellum Velzen I; de botvondsten van de opgravingscampagne 1982. MSc thesis IPP. Amsterdam University, the Netherlands.

Schnitger, F.W. 1990. Het botmateriaal van de laat-Neolithische en Bronstijd nederzettingen in de Gouw (campagne 1989). Report Archeozoölogie / Rijksdienst voor het Oudheidkundig Bodemonderzoek, Amersfoort, the Netherlands.

Suwijn, M. 1981. Oude koeien (etc.) uit een sloot bij Hoogkarspel (ca. 700 v. Chr.); een archaeozoölogische studie. MSc thesis archeozoölogie BAI, Groningen State University, the Netherlands.

Swaen, A.E.H. 1948. Jacht-Bedryff. Brill, Leiden, the Netherlands.

Theunissen, E.M. 1993 (1996). Once again Toterfout-Halve Mijl. Analecta Praehistorica Leidensia 26: 29-43.

Theunissen, E.M. 2001. Site-dossiers. In: R.M. van Heeringen & E.M. Theunissen (eds.). Kwaliteitsbepalend onderzoek ten behoeve van duurzaam behoud van neolithische terreinen in West-Friesland en de Kop van Noord-Holland. Deel 2. Archeologische onderzoeksverslagen. Nederlandse Archeologische Rapporten 21. Rijksdienst voor het Oudheidkundig Bodemonderzoek, Amersfoort, the Netherlands.

Vader, H. 2007. De oudste bewoners van de Amsterdamse Waterleidingduinen. Tussen Duin & Dijk 7 (4): 8-11.

van Bree, P.J.H. 1961. On the remains of some Carnivora found in a prehistoric site at Vlaardingen, the Netherlands. Beaufortia 8 (91): 109-118.

van der Jagt, I.M.M., F.J. Laarman, W.J. Kuijper, A.M. Nieman, B.J.H. van Os & J.C. Zwaan 2014. Dierlijk materiaal. In: R.C.G.M. Lauwerier & J.W. de Kort (eds.). Merovingiers in een villa 2. Romeinse villa en Merovingisch grafveld Borgharen – Pasestraat. Onderzoek 2012: 157-190. Rapportage Archeologische Monumentenzorg 222. Rijksdienst voor het Cultureel Erfgoed, Amersfoort, the Netherlands.

van der Kamp, M.D. 1995. Het botmateriaal van de opgraving Gennep 1989-1990. Verslag zoö-archeologisch practicum 1995. IPP, Amsterdam University, the Netherlands.

van der Plicht, J., S. Wijma, A.T. Aerts, M.H. Pertuisot, H.A.J. Meijer 2000. The Groningen AMS facility: status report. Nuclear Instruments and Methods B172: 58-65.

van Dijk, J. 2009. Zoogdieren, vogels en reptielen. In: T.A. Goossens (ed.). Opgraving Hellevoetsluis-Ossenhoek. Een nederzetting van de Vlaardingen-groep op een kwelderrug in de gemeente Hellevoetsluis: 113-145. Rapport 87. Archol, Leiden, the Netherlands.

van Heeringen, R.M. & R.C.G.M. Lauwerier 1996. Bewoningssporen uit de Midden Bronstijd en Vroege IJzertijd in de Hoeksche Waard, provincie Zuid-Holland. Westerheem 45: 132-140.

van Renswoude, J. & D. Habermehl (eds.) 2014. Archeologische opgravingen te Tiel-Dominicuskwartier. Onderzoek naar een vroeg-middeleeuwse ringwalburg, een mottoversterking, Ottoonse nederzettingsresten, een versterkt huis en laat- en postmiddeleeuwse resten in de oude binnenstad. Zuidnederlandse Archeologische Rapporten 56. Vrije Universiteit, Amsterdam, the Netherlands.

van Til, M. & J. Mourik 1999. Hiëroglyfen van het zand. Vegetatie en landschap van de Amsterdamse Waterleidingduinen. Gemeentewaterleidingen Amsterdam, the Netherlands.

Verhagen, M. 1989. De beer in de Nederlandse pre- en protohistorie. Cranium 6 (3): 65-71.

Verhagen, M. 1990. De bruine beer (*Ursus arctos* L.) in Valkenburg (Z.H.). In: E.J. Bult & D.P. Hallewas (eds.). Graven bij Valkenburg III. Het archeologisch onderzoek in 1987 en 1988: 175-181. Eburon, Delft, the Netherlands.

von den Driesch, A. 1976. A guide to the measurement of animal bones from archaeological sites.

Peabody Museum Bulletin 1. Peabody Museum of Archaeology and Ethnology, Harvard University, Cambridge, MA, USA.

Vossen, I. 2007. Archeologische begeleiding Vernattingsproject De Zilk, Amsterdamse Waterleidingduinen. Archeologische Rapporten Oranjewoud 2007/86. Oranjewoud B.V., Heerenveen, the Netherlands.

Zeiler, J.T. 1997. Hunting, fowling and stock-breeding at neolithic sites in the western and central Netherlands. PhD thesis. Groningen State University, Groningen, the Netherlands.

Zeiler, J. 2006. Mammals. In: L. P. Louwe Kooijmans & P.F.B. Jongste (eds.). Schipluiden, a neolithic settlement on the Dutch North Sea coast c. 3500 cal BC. Analecta Praehistorica Leidensia 37/38: 375-420.

Zeiler, J.T. & D.C. Brinkhuizen 2011. Archeozoölogisch onderzoek. In: W. Roessingh & E. Lohof (eds.). Bronstijdboeren op de kwelders. Archeologisch onderzoek in Enkhuizen – Kadijken: 191-218. ADC Rapport 2200/ADC Monografie 11. ADC Archeo-Projecten, Amersfoort, the Netherlands.

Zeiler, J.T. & D.C. Brinkhuizen 2014. Faunal remains. In: E.M. Theunissen, O. Brinkkemper, R.C.G.M. Lauwerier, B.I. Smit & I.M.M. van der Jagt (eds). A Mosaic of Habitation at Zeewijk (the Netherlands), Late Neolithic Behavioural Variability in a Dynamic Landscape. Nederlandse Archeologische Rapporten 47: 177-196.

Samenvatting

Een van de laatste wilde bruine beren (*Ursus arctos*) in Nederland (Noordwijk)

Tijdens onderzoek van Holocene bodems in de Amsterdamse Waterleidingduinen ten noorden van Noordwijk kwamen enkele resten van de bruine beer tevoorschijn. Het materiaal is beschreven en gemeten. Het bleek om een vrijwel complete linkervoorpoot van een individu van gemiddelde grootte te gaan. Door de hoogteligging en door vergelijking met geologische bodemprofielen van de directe omgeving kwam een jong-Holocene ouderdom in aanmerking. Het gaat om een vondst in een bodem gevormd in de top van de Oude Duinen. Deze duinen zijn omstreeks het jaar 1000 overstoven door de Jonge Duinen. Door een ^{14}C datering werd dit bevestigd: de ouderdom ligt tussen de 880 en 970 kalenderjaren AD. Het betreft daarmee een van de laatste in het wild levende bruine beren in Nederland. Door ontbossingen en jacht verdween de bruine beer omstreeks 1000 AD uit Nederland.

Het onderzoek in het Noordwijkse duingebied betrof een malacologische analyse van jong-Holocene afzettingen. De schelpen waren van soorten die aangeven dat hier vroeger een oud, ongestoord, vochtig loofbos aanwezig was. Enkele waterslakken en planten (zaden) geven plaatselijke, natte omstandigheden aan. Andere zoogdieren waarvan de resten werden aangetroffen zijn noordse woelmuis (*Microtus oeconomus*), bosmuis (*Apodemus sylvaticus*) en edelhert (*Cervus elaphus*). De vondst van de bruine beer past goed in dit beeld van het landschap.

Uit geologisch, botanisch (pollen) en historisch onderzoek weten we dat in de duinen tussen Velzen en Noordwijk een groot bosgebied aanwezig was. Het betreft het grensgebied tussen Rijnland en Kennemerland.
Aanvullend op ons onderzoek geven we een actueel overzicht van alle Holocene vondsten van beren in Nederland. Hiermee is dit een vervolg op de publicaties van Verhagen (1989) en Ervynck (1993). De meeste resten in dit overzicht komen uit archeologische opgravingen. Vooral wanneer het een doorboorde tand betreft is het niet zeker dat de beer ook in het gebied rond de onderzochte nederzetting leefde. De vondsten van Noordwijk en (mogelijk) Schouwen zijn in ongestoorde afzettingen gedaan, dit in tegenstelling tot alle andere vondsten in Nederland en België. Deze zijn door toedoen van de mens in of bij nederzettingen terecht gekomen. Uit het overzicht blijkt dat de bruine beer gedurende vrijwel het gehele Holoceen in Nederland leefde. Hoewel zeldzaam, zijn de botten en tanden verspreid over het gehele land aangetroffen.

Received: 30 September 2016
Accepted: 7 November 2016

Supposedly lost syntype of the rough-toothed dolphin (*Steno bredanensis* (Lesson, 1828)) traced back at the Ghent University Museum

Jan Piet Bekker[1], Mark E.J. Bosselaers[2,3] & Gerard R. Heerebout[4]

[1] Curator Terrestrial mammals, Koninklijk Zeeuwsch Genootschap der Wetenschappen, P.O. Box 378, NL-4330 AJ Middelburg, the Netherlands, e-mail: jpbekker@zeelandnet.nl
[2] Curator Marine mammals, Koninklijk Zeeuwsch Genootschap der Wetenschappen
[3] Koninklijk Belgisch Instituut voor Natuurwetenschappen, Operationele Directie Aarde en Geschiedenis van het Leven, Vautierstraat 29, B-1000 Brussel, Belgium
[4] Curator Naturalia, Koninklijk Zeeuwsch Genootschap der Wetenschappen

Abstract: Van Breda (1829) published the first extensive description of the rough-toothed dolphin *Steno bredanensis* (Lesson, 1828). The whereabouts of the skull of the dolphin that Van Breda depicted, remained unknown. In the collection of the Ghent University Museum, skulls of three rough-toothed dolphins are present, without information on the locality or date of collection. The positions of the foramina in dorsal view of one of these skulls (MDV50426) perfectly match those in the depicted skull in Van Breda's publication. Beyond reasonable doubt, this is the specimen described in Van Breda (1829) as *Delphinus bredanensis* Lesson, 1828. There are two syntypes referred to in the taxon *Steno bredanensis* Lesson (1828). The first is the animal later depicted in Van Breda (1829). The second is a specimen from Brest (Brittany, France), however no parts of this specimen seem to be available anymore. Therefore, the rediscovery of the skull MDV50426 is important.

Keywords: rough-toothed dolphin, *Steno bredanensis*, syntype, Ghent University Museum.

Introduction

Van Breda (1829) published the first extensive description of the rough-toothed dolphin (*Steno bredanensis* (Lesson, 1828)) and he depicted details, especially of the skull and tooth morphology, of a specimen then described as *Delphinus bredanensis*. Van Breda included several interesting details, such as a long thin rostrum and the absence of a groove between rostrum and forehead. When Van Breda showed the drawings of the exterior and skull of an unknown dolphin species in 1825 to G. Cuvier, the latter realised that a new dolphin species had to be added to his new book. As the printing process of the last volume of this extensive series on fossil bones was already in an advanced stage (Cuvier 1823-25), only a probable last minute annotation could be included as a correction note, but no proper name nor specific characteristics were included.

Lesson (1828) described the rough-toothed dolphin in a volume on cetaceans in the series on mammals and birds discovered since 1788, formally using the name *Delphinus bredanensis* Cuv. for the first time. Apart from the external discriminating criteria, he notably described the exterior of the specimen Van Breda observed, and mentioned a length of eight feet, a dorsal fin with a semilunar out-

line and a semilunar tail fluke with an indentation [...] in the middle. Lesson (1828) continued describing the gradually sloping profile of the skull as most characteristic. Other peculiarities of the skull he mentioned were a compressed snout, broad nasal bones, touching the premaxillare, a prominent occipital ridge and as the temporal region is much larger, a smaller occipital region. However he did not mention the characteristic rough dental grooves nor the long mandibular symphysis.

Without further details, Lesson (1828) briefly mentioned a drawing sent from Brest (Brittany, France) which he also designated as *Delphinus bredanensis*. G. Cuvier's brother Fréderic mentions a specimen on a drawing from Brest, of which twenty years later the drawing was published (Cuvier 1836). Based on Lesson's (1828) description, this original drawing represents one of the syntypes.

The zoological collections of the Ghent University, as well as the Royal Belgian Institute of Natural Sciences in Brussels, hold several rough-toothed dolphin skulls, but according to De Smet (1974) it was not possible to determine whether one of these had belonged to this specimen. De Smet (1974) tried to reconstruct how a broken mandible of a rough-toothed dolphin that ended up in a ditch near Bruinisse (Zeeland, the Netherlands) could have been part of the dolphin Van Breda described. However, Heerebout et al. (2014) provide a more plausible explanation for the origin of that mandible, suggesting it was the discarded evidence for the bounty set up by the Dutch government to help support the local fisheries. As such, the whereabouts of the skull of the rough-toothed dolphin Van Breda depicted still remained unknown.

Therefore we investigated skulls and other clues of rough-toothed dolphins in zoological collections in Belgium and the Netherlands in order to identify the lost skull Van Breda described. We also mention the discriminating morphological criteria for this species provided by Lesson (1828) and Van Breda (1829), and compare them with the current criteria.

Material and methods

As Van Breda lectured at the Ghent University from 1822-1830 (Breure 1979), the Ghent University Museum plays a prominent role in the search for the skull described by Van Breda. The Ghent University Museum was founded in 1817 (as Rijksmuseum by Willem I, King of the Netherlands – at that time Belgium had not been founded) and, as zoological objects were needed for study and teaching, Coenraad Jacob Temminck, a well-known zoologist, was asked in 1818 to buy zoological specimens for the collections of the universities of Gent (Ghent), Leuven (Louvain) and Liège (Liege) (Poot et al. 2014). Gijzen (1938) mentions for example that Temmick bought zoological objects in a sale of Bullocks's Museum, London. Only in 1853 the registration of incoming objects ('Registre d'entrée') in the Ghent University Museum started (Dominick Verschelde, personal communication). In the collection of this museum, skulls of three rough-toothed dolphins are present: MDV50425, MDV50426 and MDV50427; the abbreviation MDV is the acronym for "Museum Dierkunde Vertebraten" (Museum Zoology Vertebrates). Each of them is labelled with typed general information for this species, reading (in translation): *C[lass] Mammalia*, *O[rder] Cetaceae*, *F[amily] Stenidae*, *Steno rostratus Desmarest, 1817*, *Indian Ocean*. No information on the exact origin, date or other peculiarities are provided.

The absence of a clear label with date and origin of a specimen of a rough-toothed dolphin, that would point at the original specimen Van Breda described in 1829, urges to look for an alternative method to establish the whereabouts of this specimen in a plausible manner. This could be the number and exact position of the foramens in dorsal view of the skull and the outline of the temporal-frontal suture. As the picture (drawing) of this specimen was available, comparison with eligible (museum) specimens could provide positive results.

Besides specimens from the Ghent University Museum, specimens deposited at other Belgian and Dutch museums were included as well; table 1 presents these specimens, including the museum numbers and museums.

Results

Positive indications in Gent (Ghent)

The text on the label of specimen MDV50425 reads "*CN 2265 / RN 695*" and on the occipital "*2265*" is written. In this specimen "*Delphinus Rostratis, G. Cuv.*" has been marked at the dorsal side of the left premaxilla in a more recent handwriting compared to the writing on specimen MDV50426. The label on specimen MDV50426 reads "*Steno rostratus* / CN 606", while at the occipital "606 CS" is denoted. At the dorsal side of the left premaxilla "*Delphinus Bredanensis*" is written in late 18th - early 19th century handwriting. At the right premaxilla there is some unclear text of three characters (figure 1). Reading from lateral to medial, the first character is a "*9*" and the second probably is a "*5*", while the third character could be a symbol for an ordinal number, so interpreted as the 95th specimen from an unknown collection. Initials are drawn respectively on the vomer: "*V*", the right nasal: "*N*", the left premaxilla: "*PM*" (figure 2a). On the right frontal, an "*F*" and on the left maxilla an "*M*" are marked, suggesting use for studies of comparative anatomy. The tip of the maxilla of this specimen is cracked, possibly caused by a fall. Specimen MDV50427 bears no specific signs or writing, except for the fact that the tip of the snout is still covered with skin. In conclusion of the direct study of the three skulls deposited in Gent (Ghent), skull number MDV50246 having the name "*Delphinus Bredanensis*", written in late 18th - early 19th century handwriting, indicates that this skull would be a candidate of being the one Van Breda reported on and subsequently collected.

In his Catalogue of the anatomical collection of the Ghent University Museum, Poelman (1868) mentions, in the part for the seventh mammalian order, among the nine skulls and/or mandibles of cetaceans, two skulls of rough-toothed dolphins, both indicated with the scientific name *Delphinus rostratis* G. Cuv.

Table 1. Studied available skull / mandibles of the rough-toothed dolphins (*Steno bredanensis*) in museal collections in Belgium, the Netherlands, all with museal numbers.
MDV: Museum Dierkunde Vertebraten" (Museum Zoology Vertebrates) of Ghent University Museum, Ghent; IRScNB: Institut royal des Sciences naturelles de Belgique, Bruxelles; KZWG: Koninklijk Zeeuwsch Genootschap der Wetenschappen (in Zeeuws Museum), Middelburg; ZMA: Zoological Museum Amsterdam, now Naturalis Biodiversity Centre, Leiden; NMR: Natuurhistorisch Museum Rotterdam, Rotterdam.

Museum number	Year/Origin	Material
MDV 50425	unknown	skull
MDV 50426	unknown	skull
MDV 50427	> 1868 / unknown	skull
IRScNB 1515γ / 822β / I.G. 2534	7-12-1865 / unknown	skull
IRScNB 1515 / 821 / I.G. 9332	> 1844, < 1936 / via Zoo Antwerp	skull
KZGW / NHG 22701	unknown	skull
KZGW / NHG 22703	1877 / Bruinisse, the Netherlands	jaw distally L/R
ZMA 13010	< 1889 / unknown	skull
ZMA 13347	1948 / Cambérène, Sénégal	skull
ZMA 31176	1969 / Dakar, Sénégal	skull
NMR 9990-00388	1892 / Luanda, Angola	skull

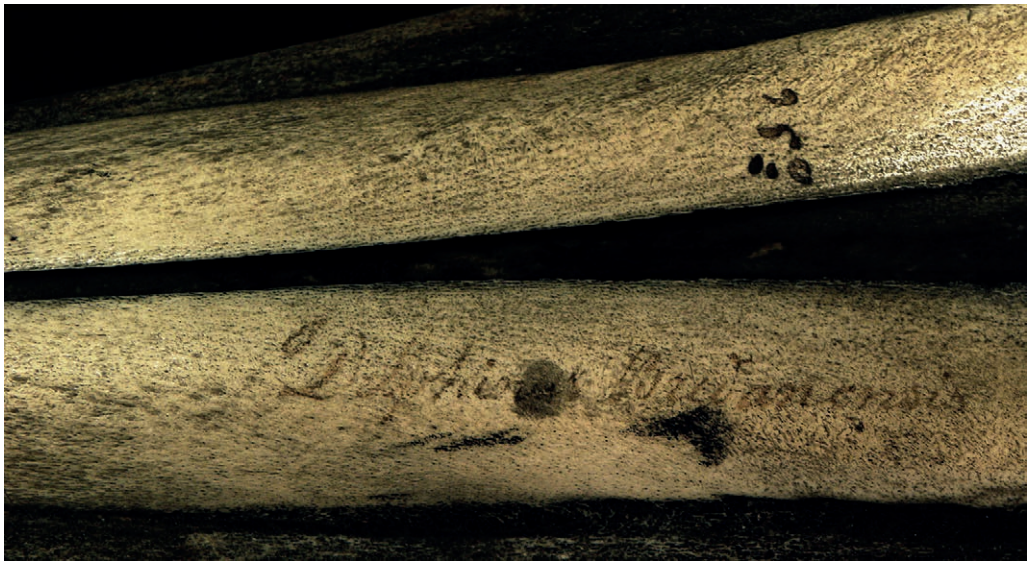


Figure 1. Left and right (upper) premaxilla of specimen MDV50426, reading respectively "*Delphinus Bredanensis*" and (supposedly) "95th".

/ *Delphinus bredanensis* Fisher (obviously meant as synonyms). The first one in this Catalogue has the number 6 and the second one has the catalogue number 2265. The latter must refer to the skull with 2265 on the occipital (= specimen MDV50425). We suppose that after some time Poelman or a later curator of the collection started a new numeration system: "Collectie Nummer" (= CN) and "Collection Systématique" (= CS). There was a good reason to do so, as many objects of different orders had the same number. The catalogue of Poelman seems to be enumerating the objects brought together from different origins, with existing collection numbers. Collection number 6 can also be found on the skull of a bird (rhinoceros hornbill), on a preparation of the muscles of a dog, and on a general preparation of a dog. For that reason someone must have changed the number 6 of the cetaceans into number 606 in the new numeration system. Another cetacean specimen, e.g. "Épaulard à tête ronde *Delphinus globiceps* [long-finned pilot whale (*Globicephala melas*)]", according to Poelman (1868) with catalogue number 8, received number 608 in this system. In the catalogue of Poelman (1868) no skeletons, skulls or other body parts of rough-toothed dolphin are mentioned. We suppose specimen MDV50427 has been collected after Poelman completed his catalogue in 1868 as it is not mentioned in the catalogue.

So there are strong indications that the skull labelled CN 606 and 606 CS (= specimen MDV50426) on the occipital is identical with number 6 in the catalogue of Poelman (1868), being the lowest number that rough-toothed dolphin skulls or any other cetacean received in this catalogue of the collected mammal specimens of the Ghent University Museum.

MDV50426 compared with the depicted specimen

The condition of specimen MDV50426 is fairly good: apart from the mentioned (post-mortally) broken tip of the combined premaxilla and maxilla, no other damages of the skull are present and almost all teeth are in situ. However, the tips of most of the teeth are crumbled, all in a characteristic manner, leav-

Table 2. Skull measurements (mm) and tooth counts of the rough-toothed dolphins (*Steno bredanensis*) in the collection of the Ghent University Museum. Measurements are according to Robineau et al. (1994a). The ranges are taken from the literature and provided for comparison with the measurements of MDV50246.
* in Miyazaki & Perrin 1994 ** in Maigret 1994

Specimen	MDV50426	Range (*n*)
Condylobasal length	531	472–555 (66)*
Rostrum length	309	274–343 (59)*
Rostrum width at base	105	87–119 (58)*
Rostrum width (halfway)	52	38–64 (58)*
Postorbital width	219	202–239 (6)*
Praeorbital width	182	169–196 (6)*
Zygomatical width	223	188 and 214 (2)**
Mandible length	438	431 and 445 (2)**
Mandible heigth (L/R)	86/88	83-84 (2)**
Length of mandibular symphysis	146	ca. 1/3 mandible length*
Upper tooth count (L/R)	24/24	19-26*
Lower tooth count (L/R)	22/23	19-28*

ing several segmental fractures in occlusal view of the remnant tooth. Deposits of dust in different shades of grey reflect that the crumbling events took place at different moments in time. The condition of the teeth suggest a long conservation, consistent with the longest stored rough-toothed dolphin skulls in the Ghent University Museum, in suboptimal and unstable climatic conditions.

The mandibles are not fused, but fixed together at the symphysis. Based on the ossification of the cranial sutures and the worn dental ridges, the individual the skull belonged to was probably an adult. The standard skull measurements of specimen MDV50426 are listed in table 2.

In the next step to find out if one of the skulls could have been the one depicted in van Breda (1829), we compared the foramina of the skulls in dorsal view (figure 2A, B) with the drawing. The positions of the dorsal infraorbital foramina in the right maxilla (1, 2, 3, 5, 6) in the skull of MDV50426 perfectly matched those in the depicted skull in Van Breda, as is the case for the premaxillary foramen (4) in the right premaxilla. The foramina in the left maxilla (13, 14, 15 (three foramina in a row), 16) and also the premaxillary foramen (17) in the left premaxilla are in identical positions. The right ascending process of the premaxilla (7: long, broad and as the broad end of a tie) and the left equivalent (8: short, narrow as the other end of the same tie) are very similar. The skull as well as the drawing show a rough, broad, raised ridge on the frontal (9, nuchal crest) and well delimited semicircular depressions on both sides on the supraoccipital shield (10). The suture between nasals and frontals in skull and drawing show the same position and forms, as well as a very similar, slight asymmetry (11, 12).

Despite numerous superficial indentations, the parieto-squamosal suture in the temporal fossa of Van Breda's illustration and of MDV50426 (figure 3A, B) show the same basic outline in right lateral view.

The tooth count in MDV50426 for the number of right upper teeth/alveoles, left upper teeth/alveoles, right lower teeth/alveoles and left lower teeth/alveoles equals 23, 23, 23, 23 respectively. There is, however a contradiction in Van Breda's (1829) paper. He explicitly remarks the number of teeth being 46 for each cheek. This is in accordance with the depicted number of the lower cheek in Pl. I, figure 3 (figure 4), being 23 for both sides. However,

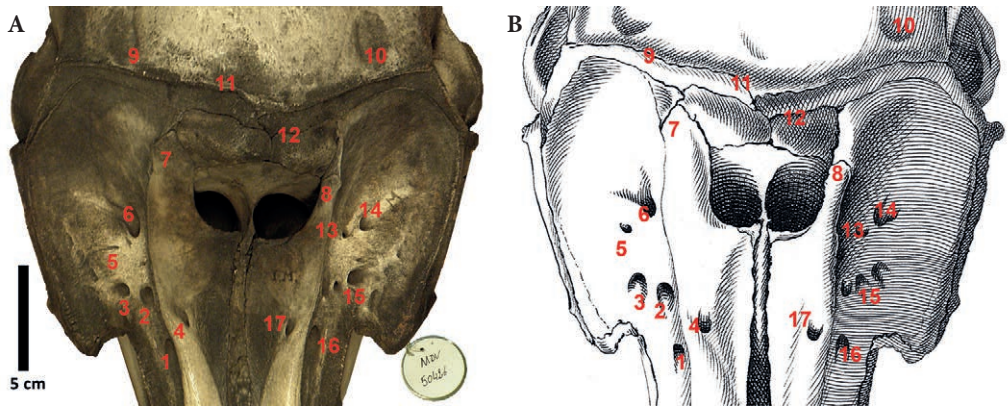


Figure 2. Dorsal view of the skull MDV50426 (A) and a reprint of figure 1 of Plate II (Van Breda 1829) (B). Initials (in black) drawn respectively on the vomer: "V", the right nasal: "N", the left premaxilla: "PM"; numbers in red indicate the dorsal infraorbital foramina, premaxillary foramina and other cranial features observed in both MDV50426 and the figure by Van Breda.

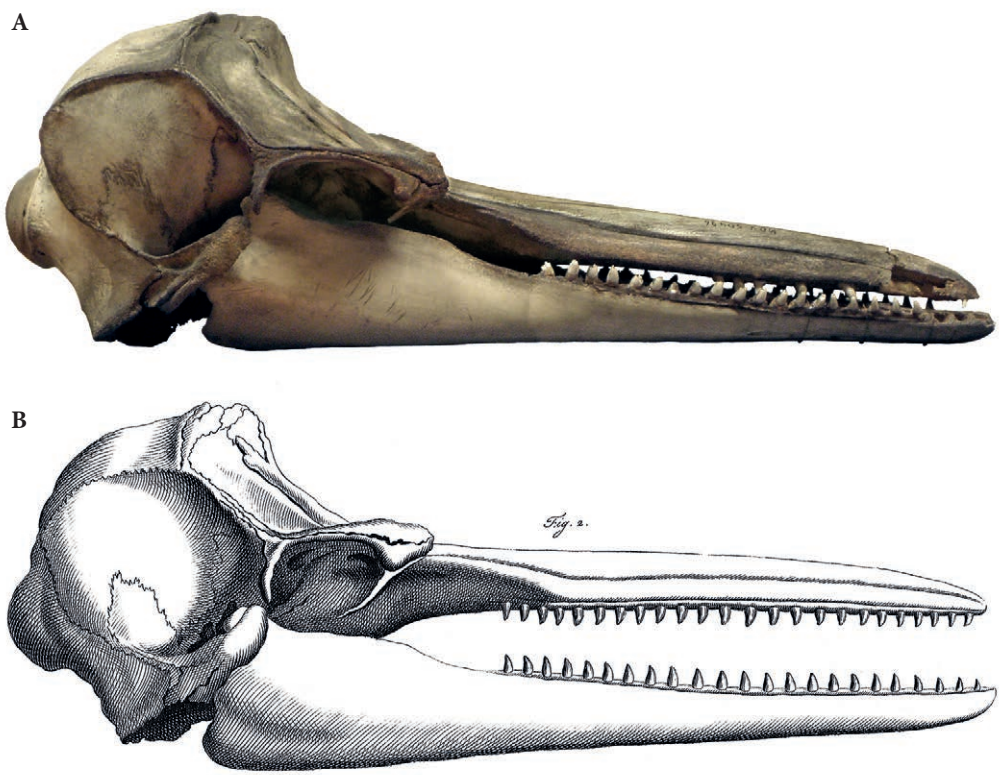


Figure 3. A. Right lateral view of the skull MDV50426. B. Reprint of figure 2 of Plate II (Van Breda 1829). The numbers in both MDV50426 and the figure by Van Breda of right upper and lower teeth in the figure of Van Breda (1829), being respectively 24 and 23.

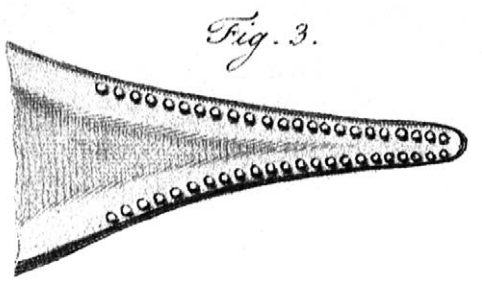


Figure 4. The mandible with the right and left lower tooth count of 23 both sides (as in Fig. 3 of Pl. I (in Van Breda 1829).

on Plate II, figure 2 (see figure 3B), showing the right lateral side, the upper tooth count equals 24, while the lower tooth count is 23.

Other museal specimens

Other specimens of the rough-toothed dolphin in Belgian and Dutch museal collections, listed in table 1, were collected well after 1825-1829 (IRScNB 1515γ / 822β / I.G. 2534, IRScNB 1515 / 821 / I.G. 9332, ZMA13010, ZMA13347, ZMA31176, NMR 9990-00388) and therefore can be eliminated as having served as the model for the drawings in Van Breda (1829). Dorsal and lateral views of the unknown or not precisely dated specimens (other than MDV 50426) in table 1, MDV 50425, MDV 50427 and KZGW / NHG 22701 have been studied. They show a pattern of the dorsal foraminae and/or the outline of the right parieto-squamosal suture which is distinct from the drawings of Van Breda (see also figures 2, 3). The tooth or socket count of the mandible of specimen NHG22703, being 22 at both sides, does not correspond to the number of 23 in figure 3, Pl. I, and figure 2, Pl. II, in Van Breda (1829).

We conclude that the picture of the dorsal and right lateral view of the skull in Van Breda (1829) has been drawn after the specimen MDV50426, kept at the Ghent University Museum.

Discriminating morphological criteria

Nowadays the criteria that distinguish the rough-toothed dolphin from all other European dolphin species are the long muzzle and sloping profile without a furrowed line for the external body shape and, for the skull, the compressed snout, the long mandibular symphysis and rough dental grooves (Robineau et al. 1994b).

Lesson (1828), describing the exterior characteristics of the species after the drawings of the specimen of Van Breda, mentioned the gradually sloping profile of the head as most characteristic for the species. For the characteristics of the skull, Lesson (1828) furthermore mentioned a compressed snout, broad nasal bones touching the premaxilla, and the prominent occipital ridge as well as the smaller occipital. However, he did not mention the characteristic rough dental grooves nor the long mandibular symphysis.

A year after Lesson (1828) Van Breda (1829) presented the gradually sloping profile in his description of *Delphinus Bredanensis*, but he described no other currently accepted discriminating details. However, in Plate I, figure 4, and to a lesser extent in Plate II, figure 2 of Van Breda (1829), the dental grooves are clearly depicted. Also in Plate I, figure 3, a long mandibular symphysis is depicted (more than eight teeth are depicted almost parallel, suggesting a long symphysis), but it is not described in the text.

Discussion and conclusion

There is a perfect match between MDV50426, the specimen from the Ghent University Museum, and the specimen depicted in Van Breda (1829), while no match could be found with the other specimens studied in the collections of the Ghent University Museum, Naturalis Biodiversity Centre, Leiden, Koninklijk Zeeuwsch Genootschap der Wetenschappen in the Zeeuws Museum, Mid-

delburg and Natuurhistorisch Museum Rotterdam. Therefore, beyond reasonable doubt, the specimen described in Van Breda (1829) is the skull MDV50426, *Delphinus bredanensis* Lesson, 1828, nowadays renamed as *Steno bredanensis* (Lesson, 1828). This perfect match is corroborated by inscription of "*Delphinus Bredanensis*" in late 18th - early 19th century handwriting on skull MDV50426 and by the numbering in the catalogue of Poelman (1868).

Already in the 19th century there was a mystery around the origin of the rough-toothed dolphin Van Breda had described. A summary of the discussions was given by De Smet (1974). Recently Smeenk & Camphuysen (2016) followed Schlegel (1862), where he stated "[…] caught near the mouth of the river Scheldt", as he, Schlegel, knew Van Breda and undoubtedly got this information directly from the him.

There is no holotype of the taxon *Steno bredanensis*, but there are two syntypes. The first is the animal drawn by Van Breda which Lesson (1828) referred to and this drawing with description was later published by Van Breda (1829). The second one is a specimen from Brest, also drawn, and mentioned by Lesson (1828). Recently West et al. (2011) mention that the fate of the type specimen is unclear and it may have been lost. It is therefore important that the skull MDV50426, which was the original model for the drawing of this syntype, has been rediscovered in the depository of the Ghent University Museum.

Acknowledgements: We are very grateful towards Dominick Verschelde of the Ghent University Museum, Belgium, for the permission to study the skulls in the museum, his kind assistance in presenting the original, annotated catalogue of Poelman (1868) and the useful discussions on the topic of old museum collections. We would like to thank Frank de Klerk, Ivo van Loo and Katie Heyning for their interpretation of the 19th century curator's handwriting and abbreviation. We also thank Chris Smeenk for his accurate and valuable advice. Furthermore we would like to thank Olivier Lambert and members of the editorial board for their critical and constructive comments. Last but not least we want to memorise the excellent quality of the artist D. Sluyter, who made the drawings for Van Breda's paper in 1829. Thanks to his craftsmanship of the dorsal and lateral views on the skull and the teeth, all in remarkable fine details, the analysis described in this paper was possible.

References

Breure, A.H.S. 1979a. Biografie. In: A.H.S. Breure & J.G. de Bruijn (red.). Leven en werk van J.G.S. van Breda (1788-1867): 13-30. Hollandsche Maatschappij der Wetenschappen, Haarlem / Tjeenk Willink, Groningen, the Netherlands.

Cuvier, F. 1836. De l'histoire naturelle des cétacés, ou recueil et examen des faits dont se compose l'histoire naturelle de ces animaux. Libraire Encylopédique de Roret, Paris, France.

Cuvier, G. 1823-1825. Recherches sur les ossemens fossiles, où l'on rétablit les caractères de plusieurs animaux dont les révolutions du globe ont détruit les espèces. Nouvelle édition, entièrement refondue, et considérablement augmentée. Tome cinqième. Première partie, contenant les rongeurs, les édentés, et les mammifères marins. G. Dufour & E. d'Ocagne, Paris, France / Amsterdam, the Netherlands.

De Smet, W.M.A. 1974. Inventaris van de walvisachtigen (Cetacea) van de Vlaamse kust en de Schelde. Bulletin van het Koninklijk Belgisch Instituut voor Natuurwetenschappen, Biologie 50 (1): 1-156.

Gijzen, A. 1938. 's Rijks Museum van Natuurlijke Historie 1820-1915. Proefschrift Rijksuniversiteit Leiden. W.L. & J. Brusse's Uitgeversmaatschappij N.V., Rotterdam, the Netherlands.

Heerebout, G.R., M.E.J. Bosselaers & J.P. Bekker 2014. On two specimens of rough toothed dolphin (*Steno bredanensis* Lesson, 1828) in a zoological collection in the Netherlands. Lutra 57 (1): 38-42.

Lesson, R.P. 1828. Histoire naturelle générale et particulière des mammifères et des oiseaux découverts depuis 1788 jusqu'a nos jours. Cétacés. Baudoin Frères, Paris, France.

Maigret, J. 1994. *Steno bredanensis* (Lesson, 1828) –

Rauhzahndelphin (auch Langschnauzendelphin). In: J. Niethammer & F. Krapp (eds.). Handbuch der Säugetiere Europas, Band 6: Meeressäuger, Teil I: Wale und Delphine 1: 269-280. Aula-Verlag, Wiesbaden, Germany.

Miyazaki, N. & W.F. Perrin 1994. Rough-toothed dolphin *Steno bredanensis* (Lesson, 1828). In: S.H. Ridgeway & R. Harrison (eds.). Handbook of Marine Mammals Volume 5: 1-21. Academic Press Limited Press, London, UK.

Poelman, C.A.C. 1868. Catalogue des collections d'anatomie comparée, y compris les ossements fossiles, de l'Université de Gand. Vanderhaeghen, Ghent, Belgium.

Poot, N., G. Vanpaemel & S. Walkens 2014. Een walvis in de stad; de collecties van de Leuvense Faculteit Wetenschappen. Lipsius, Leuven, Belgium.

Robineau, D., R. Duguy & M. Klima 1994a. A. Einführung. In: J. Niethammer & F. Krapp (eds.). Handbuch der Säugetiere Europas, Band 6, Meeressäuger, Teil I: Wale und Delphine 1: 11-25. Aula-Verlag, Wiesbaden, Germany.

Robineau, D., R. Duguy & M. Klima 1994b. Familie Delphinidae Gray 1821 - Delphine. In: J. Niethammer & F. Krapp (eds.). Handbuch der Säugetiere Europas, Band 6, Meeressäuger, Teil I: Wale und Delphine 1: 265-268. Aula-Verlag, Wiesbaden, Germany.

Smeenk, C. & C.J. Camphuysen 2016. Snaveldolfijn *Stena bredanensis*. In: S. Broekhuizen, K. Spoelstra, J.B.M. Thissen, K.J. Canters & J.C. Buys (red.). Atlas van de Nederlandse zoogdieren. Natuur van Nederland 12: 354-355. Naturalis Biodiversity Center & EIS Kenniscentrum Insecten en andere ongewervelden, Leiden, the Netherlands.

Schlegel, H. 1862 Natuurlijke historie van Nederland. De dieren van Nederland. Gewervelde dieren. Zoogdieren. A.C. Kruseman, Haarlem, the Netherlands.

van Breda, J.G.S. 1829. Aanteekening omtrent eene nieuwe soort van dolfijn. Nieuwe Verhandelingen, 1ste Klasse, Koninklijk Nederlandsch Instituut II: 235-237.

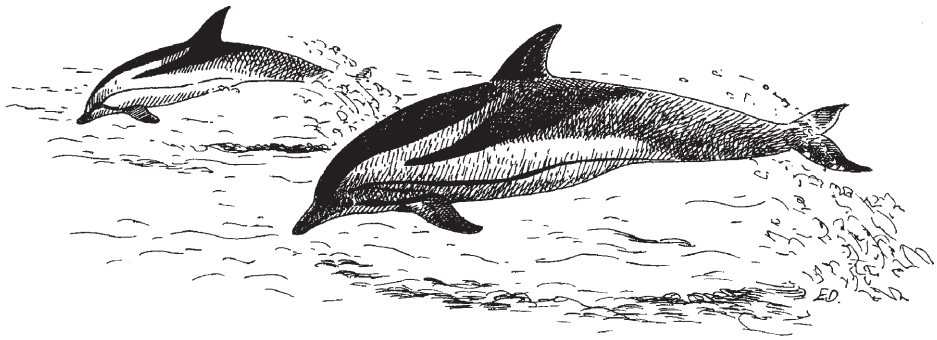
West, K.L., J.G. Mead & W. White 2011. *Steno bredanensis* (Cetacea: Delphinidae). Mammalian Species 43 (886): 177-189.

Samenvatting

Verloren gewaand syntype van snaveldolfijn (*Steno bredanensis* (Lesson, 1828)) gelokaliseerd in het Universitair Museum Gent, België

Van Breda (1829) publiceerde de eerste uitgebreide beschrijving van de snaveldolfijn (*Steno bredanensis* (Lesson, 1828)), inclusief gedetailleerde tekeningen van de schedel. Waar de schedel van deze dolfijn werd bewaard, was tot nu toe niet bekend. Na gedetailleerd onderzoek van schedels van de snaveldolfijn in Belgische en Nederlandse collecties en vergelijking met de afbeelding in Van Breda (1829) besluiten we dat een van de schedels in de collectie van het Gents Universitair Museum ongetwijfeld deze is die door Van Breda werd beschreven en staat afgebeeld. De uiterlijke kenmerken die snaveldolfijnen onderscheiden van alle andere Europese dolfijnen zijn de lange snuit en het geleidelijk oplopende profiel zonder groef en voor de schedel de zijdelings samengedrukte snuit, de lange symfyse van de onderkaken en de gegroefde tanden. Lesson (1828) beschrijft wel het geleidelijk oplopende profiel en de zijdelings samengedrukte snuit, maar hij vermeldt de karakteristieke lange symfyse van de onderkaken en de gegroefde tanden niet. Van Breda (1829) vermeldt ook het geleidelijk oplopende profiel, maar de gegroefde tanden en lange symfyse staan alleen afgebeeld. Er zijn twee syntypes van het taxon *Steno bredanensis* waar Lesson (1828) naar verwijst. De eerste is het dier afgebeeld in Van Breda (1829). Het tweede is een specimen van Brest (Bretagne, Frankrijk), ook getekend. Van dit laatste dier zijn mogelijk geen delen bewaard gebleven. Omdat het een van de twee syntypes is, is het belangrijk dat schedel MDV50426 in de collectie van het Gents Universitair Museum als dusdanig gelokaliseerd werd.

Received: 3 July 2016
Accepted: 24 October 2016



Cetaceans stranded in the Netherlands in 2008-2014

Guido O. Keijl[1], Lineke Begeman[2], Sjoukje Hiemstra[2], Lonneke L. IJsseldijk[2], Pepijn Kamminga[1] & Seal Centre Pieterburen[3]

[1] Naturalis Biodiversity Center, P.O. Box 9517, NL-2300 RA Leiden, the Netherlands, e-mail: guido.keijl@naturalis.nl
[2] Faculty of Veterinary Medicine, Department of Pathobiology, Utrecht University, Yalelaan 1, NL-3584 CL Utrecht, the Netherlands
[3] Seal Rescue Centre Lenie 't Hart (nowadays called: Seal Centre Pieterburen), Hoofdstraat 94a, NL-9968 AG Pieterburen, the Netherlands

Abstract: We present a validated list of cetaceans stranded from 2008 up to and including 2014. A total of 4406 cetaceans was found on the Dutch coast during this period, comprising 4346 harbour porpoises (*Phocoena phocoena*) (98.6% of all strandings) and 59 individuals of twelve other species. The next most numerous species was white-beaked dolphin (*Lagenorhynchus albirostris*) (14 individuals). All individual cases of stranded cetaceans are included, excepting those of harbour porpoise. During the present period, the years with the highest numbers ever of harbour porpoise have been recorded, although numbers in the early twentieth century or before may have been equally high. Largest numbers of harbour porpoise, both absolute and expressed as average per stretching kilometre, are found in the Wadden Sea area, with a gradually decreasing density further south.

Keywords: Cetacea, harbour porpoise, mortality, North Sea, *Phocoena phocoena*, sex bias.

Introduction

This report on cetacean strandings in the Netherlands is the 39th report in the series reviewing at least one entire year since the first report on the same topic by Van Deinse (1933). After his first review, Van Deinse regularly reported on strandings up to and including 1964 (van Deinse 1966). Van Deinse started his study of dead cetaceans in 1914 (Kompanje & Reumer 2002); this report therefore concludes an impressive period of an entire century of cetacean strandings. Reviewing Dutch cetacean strandings has become easier with the digital national strandings database in 2006, available at walvisstrandingen.nl. The database is updated on a weekly basis, and apart from special events, monthly and yearly overviews are published on its news page. All individual records are digitally accessible and often accompanied with photographs. Despite this, the overview becomes obscured by strandings of the numerous harbour porpoise (*Phocoena phocoena*), especially since 2004, making it harder than before to keep track of changes in the Dutch cetacean fauna. Hence, by reporting on a regular basis, we would be able to present data from a fairly considerable period without being out of topicality. Since the last update (Camphuysen et al. 2008) however, reports have been delayed.

Recently, extensive information on long-term strandings data of cetaceans in the Netherlands has been published (Broekhuizen et al. 2016), and we refer to that publication for more information on the status of cetaceans in Dutch waters. Although the data in Broekhuizen et al. (2016) are based on the same database as those in the present report, there may be slight differences, due to including

skeletal remains and floating corpses at sea.

Apart from merely reporting the strandings of the past couple of years, this publication is meant to be a validated list of recent stranded cetaceans in the Netherlands. Although information on parasites is collected, the data will not be presented in this overview; they can, however be viewed on www.walvisstrandingen.nl under the respective species. The purpose of reporting on strandings is not just to publish on recent findings of fresh carcasses. In order to gain insight in the cetacean community in the North Sea and adjacent waters, long-term monitoring not just involves surveying live animals offshore (e.g. Hammond et al. 2013, Scheidat et al. 2013) and nearshore (trektellen.nl), but also counting dead animals on the beach (Pyenson 2011), no matter whether these have died recently. Therefore, subfossil records are included in this report as well.

Methods

Following conventions in previous reviews of stranded cetaceans, details in this report are listed for each individual found ashore, whether alive or dead. An exception is made for harbour porpoise; results of this species are summarised with emphasis on temporal and spatial patterns in strandings, sex ratio and age composition. Some long-term trends are evaluated overseeing the period since 2000. Another exception is made for carcasses found floating in Dutch waters, or brought into a Dutch harbour on the bulb of a ship; these are included because they may have been found on the beach later on, for instance when they would slip off a ship's bulb.

All records mentioned in this publication have been reported to walvisstrandingen.nl through a number of parties within the Dutch cetacean network (see: Acknowledgements) and are incorporated in the national database, maintained by Naturalis Biodiversity Center in Leiden. Strandings of harbour porpoise are nowadays usually accompanied with digital photographs, which are added to the database. In case a species other than harbour porpoise is found, it is usually tried to get sufficient photographs in order to identify the species. Also, (part of) the skeleton or other material (tissue, parasites, stomach contents) is usually collected and stored by Naturalis or a provincial or regional museum. The database is publicly available on www.walvisstrandingen.nl. Collection numbers, if known, are also given below.

Area

The Dutch beach stretches from the border with Germany in the northeast to the border with Belgium in the southwest. To find out whether there are differences in densities in numbers of harbour porpoise washing ashore, the coastal area of the Netherlands is subdivided into three physically different parts (table 1; see also figure 3 in Camphuysen et al. (2008)): a. the Delta area, in the southwest, from the Belgian border up to and including Maasvlakte; b. the mainland coast between Hoek van Holland and Den Helder; and c. the Wadden Sea. The 'inner Delta' includes (open) rivers Westerschelde, and (partly closed) Oosterschelde and Grevelingenmeer. The mainland coast consists of provinces Zuid-Holland (but excluding Goeree, Voorne and Maasvlakte) and Noord-Holland. The division between the two in this report is the harbour of IJmuiden, about 15 km north of the administrative boundary. The Wadden Sea is divided into the North Sea coast of the islands and the Wadden Sea proper, which includes the Wadden Sea side of the islands, the northeastern part of Noord-Holland, the Afsluitdijk and the mainland coast of Friesland and Groningen. Razende Bol is combined with Texel (North Sea coast), Griend with Vlieland (Wadden Sea), and Engelsmanplaat with Schiermonnikoog (North Sea coast), while the easternmost islets Rottumerplaat and

Table 1. Total number of harbour porpoise in 2008-2014 in the Netherlands per subarea. Given are average density (*n*/km/year), sexual composition (percentage of males, with total number of sexed individuals between brackets), and percentages per length class (in cm; see text). See also the Methods section for the geographic subdivision.

	total	density	% males (*n*)	<90	90-130	>130	(*n*)
Delta (121 km)	1243	0.3	63.5 (854)	12.8	68.5	18.7	658
Zeeuws-Vlaanderen	28	0.3	60.0 (20)	15.0	40.0	45.0	20
Walcheren	439	1.5	64.4 (351)	11.2	71.9	16.9	249
Schouwen	215	1.3	60.7 (163)	16.7	56.8	26.5	132
Goeree	254	2.0	64.2 (106)	7.1	81.6	11.2	98
Voorne	31	0.5	65.4 (26)	6.3	87.5	6.3	16
inner Delta	201	0.1	64.2 (128)	18.7	68.2	13.1	107
Maasvlakte	75	0.6	62.5 (40)	8.3	61.1	30.6	36
mainland coast (119 km)	1415	1.3	57.8 (770)	13.5	60.6	26.0	936
Zuid-Holland	740	1.4	59.0 (434)	14.8	57.5	27.7	480
Noord-Holland	675	1.2	55.7 (336)	12.1	63.8	24.1	456
Wadden Sea total (431 km)	1688	0.6	51.02 (566)	14.0	60.9	25.1	1189
North Sea coast (111 km)	1415	1.9	53.5 (473)	15.6	60.4	23.9	927
Texel	410	1.8	53.4 (221)	14.9	59.2	25.9	316
Vlieland	413	2.0	57.1 (42)	16.1	62.9	21.1	299
Terschelling	179	2.3	40.5 (42)	17.9	60.7	21.4	56
Ameland	288	2.6	56.0 (150)	12.2	59.5	28.3	205
Schiermonnikoog	125	0.6	55.6 (18)	29.4	56.9	13.7	51
Wadden Sea (320 km)	273	0.1	39.8 (93)	8.4	62.6	29.0	131
Texel	54	0.3	57.7 (26)	9.5	61.9	28.6	42
Vlieland	26	0.3	50.0 (4)	5.3	63.2	31.6	19
Terschelling	40	0.2	16.2 (37)	6.3	56.3	37.5	16
Ameland	12	0.1	100.0 (3)	11.1	88.9	0.0	9
Schiermonnikoog	6	0.0	0 (0)	20.0	80.0	0.0	5
Rottum	41	0.6	50 (4)	0.0	36.2	63.6	11
Noord-Holland	7	0.0	66.7 (3)	14.3	71.4	14.3	7
Friesland	41	0.1	54.5 (11)	6.7	60.0	33.3	15
Groningen	28	0.1	20.0 (5)	14.3	71.4	14.3	7
total	4346	0.6	58.2 (2190)	13.5	62.6	23.9	2783

Rottumeroog are combined into 'Rottum' and included in the inner Wadden Sea area. The coastal length of the subareas is given in table 1.

Coverage

Coverage of the coastline in the Delta area is thought to be close to 100% as far as the sandy beaches bordering the North Sea are concerned; this means that probably all cetaceans are being found and reported to walvisstrandingen.nl. The mainland coast of Zuid-Holland and Noord-Holland is probably equally well covered, although we know that even on these busy beaches most harbour porpoises may be discovered, but not always reported. Coverage on the westernmost Wadden Sea island of Texel is also close to 100% on the western section (North Sea beach). Coverage of the remainder of the inner Delta area, the other Frisian islands and the mainland coast of the Wadden Sea varies from fair to very poor, partly because of the extensiveness of the areas and the low visiting rate,

Table 2. Relative proportion of harbour porpoise (including number, *n*) found in the three subareas (% porpoise) compared to the relative proportion of coastal length (% km). The same is presented separately for the Wadden Sea (breakdown Wadden Sea), where the sandy North Sea side of the islands is compared to the generally more muddy Wadden Sea proper.

	% porpoise	% km	*n* porpoise
Delta	28.6	50.4	1243
mainland	32.6	14.1	1415
Wadden Sea (total)	38.8	35.5	1688
breakdown Wadden Sea			
North Sea	83.8	27.9	1415
Wadden Sea	16.2	72.1	273

partly because of poor recording. It is therefore impossible to estimate the coverage of these areas, but see table 2 for an evaluation of missed porpoises.

Research

During 2008-2014 a total of 902 fresh and decomposed harbour porpoises has been collected for dissections performed by staff of the Faculty of Veterinary Medicine of Utrecht University. The corpses have been scrutinised for causes of death, in assignment of the ministry of environment (currently a subdivision of the ministry of economic affairs), and tissue samples and stomachs collected and deep-frozen for future research. The main conclusions of the dissections are at the moment of writing still under embargo.

Smaller cetaceans used to be transported directly to Naturalis in Leiden up to about 2009. Since then they are transported to the Faculty of Veterinary Medicine at Utrecht University. (Very) large cetaceans are dissected on the beach, in the past only by Naturalis personnel, presently also in cooperation with pathologists. All cetaceans are dissected and tissue samples are collected. Skeletons of species other than harbour porpoise are subsequently integrated in the Naturalis collection. Although research on dead cetaceans is not the scope of this publication, we will briefly report on interesting findings, for instance those that may shed light on the cause of death.

Systematic list

During 2008-2014 a total of 4406 beached cetaceans was recorded, representing at least twelve species; there were six small whales and/or dolphins that remained unidentified. In 2008 five different species were reported, in 2009 six, in 2010 and 2011 (at least) seven, in 2012 and 2013 (at least) six, and in 2014 nine. As usual, virtually all records (98.6%) referred to harbour porpoises. Of the 59 other whales, stranded along the entire coastline, 11 involved live strandings, at least 8 were suspected to have been ship-assisted, and 13 involved finds of subfossil bones. Remains kept in the scientific collection of Naturalis are preceded by 'RMNH'. The taxonomic order of the cetaceans follows Wilson & Reeder (2005).

Northern minke whale (*Balaenoptera acutorostrata*)

2008-2014: 5 records
2000-2007: 4 records
before 2000: 24 records

6/5/2008 North Sea north of Terschelling, Friesland. Sex and weight unknown, 600 cm (estimated). Fresh, complete. Discarded at sea. Reported by J. Smid.

22/8/2009 Ritthem, Zeeland. Probably female, 520 cm (estimated), weight unknown. Rotten, complete. Skull and tail vertebrae collected (RMNH.MAM.51190). Reported by J. van der Hiele.

19/5/2010 Wadden Sea near Wierum, Friesland. Sex and weight unknown, 400 cm (estimated). Rotten, incomplete. Vertebrae collected (RMNH.MAM.45228). Reported by A.R. de Boer, T. de Boer, G. Hoekstra and T. Talsma.

3/4/2011 Breskens, Zeeland. Male, 760 cm (estimated). Rotten and incomplete, remainder weighing 2600 kg (measured). Not collected. Reported by J. van der Hiele.

12/6/2014 Terschelling, near beach pole 8, Friesland. Sex, length and weight unknown. Broken and incomplete skull and skin fragments only. Not collected. Reported by A. and L. Duursma.

The minke whale from 6 May 2008 was seen floating at sea north of Terschelling (Visserijnieuws 18 mei 2008; http://tinyurl.com/p5w2bdp). It was taken on board N350 by the fishermen and discarded at sea after pictures were taken. It concerned a fresh minke whale, as can be seen on the picture in the news clipping, and probably complete, although the presence of head nor flippers can be evaluated properly from the photograph. The exact location is unknown.

The minke whale from Ritthem from 22 August 2009 was complete, but very putrefied. It could be fairly accurately measured, but it was impossible to establish the sex, because of the expanded and damaged abdomen. In all cetacean males the penis usually comes out after death, as the muscles relax, especially when the body starts to decompose. This was not the case in this individual.

A decomposing minke whale was floating in the Wadden Sea near Wierum, Friesland on 19 May 2010. It washed ashore some days later on the nearby island Engelsmanplaat, where the scapula and a single vertebra were collected. The remains refloated spontaneously during high tide and washed ashore on the eastern tip of Schiermonnikoog, near beach pole 13. A tail vertebra was collected on Schiermonnikoog and is now on permanent exhibition in the sea shell museum in the village of Schiermonnikoog.

The minke whales at Ritthem and Breskens were too decomposed to etablish the cause of death, but the proximity of the harbours of Vlissingen and Antwerp make them suspect of being ship-assisted. The minke whale from 19 May 2010 was the ninth since 2000 and the seventeenth for the Wadden Sea area (including Wieringen (1), the mainland coast of Friesland (1) and the North Sea coast of Texel (3)). The other ones stranded on the mainland coast of Noord-Holland (4), Zuid-Holland (4) and the Delta area (7). Out of the fifteen individuals sexed, there is a slight preponderance of females (9). Of 23 minke whales the length is known, but all carcasses prior to 1974, and a few after that year, have probably been estimated, considering the rounded figures: there are for instance four individuals of 900 cm. The average length was 661 cm. Males tended to be slightly smaller than females (592 versus 705 cm). If only measured lengths are included, all minke whales together measured 624 cm (n=16), males 606 cm (5) and females 675 cm (7).

Fin whale (*Balaenoptera physalus*)

2008-2014: 6 records
2000-2007: 4 records
before 2000: 27 records

30/8/2011 Rotterdam, Zuid-Holland. Male, 1300 cm (measured), weight unknown. Fairly fresh, complete. Skull, part of skeleton, tissue and baleens collected (RMNH.MAM.55014. a-d). Reported by Havenbedrijf Rotterdam.

15/1/2012 Vlissingen, Zeeland. Female, 877 cm (measured), ca. 6000 kg (measured).

Figuur 1. A 18.5 metres long fin whale draped over a the bulb of a ship at Rotterdam harbour, 6 June 2012. Baleen whales often collide with marine traffic; in the Mediterranean the entire fin whale population is even thought to be at risk because of this, with a shockingly high number of 16% out of 287 individuals having died from collisions with a ship (Panigada et al. 2006). *Photo: Havenbedrijf Rotterdam.*

Fairly fresh, complete. Skull, baleens, flipper, neck vertebrae and tissue collected (RMNH. MAM.55019.a-c). Reported by J. van der Hiele. 6/6/2012 Rotterdam, Zuid-Holland. Male, 1850 cm (measured), 49,000 kg (measured). Not fresh, complete. Not collected. Reported by Havenbedrijf Rotterdam.

2/8/2013 Rotterdam, Zuid-Holland. Female, 1250 cm (measured), 11,000 kg (measured). Rotten, complete. Tissue and baleens collected (RMNH.5000156.a-c). Reported by Havenbedrijf Rotterdam.
16/9/2013 ‘s-Gravenzande, Zuid-Holland. Male, 1650 cm (measured), weight unknown. Rotten, complete. Tissue and entire skeleton collected (RMNH.5000109.a-c). Reported by D. Frerichs and R. Noort.

20/8/2014 Katwijk, Zuid-Holland. Male, 1680 cm (measured), weight unknown. Not fresh, complete. Tissue and entire skeleton collected (RMNH.5069812.a-c). Reported by K. Kooimans.

All six fin whales that stranded during this period were proven or suspected to have been brought in on a ship’s bulb (figure 1). Since fin whales do not normally occur in the southern North Sea but are common in the Bay of Biscay in late summer (Chaudry et al. 2005), it is likely that they were brought in from that area. Fin whale also holds one or more populations in the Mediterranean (e.g. Notarbartolo di Sciara et al. 2003). Although at least two of the ships carrying fin whales had crossed the Mediterranean, and could thus have potentially brought fin whales from there, two individuals had fed in the North Atlantic and showed no connection with the Mediterranean fin whale population (Camalich et al. 2014). The dissected fin whales (all but those from 2013) were well nourished, and some showed various degrees of subcutaneous and/or intramuscular bleeding, indicating they were hit by a ship when still alive (IJsseldijk et al. 2014a).

The intestines of the female from 15 January 2012 contained remains of milk. She had an inflammation of the peritoneum. Although speculation, the inflammation may have caused the whale to be less mobile, which in turn may have resulted in it being hit by the ship. The stomach of the fin whale from 2 August 2013 contained northern krill (*Meganyctiphanes norvegicus*) and two otoliths of a *Myctophum* species, possibly *Myctophum punctatum* (M. Leopold, personal communication, Bravo Rebolledo et al. 2016).

The fin whale of 16 September 2013 was found floating 18.5 km west of Maasvlakte in the shipping lane, and stranded the next day at ‘s Gravenzande (figure 2). It was reported as being a container. Also the fin whale from 20 August 2014 was found floating in the shipping lane six km off Katwijk. Since it was a ‘possible hazard’ (traffic obstruction), it was to be towed away, and luckily could be landed at Scheveningen beach, to allow identification and proper dissection on the beach. This also gave the public the rare opportunity to see a large whale up close.

Figuur 2. This fin whale, photographed at 's-Gravenzande on 16 September 2013, is easily identified by the bicoloured set of baleens on the right side. Note the broken flipper. *Photo: Rinus Noort.*

Figure 3. Because of the high body temperature, and the perfect insulation layer of blubber, all cetaceans soon start to decompose after death. The developing gases cause the body to expand, sometimes to impressive proportions, like in this humpback whale at Ameland, 8 September 2009. After the gases have escaped from the body and the carcass is still at sea, it usually sinks to the sea floor. *Photo: Jan Spoelstra.*

Humpback whale
(*Megaptera novaeangliae*)
2008-2014: 4 records
2000-2007: 3 records
before 2000: 0 records

8/10/2009 Westgat, Hollum, Ameland, Friesland. Male, 850 cm (measured), weight unknown. Rotten, complete. Entire skeleton and baleens collected (RMNH.MAM.43465). Reported by D. Visser.

18/8/2010 beach pole 87, Katwijk, Zuid-Holland. Sex and weight unknown, about 450 cm. Rotten, incomplete. Ulna, radius and hand collected (RMNH.MAM.45229). Reported by K. Kooimans and A. Oosterbaan.

23/3/2012 mudflats off de Cocksdorp, Texel, Noord-Holland. Single vertebra. Ecomare collection number B2-78. Reported by J. Hottentot and A. Oosterbaan.
12/12/2012 Razende Bol, Noord-Holland. Female, 16,000 kg (measured), 1034 cm (measured). Live stranding, died 16/12/2012. Entire skeleton, skin samples and baleens collected (RMNH.MAM.55066.a). Reported by S. de Wolf and A. Oosterbaan.

The humpback whale found in 2009 at Hollum, Ameland, had died at least a week before it washed ashore. The rotting carcass floated between the islands of Terschelling and Ameland and was towed to the southwestern tip of Ameland (figure 3). It concerned a juvenile, probably not older than two years. The cause of death could not be established.

The individual found at Katwijk in 2010 was decomposed and very incomplete: only a fore flipper and a few other bones could be recovered from the rotting flesh, and the flipper was the only body part that could be measured. It was about 150 cm long. Flippers of humpback whales are about one-third of the total body length (Winn & Reichley 1985), so this individual must have been about 450 cm when it died. This is about the length baby humpback whales have when they are born, which means that a humpback whale gave birth in, or close to, the Southern Bight, something that has never been recorded before in this area.

The humpback whale that stranded on Razende Bol, a sand spit just southwest of Texel, caused a national stir, because it stranded alive. Hours after it stranded, the incoming tide got it floating again, and it is possible that it would have gotten away by

Figure 4. Common dolphins are known for their colourful hourglass pattern, but not much is left of it in this individual, probably because colours soon fade after death. 17 April 2011, Oostvoorne. *Photo: Jolanda Meerbeek.*

itself. However, it got stuck even higher up the beach after it was visited by boats and a helicopter at dusk. The next few days the living whale – named Johanna – was all over the news, and even made it into international newspapers, until it died on 16 December. The stomach and intestines of this humpback contained some sprat (*Sprattus sprattus*) remains (M. Leopold, personal communication). In a sample of the intestinal tract sixteen plastic particles were found, varying between 1 mm to 17 cm in length; if extrapolated, the total intestinal tract might have held 160 pieces of plastic (Besseling et al. 2015).

These humpback whales constituted only the fourth to sixth records of dead humpback whales for the Netherlands (excluding the record of 23 March 2012). The first humpback whale ever for the Netherlands was found as recent as 29 September 2003, floating in river Nieuwe Waterweg near Rotterdam, Zuid-Holland (Camphuysen et al. 2008). Just prior to and during the present reporting period, there have also been sightings of various living and apparently healthy individuals in Dutch waters (yearly from 2007 onwards, except 2010 (source: waarneming.nl)), while there have also been sightings after 2014. Although the sudden and remarkable occurrence in the North Sea of this spectacular, surface feeding and often coastal species still remains unexplained, humpback whales in the North Atlantic have increased to about 20,000 individuals over the past decades (Smith & Pike 2009, Ruegg et al. 2013). The population once comprised 112,000 individuals, but was hunted down to less than 1000 in the late 1960s (Katona & Beard 1990). On the one hand, the recent population growth seems a logical explanation for the increase in sightings, on the other hand, if the humpback whale population was so large in former times, why haven't there been any strandings or sightings since 1255 (the oldest record in walvisstrandingen.nl) and prior to 2003 on or near Dutch shores? A logical alternative explanation could be found in a change in feeding possibilities.

Common dolphin (*Delphinus delphis*)

2008-2014: 2 records
2000-2007: 2 records
before 2000: 82 records

17/4/2011 Oostvoorne, Zuid-Holland. Male, 153 cm (measured), 39 kg (measured). Live stranding. Entire skeleton collected (RMNH.MAM.45368). Reported by E. Everaarts and J. Meerbeek.

15/3/2014 Ouddorp, Zuid-Holland. Female, 189 cm (measured), 92 kg (measured). Rotten, complete. Entire skeleton and tissue collected (RMNH.5069675.a). Reported by J. van der Hiele.

The common dolphin from Oostvoorne stranded alive and was taken into care. It was in bad condition and died that night (figure 4). Considering the length it was probably two years old.

The individual found at Ouddorp was well-nourished and the stomach contained many fish bones and otoliths of herring (*Clupea harengus*), seabass (*Dicentrarchus labrax*), whiting (*Merlangius merlangus*), smelt (*Osmerus eperlanus*), plaice (*Pleuronectes platessa*), sand goby (*Pomatoschistus minutus*), two-spotted goby (*Gobiusculus flavescens*), European squid (*Loligo vulgaris*), bobtail squid (*Sepiola atlantica*) and two species of nereid worms (M. Leopold & G. Keijl, personal communication). Parasite burden appeared mainly mild, and was probably not the cause of stranding. Pathological results, like internal bleeding of the adrenal glands, suggested an acute traumatic death, so it possibly died in fishing gear.

Most stranded common dolphins – since the first in 1860 – have been found in August (30%), and just over half of them in July-October (53%). However, there appears to be a tiny peak in March-May as well (18%, *n*=14), and the two found during the present period were recorded exactly in these months. From all common dolphins, just over half stranded in the southern half of the Netherlands (58% in the Delta and Zuid-Holland, *n*=83).

Long-finned pilot whale (*Globicephala melas*)

2008-2014: 1 record
2000-2007: 2 records
before 2000: 18 records (124 individuals)

17/12/2014 Nieuw-Haamstede, Zeeland. Male, 381 cm (measured), 410 kg (measured). Rotten, complete. Entire skeleton and tissue collected (RMNH.5069954.a). Reported by R. van de Guchte and J. van der Hiele.

Long-finned pilot whale, a deep-water species, is a rare straggler in the southern North Sea. There appears to have been an increase in stranding records in the Netherlands since the 1950s: 1500-1950 8 stranding events (with three events concerning 37, 11 and 61 individuals), and 1950-2014 13 events (13 individuals). It is possible however that rotten and incomplete pilot whales in the past have been mistaken for other, similar-sized species.

The pilot whale from December 2014 (figure 5) died of asphyxiation because a common sole (*Solea solea*) got stuck in its nasal cavity (IJsseldijk et al. 2015). Other prey remains were sand goby, plaice, herring, river lamprey (*Lampetra fluviatilis*), brown shrimp (*Crangon crangon*) and common cuttlefish (*Sepia officinalis*). Pilot whales habitually feed on deep-water cephalopods, but stomach contents have shown them to at least occasionally feed on mesopelagic fish as well, which may have been taken around fishing vessels (Gannon et al. 1997).

White-sided dolphin (*Leucopleurus acutus*)

2008-2014: 1 record
2000-2007: 4 records
before 2000: 8 records

21/3/2008, beach pole 44, Castricum, Noord-Holland. Male, 238 cm (measured), 159.5 kg (measured). Fresh, complete. Entire skeleton collected (RMNH.MAM.43756). Reported by D. Bakker and M. Amoureus.

According to LeDuc et al. (1999) and May-Collado & Agnarsson (2006), the (former) genus *Lagenorhynchus* is polyphyletic (meaning that the various species in this genus originated from different ancestors); they put this species into the – monotypic – genus *Leucopleurus*. White-sided dolphin, a pelagic spe-

Figure 5. It is interesting to note that pilot whales, which largely feed on squid, have teeth in both upper- and lower jaws, clearly seen in this individual, while sperm whales, also specializing on squid, have teeth only in the lower jaws. Haamstede, 17 December 2014. *Photo: Jaap van der Hiele.*

cies occurring in deep water, is rare in the Netherlands.

The individual found at Castricum was malnourished, suffered from severe pulmonary edema and had a parasitic cyst on the bladder ligament. In the stomach otoliths from sandeel Ammodytidae were found, as well as several species of goby Gobiidae, among which a fair number of transparent goby (*Aphia minuta*) (M. Leopold, personal communication), a pelagic shoaling fish measuring up to five cm. This fish is rather rare in the Netherlands, though possibly overlooked (Ellis & Rogers 2015).

Out of the twelve white-sided dolphins stranded in the Netherlands thus far, five were found in March and four in December (together 75%). Remarkably, of the six stranded since 1985, three were still alive, while the other three were extremely fresh and possibly stranded alive as well, or died immediately prior to or during stranding. The first white-sided dolphin for the Netherlands was captured alive near Vlissingen on 20 December 1863 (van Deinse 1961). Another seven followed in the twentieth century and four since 2000. No details are known from the first individual, but since white-beaked dolphins are a gregarious and fast moving species from deep water, it is unusual for a healthy individual to be caught nearshore. The skeleton (and possibly skin as well) are kept in the zoological museum of the University of Gent, Belgium (figure 6).

White-beaked dolphin (*Lagenorhynchus albirostris*)

2008-2014: 14 records
2000-2007: 43 records
before 2000: 171 records

2/2/2008, Vliehors near beach pole 37, Vlieland, Friesland. Female, 290 cm (estimated), weight unknown. Rotten, complete. Skull and tissue collected (RMNH.MAM.46032). Reported by W. Stel and F. Janssens.
3/2/2008, Kaloot, Borssele, Zeeland. Female, 249 cm, 197 kg. Fresh, complete. Skull and tissue collected, RMNH.MAM.43753. Reported by M. Geerse, J. van der Hiele and A. Dijkstra.
16/10/2008, Texel, Noord-Holland. Female, 240 cm (estimated), weight unknown. Rotten, complete. Not collected. Reported by K. Uitgeest and A. Oosterbaan.

26/12/2009, Maasvlakte, Zuid-Holland. Female, 201 cm, 107 kg. Fresh, complete, possible live stranding. Entire skeleton collected (no RMNH-number yet). Reported by A. Schrauwen and J. van der Hiele.
27/12/2009, Ameland, Friesland. Female, 176 cm (measured), 68.5 kg. Fairly fresh, complete. Apparently not collected. Reported by J. Krol.

Figure 6. Detail of the first white-sided dolphin for the Netherlands, captured alive in the former water Sloe, running between the former islands Walcheren and Zuid-Beveland, Zeeland, on 20 December 1863. The skeleton is preserved in Museum voor Dierkunde, Universiteit Gent. *Photo: Guido Rappé.*

27/12/2009, Ameland, Friesland. Female, 246 cm (measured), 204.5 kg. Live stranding, euthanised. Skull and tissue collected (RMNH.MAM.55022.a-b). Reported by J. Krol.

16/2/2010, Neeltje Jans, Oosterschelde, Zeeland. Female, 175 cm (measured), 72.5 kg (measured). Fresh, complete. Entire skeleton collected (RMNH.5000002). Reported by H.L.J. Eland.
7/3/2010, beach pole 10, Ouddorp, Zuid-Holland. Male, 182 cm (measured), 61 kg. Rather fresh, complete. Apparently not collected. Reported by J. van der Hiele.

14/4/2011 Terschelling, beach pole 7, Friesland. Sex unknown, 300 cm (estimated), weight unknown. Rotten, complete. Locally buried. Photos of skeleton. Reported by A. Voorbergen.
12/6/2011 Bloemendaal, beach pole 58, Noord-Holland. Sex unknown, 160 cm (estimated), weight unknown. State of carcass unknown, complete. Locally buried, no photos. Reported by K. Kooimans and R. Noort.
12/6/2011 Ameland, beach pole 18, Friesland. Male, 220 cm (measured), 134 kg (measured). Live stranding, refloated. Reported by R. Knoeff & J. Krol. Stranded again and taken into care, died 12 December 2011. Skull kept by SOS Dolfijn in Harderwijk (LA111205). See: van Elk et al. (2014).
4/12/2011 Den Helder, Noord-Holland. Female, 158 cm (measured), 52.2 kg (measured). Live stranding, taken into care, died 5 December 2011. Reported by zeezoogdieren.org. Skull kept by SOS Dolfijn in Harderwijk (LA111211). See: van Elk et al. (2014).

3/1/2012 Between Dishoek - Zoutelande, Zeeland. Male, 274 cm (measured), 255 kg (measured). Fresh, complete. Reported by A. Dijkstra and J. van der Hiele. Entire skeleton and tissue collected (RMNH.MAM. 55020.a-b)

25/1/2014 Petten, Noord-Holland. Only left lower mandible, no recent stranding, in private collection.

The adult female found on the Kaloot, Borssele, just east of Vlissingen, on 3 February 2008, was malnourished. There were fractures of three vertebrae and multiple lateral spinous processes in the tailstock at the level of the pelvic bones, with a large hematoma, new bone formation and remodelling, and probable osteomyelitis. She also suffered from severe pulmonary edema. The oesophagus/stomach contained remains of ten cod (*Gadus morhua*) though, and, remarkably also two stalked sea squirts (*Styela clava*) (Tunicata, Styelidae). These are not known to be part of the dolphin's regular diet (e.g. Jansen 2013) and may have been secondary prey (i.e. eaten by the cod). Given the poor condition how-

ever, it is possible that this female had been unable to hunt and turned to anything edible. Apart from food remains, the stomach contained a large quantity of the parasitic nematode *Anisakis simplex*, a parasitic worm often found in stomachs of white-beaked dolphins.

The immature female found on Maasvlakte on 26 December 2009 was very fresh, complete and full of blood smears when found, so it had possibly stranded alive. It was reported to walvisstrandingen.nl as harbour porpoise, but could be identified, and preserved, thanks to the excellent photographs attached to the digital report. It was emaciated, even though there were remains of whiting in the stomach. It suffered from lung edema and slightly inflamed intestines.

Two white-beaked dolphins were reported from Ameland on 27 December 2009: a juvenile female lying dead on the water line when found, and an adult female that stranded alive a while after. The juvenile was slightly undernourished and had a haemorrhage on the left lower jaw. The stomach contained large quantities of the parasitic nematode *Anisakis simplex*, brown shrimp and the bobtail squid. The large individual, supposed to be the mother of the calf, was lactating (Keijl & Cremers 2010). She was slightly underweight, but did not show signs of trauma or illness. The stomach contained a few heavily worn otoliths of whiting.

Autopsies performed on the female from Neeltje Jans from 16 February 2010 and the male from Ouddorp from 7 March 2010 did not reveal any (obvious) causes of death: both were slightly undernourished, while the male showed haemorrhage and edema around the scapula and mandible. Curiously, the male had its dorsal fin tip missing.

The individual from 12 June 2011 was taken into care, and lived until 12 December of that year. See van Elk et al. (2014) for a description of health status, behaviour in captivity, and autopsy results from this individual and the one that stranded on 4 December 2011 in Den Helder.

Even though white-beaked dolphin is the most common cetacean in Dutch waters after harbour porpoise, it is still uncommon, with on average six strandings per year during 1980-1999 (range 1-13) and four in 2000-2014 (range 0-11). There are some sightings of live animals near the coast during the same period (see for instance: waarneming.nl). Prior to 1980 it was rarer, with a total of only 38 stranded individuals reported, and on average 1.3 strandings per year during 1945-1980. Strandings have occurred in all months (figure 7). Over the years since 1970, the stranding pattern of this species is undulating (see figures in: Camphuysen et al. 2008 and Keijl & Cremers 2010). After an apparent influx of white-beaked dolphins during the 1990s, we are presently apparently in a 'low'. It remains to be seen whether this species will keep on occurring in the southern North Sea during the warming climate, or will retreat northwards.

Out of the total of 228 stranded white-beaked dolphins, 156 (68%) have been sexed. There is a preponderance of females (62% on average, since 1886, i.e. a sex ratio of 1.6 female to 1 male) and though the sex ratio fluctuates slightly through time, there have always been more females than males on the beach, at least since 1961 (n=144). A skewed sex ratio for white-beaked dolphins has been recorded elsewhere in the North Sea as well (e.g. 1.2 female to 1 male in British waters (Canning et al. 2008)). The reason for this is unknown. Interestingly, a skewed sex ratio was found in fetuses of the related dusky dolphin (*Lagenorhynchus obscurus*) in Peru (1.3 female to 1 male; Van Waerebeek & Read 1994). There is no information on sex ratio in fetuses of white-beaked dolphins. A skewed sex ratio of up to 1 male : 13 females for dusky dolphins in New Zealand was explained as a seasonal effect: females with young were said to keep closer inshore than males (Würsig et al. 1997, Harlin et al. 2003). The latter seems a less likely explanation for the Dutch situation though, since the calving season of white-beaked dolphin is summer while most of the strandings on the Dutch coast take place in

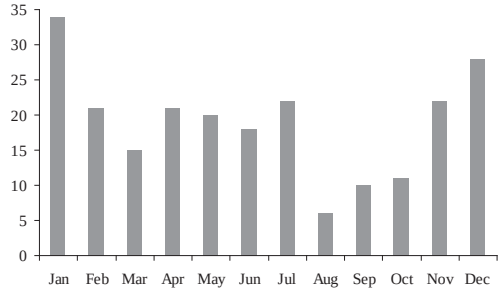


Figure 7. Total number of white-beaked dolphins per month since the first stranding in 1886, up to and including 2014 (*n*=228).

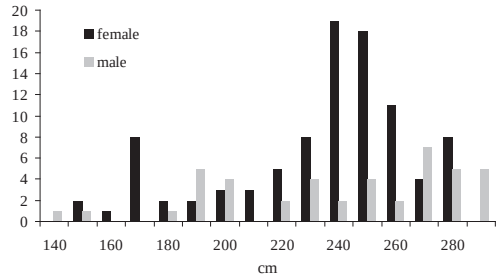


Figure 8. Size distribution of stranded male and female white-beaked dolphins in the Netherlands, 1886-2012, *n*=147.

winter, and first-year calves, with an estimated length below 170 cm (cf. Galatius et al. 2013; calves measure 110-125 cm at birth) are rare among the stranded animals (two males from July and October, three females from July, November and December; figure 8).

In our sample there is no difference in length between the sexes (females 237.7 cm (*n*=94), males 238.2 cm (*n*=53)), but the largest individuals were males (longest female 285 cm, longest male 297 cm, with five males exceeding 285 cm). The maximum length reached by females is about 270 cm, so the high number of females measuring 240-270 cm (51%, *n*=48) indicates that these involved mature individuals. According to the model presented in Galatius et al. (2013), this length is reached at about eight years of age. White-beaked dolphins can live over thirty years. A similar length distribution pattern would be expected for males; the absence of a distinct peak is therefore possibly caused by the smaller sample size.

Killer whale (*Orcinus orca*)

2008-2014: 4 records
2000-2007: 0 records
before 2000: 27 records

12/9/2009 Scheveningen, Zuid-Holland. Skull only, kept in private collection.

22/6/2010 Lauwersoog, Friesland. Female, captured alive, 350 cm (estimated), weight unknown. Kept in captivity (nowadays on Tenerife, Canary Islands, Spain). Reported by K. Kruijer and N. Osinga.

25/6/2013 Texel, Noord-Holland. Male, lower right mandible, 40 cm (measured). Reported by J. Waverijn and A. Oosterbaan.

11/8/2014 Noordwijk, Zuid-Holland. Lower right mandible, 75 cm long (measured). Kept in private collection.

Remarkably, three subfossil killer whale remains were found during this period. See http://tinyurl.com/ova2jzy and http://tinyurl.com/pvp6rj4 for information on the lower mandible found on Texel. The skull found in the surf zone at Scheveningen was not very recent, but the whale, considering its state, likely died somewhere nearby during the early twentieth century. All mentioned killer whale remains are kept by the respective finders.

On 22 June 2010 a living 'large dolphin or small whale' was reported in the (shallow) Dutch Wadden Sea just north of Lauwersoog, Friesland. It was the 29th for the Netherlands and the first 'complete' one in 47 years: the previous killer whale in Dutch waters concerned a female of about 500 cm washed ashore on 18 October 1963. The calf from 2010, the 13th for the Wadden Sea area, did not actually wash ashore, but more or less floated around

Figure 9. This living striped dolphin superficially resembles the common dolphin depicted in figure 4. It is however easily identified by the dark stripe from the eye across the flank to the tailstock, and the characteristic broad blue-grey stripe above it, which divides halfway between the eye and the dorsal fin, with the upper part pointing towards the dorsal fin. 31 March 2010, Vlieland. *Photo: Folkert Janssens.*

close to the dike. It was captured on 23 June, brought to SOS Dolfijn at the dolphin park Dolfinarium Harderwijk, Gelderland, where it recovered, and subsequently to Loro Parque on 29 November 2011, a dolphin park at Tenerife, Canary Islands, Spain, where a pod of killer whales lives in captivity. Once arrived in Loro Parque, research performed by an international team of scientists showed that her hearing is severely impaired, meaning that she would probably never had been able to communicate normally with her relatives or other conspecifics, and would never have been able to hunt for herself, nor to navigate (K. Lucke, personal communication).

Striped dolphin (*Stenella coeruleoalba*)
2008-2014: 1 record
2000-2007: 2 records
before 2000: 6 records

31/3/2010 Beach at north-east side of Vliehors, Vlieland, Friesland. Sex and weight unknown, 170 cm (estimated). Stranded alive, refloated. Reported by F. Janssens.

A striped dolphin stranded alive on the Wadden Sea island Vlieland (figure 9). It was lively and looked unharmed, except for some light scarring on the left flank and a small bruise on the lower jaw, possibly from wriggling in the shallows or from being tossed around in the surf. It was refloated three kilometres offshore in the North Sea, where it swam away. Five days later, on 4 April, a jumping dolphin was seen from the beach of Vlieland by Jan Koning, but information on this sighting is lacking, so it remains unknown whether this concerned a (or the same) striped dolphin. The stranding constituted only the ninth record of this southern and pelagic species for the Netherlands. Surprisingly, four (possibly five) out of nine striped dolphins found in the Netherlands stranded alive. Also in Scotland, just over half – 29 out of 52 – were live strandings (Santos et al. 2008). In the United Kingdom, sightings and strandings occur increasingly further north along the coast, thought to be indicative of a changing climate (MacLeod et al. 2005). An increase in numbers obviously causes an increase in chance of stranding, but does not elucidate the reason for live stranding. The first record for the Netherlands concerned a male near Delfzijl, Groningen, as recent as 17 April 1967. Although numbers in the Netherlands are not high, all excepting the first were found after 1986 (one in 1987, four in the 1990s, three since 2000).

Bottlenose dolphin (*Tursiops truncatus*)
2008-2014: 6 records
2000-2007: 1 record
before 2000: 338 records (largely incomplete)

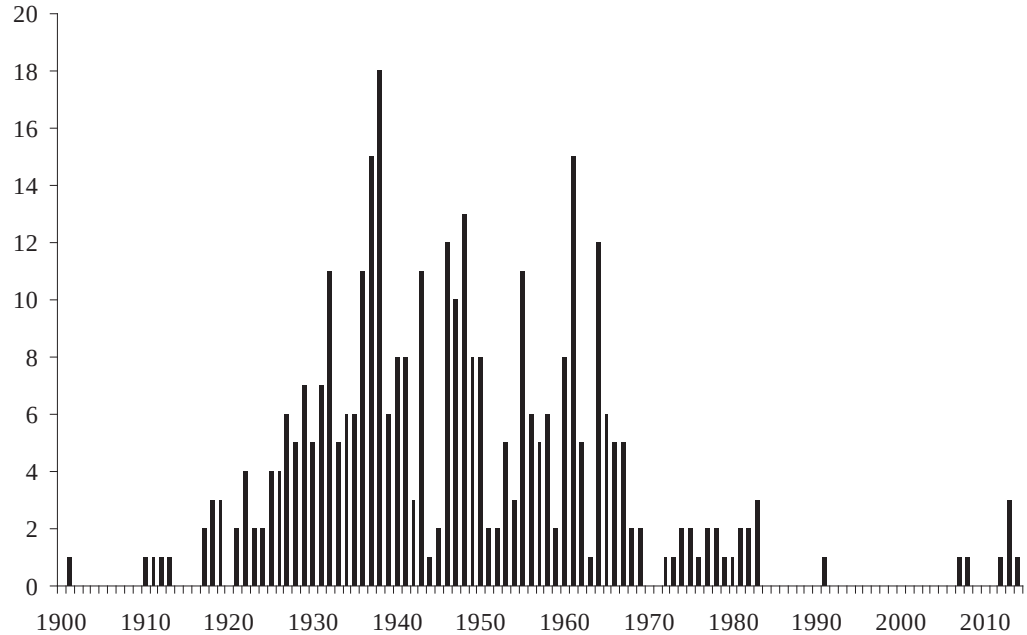


Figure 10. Stranding pattern of bottlenose dolphin between 1914-2014 (*n*=353).

26/11/2008, Terschelling, Friesland. Skull. Reported by Persbureau Ameland, H. de Jong and D. Visser. Probably in private collection.

14/4/2012 Vlieland, Friesland. Lower left mandible, in private collection.

29/1/2013 Ameland, Friesland. Vertebrae, in private collection.
20/4/2013 Texel, Noord-Holland. Single vertebra, in private collection.
27/6/2013 Krabbendijke, Zeeland. Female, 266 cm (measured), 196.5 kg (measured). Fresh, complete, probably live stranding. Entire skeleton and tissue collected (RMNH.5000093).

0/8/2014 Terschelling, Friesland. Lower right mandible, 42.5 cm (measured). In private collection.

The only record of a complete bottlenose dolphin in 2008-2014 was a fresh female on 27 June 2013. It was seen alive in the area since 18 June 2013 before it stranded. Although dead when found, the body was warm and the internal parasites were still alive, so it died nearshore or on the beach. This single sighting in seven years is in stark contrast with the numerous strandings of this species in former times (figure 10).

Harbour porpoise (*Phocoena phocoena*)

2008-2014: 4346 records*
- 2008: 345 records
- 2009: 500 records
- 2010: 437 records
- 2011: 872 records
- 2012: 746 records
- 2013: 873 records
- 2014: 573 records

2000-2007: 1846 records

* The numbers presented here are the numbers at the time of writing. Especially those in recent years are regularly corrected due to e.g. individuals double-counted or missing from the database (see also: http://tinyurl.com/h5y2y3u; viewed 22 November 2016).

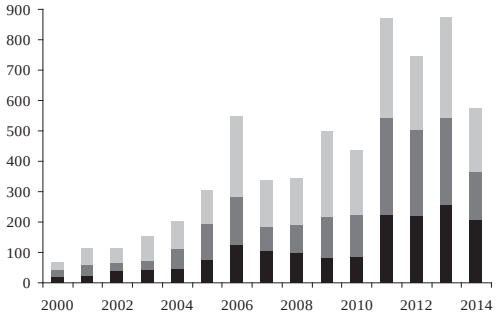


Figure 11. Number of dead harbour porpoise in 2000-2014 along the Dutch coast (walvisstrandingen.nl, *n*=6192). Light grey = Wadden Sea, dark grey = mainland, black = Delta.

before 2000: 2307 records (largely incomplete)

Still higher numbers

In their review of cetaceans stranded during 1998-2007 Camphuysen et al. (2008) extensively reported on the presence of living and dead harbour porpoise. Early in the twentieth century the species was so common in the Dutch part of the North Sea, Wadden Sea and IJsselmeer that records on strandings were only collected opportunistically (e.g. van Deinse 1931). Porpoises strongly decreased from the 1950s onwards, and increased again since the late 1980s, with a particularly steep increase since the early 2000s, clearly reflected in the strandings pattern (figure 11). During 2008-2014, dozens were reported per month, and hundreds per year. The year 2006 saw a (then) unprecedented high number of 546 dead harbour porpoises (Camphuysen et al. 2008 mentioned 539, but a few more records have been received since). Yearly numbers in 2008-2014 were higher still, in line with the increase of the species in the southern North Sea since 1994 (trektellen.nl, Hammond et al. 2013).

Numbers per subarea

Most dead porpoises have been reported from the Wadden Sea area (table 1, table 2, figure 12), as expected, because from the three geographical subareas the Wadden Sea has the longest coastline. A significantly higher proportion is reported from the (sandy) North Sea side of the islands than from the (mainly muddy) Wadden Sea proper. The density of 0.6 dead porpoises per km per year for the entire Wadden Sea area is greatly influenced by the low density in the Wadden Sea itself, as the average density on the sandy shores is 1.9. This is notably higher than the average on the mainland coast, which in turn is higher than the density in the Delta.

On the narrow sandy beach of the mainland coast, no dead porpoise goes unnoticed, although it may not be reported. In the Delta area, higher densities are noticed on Walcheren, Schouwen and Goeree, and overall reporting rate is very high due to a tight and

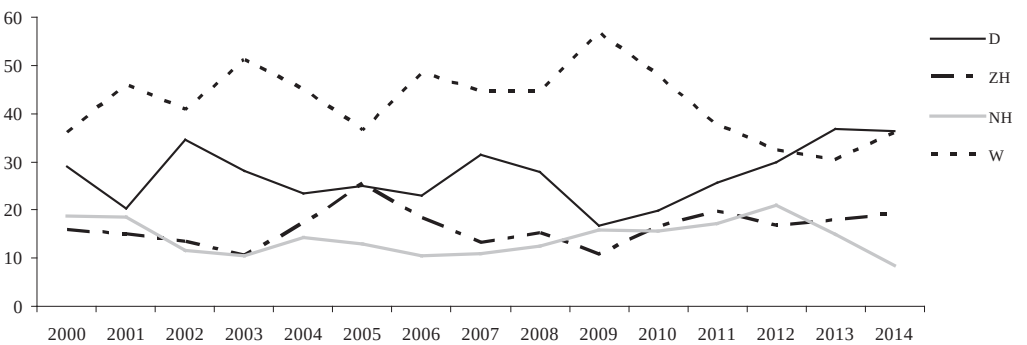


Figure 12. Proportion of dead harbour porpoise in four subareas, 2000-2014. In this graph, subarea mainland coast has been subdivided per province (NH and ZH). W = Wadden Sea, NH = Noord-Holland, ZH = Zuid-Holland, D = Delta area. See table 1 for numbers.

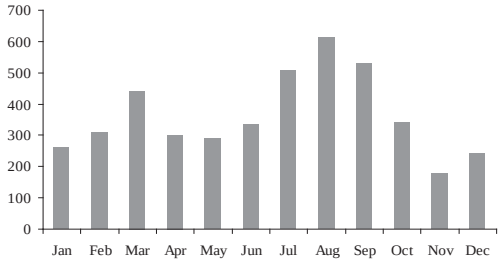


Figure 13. Cumulated number of dead harbour porpoise per month for 2008-2014 (*n*=4346).

well-kept local network. The high reporting rate in this area is explained by the narrow sandy beaches on these former islands. The stranding rate is higher in these areas because of their exposed (more westerly) position. The beach of neighbouring Voorne, for instance, is sandy as well, equally narrow, equally well visited, and stretches for only nine km, but lies hidden behind Schouwen from the prevailing south-westerly wind. The sandy coast of adjacent protruding Maasvlakte, a well-exposed artificial sand spit, is less visited, which is reflected in a lower average per kilometre.

Numbers per month

Data per month are fluctuating, but show two distinct peaks: the largest in July-September (37.9% of the total) and a smaller one in March (10.2 %, figure 13). It largely resembles the yearly recurrent pattern (see also: Camphuysen et al. (2008), who found a comparable pattern over 1998-2007). The stranding pattern however may vary considerably if single years are considered (e.g. in 2009 the spring peak started in February; in 2013 the spring peak was higher than usual and lasted until May; in October 2008 a second large peak occurred, after a low in September 2008). A true 'mass stranding' occurred in 2011, when mainly rotten carcasses washed ashore from late June until late September, with monthly numbers reaching three times those of the long-time average. The peak moved like a wave along the coast from south to north and also reached the Wadden Islands. Although the strandings network was alerted and a total of 355 carcasses was collected for research, the cause of the mass stranding has until now not been elucidated.

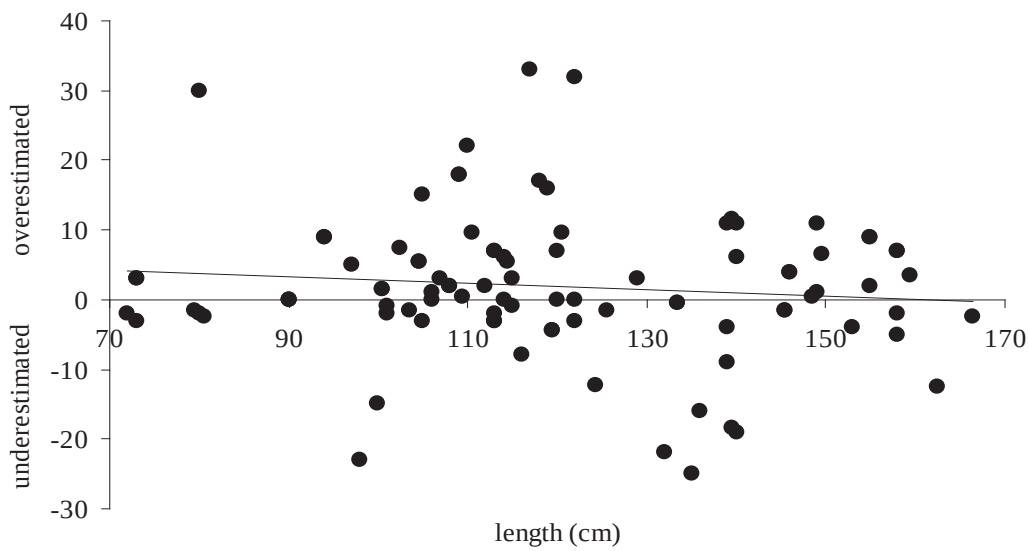


Figure 14. Deviation of length (in cm, y-axis) of harbour porpoise measured or estimated on the beach by various people, and subsequently measured at the Faculty of Veterinary Medicine of Utrecht University (*n*=99). The equation of the line is y=-0.0524x + 8.1029, r^2 = 0.0167

Length
From 64.0% of the porpoises total length was reported. Although some corpses were not measured but estimated, length estimates appear to be fairly reliable (figure 14). Although estimates, or even measurements, on the beach may deviate as much as 33 cm, 58% lies within 5 cm of the true length, and 79% within 10 cm (correct length is considered the length measured during autopsy at Utrecht University). Size is a rough indication of age: those smaller than 90 cm are generally called juvenile, those from 91-130 cm immature, and larger ones sexually mature (M. Addink, personal communication). The size classes (age categories) seem to be fairly similarly distributed along the entire coast (table 1). Neonates make up 13.5% of the total number of strandings, comparable to that in 1998-2007 (12%), and the amount of immatures during both study periods was similar (72% *versus* 63%, chi-square test with Yates' correction, chi^2=0.079, *P*=0.78). There seems to be a gradient in the number of neonates reported along the coast, which, if mortality would be the same in all subregions, could be an indication for more young to be born (or more young dying) in northern waters. Geelhoed et al. (2013) observed calves both off the mainland coast, off Texel, and in the Dogger Bank area, but not in the Delta area; note however that their study covered only one month in a single year, July 2010. (Also in the summers of 2014-2015 aerial surveys have been performed, but the reports (Geelhoed et al. 2014, 2015) do not mention the distribution of the calves in those years.) Dead adults were also slightly more common in the north than in the south. In the past this has not been analysed.

Sex ratio
A total of 2171 individuals was sexed (50.4%), either on the beach, afterwards from photographs, or during autopsy. Almost 1 out of 10 porpoises turned out to have been sexed wrongly (9.9% out of a sample of 91), even by regular observers. Some mistakes are corrected afterwards, if the record is accompanied by photographs showing the ventral side. However, mistakes are made 'both ways' (six males reported as female, three females reported as male), and it is considered unlikely that these will greatly influence the overall picture. The percentage of males fluctuates between years, for instance during the present study period from 53.2% in 2010 to 65.9% in 2013, but there is always preponderance of males (58.2% on average). Interestingly, the percentage of males decreases from south to north (table 1; GLM with binomial distribution and logit link, F1,2175=15.83, *P*<0.001). Camphuysen et al. (2008) noticed a similar trend, although it was not significant during their study period. Both juveniles (64.4 %, *n*=191) and immatures (61.2 %, *n*=1161) had a male-biased sex ratio, but it was reversed in adults (41.5 %, *n*=451; age categories estimated from length, see below).

Causes of death
A major cause of death is by-catch, during the period discussed here to be calculated at 14-20% (*n*=902; Begeman et al. 2013, IJsseldijk & Gröne 2015). Other causes of death are infectious disease (11-35%) and emaciation (13-20%) (Wiersma & Gröne 2009, Begeman et al. 2010, 2011, 2012, 2013, IJsseldijk & Gröne 2015), while starvation (3-9%) is mainly seen among neonates. However, a large category of over 40% remains of which the cause of death could not be established, for instance because the collected corpses were too decomposed to be properly evaluated.

Other comments
Three remarkable strandings have come to our knowledge during this reporting period:
- on 2 March 2008 a harbour porpoise became trapped on a flooded meadow during extreme high tide near Paesens, Friesland. It was swimming around in the still flooded but very shallow water on the meadow, trying to find a way out. The observer went into the water and

caught it by hand. The animal looked fit and healthy and was released into the Wadden Sea (R. Cazemier, personal communication);
- on 27 December 2009 a harbour porpoise stranded alive near the pier of Holwerd, Friesland, during low tide. It stayed on the mudflat until it refloated during the next rising tide and swam away apparently unharmed (lauwersmeer.com);
- three dead harbour porpoises were reported from Grevelingenmeer, Delta area (on 27/3/2003, 5/8/2014 and 3/9/2014), the largest salt water lake in Europe. The lake was completely closed off from the North Sea during 1971-1978 and slowly turned into a fresh water lake. Although only a single harbour porpoise is supposedly present in this area (J. van der Hiele, personal communication), some harbour porpoise apparently occasionally sneak in since the opening of the sluices in 1978. It is interesting to see whether this area will also be, or turn into, an ecological trap, as has recently been described for nearby Oosterschelde (Jansen et al. 2013).

An exceptional case of a twin foetus was found during dissections in the uterus of a female found in March 2011 (IJsseldijk et al. 2014b). Cetaceans give birth to a single young only, and twinning in Phocoenidae has been described only once before (Nakamatsu 2001).

Sperm whale (*Physeter macrocephalus*)

2008-2014: 5 records
2000-2007: 4
before 2000: 57

16/4/2011 Rottumeroog, Groningen. Subfossil lumbar vertebra, kept by finder. Reported by H. Mellema, T. van Nus and E. Kompanje.
3/11/2011 Stellendam, Zuid-Holland. Male, 1400 cm (estimated). Live stranding, swum away. Reported by the press.

15/12/2012 Razende Bol, Noord-Holland. Male, 1500 cm (estimated), weight 26,800 kg (weighed). Fresh, complete. Entire skeleton, tissue, parasites and ambergris collected RMNH.5000068a-c and Ecomare B2-150. Reported by K. Kooimans.

Figure 15. Lower jaw of the sperm whale from Terschelling, 29 July 2013. The teeth were initially thought to be malformed, which in turn was assumed to have been caused by the broken jaw. Recently though, stranded sperm whales with normal jaws also showed these peculiar teeth. *Photo: Bas Perdijk.*

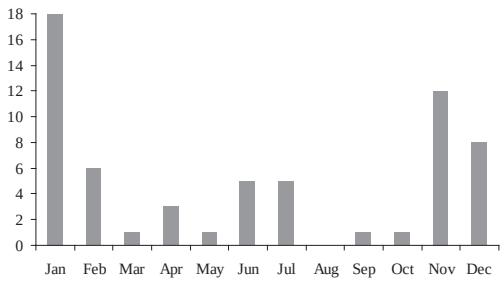


Figure 16. Strandings of sperm whales per month, 1306-2014 (*n*=61).

29/7/2013 easternmost tip of North Sea beach of Terschelling, Friesland. Male, 1350 cm (measured), weight 31,000 kg (measured). Live stranding. Entire skeleton and tissue collected (RMNH.5000152.a-e). Reported by J. Stokroos. Figure 15.

25/6/2014 between Wassenaar and Scheveningen, Zuid-Holland. Sex, length and weight unknown. Rotten. Tissue and neck vertebrae collected (RMNH.5069793). Reported by A. de Schelpenvisser and K. Kooimans.

The sperm whale at Stellendam from 3 November 2011 got stuck in a gully nearshore. Thanks to the incoming tide, and with a little help from ships, it was able to struggle free and to find its way back to deeper water. Since it was impossible to get good photographs of the tail, we will never know whether the sperm whale that stranded on 17 November 2011 on the German Wadden Sea island Pellworm concerned the same individual.

The sperm whale from Razende Bol on 15 December 2012 got much less attention than stranded sperm whales usually get, because it stranded close to a humpback whale that got ashore on 12 December and was still alive on the 15th. Even though this sperm whale was the 65th for the Netherlands, it was unusual in that its stomach contained a large amount of ambergris (supposedly 83 kg). The stomach further contained a large amount of squid beaks from the following species: *Gonatus fabricii*, *Haliphron atlanticus*, *Histiotheutis bonellii*, *Teuthowenia megalops* and *Todarodes sagittatus*.

The next two sperm whales were equally notable, because both stranded in summer. The first of these (Terschelling, 29 July 2013) stranded alive. Attempts to refloat it failed, and it died within a few hours (see: http://tinyurl.com/neah2qd for video footage). Its lower mandible was shorter than usual and the tip had been broken off in the past, while the teeth were possibly malformed (figure 15). This whale was well-fed, but its stomach virtually empty: it only contained remains of rose fish (*Sebastes marinus*), pollack (*Pollachius pollachius*), blue whiting (*Micromesistius poutassou*) and lumpsucker (*Cyclopterus lumpus*) (M. Leopold, personal communication). These seem unusual prey for a sperm whale and may have been taken because normal foraging was hampered by the shortened jaw.

The sperm whale from 25 June 2014 was spread out over several kilometres of beach; identification on basis of the neck vertebrae was confirmed by DNA-analysis.

Most sperm whales strand in winter (62.3% in November-January, figure 16); strandings in summer are uncommon, but, as the figure shows, strandings can be expected in any month. August is up till now the only month in the Netherlands without any records.

Sowerby's beaked whale (*Mesoplodon bidens*)

2008-2014: 4 records
2000-2007: 1 record
before 2000: 16 records

8/8/1957 Veere, Walcheren, Zeeland. Sex and weight unknown, estimated 300 cm. Probably fairly fresh, skeleton probably lost. Reported by J. van der Hiele.

4/10/2009 Maasvlakte, Zuid-Holland. Sex and weight unkown, 450 cm (estimated). Stranded alive, refloated. Reported by H. Klein.

18/7/2010 Egmond aan Zee, Noord-Holland. Male, 446 cm (measured; see below), 1090 kg (measured, see below). Stranded alive, refloated. Reported by Egmondse Reddingsbrigade.

10/8/2011, Ameland, near beach pole 16, Friesland. Only single vertebra, kept by finder. Reported by J. Krol.

18/7/2013 Schiermonnikoog, near beach pole 9, Friesland. Female, 366 cm (measured), weight unknown. Stranded alive. Entire skeleton and tissue collected (RMNH.5000154.a-c). Reported by A. Talsma, K. Tuinenga en D. Dijk.

Beaked whales are notoriously difficult to identify, especially in the field, but also on the beach. Adult males are easiest to name, based on the position of the teeth in the lower mandible.

Recently, Jaap van der Hiele came across a picture of a Sowerby's beaked whale published by Midavaine (1996). It had been published previously in a local newspaper (Anonymous 1957), but had remained invisible to cetacean investigators until now, aptly suiting the species. This whale beached near the Campveerse

tower in Veere, Walcheren, on 8 August 1957. A severe cut of about twenty centimetres on the head was mentioned ('perhaps caused by a ship's screw'), but whether this was (suspected to be) the cause of death was not indicated. The weight was estimated at 800-1000 kg, the length 300 cm. The body was disposed of; only a flipper was collected by a tourist, but its whereabouts are presently unknown. This Sowerby's was at the time the eleventh record for the Netherlands.

The beaked whale that stranded alive on Maasvlakte on 4 October 2009 was found by surfers and refloated as quickly as possible. Luckily it was photographed, so it could be identified as beaked whale (*Mesoplodon* sp.). Teeth are not visible, but identification was clinched on basis of the shape of the head and the length of the individual. Since the underside was not photographed, the sex was not established.

On 18 July 2010 a mirror-case to the one on Maasvlakte occurred at Egmond aan Zee, where an unidentified beaked whale stranded alive and was refloated immediately. It had a piece of plastic in its blowhole, which was removed. Although it was photographed and videod, it could not be identified since the pictures were taken from a distance and the head was not visible. Four days later, on 22 July 2010, a freshly dead beaked whale stranded in Seasalter, Kent, South-east England. It was photographed, measured, collected and autopsied. Good photographs were now available, and some stills could be fabricated from a video from the Egmond individual. The whale turned out to be the same individual, with the pictures convincingly showing the matching scarring. The sex was now determined, as were weight and measurements (see above). No other cause of death than 'live stranding' could be established. Pictures of the whale at Egmond and in England, where the scarring is compared, can be viewed on tinyurl.com/z39r8dd and tinyurl.com/noh6zkt.

The third Sowerby's beaked whale that stranded alive during this period was found on Schiermonnikoog. It died soon after finding. The lungs contained a lot of sand, probably inhaled during prolonged rolling in the surf. The cause of stranding remains unclear. The stomach was empty.

Of the twenty strandings of this species in the Netherlands, only three happened outside the period July-September (February, October and December). Until now six have stranded alive, of which four females and one male.

Unidentified cetaceans

Small whale

4/9/2010 Rottumerplaat, Groningen. Rotten, incomplete, sex and length unknown. Vertebrae in collection of Natuurmuseum Fryslân (Frisian Natural History Museum). Reported by J. de Boer.

3/5/2013 Vlieland, Friesland. Single rib, in private collection.

A carcass of a small whale was found on the uninhabited island Rottumerplaat, east of Schiermonnikoog, on 4 September 2010. The skull was missing and identification on the spot proved impossible. A shoulder blade was reportedly collected by Zeehondencrèche Pieterburen, but is presently missing. The whale was initially identified from the pictures as 'definitive long-finned pilot whale (*Globicephala melas*)', but later on, on basis of a single tail vertebra, as 'probably a baleen whale' (E. Kompanje, P. Koomen & A. Oosterbaan in litt.). It was not the minke whale found on Schiermonnikoog in June 2010 (see above).

Dolphin

7/1/2010, beach pole 0, Terschelling, Friesland. Length 150 cm (estimated), sex unknown. No information on completeness or decomposition state. Destructed or locally buried. Reported by H. Wiegman and Zeehondencrèche Pieterburen.

1/1/2012 Zandvoort, Zuid-Holland. Part of right lower mandible, in private collection.
17 September 2012 Wassenaar, Zuid-Holland. Complete left lower mandible, in private collection.

6/5/2013 Wadden Sea southwest of Terschelling, Friesland. Condition unknown. Reported by MS charter Mermaid through Diny Dijk RWS.

From the dolphin from Terschelling in January 2010 no details are known, no photographs were made and no bones were collected. The finder is familiar with harbour porpoise.

The dolphin of May 2013 was found floating in the Wadden Sea southwest of Terschelling. The reporter was familiar with harbour porpoise, and this individual was 'definitely much larger', although no length estimate was given. No photos were taken and the individual was not collected.

White-sided / white-beaked dolphin *(Leucopleurus acutus / Lagenorhynchus albirostris)*

16/9/2010 Texel, Noord-Holland. Sex and weight unknown, 210 cm (measured). Rotten, incomplete, not collected. Reported by S. de Wolf.

The dolphin stranded on Texel in September 2010 was reported as white-beaked dolphin, but was transported to a destruction centre without being photographed and without any parts being collected, failing us with the correct specific name, as e.g. white-sided dolphin could not be excluded.

Discussion

The total number of 13 cetacean species recorded over 2008-2014 is high for the Dutch part of the North Sea, considering the waters are shallow and sandy; most of these species prefer deep water. Basically only minke whale, white-beaked dolphin and harbour porpoise can be considered to be regular guests, albeit offshore. Nevertheless, also during the previous ten years a large number of species was reported (15; Camphuysen et al. 2008). Although 24 species have been recorded in the Netherlands thus far, the average number of species washing ashore per year since 1950 is only four (walvisstrandingen.nl) and, indeed, in most years (58%) only 3-4 species are reported. Up to and including 2014 there have been only four years with seven species, of which three after 2000 (1935, 2006, 2010, 2011), while in 2014 even nine species were found. Consequently, there is a slight (but not statistically significant) increase in average number of species: 3.5 in 1985-1994, 4.2 in 1995-2004 and 6.2 in 2005-2014 (figure 17).

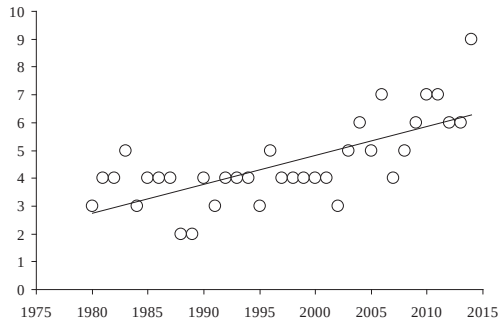


Figure 17. Number of stranded cetacean species in the Netherlands, 1980-2014 (r^2 = 0.499).

More and more photographs are taken of stranded cetaceans. Pictures have turned out to be very important for validating: not only do they substantiate a record, they also sometimes offer the possibility to (re-)identify the species afterwards, provide information on the state of the carcass, on the sex, and on specific marks and wounds. The majority of photographs is shown on walvisstrandingen.nl and together build an important archive. A striking example are those of a 'harbour porpoise' found on Maasvlakte on 26 December 2009: the photographs attached to the e-mail showed a fresh white-beaked dol-

Figure 18. Badly damaged harbour porpoises are now thought to have died from grey seal predation. Characteristic are the sharp cuts and the scratches on the body, the latter caused by the seal's nails. Note however that porpoises feeding on pelagic fish are attacked from a different angle, and thus show different wounds than this one; this porpoise, with the so-called zigzag pattern, had been feeding on demersal fish (gobies) when attacked. Scheveningen, 23 March 2014. *Photo: Huib den Heijer*.

phin. Another example are the photographs from walvisstrandingen.nl used by Leopold et al. (2015) to evaluate patterns of attack and estimate mortality rate inflicted by grey seals (*Halichoerus grypus*) (see below). Nevertheless, it is important to collect (parts of) the skull and/or skeleton for other purposes, like for instance DNA extraction for post hoc identification.

Camphuysen et al. (2008) discussed the strandings pattern of harbour porpoises along the coast over a period of ten years, and by comparing densities concluded that at least four out of fifteen subregions were under-recorded. However, physical features of the coast are probably more important than previously thought: it has been shown repeatedly that strong and onshore winds cause a rise in dead harbour porpoises washing ashore (see for instance: the monthly and yearly reviews on the news page of walvisstrandingen.nl). The beach of Zeeuws-Vlaanderen on a sunny day is just as crowded as that of, for instance, the mainland coast, and a dead cetacean is soon found and readily reported. Hence, low densities from some areas, notably Zeeuws-Vlaanderen and Voorne, considered too low by Camphuysen et al. (2008), are more likely caused by their exposure, while others, such as the eastern Wadden Sea islands and Maasvlakte, but also the extensive shores of the Westerschelde, are definitely under-recorded. Apart from that, strong and onshore winds cause a rise in dead harbour porpoises washing ashore (see for instance the monthly and yearly reviews on the news page of walvisstrandingen.nl), a phenomenon independent from the yearly pattern (Peltier et al. 2013). It seems as if there is an endless stock of dead harbour porpoises floating offshore; we are only becoming aware of it with onshore wind. To properly evaluate differences in coastal subareas, a more in-depth study would be necessary.

The recurrent seasonal pattern of harbour porpoise strandings, with peaks in spring and autumn, was only vaguely visible in the 1990s and early 2000s, and has become pronounced due to larger numbers. The cause of this pattern is still not understood, but possibly both reflect north-south migration (e.g. Geelhoed et al. 2013), as well as inshore-offshore movement. A downward trend in stranded numbers immediately after 2006 was noticed after the strong increase since the late 1990s, and raised speculation on a decline of harbour

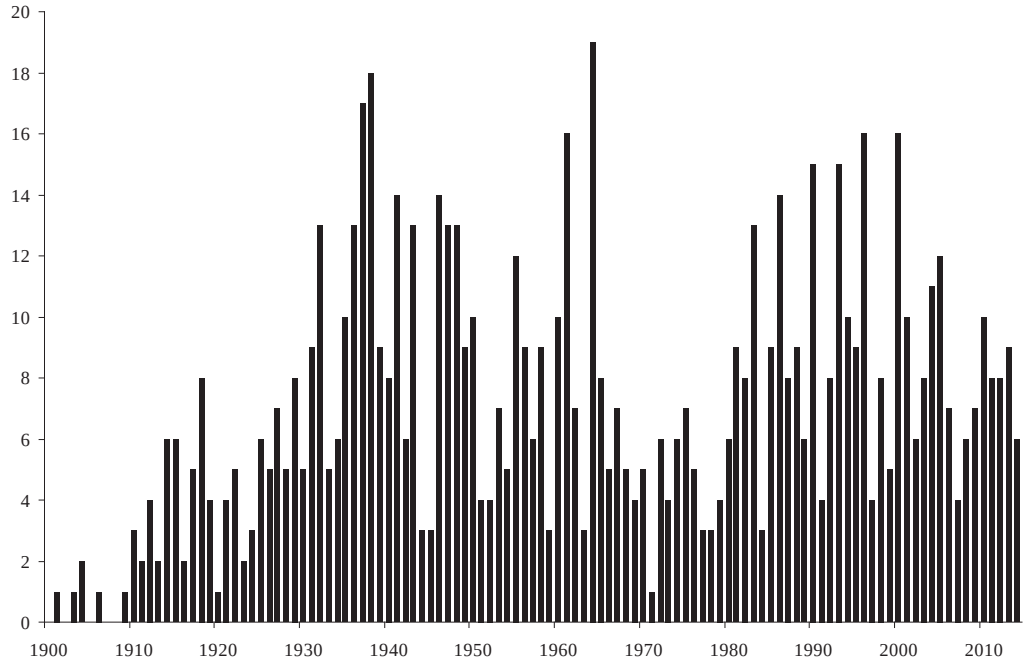


Figure 19. Total number of stranded cetaceans per year in 1900-2014 without harbour porpoise, but including unidentified whales and dolphins (*n*=799).

porpoises in the Dutch part of the North Sea (Camphuysen 2008, Camphuysen et al. 2008). The increase of the number of dead harbour porpoise after 2008, and the decrease since 2013, however shows that the numbers have again fluctuated strongly since 2006 (cf. Haelters & Geelhoed 2015), and that long time series are needed to properly evaluate trends.

With respect to causes of death during 2008-2014, results from during 2008-2014 deviate strongly from those in previous periods (Begeman et al. 2013, IJsseldijk & Gröne 2015): harbour porpoise carcasses ripped apart were until recently allegedly damaged by fishermen (e.g. Camphuysen & Oosterbaan 2009, Begeman et al. 2011) or sand dredgers (Oudenaarden 2012, Leopold et al. 2013). Hence, the percentage of harbour porpoise having drowned in fishing nets was estimated to be 50% or even higher (e.g. Camphuysen & Siemensma 2011). Research however has shown the grey seal to have become an increasingly important predator of harbour porpoise since 2003 (figure 18; Haelters et al. 2012, van Bleijswijk et al. 2014, Leopold et al. 2015): grey seals – probably adult males only – are now thought to be responsible for mutilated porpoise carcasses.

The number of dead cetaceans on the Dutch coast keeps on rising, caused exclusively by harbour porpoise. If the total number of stranded whales and dolphins without harbour porpoise is considered since 1900, it is obvious that all other species are infrequent visitors at best: only twelve years exceed fifteen individuals per year (figure 19). The period with many strandings, from the mid-1930s until the mid-1960s, reflects a time when the Netherlands still harboured an indigenous population of bottlenose dolphin, while during that same period common dolphins made a brief but regular appearance; both species were repeatedly found on the beach during that time. Figure 19 also reflects

the marked influence of A.B. van Deinse, who started registration of dead cetaceans in 1914. During the first years, he still had to build his network, visible by slowly increasing numbers, while his death in 1965 is also visible: there is a gap with few records in the late 1960s and early 1970s. The increase in numbers from the early 1980s onwards is especially due to white-beaked dolphin being relatively numerous.

The study of dead cetaceans found on the Dutch coast is needed to gain more knowledge on the current state of the population (cf. Pierce et al. 2015), and this goes especially for harbour porpoise. About one-third of the world population of this species is said to occur in the North Sea (Hammond et al. 2008, 2013), and all bordering countries, having ratified the ASCOBANS-agreement, have an obligation to protect it. Wild animals die of natural causes in any population, and since porpoises have increased in the southern North Sea in recent times, more individuals washing ashore could be expected. However, every year a number is proven or suspected to have died of non-natural causes, be it fisheries, pollution, or underwater noise. A review showed that 38-52% of harbour porpoise in the Netherlands probably drowned after being accidentally by-caught during fishing activities (Camphuysen & Siemensma 2011), but this figure now seems to be reduced by more than half, because casualties from grey seal attacks were not recognised as such.

Although harbour porpoise in declined in Dutch waters since the Second World War (Viergever 1955, van Deinse 1956), the pollution during the 1960-1970s no doubt took its toll on cetaceans as well, particularly by toxic organochlorine pesticides (e.g. Koeman 1971), which in Dutch waters caused a crash in marine piscivorous bird populations and common seal (*Phoca vitulina*) (e.g. Reijnders 1980, Brenninkmeijer & Stienen 1992). The situation has improved from the 1980s onwards, but neither population of common or bottlenose dolphin returned. The fact that harbour porpoises have returned could be a positive sign. It could equally fill us with concern, as the marine environment gets more and more crowded by human traffic and construction and is still not healthy and safe for marine mammals; it has even been suggested that the increase of harbour porpoise in the southern North Sea is caused by a shift from more northern waters, induced by increased fisheries (e.g. Hammond et al. 2013). Hence, persistently registering top predators, like whales on the beach, is an important tool for monitoring the marine environment (Pyenson 2011). Compiling reviews like this one requires a solid network of people reporting stranded cetaceans. The dip in the late 1960s in figure 19, after the death of van Deinse, is a clear illustration of the energy that should be put into keeping an efficient network. Virtually all people presently reporting dead cetaceans on a more or less regular basis are volunteers. They spend time patrolling the beach, report the animals, and often collect them as well, either to send them to destruction facilities or transport them for further research. Support of this network should be endorsed by governmental agencies.

Acknowledgments: Most important in compiling reviews like the present one are the numerous people and organizations who voluntarily report strandings to walvisstrandingen.nl, keep other websites updated with strandings, or are in some other way involved. Together they form an impressive list. In 2008-2014 reports were received from (in alphabetical order): G. Aalbersberg, B. Aalders, J. Aalders, J. Afanja, H. Ahrens, mevr. Alblas, R. Alewijnse, P. Alting, W. Altorffer, ambulance Vlieland, M. Amoureus, R. Antenbrink, I. Anzion, Arjen, H. Arts, I. Atema, J. Auwerda, M. Baak, P. Baars, F. Baiko, C. Bakker, D. Bakker, M. Bakker, W. Bakker, M. Baptist, A. Barendrecht, H. Bartels, E. Baudoin, E. Beckers-Kuiper, J. Beek, J. Beekman, J. Been, A. Belfroid, G. Bellis, Ben, bemanning van TX20, H. Berkhoudt, M. Berner, R. Beukema, M. Bigot, J. Bijl, M. Bijl, R. Bijlhout, J. Bilder, J. Blankena, L. Blaauw, dhr. Bleeker, J. Bloem, C. Blok, J. Blok, M. Blok, K. Blokland, R. Blom, F. Boelens, R. Boiten, V. Bol, E. Bolt, F. Bolte, J. Boltendal, M. Bonfrer,

P. Bonnet, J. Booij, P. Booij, A. Boon, M. Boon, J. Boonstra, R. Boonstra, T. Borger-Folkertsma, J. Borneman, O. Bos, V. Bos, B. Bosch, J. Bosch, B. Boswinkel, C. both, H. Botman, N. Bottema, O. Bouma, J. Bouman, J. Bourgonje, E. Bout, E. Bouter, T. Bouveroux, F. Bouwkamp, J. Bouwman, H. Bouwmeester, T. Bouwmeester, A. Boven, T. Braaksma, K. Braamskamp, T. Brantjes, mevr. Bras, S. Brasseur, R. Bravo Rebolledo, F. Breijer, E. Brink, M. Brinkman, P. Brolsma, S. Brommer, W. Brommersma, R. Brouwer, A. Brouwers, M. Brugge, J. Bruijn, R. Bruijne, A. Bruin-Kommerij, C. Bruin, D. Bruin, J. Bruin, K. Buijtelaar, W. Buitelaar, T. Bult, B. Bulsink, M. Bunskoek, C. Bustin, J. Butter, P. Bylsma, G. Cadée, J. Camalich Carpizo, K. Camphuysen, dhr. Cappel, R. Cazemier, Centrale Meldpost Waddenzee, J. Cevat, charter Mermaid, B. Clason, T. Compton, M. Conjong, J. Coolen, J. Cossen, R. Costers, B. Couperus, H. Cremers, J. Cuperus, J. Daalder, S. Daalder, A. Dänhart, K. Dantuma, F. de Bie, A. de Boer, C. de Boer, H. de Boer, J. de Boer, M. de Boer, P. de Boer, T. de Boer, Y. de Boer, H. de Bont, M. de Bont, N. de Both, L. de Bruijn, R. de Bruin, L. de Fockert, J. de Gans, B. de Goede, O. de Graauw G. de Graaf, M. de Groen-de Jong, A. de Groot, J. de Groot, mevr. de Groot, T. de Groot, E. de Haan, M. de Haan, T. de Haan, A. de Hoon, M. de Jager, H. de Jong, J. de Jong, K. de Jong, M. de Jong, S. de Jong, Y. de Jong, M. Dekee, G. Dekkema, B. Dekker, E. Dekker, R. Dekker, A. de Klerk-Vuijk, N. de Kok, D. de Koning, M. de Kort, E. de Lange, J. de Levita, B. de Maat, D. de Mol, L. den Bol, H. den Heijer, L. de Raad, J. de Regt, W. de Roover, M. de Ruiter, R. de Ruiter, R. de Ruiter, P. De Smedt, H. de Tollenaere, J. de Visser, T. Devlin, A. de Vries, G. de vries, H. de Vries, J. de Vries, L. de Vries, M. de Vries, N. de Vries, S. de Vries, W. de Vries-Folkertsma, J. de Waard, E. de Weerd, T. de Wijs, T. de Winter, W. de Wilf, W. de Wit, M. de With, S. de Wolf, R. de Zeeuw, M. den Engelse, H. den Heijer, L. den Heijer, J. Dera, Desiree, C. Dieleman, dierenambulance Den Haag e.o., dierenambulance Den Helder, dierenambulance De Wijs, dierenambulance Haarlem, dierenambulance Kennemerland, dierenbescherming Vlaardingen, D. Dijk, A. Dijkhuis, J. Dijkhuizen, K. Dijksterhuis, A. Dijkstra, E. Dijkstra, C. Dingemans, H. Dingemanse, Dolfinarium Harderwijk, Dolores, E. Dondorp, mevr. Donker, P. Donkersloot, P. Doorn, P. Doornbos, dhr. Doornekamp, C. Doorns, C. Dost, douane Noord-Holland, B. Douma, M. Drent, O. Drent, J. Drost, W. Dubbeldam, A. Duijnhouwer, duinpaviljoen Schoos, S. Duijvesteijn, P. Duin, D. Duineveld, T. Duineveld, M. Duisterwinkel, M. Duiveman, B. Duivenvoorden, L. Duursma, Ecomare, T. Eggenhuizen, EHBZ-team Noordwijk, EHBZ-team Velsen, EHBZ-team Zuidwest, E. Ehrlich, J. Ekkel, H. Eland, Elvira, S. Emmens, B. Engels, G. Epping, Erika, R. Essenstam, C. Everaars, E. Everaarts, H. Faber, W. Faber, E. Feenstra, J. Feddema, M. Feis, B. Fey, M. Figaroa, T. Fijen, L. Fitsch, G. Flier, R. Flohil, A. Fokkens, I. Fontijn, R. Foppen, R. Fouwels, Frank, Frederik, D. Frerichs, Frieling, F. Galis, H. Garstenveld, M. Geboers, S. Geelhoed, J. Geertse, M. Geerse, gemeente Ameland, gemeente Bergen, gemeente Castricum, gemeente Den Helder, gemeente Harlingen, gemeente Texel, gemeente Wassenaar, T. Gerrietsen, L. Gerringa, L. Giesberts, P. Gjaltema, L. Glasbergen, T. Glastra, M. Golstein, S. Gomes, P. Gooijer, J. Govers, Govert, S. Goudsmit, J. Grijpstra, J. Groen, S. Groen, K. Groenewoud, A. Gronert, R. Gronert, J. Grul, M. Gul, H. Haakman, W. Halfwerk, H. Haakman, P. Haanstra, L. Haasnoot, S. Haasnoot-Timmerije, K. Hacken, A. Hahn, C. Halfmouw, W. Halfwerk, G. Hansma, B. Harthoorn, havenbedrijf Rotterdam, J. Harthoorn, L. Heemskerk, N. Heetkamp, J. Helmus, A. Helsen, E. Hemmes, K. Hendriks, D. Hermes, A. Hessel, S. Hiemstra, J. Hille, HMS Den Helder, E. Hoedjes, W. Hoeffnagel, J. Hoekendijk, G. Hoekstra, B. Hoeve, R. Hofland, F. Hofman, T. Hofmeester, W. Hogenbirk, B. Holthof, M. Holthuijsen-Vloemans, K. Holtrop, P. Honkoop, J. Hoogendoorn, hoogheemraadschap Noord-Holland, T. Hooghiemstra, G. Hoop, J. Hooymans, N. Hopman, H. Horn, M. Horn, H. Horst, J. Hottentot, M. Hougee, M. Hougee, A. Hoven, F. Hovenkamp, P. Hovenkamp, M. Huijsman, J. Huizenga, Y. Huizer, H. Huizinga, D. Hutteman, J. Idskema, IFG, J. IJnsen, Imares Den Helder, Imares IJmuiden, informatiecentrum De Noordwester, Iris, A. Jaartsveld, P. Jaartsveld, L. Jacobs, M. Jacobs, P. Jacobs, Z. Jager, C. Jansen, K. Jansen, F. Janssens, B. Jenster, John, M. Jonker, A. Joon, L. Joosse, I. Kaars Sijpesteijn, J. Kamermans, M. Kamp, A. Kaper, W. Kartens, D. Keevel, G. Keijl, P. Keijzer, J. Keizer, fam. Kelder, L. Kelder, H. Kemper, Keuning, J. Kienstra, P. Kieviet, L. Kiewiet, R. Kiewiet, L. kikkert, D. Kikstra, J. Kikstra, V. Kikstra, C. kleimeer, H. Klein, Kleinhuis, M. Klemann, G. Klijn, G. Klijzingen, E. Klink, J. Kloet, M. Klootwijk, R. Knoeff, I. Knot, KNRB ouddorp,

KNRM Egmond, KNRM Vlieland, KNRM Zandvoort, J. Koekendorp, R. Koelewijn, C. Koersen, A. Kok, B. Kok, C. Kok-Van der Bend, J. Kok, T. Kolk, P. Kollenveld, M. Kolthoff, J. Koning, koninklijke marechaussee, E. Kooi, K. Kooimans, L. Kooistra, B. Koole, Koolhaas, S. Koolwijk, P. Koopmans, J. Koops, R. Koops, R. Kootker, E. Kop, P. Korstanje, P. Kossen, D. Koster, F. Koster, J. Koster, L. Kraaijeveld, G. Kremer, G. Krijnen, D. Krol, J. Krol, R. Krol, A. Kruger, K. Kruijer, B. Kruijsen, W. Kruiswijk, R. Kruit, S. Kruk, N. Kruys-Harkema, S. Kühn, K. Kuijt, C. Kuiken, D. Kuiken, B. Kuipers, R. Kuipers, M. Kusters, kustwacht, L. Laan, T. Laanen, S. Lagerveld, R. Lam, W. Lamain, S. Lamberts, J. Lamers, R. Landman, W. Langendoen, H. Lansbergen, lauwersmeer.com, J. Leenhouts, J. Lehmhus, M. Leopold, K. Leusink, R. Leyen, D. Liefhebber, Y. Ligterink, M. Ligthart, P. Lindeboom, R. Lindeboom, P. Lindenburg, E. Loen, S. Lolkema, S. Lous, luchtmacht Vlieland, R. Lukkien, C. Luteijn, D. Lutterop, I. Maas, L. Maljaars, E. Marits, D. Marckmann, Mariëlle, E. Marijs, M. Marinissen, Marnix, H. Martens, G. Mast, Maurice, H. Meek, J. Meerbeek, R. Meerman, B. Meerstra, R. Meesters, A. Meijer, fam. Meijer, H. Mellema, S. Mellema, G. Mensink, R. Mes, dhr. Metselaar, P. Metz, P. Meuldijk, J. Midavaine, K. Minnaar, Miriam, M. Molenberg, A. Molenkamp, S. Möller, L. Monster, R. Moonen, L. Mortilli, H. Mosterman, S. Mostert, MS Krukel, MS Phoca, MS Stormvogel, M. Mud, H. Mulder, J. Mulder, M. Mulder-de Zwart, E. Muller, M. Muller, T. Muller, G. Muyzert, S. Mylius, P. Naber, N. Nachbar, K. Nanninga, T. Näring, Nelleke, N. Nicolai, fam. Nieuwbroek, R. Nieuwstad, M. Nijman, K. Nobel, Noord-Hollandse reddingsbrigade, R. Noort, S. O'Brien, M. Olivierse, M. Onnes, A. Oosterbaan, T. Oosterbaan, W. Oosterbaan, J. Oosterboer, H. Oosterhof, F. Oosterhoff, N. Osinga, C. Oste, H. Ottema, N. Otten, M. Oudenaarden, P. Ouwehand, T. Overdiep, K. Overwater, W. Ozinga, Ö. Özkan, J. Paap, F. Padmos, E. Parée, A. Pauptit, L. Pauwels, J. Peperkamp, W. Penners, persbureau Ameland, P. Persoon, R. Peters, A. Petersen, A. Piek, C. Pidancet, C. Pisa, R. Planting, D. Plu, A. Poelmans, mevr. Poelstra, K. Polderman, politie Ameland, politie Den Haag, politie Friesland, politie Haaglanden, politie Zandvoort, politie te water, M. Poolman, M. Poot, T. Porebska, R. Portier, J. Postema, R. Posthuma, H. Praagman, B. Prak, J. Prins, P. Pruisscher, P. Pulles, Y. Pulles, F. Putker, R. Raats, M. Radix, T. Rammelt, reddingsbrigade Bergen, reddingsbrigade Bloemendaal, reddingsbrigade Castricum, reddingsbrigade Callantsoog, reddingsbrigade Egmond, reddingsbrigade Groote Keeten, reddingsbrigade Heemskerk, reddingsbrigade Petten, reddingsbrigade Schoorl, reddingsbrigade Sint Maartenszee, reddingsbrigade Texel, rederij Vrolijk, B. Reinders, Remco, René, V. Rens, I. Riethoven, rijkspolitie Waddenzee, rijkswaterstaat Ameland, rijkswaterstaat Zeeland, J. Ringrose, Robbin, T. Roeke, H. Roemers, H. Roersma, J. Roest, J. Rohlof, H. Romkema, R. Roos, T. Roos, A. Rollingswier, K. Roselaar, R. Rotscheid, J. Rovers, RTV Noord-Holland, E. Ruder, M. Ruhland, E. Ruiter, P. Ruiters, M. Rullens, C. Rund, E. Sandberg, Sandra, J. Saulino, A. Schaap, J. Schagen, S. Schagen, A. Schager, P. Schaper, I. Scheek, H. Schekkerman, Y. Scherf, B. Schilder, J. Schinkel, C. Schipper, M. Schipper, U. Schipper, L. Schmahl, J. Schoemaker, M. Schoemaker, H. Schoenmakers, L. Schoenmakers, M. Scholten, T. Schoos, S. Schotanus, J. Schoutsen, E. Schram, M. Schrama, A. Schrauwen, L. Schreurs, B. Schrieken, E. Schrijver, M. Schrijver-Bastiaans, R. Schurer, F.R. Selie, H. Sieben, N. Shillcock, M. Sikkema, T. Sikkema, B. Sikkens, A. Slagt, M. Sluijter, K. Snijder, J. Smit, F. Smits, H. Snater, J. Soek, C. Soepboer, P. Soer, E. Soldaat, L. Solé, J. Somers, SOS Dolfijn, fam. Speijers, P. Spijker, R. Sonselee, Staatsbosbeheer Ameland, Staatsbosbeheer Vlieland, J. Stadhouder, C. Stal Edda, E. Stam, M. Star, E. Steeman, K. Steendijk, B. Stegeman, A. Stel, W. Stel, O. Stenvers, J. Steverink, Stichting de Noordzee, Stichting SOS Dolfijn, J. Stok, J. Stokroos, P. Stols, E. Stolte, V. Stork, B. Storm, J. Stout, M. Stouwie, strandexploitatie Den Helder, strandexploitatie Walcheren, strandpaviljoen Deining, strandpaviljoen de Zeester, strandpaviljoen Key West, strandpaviljoen 't Badhuys, J. Stuivenberg, J. Stuut, M. Sweens, S. Szlachcic, F. Talsma, T. Talsma, A. Talsma-Blaauwwiekel, R. Tamerus, G. Tanis, H. Tasma, E. ten Brink, J. ten Horn, L. ten Hove, E. ten Velden, M. ter Ellen, H. ter Vrugt, M. Tesser, W. Thijssen, E. Tibboel, B. Tigelaar, E. Timmerman, transportbedrijf HMS Den Helder, R. Tromp, K. Tuinenga, S. Twietmeyer, J. Twigt, B. Ubels, Universiteit Utrecht, S. Ursem, F. Valk, T. Valk, M. van Aalst, K. van Abshoven, T. van Andel, J. van Belle, R. van Bemmelen, A. van Berge Henegouwen, B. van Bommel, N. van Brederode, R. van Breugel, G. van Buiten, dhr. van Campen, P. van de Berg, R. van de Guchte, G. van de Kamp, S. van de

Klundert, A. van Dekken, B. van de Meulengraaf, C. van de Meulenhof, A. van den Berg, F. van den Berg, J. van den Berg, S. van den Berg-Blok, D. van den Bos, A. van den Dorpel, R. van den Driest, P. van den Hout, C. van den Hoven, R. van den Oever, M. van den Tillaart, fam. van der Berg, K. van der Blom, T. van der Es, fam. van der Ham, mevr. van der Ham, R. van der Ham, E. van der Heide, S. van der Heijde, J. van der Hiele, J. van der Hoorn, S. van der Horst-van de Siepkamp, J. van der Kamp, T. van der Knaap, K. van der Korf, J. van der Laan, P. van der Lem, C. van der Linde, fam. van der Linden, S. van der Lugt, J. van der Meer, M. van der Meij, A. van der Meule, dhr. van der Meulen, S. van der Mije, J. van der Molen, A. van der Plas, fam. van der Putten, firma van der Putten, W. van der Ree, B. van der Sanden, M. van der Sanden, L. van der Vaart, E. van der Veen, P. van der Ven, R. van der Vliet, R. van der Wal, J. van der Weele, A. van der Weide, F. van der Weij, M. van der Weij, K. van der Wende, B. van der Werf, J. van der Wijst, P. van der Zande, G. van de Sande, J. van de Star, W. van der Schot, J. van der Sluijs, A. van der Spoel, L. van der Vaart, A. van der Veen, A. van der Velde, R. van der Vliet, M. van der Wal, H. van der Weijden, M. van der Zee, R. van de Veerdonk, C. van de Water, O. van de Zevenster, H. van Diek, A. van Dijk, E. van Dijk, J. van Dijk, K. van Dijk, J. van Dillen-Staal, S. van Dongen, A. van Duijn, L. van Duijn, M. van Duijn, A. van Duyse, J. van Eerbeek, H. van Erp, E. van Es, M. van Es, W. van Esseveldt, E. van Faassen, L. van Fraaijenhove, J. van Franeker, J. van Gasteren, J. van Gent, M. van Gent, J. van Goethem, C. van Haaster, H. van Haaster, H. van Haren, C. van Heerden, S. van Heijst, B. van Holst, W. van Holten, A. van Hoorne, A. van Houten, D. van Houten, H. van Houten, J. van Houten, P. van Horssen, D. van Houwelingen, C. van Hoven, T. van Hoytema, E. van IJsseldijk, S. van Katwijk, M. van Keulen, L. van Kooten, A. van Krimpen, G. van Leeuwen, J. van Leeuwen, M. van Lith, L. van Loenen, dhr. van Loon, P. van Loon, familie van Lunteren, T. van Marle, A. van Marrewijk, T. van Noort, C. van Nuenen, T. van Nus, F. van Oirschot, R. van Oosten, M. van Oostveen, N. van Pelt, M. van Reek, L. van Rooij, M. van Rooijen, M. van Roomen, K. van Rosevelt, A. van Scherpenzeel, T. van Schie, A. van Schooten, B. van Soest, T. van Spanje, F. van Spelde, M. van Straten, P. van Suijlekom, R. van 't Hof, B. van 't Spijker, P. van Tuinen, S. van Twuijver, W. van Urk, R. van Veghel, D. van Vliet, dhr. van Vliet, K. van Vooren, P. van Vossen, M. van Vuuren, L. van Walraven, W. van Went, K. van Werde, M. van Werkhoven, P. van Wijck, B. van Winden, M. van Winden, A. van Woensel, W. van Yperen, R. van Zeeland, G. van Zon, G. Veenstra, J. Veenstra, E. Veerman, R. Veldhuizen, W. Vellinga, F. Venselaar, J. Verbeek, M. Verbeek, F. Venselaar, A. Verbiest, H. Verdaat, L. Verhage, fam. Verleng, M. Vermulst, A. Verrips-Epping, J. Verschoor, G.J. Versteeg, M. Versteeg, J.D.Verveen, Violet, F. Visscher, D. Visser, G. Visser, K. Visser, P. Visser, S. Visser, T. Visser, W. Visser, Vivian, J. Vlaming, M. Vlaming, A. Vleugel, Vlielander schooljeugd, H. Vogel, S. Vogelaar, M. Vogels, D. Vogelzang, H. Vonk, W. Vonk-van Rijsinge, A. Voorbergen, E. Voorsluijs, H. Vos, R. Vos, V. Vos, W. Vos, G. Voss, J. Vroege, B. Vroegindeweij, I. Vroegop, VWG Katwijk, waarneming.nl, F. Wagemans, G. Wagtendonk, J. Wardenier, M. Wassink, J. Waverijn, C. Wegstapel, E. Wessels, J. Wessels, I. Westdijk, J. Westra, A. Wester, H. Wiegman, M. Wielstra, A. Wijker, H. Wijnberg, A. Wildeboer, L. WIllems, P. Willemsen, R. Wiltjer, G. Witte, M. Witte, R. Witte van den Bosch, A. Witteveen, B. Woets, H. Wolfswinkel, M. Woning, H. Wouda, A. Wuite, J. Ybema, D. Ynsen, L. Zandbergen, fam. Zandwijk, R. Zant, zeehondencrèche Lenie 't Hart, zeehondencrèche Pieterburen, zeenon.nl/vangstbarometer, zeezoogdieren.org, M. Zekhuis, E. Zijlstra, J. Zoeter, C. Zuhorn, J. Zuhorn, A. Zuidema, W. Zuidersma, S. Zuidwijk, M. Zutt-van der Made, A. Zuurbier, J. Zwagerman, W. Zweemer, H. Zwennes, J. Zwijnenburg, P. Zwitser, and 112bollenstreek.nl.

Apart from these people, others are acknowledged for various information. They are, in no specific order: Marjan Addink, Wojtek Bacchara and Erwin Kompanje, for sharing their knowledge on identification and biology of cetaceans; Rob Deaville and Werner Visser for information on the Sowerby's beaked whale that first stranded in Egmond and later in England; Sandra Vreugde and Peter Blom from municipality Veere and Mieke Meijer from the picture library from Zeeland ('beeldbank van de Zeeuwse bibliotheek') in Middelburg for sending pictures of the Sowerby's whale from 1957; Okka Jansen for information on strandings and diet of white-beaked dolphins; Mardik Leopold of Imares Den Helder for dietary information; Andrea Gröne of the Faculty of Veterinary Medicine of Utrecht University for leading the research on

causes of death of Dutch stranded harbour porpoise since 2007; Lidewij Wiersma for setting up the post-mortem investigations at Utrecht University; Hein van Grouw for managing the strandings database up to early 2008; Rommert Cazemier for bringing strandings of harbour porpoises mentioned on lauwersmeer.com to our attention; Jolanda Meerbeek and Eligius Everaarts from SOS Dolfijn and Niels van Elk from Dolfinarium Harderwijk for information of live strandings; Hans Schekkerman for help with statistical analysis; and Dominick Verschelde, curator in Museum voor Dierkunde in Gent, Belgium, for information on, and permission to photograph, the first white-flanked dolphin for the Netherlands. Also the photographers are greatly acknowledged.

References

Anonymous 1957. Dode dolfijn dook op in Veere. PZC 9 augustus 1957.

Begeman, L., A. Gröne & L. Wiersma 2010. Postmortaal onderzoek van in Nederland gestrande bruinvissen van december 2009 tot november 2010. Rapport 2010. Departement Pathobiologie, Faculteit Diergeneeskunde, Universiteit Utrecht, the Netherlands.

Begeman, L., A. Gröne & S. Hiemstra 2011. Postmortaal onderzoek van bruinvissen uit Nederlandse wateren van 2009 tot 2011. Rapport 2011. Departement Pathobiologie, Faculteit Diergeneeskunde, Universiteit Utrecht, the Netherlands.

Begeman, L., A. Gröne & S. Hiemstra 2012. Postmortaal onderzoek van bruinvissen uit Nederlandse wateren van 2009 tot 2012. Report 2012. Department Veterinary Pathobiology, Utrecht University, the Netherlands.

Begeman, L., L.L. IJsseldijk & A. Gröne 2013 Postmortaal onderzoek van bruinvissen (*Phocoena phocoena*) uit Nederlandse wateren van 2009 tot 2013. Rapport 2014. Departement Pathobiologie, Faculteit Diergeneeskunde, Universiteit Utrecht, the Netherlands.

Besseling, E., E.M. Foekema, J.A. Van Franeker, M.F. Leopold, S. Kühn, E.L. Bravo Rebolledo, E. Heße, L. Mielke, J. IJzer, P. Kamminga & A.A. Koelmans 2015. Microplastic in a macro filter feeder: Humpback whale *Megaptera novaeangliae*. *Marine Pollution Bulletin 95: 248-252.*

Bravo Rebolledo, E.L., L.L. IJsseldijk, L. Solé, L. Begeman, S. de Vries, L. van den Boom, J. Camalich Carpizo & M.F. Leopold 2016. Unorthodox sampling of a fin whale's (*Balaenoptera physalus*) diet yields several new mesopelagic prey species. Aquatic Mammals 42 (4): 417-420.

Brenninkmeijer A. & E.W.M. Stienen 1992. Ecologisch profiel van de visdief (*Sterna hirundo*). RIN-rapport 92/18. Instituut voor Bos- en Natuuronderzoek, Arnhem, the Netherlands.

Broekhuizen, S., K. Spoelstra, J.B.M. Thissen, K.J. Canters & J.C. Buys (redactie) 2016. Atlas van de Nederlandse zoogdieren. Natuur van Nederland 12. Naturalis Biodiversity Centre & EIS Kenniscentrum Insecten en andere ongewervelden, Leiden: 302-374.

Camalich, J., E. Svensson, L.L. IJsseldijk, S. Brasseur, R. Witbaard & S. Schouten 2014. Bulk and amino acid stable isotope analysis of fin whale baleens. Poster presented at ECS Conference, 5-9 April 2014, Liège, Belgium.

Camphuysen, K. 2008. Bruinvis *Phocoena phocoena* op zijn retour in de zuidelijke Noordzee. Sula 21: 39-43.

Camphuysen, C.J. & A. Oosterbaan 2009. Het raadsel van de bruinvismutilaties: extreme verminking en frequente strandingen van bruinvissen in Noord-Nederland, winter 2008/2009. Sula 22: 25-34.

Camphuysen, C.J. & M.L. Siemensma 2011. Conservation plan for the Harbour Porpoise *Phocoena phocoena* in The Netherlands: towards a favourable conservation status. NIOZ Report 2011-07. Royal Netherlands Institute for Sea Research, Texel, the Netherlands.

Camphuysen, K. (C.J.), C. Smeenk, M. Addink, H. van Grouw & O.E. Jansen 2008. Cetaceans stranded in the Netherlands from 1998 to 2007. Lutra 51: 87-122.

Canning, S.J., M. Begoña Santos, R.J. Reid, P.G.H. Evans, R.C. Sabin, N. Bailey & G.J. Pierce 2008. Seasonal distribution of white-beaked dolphins (*Lagenorhynchus albirostris*) in UK waters with new information on diet and habitat use. Journal of the Marine Biological Association of the UK 88: 1159-1166.

Chaudry, F., N. Clark, N. Reay, R. Scullion & K. Macleod 2005. The distribution of Fin Whales in the Bay of Biscay in relation to bathymetry and sea surface temperature. Poster presented at the 19th Annual Conference of the European Cetacean Society, La Rochelle, France, 2-7 April 2005.

Ellis J. & S. Rogers 2015. 67. Gobies (Gobiidae). In: H.J.L. Heessen, N. Daan & J.R. Ellis (eds.). Fish atlas of the Celtic Sea, North Sea, and Baltic Sea: 396-411. Wageningen Academic Publishers, KNNV Publishing, Wageningen, the Netherlands.

Galatius, A., O.E. Jansen & C. Kinze 2013. Parameters of growth and reproduction of white-beaked dolphins (*Lagenorhynchus albirostris*) from the North Sea. Marine Mammal Science 29: 348-355.

Gannon, D.P., A.J. Read, J.E. Craddock, K.M. Fristrup & J.R. Nicolas 1997. Feeding ecology of long-finned pilot whales *Globicephala melas* in the western North Atlantic. Marine Ecology Progress Series 148: 1-10.

Geelhoed, S.C.V., M. Scheidat, R.S.A. van Bemmelen & G. Aarts 2013. Abundance of harbour porpoises (*Phocoena phocoena*) on the Dutch Continental Shelf, aerial surveys in July 2010-March 2011. Lutra 56: 45-57.

Geelhoed, S.C.V., S. Lagerveld, J.P. Verdaat & M. Scheidat 2014. Marine mammal surveys in Dutch waters in 2014. Report C180/14. IMARES, Wageningen, the Netherlands.

Geelhoed, S.C.V., S. Lagerveld & J.P. Verdaat 2015. Marine mammal surveys in Dutch North Sea waters in 2015. Report C189/15. IMARES, Wageningen, the Netherlands.

Haelters J. & S. Geelhoed 2015. Over enkele jaren weer zeldzaam? Minder bruinvissen in de zuidelijke Noordzee. Zoogdier 26 (4): 1-3.

Haelters, J., F. Kerckhof, T. Jauniaux & S. Degraer 2012. The grey seal (*Halichoerus grypus*) as a predator of harbour porpoises (*Phocoena phocoena*)? Aquatic Mammals 38 (4): 343-353.

Hammond, P.S., G. Bearzi, A. Bjorge, K. Forney, L. Karczmarski, T. Kasuya, W.F. Perrin, M.D. Scott, J.Y. Wang, R.S. Wells & B. Wilson 2008. *Phocoena phocoena*. In: IUCN 2010. IUCN Red List of Threatened Species. Version 2010.4. URL: www.iucnredlist.org; viewed October 2015.

Hammond, P.S., K. Macleod, P. Berggren, D.L. Borchers, L. Burt, A. Canadas, G. Desportes, G.P. Donovan, A. Gilles, D. Gillespie, J. Gordon, L. Hiby, I. Kuklik, R. Leaper, K. Lehnert, M.F. Leopold, P. Lovell, N. Oien, C.G.M. Paxton, V. Ridoux, E. Rogan, F. Samarra, M. Scheidat, M. Sequeira, U. Siebert, H. Skov, R. Swift, M.L. Tasker, J. Teilmann, O. Van Canneyt & J.A. Vazquez 2013. Cetacean abundance and distribution in European shelf water to inform conservation and management. Biological Conservation 164: 107-122.

Harlin, A.D., T. Markowitz, C. Scott Baker, B. Würsig & R.L. Honeycutt 2003. Genetic structure, diversity, and historical demography of New Zealand's Dusky Dolphin (*Lagenorhynchus obscurus*). Journal of Mammalogy 84: 702-717.

IJsseldijk, L.L. & A. Gröne 2015. Postmortaal onderzoek van Bruinvissen (*Phocoena phocoena*) uit Nederlandse wateren 2014. Intern rapport 2015. Departement Pathobiologie, Faculteit Diergeneeskunde, Universiteit Utrecht, the Netherlands.

IJsseldijk, L.L., J. Steenbergen, A. Gröne, S. Hiemstra, M.J.L. Kik & L. Begeman 2014a. Apparent emergence of bow-caught fin whales (*Balaenoptera physalus*) found in the Netherlands. Aquatic Mammals 40: 317-320.

IJsseldijk, L.L., A. Gröne, S. Hiemstra, J. Hoekendijk & L. Begeman 2014b. A record of twin fetuses in a harbour porpoise (*Phocoena phocoena*) stranded on the Dutch coast. Aquatic Mammals 40: 394-397.

IJsseldijk, L.L., M.F. Leopold, E.L. Bravo Rebolledo, R. Deaville, J. Haelters, J. IJzer, P.D. Jepson & A. Gröne 2015. Fatal asphyxiation in two Long-Finned Pilot Whales (*Globicephala melas*) caused by Common Soles (*Solea solea*). PLoS ONE 10 (11): e0141951. DOI: 10.1371/journal.pone.0141951.

Jansen, O.E. 2013. Fishing for food. Feeding ecology of harbour porpoises *Phocoena phocoena* and white-beaked dolphins *Lagenorhynchus albirostris* in Dutch waters. PhD thesis. Wageningen University, Wageningen, the Netherlands.

Jansen, O.E., G.M. Aarts & P.J.H. Reijnders 2013. Harbour porpoises *Phocoena phocoena* in the eastern Scheldt: a resident stock or trapped by a storm surge barrier? PLOS One 8 (3): 10.1371/journal.pone.0056932.

Katona, S.K. & J.A. Beard 1990. Population size, migra-

tions and feeding aggregations of the humpback whale (*Megaptera novaeangliae*) in the western North Atlantic Ocean. Report of the International Whaling Commission 12 (special issue): 295-305.

Keijl, G.O. & H. Cremers 2010. Twee witsnuitdolfijnen op Ameland. Zoogdier 21 (3): 22-23.

Koeman, J.H. 1971. Het voorkomen en de toxicologische betekenis van enkele chloorkoolwaterstoffen aan de Nederlandse kust in de periode van 1965 tot 1970. Proefschrift. Rijksuniversiteit Utrecht, Utrecht, the Netherlands.

Kompanje, E. & J. Reumer 2002. Walvisachtigen, van archivering van strandingen tot analyse. In: R. Lange, A. Martens, K. Schulte Fischedick & F. van der Vliet. Op zoek naar zoogdieren. 50 jaar Vereniging voor Zoogdierkunde en Zoogdierbescherming, 1952-2002: 106-111. KNNV Uitgeverij, Utrecht, the Netherlands / VZZ, Arnhem, the Netherlands.

LeDuc, R.G., W. Perrin & E. Dizon 1999. Phylogenetic relationships among the delphinid cetaceans based on full cytochrome B sequences. Marine Mammal Science 15: 619-648.

Leopold, M.F., M.J. Baptist, L. IJsseldijk & B. Engels 2013. Waarnemingen van bruinvissen in maart 2013 vanaf een zandzuiger in het Slijkgat bij Ouddorp. Rapport C096/13. IMARES, Texel, the Netherlands.

Leopold, M.F., L. Begeman, E. Heße, J. van der Hiele, S. Hiemstra, G.O. Keijl, E.H. Meesters, L. Mielke, D. Verheyen & A. Gröne 2015. Porpoises: from predators to prey. Journal of Sea Research 97: 14-23.

MacLeod, C.D., S.M. Bannon. G.J. Pierce. C. Schweder. J.A. Learmonth & J.S. Herman & R.J. Reid 2005. Climate change and the cetacean community of north-west Scotland. Biological Conservation 124: 477-483.

May-Collado, L. & I. Agnaarsson 2006. Cytochrome b and bayesian inference of whale phylogeny. Molecular Phylogenetics and Evolution 38: 344-354.

Midavaine, J.H. 1996. Veere in vroeger tijden. Deel 3. Deboektant, Oostvoorne, the Netherlands.

Nakamatsu, N. 2001. A record of twin fetuses of Dall's porpoise (*Phocoenoides dalli*) off the Pacific coast of Japan. Otsuchi Marine Science 26: 51-54.

Notarbartolo di Sciara, G., M. Zanardelli, M. Jahoda, S. Panagida & S. Airoldi 2003. The fin whale *Balaenoptera physalus* (L. 1758) in the Mediterranean Sea. Mammal Review 33: 105-150.

Oudenaarden, M. 2012. Bruinvissen door de gehaktmolen? Slagveld dode bruinvissen op de stranden van Goeree. Visserijnieuws 14-03-2012. URL: http://tinyurl.com/o3p5sso; viewed 2 October 2015.

Panigada, S., G. Pesante, M. Zanardelli, F. Capoulade, A. Gannier & M.T. Weinrich 2006. Mediterranean fin whales at risk from fatal ship strikes. Marine Pollution Bulletin 52: 1287-1298.

Peltier, H., H.J. Baagøe, K.C.J. Camphuysen, R. Czeck, W. Dabin, P. Daniel, R. Deaville, J. Haelters, T. Jauniaux, L.F. Jensen, P.D. Jepson, G.O. Keijl, U. Siebert, O. Van Canneyt & V. Ridoux 2013. The stranding anomaly as population indicator: the case of harbour porpoise *Phocoena phocoena* in the-western Europe. PLoS ONE 8 (4): e62180. DOI: 10.1371/journal.pone.0062180.

Pierce, G.J., F.L. Read, A. Brownlow, N. Davison, M. ten Doeschate, N. Anderson, M. Skinner, M.B. Santos, A. Llavona, C. Saavedra, S. Murphy, P. Jepson, R. Deaville & V. Ridoux 2015. Can we obtain MSFD indicators from cetacean strandings data? Annual Science Conference (ASC-ICES), 12-25 September 2015, Copenhagen, Denmark.

Pyenson, N.D. 2011. The high fidelity of the cetacean stranding record: insights into measuring diversity by integrating taphonomy and macroecology. Proceedings of the Royal Society B 278: 3608-3616.

Reijnders, P.J.H. 1980. Organochlorine and heavy metal residues in harbour seals from the Wadden Sea and their possible effects on reproduction. Netherlands Journal of Sea Research 14: 30-65.

Ruegg, K., H.C. Rosenbaum, E.C. Anderson, M. Engel, A. Rothschild, C.S. Baker & S.R. Palumbi 2013. Long-term population size of the North Atlantic humpback whale within the context of worldwide population structure. Conservation Genetics 14: 103-114. DOI: 10.1007/s10592-012-0432-0.

Santos, M.B., G.J. Pierce, J.A. Learmonth, R.J. Reid, M. Sacau, I.A.P. Patterson & H.M. Ross 2008. Strandings of striped dolphin *Stenella coeruleoalba* in Scottish waters (1992–2003) with notes on the diet of this species. Journal of the Marine Biological Association of the UK 88: 1175-1183.

Scheidat, M., R. Leaper, M.J. van den Heuvel-Greve &

A.J. Winship 2013. Setting maximum mortality limits for harbour porpoises in Dutch waters to achieve conservation objectives. Open Journal of Marine Science 3: 133-139.

Smith, T.D. & D.G. Pike 2009. The enigmatic whale: the North Atlantic humpback. NAMMCO Scientific Publications 7: 161-178.

van Bleijswijk, J.D.L., L. Begeman, H.J. Witte, L.L. IJsseldijk, S.J.M. Brasseur, A. Gröne & M.F. Leopold 2014. Detection of grey seal *Halichoerus grypus* DNA in attack wounds on stranded harbour porpoises *Phocoena phocoena*. Marine Ecology Progress Series 513: 277-281.

van Deinse, A.B. 1931. De fossiele en recente Cetacea van Nederland. Dissertatie, Utrecht, the Netherlands.

van Deinse, A.B. 1933. Aanspoelingen van cetacea in Nederland in de jaren 1931 en 1932. Natuurhistorisch Museum te Rotterdam 2: 7-20.

van Deinse, A.B. 1956. Walvissennieuws over 1955. Mededelingenblad van de Vereniging voor Zoogdierkunde en Zoogdierbescherming 12: 127-130.

van Deinse, A.B. 1961. Walvisnieuws over 1960. Lutra 3: 19-23.

van Deinse, A.B. 1966. Walvisnieuws over 1964. Lutra 8: 22-26.

van Elk, C.E., M.W.G. van de Bildt, T. Jauniaux, S. Hiemstra, P.R.W.A. van Run, G. Foster, J. Meerbeek, A.D.M.E. Osterhaus & T. Kuiken 2014. Is dolphin morbillivirus virulent for white-beaked dolphins (*Lagenorhynchus albirostris*)? Veterinary Pathology 51 (6): 1174-1182.

Van Waerebeek, K. & A.J. Read 1994. Reproduction of dusky dolphins, *Lagenorhynchus obscurus*, from coastal Peru. Journal of Mammalogy 75: 1054-1062.

Viergever, J. 1955. Hoe staat het met de bruinvis? Het Zeepaard 15: 90-91.

Wiersma, L. & A. Gröne 2009. Postmortaal onderzoek van in Nederland gestrande Bruinvissen in 2009. Rapport 2009. Departement Pathobiologie, Faculteit Diergeneeskunde, Universiteit Utrecht, the Netherlands.

Wilson, D.E. & D.M. Reeder (eds.) 2005. Mammal Species of the World. A Taxonomic and Geographic Reference (3rd ed). Johns Hopkins University Press, Baltimore, USA.

Winn, H.E. & N.E. Reichley 1985. Humpback Whale *Megaptera novaeangliae*. In: S.H. Ridgway & Sir R. Harrison. Handbook of Marine Mammals. Volume 3. The Sirenians and Baleen Whales: 241-274. Academic Press, London, UK.

Würsig, B., F. Cipriano, E. Slooten, K. Barr, S. Yin & R. Constantine 1997. Dusky dolphins (*Lagenorhynchus obscurus*) off New Zealand: status of present knowledge. Report of the International Whaling Commission 47: 715-722.

Samenvatting

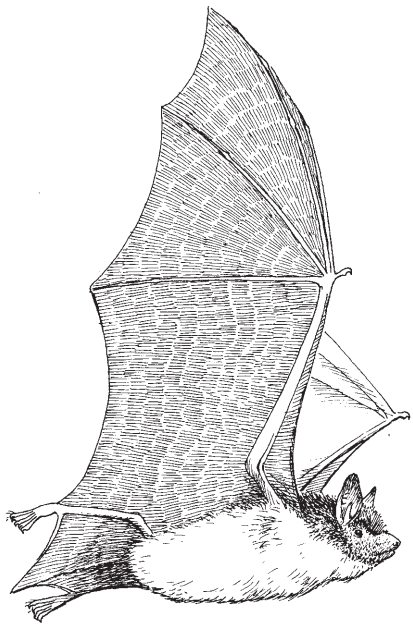
Gestrande walvisachtigen op de Nederlandse kust in 2008-2014

In de jaren 2008-2014 zijn in totaal 4406 walvisachtigen dood of levend op de Nederlandse kust gevonden, behorend tot 13 soorten. Het meest bijzonder waren bultrug (drie exemplaren, de vierde tot en met de zesde vondst), witflankdolfijn (twaalfde), orka (28e, maar de eerste sinds 1963), en gestreepte dolfijn (negende, maar al de vierde of vijfde die levend is gestrand). De bultrug van augustus 2010 moet, berekend aan de hand van de flipper, ongeveer 4,5 meter lang zijn geweest; deze lengte past bij een pas geboren bultrug, wat er op wijst dat dit jong waarschijnlijk in of vlakbij de zuidelijke Noordzee geboren is. Alle zes in deze periode gemelde gewone vinvissen zijn zeker of hoogst waarschijnlijk op de boeg van een schip aangebracht, en hetzelfde geldt voor twee (van de vijf) dwergvinvissen. De andere soorten zijn gewone dolfijn (1), griend (1), witsnuitdolfijn (14), tuimelaar (6), bruinvis (4346), potvis (5) en gewone spitssnuitdolfijn (1). Alle individuele meldingen in dit verslag worden genoemd, ook losse beenderen, behalve die van bruinvis. Deze laatste was de talrijkste walvisachtige op onze kust: het aantal bruinvissen bedroeg 98,6% van het totale aantal meldingen. In de besproken periode zijn de hoogste aantallen bruinvissen gevonden, met pieken tot bijna 900 exemplaren in zowel 2011 als 2013. Er zijn er in de geschiedenis van

de walvisstrandingenregistratie nog nooit eerder zo veel gemeld, hoewel we ons dienen te realiseren dat dode bruinvissen pas vanaf de jaren 1970 goed zijn bijgehouden: in het begin van de twintigste eeuw werd de soort 'te talrijk' geacht voor registratie en spoelden dus misschien wel vergelijkbare aantallen aan. De meeste zijn gemeld uit het Waddengebied; naar het zuiden toe neemt de dichtheid geleidelijk af. Het strandingspatroon in deze periode komt overeen met dat tijdens de vorige in Lutra besproken periode, 2000-2007, met pieken in maart en augustus. In juli-oktober 2011 vond een 'massastranding' van bruinvissen plaats: het totaal van deze maanden was ongeveer drie maal hoger dan gebruikelijk. Landelijk gezien is er een licht overschot aan mannetjes (58,2%, *n*=2171) en dat geldt zowel voor juvenielen (64,4%, 191; leeftijd gebaseerd op lengte) als subadulten (61,2%, 1161), maar niet voor adulten (41,5 % mannetjes, 451). De meerderheid van de aangespoelde bruinvissen is subadult (100-120 cm; 62,9%). Pasgeboren bruinvissen ('neonates'; 15,6%) worden meer uit het noorden van het land gemeld, waar ook het hoogste aandeel vrouwtjes wordt gevonden (48,9%). Het aantal levend gestrande bruinvissen beschouwd over 2005-2014 bedraagt 160 individuen (2,9% van het totale aantal bruinvisstrandingen). Het aanspoelpatroon van levende bruinvissen lijkt sterk op dat van alle bruinvissen, maar de voorjaarspiek is twee keer hoger dan de piek in de nazomer, andersom dus dan voor alle strandingen. Ook spoelen er wat meer levende vrouwtjes aan (55,7%), met name in maart (68%). Zwangerschapsproblemen liggen echter niet voor de hand, want verreweg de meeste levend gestrande bruinvisvrouwtjes zijn subadult (88%). Door de jaren heen neemt het aandeel levend gestrande bruinvissen af. Het aandeel bijvangsten lijkt enorm te zijn gedaald sinds het onderzoek naar doodsoorzaken is gestart; dit is echter schijn, want de ernstig verscheurde bruinvissen, waarvan men eerder meende dat ze slachtoffer waren van bijvangst, blijken ten prooi te zijn gevallen aan grijze zeehonden; het aandeel bijvangst is daarmee gedaald van ongeveer 50% naar maximaal 20%. Andere belangrijke doodsoorzaken zijn infectie (11-35%) en vermagering (13-20%). Verhongering wordt vooral geconstateerd onder pas geboren jongen; vermoedelijk zijn die dan ook hun moeder kwijt geraakt.

Sinds 1980 is het gemiddelde aantal soorten walvissen per jaar gestegen, hoewel de toename niet significant is. In de discussie wordt het belang van goede documentatie (foto en/of verzamelen van skelet(delen)) van een gestrande walvis benadrukt. Registratie geeft een beeld van het huidige voorkomen, en van veranderingen daarin op de lange termijn. Bovendien is up-to-date-registratie een 'vinger aan de pols' van het mariene milieu. Zo is de plotselinge toename van de bruinvis in Nederland sinds de jaren 1980 nog altijd onverklaard, maar is het twijfelachtig of het een signaal is van een gezonde leefomgeving. Eveneens van belang is het onderhouden van het netwerk van vrijwilligers die strandingen melden, omdat zonder hen een goede registratie onmogelijk is. In totaal zijn in deze periode van 1086 personen of instanties meldingen ontvangen.

Received: 7 February 2016
Accepted: 22 November 2016



Tail defects in two Daubenton's bats (*Myotis daubentonii*)

John Mulder[1] & René Janssen[2]

[1] Holhorstweg 4, NL-7341AC Beemte Broekland, the Netherlands, e-mail: contact@ecologischadviesbureau.nl
[2] Valderstraat 39, NL-6171 EL Stein, the Netherlands

Abstract: Two Daubenton's bats (*Myotis daubentonii*) with tail defects were caught in mist-nets in front of the entrances of two neighbouring cellars at Klein Heidekamp, a military base which is part of the Oranjekazerne in Schaarsbergen, province of Gelderland, the Netherlands. The anomalies are described and the possible etiology of the malformations is discussed. In the first case an accident, predation or frostbite is proposed, for the second bat a congenital malformation is among the plausible causes.

Keywords: tail defects, teratology, malformation, Daubenton's bat, *Myotis daubentonii*.

Introduction

The hidden lifestyle of bats prevents large-scale, detailed, close-up examination. Animals available for detailed study, either as single specimens or in low numbers at most, may either be dead museum specimens or may have ended up in health care. Catching bats alive can enlarge these numbers. Mist-netting bats is used for several reasons and gives insight in, for example, species composition, relative species abundance and bats' reproductive cycle.

In the Netherlands a mixed group of professionals and volunteers active in bat research founded a system in order to regulate catching bats, a 'bat-catching system' ('Vleermuisvangsysteem', see: www.vleermuizenvangen.nl). Together these bat workers form a sounding board. A limited number of them participate as trainers and committee members. Members of this sounding board catch swarming bats on a yearly base just prior to the hibernation period at two particular cellars next to each other known to contain large numbers of bats in winter. In this short note we report on the tail defects that we found in two of the Daubenton's bats (*Myotis daubentonii*) caught at this location.

Even with mist-netting, relatively few bats are checked at close distance and consequently anomalies are rarely encountered and reported. We consider it important to notice and describe these tail defects to understand the natural variation and incidence of anomalies. The information could also be used in decisions to be made regarding the release of injured bats from health care.

Materials and methods

On the evening of 15 October 2016 bats were caught in front of the entrances of two cellars at the Oranjekazerne military base in Schaarsbergen, province of Gelderland, the Netherlands, also known as Klein Heidekamp (52°01'35.3" N, 005°53'39.2" E). Forty meters of hair nets (Solida, Germany) were put in position near the entrances of the two cellars. Additionally, a harp trap was placed in front of both doors, not totally blocking the way in or out.

Figure 1. Ventral side of bat number 1, showing a shortened tail with a knob-like thickening. *Photo: Frans Bosch.*

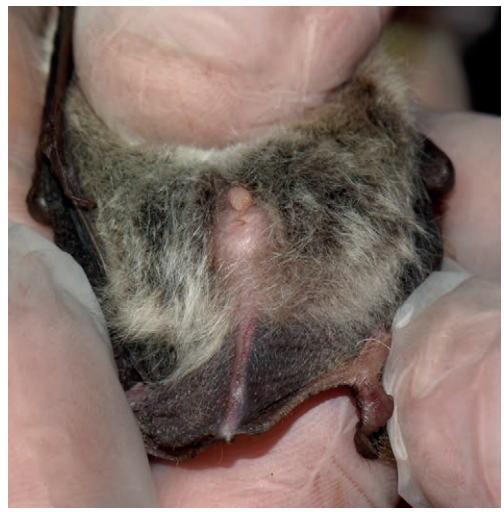


Figure 2. Ventral side of bat number 2. The tail of this bat was unusually short. *Photo: John Mulder.*

Figure 3. Dorsal side of bat number 2, showing the very short tail ending in a small 'curl'. *Photo: Jan Boshamer.*

Each bat caught was examined, i.e. its left forearm length and body mass were measured using a caliper and a spring balance. Sexual status (condition of nipples, testes and epididymides) was checked as described in Haarsma (2008).

All contributors had been vaccinated against rabies and trained and licensed to catch and handle bats. Bats were temporarily marked on the toenails using non-toxic nail polish to exclude recaptured individuals. Bat captures were carried out under license from the Dutch Ministry of Economic Affairs (permit FF/75A/2012/037a), and with the permission of the Oranjekazerne. Each bat was released within half an hour after its capture.

Results

We caught 49 individual bats, there were no recaptures. Among these bats there were 17 Daubenton's bats. While handling the bats we noticed tail defects in two of these Daubenton's bats. Hereafter we refer to these two individuals as bat number 1 and 2.

Bat number 1

The first animal, a male, showed a remarkable shortening of the tail. The tail vertebrae column missed several parts and ended in a knob-like thicker part, probably indicating a healed state after an inflammatory response. An estimated number of three vertebrae (of the usual ten) were still present. Stretching the uropatagium from feet to the remaining vertebra resulted in a upside down V-shape (figure 1). Only minor remnants of the calcars were seen near the ankles. The rim of the uropatagium showed slight irregularities. The left forearm length was 39.3 mm and the body mass was 12.6 g. The forearm length fitted well into the reported range for Daubenton's bat (Dietz & Kiefer 2015), while the bat's body mass was normal for the end of the season. Sexual condition characteristics (colour, filling and length of epididymides) showed that the bat had been sexually active during the past mating season. The chin spot suggested an age older than three years (Haarsma 2008).

Bat number 2

The second animal was also a male showing a short tail (figure 2). A smaller part of the tail seemed to be missing than in bat number 1. The overall view of the tail of this bat gave the impression of a proportionally shortened tail (figures 2 and 3). Both calcars were present and robustly built, but were connecting to a point more or less halfway the normal tail length (the end of the estimated fourth tail vertebra). The tail vertebrae column ended abruptly. A close-up view showed a small 'curl' on the dorsal side possibly presenting a vestigial tail tip (figure 3). The animal also showed a distorted orientation of the uropatagium with a massive wrinkle in the distal part at the right side. The forearm was remarkably short (left 34.8mm, right 35.1mm). This value is within the range reported for Daubenton's bat (33.1-42.0mm: Dietz & Kiefer 2015), but for the Dutch situation it is extremely low (A.-J. Haarsma, unpublished data).

Discussion

Bat tails are complex organs consisting of ten caudal vertebrae, the tail membrane or uropatagium, a pair of calcars and several structures forming a so-called venation pattern, a characteristic feature, which is thought to relate to a species' feeding strategy (Dokuchaev 2015). The tail is said to play a major role in the maneuverability of bats during flight (Vaughan 1959, 1970, Schmieder et al. 2014) and presumably also in feeding (Webster 1962).

Both caught bats seemed to be in good condition according to the amount of body fat, which was as much as can be expected for

Daubenton's bats prior to hibernation. The malformations did not seem to adversely affect their ability to fly or to take part in reproduction. The bats had just passed the peak of the male sexual cycle. Both had clearly been sexually active in the weeks prior to capture.

The aberration in bat number 1 obviously was an acquired state and the result of some amputation incident. The remaining tissue looked as if a rupture of the vertebrae along with the surrounding uropatagium had occurred. Possibly this was the result of the animal being stuck somewhere or flying across a thorn bush or barbed wire. The latter is known to cause extensive damage to wing membranes (Hinkel & Rackow 1994). Hooks belonging to fishing tackle left behind in the water could also be a serious threat to trawling bats.

One of the alternative explanations is predation by leopard slugs (*Limax maximus*). This ubiquitous, partly carnivorous slug can be found in moist subterranean places where bats hibernate, as well as in tree cavities were Daubenton's bats stay in summer. Bats in torpor may not be able to react in time on an attack by this predator. We suspect gnawing by leopard slugs to be one of the main causes of missing parts of the outer ears we regularly see in bats.

Frostbite has to be taken into consideration as a cause of the missing part of the tail too, although the ears are probably more sensitive to frostbite. Both bats had flawless ears.

In the past a high predation rate caused by wood mice (*Apodemus sylvaticus*) has been observed in subterranean hibernation sites (Haarsma & Kaal 2016) and also in the cellars of the study site, but wood mice attacks often seem to result in the death and almost total predation of their victims. Apart from wood mice, greater white-toothed shrews (*Crocidura russula*) are suspected of causing casualties among bats. Nowadays wood mice and other small mammals do not have free entrance to these cellars due to precautions taken some years ago.

Even small injuries can cause severe tissue loss due to inflammation. In bats this seems to be restricted by higher body temperatures (febrile situation) caused by a high metabolism rate during flight (O'Shea 2014).

Also worth bearing in mind are the possible effects of White-nose syndrome, a fungal disease which can have profound implications like scarring and necrosis on the wing membrane in the little brown bat (*Myotis lucifugus*) in North America (Reichard & Kunz 2009) and which may have lasting consequences for flight (Voigt 2013).

As for now the etiology of this defect in bat number 1 cannot be reconstructed, but extra attention is recommended to document and publish any future incident with for instance barbed wire, slugs, frostbite or mice.

For bat number 2 a congenital malformation seems to be a more logical explanation, though an acquired anomaly cannot be ruled out. Some sort of developmental disorder may have caused the long limb bones to reach a shorter length than normal and the distal part of the tail to be malformed. Also in this bat we can only guess for its etiology. Both prenatal exposure to teratogenic chemicals and inbreeding are known to be able to cause congenital deformations (Kunz & Chase 1983).

Tail defects in bats are very rarely reported. Constantine (1958) mentioned some deformations in two seminole bats (*Lasiurus seminolus*). Mitchell & Smith (1966) reported only two tail anomalies found in 150,000 banded Mexican free-tailed bats (*Tadarida brasiliensis*). Those defects were clearly different from the ones described here. The incidence of, especially congenital, anomalies is, however, much higher when immature bats prior to weaning age are included (Kunz & Chase 1983), due to the detrimental effect on survival of the more severe anomalies.

Several European researchers known to have caught a lot of *Myotis* species were inquired about their experiences. Summer mist-net captures above water in the Netherlands between 2008 en 2011 resulted in a

total of 715 Daubenton's bats (A.-J. Haarsma, unpublished results). A total of 572 of these bats were checked and described in detail. During this research one Daubenton's bat was found with a broken, dislocated tail curling in a dorsal direction, much like the cases in Mitchell & Smith (1966); two other bats showed inflammation of a tail joint. None of those Daubenton's bats had injuries resembling the ones in this study, which indicates a low incidence (A.-J. Haarsma, personal communication). In Germany several Natterer's bats (*Myotis nattereri*), a species with a gleaning feeding strategy, were found with lost tail membranes (C. Dietz, personal communication). One Geoffroy's bat (*Myotis emarginatus*) caught during the swarming period in the Netherlands had lost a part of the tail membrane and even some tail vertebrae, but the calcars were still present (J. van Schaik, personal communication). In England, several, mainly unilaterally, injured bat tails were seen in for instance three (among 793) long-eared bats (*Plecotus auritus*), at least one (among 991) Natterer's bat (*Myotis nattereri*) and eleven (among 2276) Daubenton's bats. In just two cases, of a Daubenton's bat and a long-eared bat, the injury resembled that of bat number 1. The Daubenton's bat was recaptured after three years and the long-eared bat after one year at which moment it was lactating (D. Linton, personal communication).

Given the low incidence of bats lacking both calcars and most of the uropatagium this can be seen as a rare state. Though only anecdotal information is available, such animals seem to handle their handicap surprisingly well. Bats in health care can, even if missing a major part of their tail, be released without problems after healing of the wounds.

Acknowledgements: Personnel in charge of the Oranjekazerne are thanked for the permission to enter the military base by night. Thanks also to Douwe van der Ploeg, Jan Boshamer, Frans Bosch, Rob Koelman, Ruud Kaal, Thijs Bosch and Thijs Molenaar for their help in catching the bats. We are grateful to Christian Dietz, Jaap van Schaik, Danielle Linton and Anne-Jifke Haarsma for additional information about their catches. Frans Bosch and Jan Boshamer are thanked for giving us permission to use their photo's in this paper. Finally we thank Daan Dekeukeleire and two anonymous reviewers for helpful comments on an earlier draft of the manuscript.

References

Constantine, D.G. 1958. Ecological observations on lasiurine bats in Georgia. Journal of Mammology 39: 64-70. DOI: http://dx.doi.org/10.2307/1376610.

Dietz, C. & A. Kiefer 2016. Bats of Britain and Europe. Bloomsbury Publishing, London, UK.

Dokuchaev, N.E. 2015.Uropatagium venation pattern in bats as diagnostic character (by the example of genus *Myotis*). Russian Journal of Theriology 14 (2): 129-132.

Haarsma, A.-J. 2008. Manual for assessment of reproductive status, age and health in European Vespertilionid bats. Electronic publication. Version 1. URL: http://www.vleermuis.net/publicatie-lijst/handleiding-vleermuisonderzoek/197-manual-for-assessment-of-reproductive-status-age-and-health-in-european-vespertilionid-bats/file; viewed 24 October 2016.

Haarsma, A.-J. & R. Kaal 2016. Predation of wood mice (*Apodemus sylvaticus*) on hibernating bats. Population Ecology 58 (4): 567-576. DOI: 10.1007/s10144-016-0557-y.

Hinkel, A. & W. Rackow 1994. Unfälle von Fledermäusen auf Kletten, Kakteen oder Stacheldraht. Nyctalus (N.F.) 5 (1): 3-10.

Kunz, T.H. & J. Chase 1983. Osteological and ocular anomalies in juvenile big brown bats (*Eptesicus fuscus*). Canadian Journal of Zoology 61 (2): 365-369.

Mitchell, H.A. & C.D. Smith 1966. Anomalous tails in *Tadarida brasiliensis*. Journal of Mammology 47 (1): 148-149. DOI: http://dx.doi.org/10.2307/1378101.

Reichard, J.D. & T. Kunz 2009. White-Nose Syndrome inflicts lasting injuries to the wings of little brown myotis (*Myotis lucifugus*). Acta Chiropterologica 11 (2): 457-464. DOI: http://dx.doi.org/10.3161/150811009X485684.

O'Shea, T.J., P.M. Cryan, A.A. Cunningham, A.R.

Fooks, D.T.S. Hayman, A.D. Luis, A.J. Peel, R.K. Plowright & J.L.N. Wood 2014. Bat Flight and Zoonotic Virusses. Emerging Infectious Diseases 20 (5): 741-745. DOI: http://dx.doi.org/10.3201/eid2005.130539.

Schmieder, D.A., S. Szebök & B.M. Siemers 2014. The tail plays a major role in the differing manoeuvrability of two sibling species of mouse-eared bats (*Myotis myotis* and *Myotis blythii*). Canadian Journal of Zoology 92 (11): 965-977.

van Schaik, J., R. Janssen, T. Bosch, A.-J. Haarsma, J.J.A. Dekker & B. Kranstauber (2015). Bats swarm where they hibernate: compositional similarity between autumn swarming and winter hibernation assemblages at five underground sites. PLoS ONE 10 (7): e0130850. DOI: 10.1371/journal.pone.0130850.

Vaughan, T. A. 1959. Functional morphology of three bats: *Eumops*, *Myotis*, *Macrotus*. University of Kansas Publications, Museum of Natural History 12: 1-153.

Vaughan, T. A. 1970. Flight patterns and aerodynamics. In: W. A. Wimsatt (ed.). Biology of bats. Vol. 1: 195-216. Academic Press, New York, USA.

Voigt, C.C. 2013. Bat flight with bad wings: Is flight metabolism affected by damaged wings? Journal of Experimental Biology 216: 1516-1521. DOI: 10.1242/jeb.079509.

Webster, F.A. & D.R. Griffin 1962. The role of the flight membrane in insect capture. Animal Behaviour 10: 332-340.

Samenvatting

Staartdefecten bij twee watervleermuizen (*Myotis daubentonii*)

Twee watervleermuizen (*Myotis daubentonii*) met staartdefecten werden met mistnetten gevangen voor de ingang van twee bunkers in Klein Heidekamp (Oranjekazerne, Schaarsbergen) tijdens een vangavond door mensen uit de klankbordgroep van het Vleermuisvangsysteem. De afwijkingen worden beschreven en mogelijke oorzaken worden opgesomd. In het eerste geval kan zowel een ongeluk (met bijvoorbeeld prikkeldraad) alsook predatie door muizen of tijgerslakken (*Limax maximus*) of bevriezing de reden van het staartdefect zijn geweest. In het tweede geval wordt een aangeboren afwijking als plausibel verondersteld.

Received: 31 October 2016
Accepted: 23 November 2016

Diurnal activity of juvenile Russian flying squirrels recorded by camera trapping

Kei K. Suzuki[1 *], Tatsuki Shimamoto[1, 2], Ryuji G. Furukawa[2] & Hisashi Yanagawa[1, 2]

[1] The United Graduate School of Agricultural Sciences, Iwate University, Iwate, Japan,
e-mail: pteromysuzuki@affrc.go.jp
[2] Laboratory of Wildlife Ecology, Obihiro University of Agriculture and Veterinary Medicine, Hokkaido, Japan

Abstract: We describe the diurnal behaviour in juvenile Russian flying squirrels (*Pteromys volans*) revealed by camera trapping. Photographs showed that juvenile Russian flying squirrels of up to approximately 30 days old are only active in daytime and often peeped out of the breeding cavity. In addition, juveniles of approximately 40 to 45 days old showed a cathemeral activity pattern: they investigated the immediate surroundings of their breeding cavity in both daytime and night-time. In contrast, older juveniles showed only nocturnal activities. These observations show for the first time that juveniles of wild Russian flying squirrels are active in the daytime when growing up, while gradually shifting to an exclusively nocturnal activity pattern when getting older. Meanwhile we emphasise that our observations concern only one litter.

Keywords: activity pattern, juvenile, rodent, Russian flying squirrel.

Introduction

As Jackson (2012) states, all species of flying squirrels are believed to be nocturnal. However, such information is usually based on adult-biased observations (e.g. Decousey 1961, Baba et al. 1982). In contrast, little is known about the behaviour and activity of juvenile gliding mammals, because finding their breeding-nest is difficult.

Among flying squirrel species, the behavioural and activity patterns of the Russian flying squirrels (*Pteromys volans*) are well known. Adult Russian flying squirrels are mainly active between sunset and sunrise (Airapetyants & Fokin 2003), and leave their nests approximately half an hour after sunset (Yamaguchi & Yanagawa 1999). At night-time, they glide between trees (Suzuki et al. 2012) and forage in canopy areas (Asari et al. 2008), mainly feeding on leaves, buds, and catkins of a variety of tree species (Hanski et al. 2000a). During the daytime, they usually rest in tree cavities (Hanski et al. 2000b, Suzuki et al. 2013).

When Russian flying squirrels were kept in captivity pre-weaned juveniles peeped out of the entrance of their nests at the age of approximately 30 days onwards and investigated the area around the nest cavity when they were 40–45 days old (Airapetyants & Fokin 2003). However, more detailed studies of the behaviour and activity patterns of free-ranging juveniles are still lacking. To get more insight in these aspects we first of all need simple observations of juveniles in their natural habitat. For this purpose we located a breeding nest of Russian flying squirrels and succeeded in

* Present address: Seikai National Fisheries Research Institute, Japan Fisheries Research and Education Agency, Nagasaki, Japan

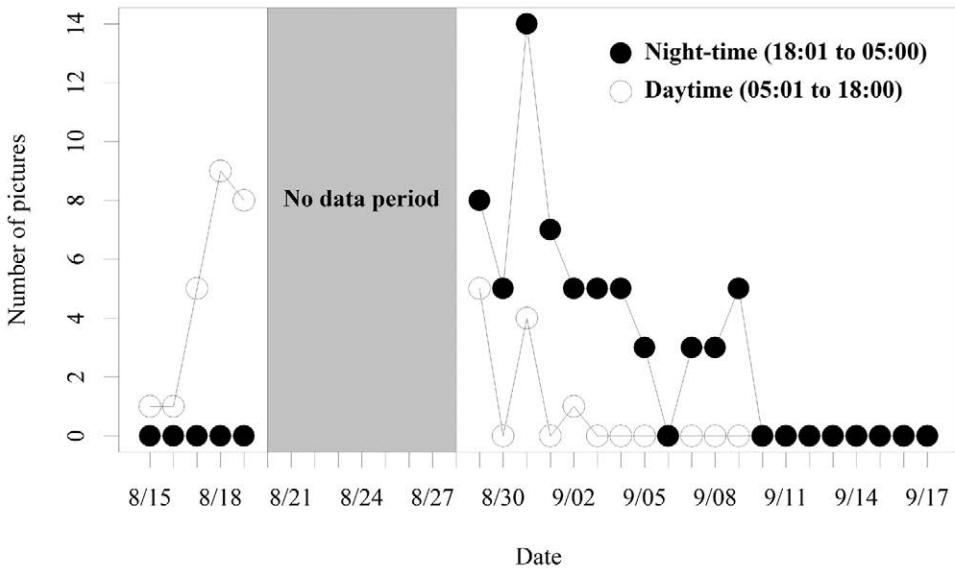


Figure 1. Number of juvenile Siberian flying squirrel pictures per calendar day in the daytime and the night-time during the study period.

photographing juvenile behaviours using a camera trap directed at the nest entrance. Here, we describe the juvenile behaviour and their activity patterns, and we evaluate these aspects concerning their ecological impact.

Methods

The Russian flying squirrel inhabits a large area, ranging from the Baltic Sea in the west (i.e. in Europe only in Finland), via Siberia, Mongolia, northern China and Korea to Hokkaido Island (Japan) in the east (Oshida 2009).

One cavity with a litter of the Russian flying squirrel was found in the trunk of a Japanese larch (*Larix kaempferi*) with the use of a CCD [charge-coupled device] camera (SNAKE-09, Kenko, Tokyo, Japan) on 15 August 2013. The larch stands in a windbreak forest (42°51′33″ N, 143°09′32″ E) in Obihiro City on Hokkaido Island, northern Japan. The entrance height of the cavity was approximately 2.6 m above the ground. At that time, the juveniles in the nest already had body hair.

For photographing the juveniles we used an automatic camera equipped with an infra-red motion sensor (SG565F, HCO Georgia, USA). The delay between pictures was set to five minutes. The time lag between animal detection by the sensor and the actual image was approximately 1.2 seconds. We placed the camera 1.5 m away from the nest, directed at the cavity at 2.6 meter height. Pictures were taken from 15 August to 17 September 2013 and the set-up continued to work all day through almost the whole study period. We changed the memory cards of the camera at noon on 20 August and 28 August. However, due to a memory card failure, there was a data gap from 20 August afternoon to noon August 28.

We counted the number of pictures taken during each hour as an indicator for the level of activity of the juvenile flying squirrels. The period from 5:01 to 18:00 was defined as daytime based on sunrise (approximately 5:00) and sunset (18:00) (Japan Coast Guard 2015).

Results

The camera trap photographed both juvenile

Figure 2. Pictures of juvenile Siberian flying squirrels during daytime (A and B) and night-time (C). Large adult flying squirrels were clearly visible during the night-time hours (D).

and adult flying squirrels. The adult flying squirrel(s) were clearly larger than the juveniles, but whether the photographed specimens represented only a single individual, i.e. the mother of the juveniles, could not be established. The juveniles were photographed only in the daytime from August 15 to 19 and during both day and night from 29 August to 2 September 2 (figure 1). Thereafter, the juveniles were photographed at night-time only, from 3 to 9 September (figure 1).

During the exclusive daytime activity period (15 to 19 August), the juvenile flying squirrels often peeped out of the cavity (figure 2A). The juveniles showing such behaviour were estimated to be approximately 30 days old based on similar behaviour of captive juveniles (Airapetyants & Fokin 2003). According to the number of pictures per hour, wild juvenile squirrels showed bimodal activity peaks around 9:00 and 17:00 (figure 3A).

From 29 August to 2 September, a maximum of three juveniles was simultaneously detected on the branches and the tree trunk within one metre from the cavity (figure 2B). We estimate from similar behaviour in captive juveniles (Airapetyants & Fokin 2003), that these wild juveniles investigating the immediate surroundings around the cavity were approximately 40 to 45 days old. In this period, juveniles showed a cathemeral activity pattern* (figures 3B and 2C), with a higher

* The activity of an organism may be regarded as cathemeral when it is distributed approximately evenly throughout the 24 h of the daily cycle, or when significant amounts of activity, particularly feeding and/or traveling, occur within both the light and dark portions of that cycle.

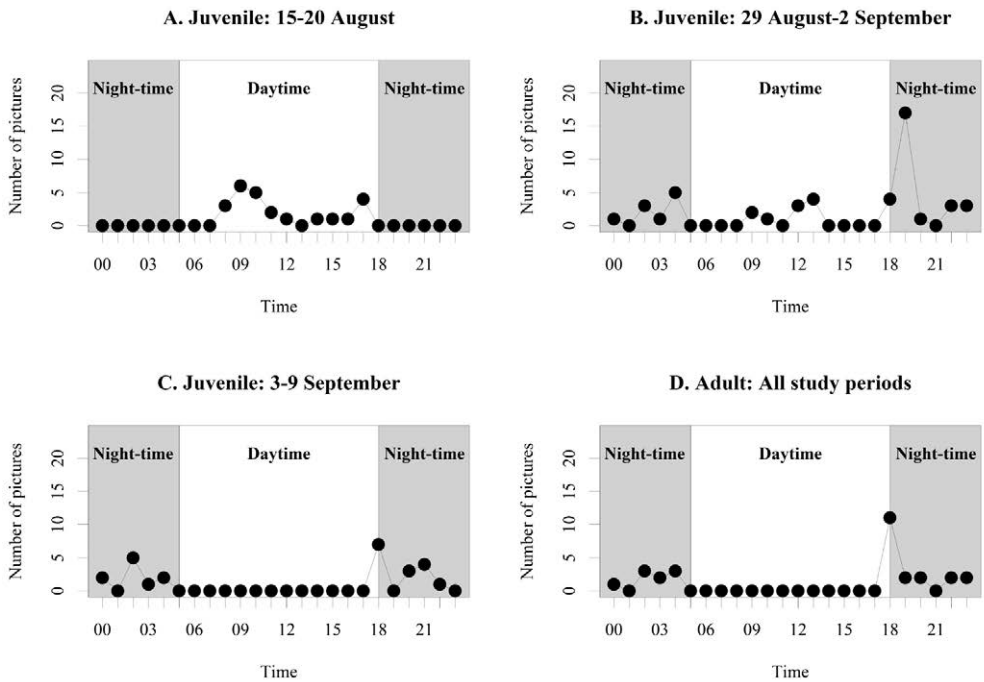


Figure 3. Number of pictures of juvenile (A to C) and adult (D) flying squirrels per hour as an indicator for activity.

night-time activity (10 photographs during the day and 39 times during the night). In the same period, juveniles showed trimodal activity peaks around 3:00, 12:00, and 19:00 (figure 3B).

From 3 to 9 September, juveniles were photographed 24 times, but only during night-time. They displayed then bimodal activity peaks around 2:00 respectively from 18:00 to 21:00 (figure 3C). This pattern is rather similar to the one of adult Russian flying squirrels photographed on the same tree trunk (figure 2D). The investigated adult flying squirrels had nocturnal bimodal activity peaks, from 2:00 to 4:00 and at approximately 18:00, throughout the entire study period (figure 3D).

Discussion and conclusions

Previously, there was only fragmented information on Russian flying squirrels' diurnal activities, such as chases in mating season (Hanski et al. 2000a) and outdoor activities of a nursing female and its young (Tormala et al. 1980). In addition, Airapetyants & Fokin (2003) mention that the flying squirrels leave their nest cavity in March and that they are equally active in day- and night-time during the short-night period, i.e. when the dark period duration is less than six hours. In contrast, this study demonstrates that juveniles can show some activity in the daytime and appear to stop doing this when getting older (figure 1). Meanwhile we emphasise that our observations concern only one litter, so the presence of this behaviour in general including its significance has still to be established.

All species of flying squirrels have been considered as nocturnal (Jackson 2012) and one of the explanations for this behaviour is a reduction of predation risks by diurnal predators (Lindenmayer 2002). Raptors, especially the Ural owl (*Strix uralensis*), eagle owl (*Bubo bubo*), and goshawk (*Accipiter gentilis*,), the main predators of Russian flying squir-

Russian flying squirrel (*Pteromys volans*). *Photo: Kei K. Suzuki.*

rels (Selonen et al. 2010), usually attack gliding mammals in the air (Lindenmayer 2002). Because juvenile Russian flying squirrels show gliding behaviour after being approximately 50 days old (Airapetyants & Fokin 2003), juveniles with an age of 30–45 days may still be unable to glide. In addition, juveniles of that age (30–45 days old) usually limit their activities in and/or around the breeding cavity (Airapetyants & Fokin 2003). Thus, they can quickly hide in the cavity when they face predators and are hence less prone to predation. In conclusion, because non-gliding juveniles seem relatively safe staying around the nest cavity compared with adults gliding between trees, juveniles do not need to limit their activity to night-time to avoid diurnal predators. Juvenile flying squirrels with an estimated age of 30 to 45 days and diurnal activities are still breast feeded (Airapetyants & Fokin 2003). It is possible that the juveniles' diurnal activities are limited to the time when they can access their mother's milk when she is resting in the cavity during the day.

Previously, diurnal and cathemeral activity patterns of flying squirrel species remained unnoticed because, so far, their activity patterns were usually investigated by direct observations in the night (Baba et al. 1982, Yamaguchi & Yanagawa 1999). In contrast, by using 24-hour camera surveillance, we were able to show that juvenile Russian flying squirrels have diurnal activity. Because our sample size was rather limited, we hope that future investigations will further improve our knowledge of the circadian activity pattern in juvenile Russian flying squirrels. Their nesting cavities can be easily detected by collecting their feces at the foot of the cavity trees (Suzuki et al. 2011). In addition, the possibility of pregnancy can be predicted by measuring fecal progesterone (Shimamoto et al. 2015). Thus, breeding cavities of flying squirrels may be found by the combination of these two methods. Further investigations with camera traps will yield more data and will enable us to get more insight in the activity patterns of the Russian flying squirrel.

Acknowledgements: We particularly thank Dr. I. Schön at the Royal Belgian Institute of Natural Sciences for English proofreading and constructive comments on earlier drafts of the paper. We are grateful to Dr. T. Oshida at Obihiro University of Agriculture and Veterinary Medicine for helpful comments concerning this study. We particularly thank the anonymous reviewers for the constructive comments on this paper.

References

Airapetyants, A.E. & I.M. Fokin 2003. Biology of European flying squirrel *Pteromys volans* L. (Rodentia: Pteromyidae) in the North-West of Russia. Russian Journal of Theriology 2: 105–113.

Asari, Y., Y. Yamaguchi & H. Yamagawa 2008. Field observations of the food items of the Siberian flying squirrel, *Pteromys volans orii*. Journal of the Japanese Wildlife Research Society 33: 7–11 (In Japanese with English abstract).

Baba, M., T. Doi & Y. Ono 1982. Home range utilization and nocturnal activity of the giant flying squirrel, *Petaurista leucogenys*. Japanese Journal of Ecology 32: 189–198.

Decousey, P.J. 1961. Effect of light on the circadian activity rhythm of the flying squirrel, *Glaucomys volans*. Zeitschrift für vergleichende Physiologie 44: 331–354.

Hanski, I.K., M. Mönkkönen, P. Reunanen & P. Stevens 2000a. Ecology of the Eurasian flying squirrel (*Pteromys volans*) in Finland. In: R. Goldingay & J. Scheibe (eds). Biology of gliding mammals: 67–86. Filander Verlag, Furth, Germany.

Hanski, I.K., P.C. Stevens, P. Ihalempiä & V. Selonen 2000b. Home-range size, movements, and nest-site use in the Siberian flying squirrel, *Pteromys volans*. Journal of Mammalogy 81: 798–809.

Jackson, S. 2012. Gliding mammals of the world. Csiro publishing, Collingwood, Australia.

Japan Coast Guard 2015. Calculate service for sunrise and sunset. Japan Coast Guard, Tokyo, Japan. URL: http://www1.kaiho.mlit.go.jp/KOHO/automail/sun_form3.html; viewed 29 August 2016. (In Japanese).

Lindenmayer, D. 2002. Gliders of Australia: A Natural History. University of New South Wales Press, New South Wales, Australia.

Oshida, T. 2009. Rodentia Sciuridae *Pteromys volans* (Linnaeus, 1758). In: S.D. Odachi, Y. Ishibashi, M.A. Iwasa, D. Fukui & T. Saitoh (eds.). The Wild Mammals of Japan: 196–197. Second edition. Shoukath, Kyoto, Japan.

Selonen, V., P. Sulkava, R. Sulkava, S. Sulkava & E. Korpimäki 2010. Decline of flying and red squirrels in boreal forests revealed by long-term diet analyses of avian predators. Animal Conservation 13: 579–585.

Shimamoto, T., K. Suzuki, R. Furukawa, M. Hamada, M. Tetsuka & H. Yanagawa 2015. Validation of fecal progesterone analysis for predicting pregnancy in Siberian flying squirrels (*Pteromys volans*). Japanese Journal of Zoo and Wildlife Medicine 20: 63–70.

Suzuki, K., S. Mori & H. Yanagawa 2011. Detecting nesting trees of Siberian flying squirrels (*Pteromys volans*) using their feces. Mammal Study 36: 105–108.

Suzuki, K., Y. Asari & H. Yanagawa 2012. Gliding locomotion of Siberian flying squirrels in low-canopy forests: the role of energy-inefficient short-distance glides. Acta Theriologica 57: 131–135.

Suzuki, K., M. Sagawa & H. Yanagawa 2013. Nest cavity selection by the Siberian flying squirrel *Pteromys volans*. Hystrix 24: 187–189.

Tormala, T., Vuorinen, H. & H. Hokkanen 1980. Timing of the Circadian Activity of the Flying Squirrel in Central Finland. Acta Theriologica 25: 461–474.

Yamaguchi, Y. & H. Yanagawa 1999. Field observations on circadian activities of the flying squirrel, *Pteromys volans orii*. Mammalian Science 34: 139–149 (in Japanese).

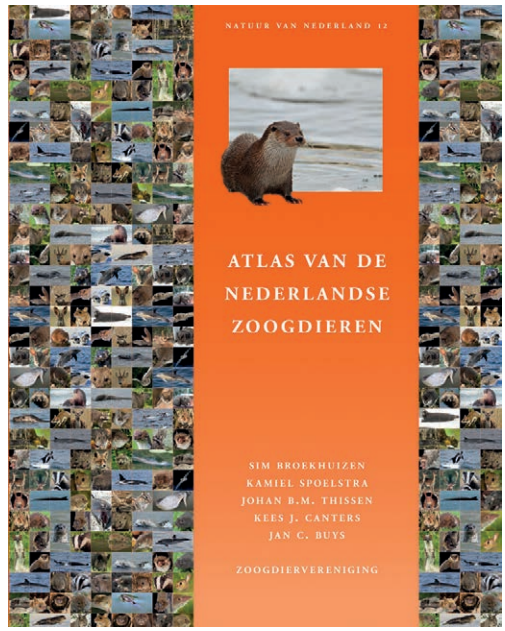
Samenvatting

Jonge vliegende eekhoorns zijn overdag actief

Aan de hand van beelden verzameld met een cameraval beschrijven wij het activiteitsritme van (wilde) jonge vliegende eekhoorns binnen en buiten de nestholte. De beelden laten zien dat halfwas jongen tot ongeveer 30 dagen oud alleen overdag naar buiten kwamen. Jongen van ca. 40-45 dagen oud bleken zowel overdag als 's nachts actief, terwijl oudere jongen tenslotte alleen nachtelijke activiteit vertoonden. Hiermee is voor het eerst aangetoond dat juveniele vliegende eekhoorns op jonge leeftijd overdag actief zijn. We benadrukken dat deze waarnemingen gebaseerd zijn op de gegevens verzameld bij slechts één nest.

Received: 11 April 2016
Accepted: 5 July 2016

De derde atlas van de Nederlandse zoogdieren – een nieuwe mijlpaal in de zoogdierkundige geschiedenis



Atlas van de Nederlandse zoogdieren. S. Broekhuizen, K. Spoelstra, J.B.M. Thissen, K.J. Canters & J.C. Buys (red.) 2016. Zoogdieren van Nederland 12. Naturalis Biodiversity Center & EIS Kenniscentrum Insecten en andere ongewervelden, Leiden, Nederland. 432 blz. ISBN 978-90-5011-534-6.

Internationale koploper

Eindelijk is het zover. De nieuwe "Atlas van de Nederlandse zoogdieren" is uit. Het is een prachtig boekwerk boordevol informatie geworden. Bij elkaar 18.000 personen (zij die minstens tien waarnemingen instuurden – zo'n 4.100 mensen – staan achter in het boekwerk met naam vermeld!) hebben jarenlang hun waarnemingen genoteerd en ingeleverd en zodoende hun steentje bijgedragen. De publicatiedatum werd verschillende malen opgeschort, maar in het voorjaar van 2016 kwam dit lijvige boekwerk (432 blz.) vers van de pers en werd op 23 april jl. te Nijmegen, gepresenteerd, op de jaarlijkse Zoogdierdag van de Zoogdiervereniging. Het ongeduld bij velen is begrijpelijk, maar het blijft toch een hele prestatie om alle informatie (1,3 miljoen waarnemingen verdeeld over 106 verschillende zoogdiersoorten!) te verwerken en alle 60 auteurs in het gelid te krijgen. Bij onze buurlanden, Duitsland, België en Groot-Brittannië, maar ook tal van andere (Europese) landen ontbreekt zo'n nationaal overzicht. En dan te bedenken dat deze atlas al de derde nationale zoogdieratlas is! Mogelijk is Nederland hiermee zelfs koploper wereldwijd.

In het licht van het beschikbare aantal waarnemers, de kleine oppervlakte en de goede infrastructuur (lees: een fijnmazig wegen- en padennet) is dit eigenlijk niet verwonderlijk. Bovendien zijn we niet belemmerd door sterke bestuurlijke deelstructuren die het aanpakken van zo'n nationale klus in de weg staan. Maar toch, zelfs als we corrigeren voor de hoge bevolkingsdichtheid en atlassen van kleinere gebieden meerekenen, spant Nederland met haar derde zoogdieratlas, op zijn minst in Europa, de kroon (zie tabel 1, voor een onvolledige, maar desalniettemin een representatieve vergelijking). Daar komt nog bij dat er in Nederland voorafgaand aan deze atlas ook nog een flink aantal provinciale zoogdieratlassen is geproduceerd.

De atlas is deel 12 van de serie "Natuur van Nederland", die door Naturalis Biodiversity Center en EIS Kenniscentrum voor Insecten en

Tabel 1. Vergelijking van verschillende recente Europese atlassen. Zie literatuurlijst voor de informatiebronnen.

	Nederland	Vlaanderen	Denemarken	Sleeswijk-Holstein	Baden-Württemberg	Saksen-Anhalt	Oostenrijk	Zwitserland
Landoppervlakte (km²)	41.850	13.682	43.094	15.761	35.751	20.447	83.871	41.284
Bron	Anonymus 2016a	Anonymus 2015a	Anonymus 2016a	Anonymus 2014	Anonymus 2013	Anonymus 2007	Anonymus 2016a	Anonymus 2016a
Bevolkingsdichtheid (inw/km²)	408	554	130	178	294	110	103	196.7
Inwoners	16.950.000	7.650.000	5.580.000	2.830.000	10.630.000	2.245.000	8.665.000	8.100.000
Bron	Anonymus 2016d	Anonymus 2015a	Anonymus 2015b	Anonymus 2014	Anonymus 2013	Anonymus 2007	Anonymus 2015c	Anonymus 2015d
Atlas	Broekhuizen et al. 2016	Verkem et al. 2003	Baagøe & Secher Jensen 2007	Borkenhagen 2011	Braun & Dieterlen 2005	Hauer et al. 2009	Spitzenberger 2001	Hausser 1995
Aantal waarnemers	18.000	1.500	386	?	> 1.000	950	650	?
Aantal waarnemingen	1.280.000	70.000	56.000	> 500.000	110.000	167.000	100.000	?
Aantal zoogdiersoorten	106	94	88	100	78	76	105	87
Aantal soortauteurs	60	21	22	1	33	22	2 (5)	53
Atlasperiode	1988-2012	1987-2002	Verschillend per soortgroep	1990-2010	1990-1998	1990-2009	1970-1999	tot 1995?
Jaar van publicatie	2016	2003	2007	2011	2005	2009	2001	1995
Tijdvenster (in jaren)	22	15	31	20	8	20	22	geen
Rastergrootte	5 x 5 km	5 x 5 km	10 x 10 km	5,5 x 6 km	5,5 x 6 km	5,5 x 6 km	5,5 x 6 km	1 x 1 km

andere ongewervelden, beide in Leiden gevestigd, wordt uitgegeven. Deze samenwerking betekent waarschijnlijk ook dat de redactie van de atlas niet de vrije hand heeft gehad bij het kiezen van inhoud en vorm. Deze beperking moet men in gedachten houden bij het lezen van deze recensie. Nieuw – voor nationale zoogdieratlassen – is dat een hele reeks van instellingen, bedrijven, maar vooral ook privépersonen de productie van de atlas financieel hebben gesteund. Hun namen worden achterin het boek genoemd, òf voor de hele atlas òf voor de "adoptie" van een specifieke soort. Op deze slimme manier kon de atlas, ondanks het wegvallen van overheidssteun, toch worden uitgegeven.

De auteurs

De redactie van de atlas bestaat zowel uit oudgedienden (Sim Broekhuizen, Johan Thissen en Kees Canters) die hun sporen hebben verdiend – de beide eersten onder meer bij de productie van de tweede atlas (Broekhuizen et al. 1992) -, als uit de middelste generatie die vandaag met beide voeten stevig in het hedendaagse zoogdierenonderzoek staat (Kamiel Spoelstra en Jan Buys). Deze spreiding in leeftijd en ervaring wordt nog duidelijker bij de soortauteurs, waaronder ook de jongste generatie goed is vertegenwoordigd: van twintiger tot tachtiger, van gedreven en veelal uiterst capabele vrijwilliger tot beroepsbioloog. De Zoogdiervereni-

ging (voorheen de Vereniging voor Zoogdierkunde en Zoogdierbescherming) is door de jaren heen door tal van activiteiten, zoals de verschillende werkgroepen, themadagen, kampen, cursussen en tijdschriften een belangrijke stimulus, leermeester en bindende factor voor al deze zoogdierkundigen geweest en samen mogen alle leden en oud-leden trots zijn op wat er nu weer is bereikt.

Inleidende hoofdstukken

De soortbesprekingen van de atlas worden voorafgegaan door inleidende en verklarende hoofdstukken. Zo wordt de naamlijst en de volgorde van de behandelde zoogdiersoorten met zowel Nederlandse als wetenschappelijke namen verantwoord.

Het hoofdstuk "Zoogdieren en mensen" is geschreven door Jelle Reumer. Reumer, voormalig directeur van het Natuurhistorisch Museum Rotterdam en tegenwoordig als hoogleraar paleontologie van vertebraten verbonden aan de Universiteit Utrecht, was tot voor kort bij de lezers van het tijdschrift "Zoogdier" vooral bekend als vaste columnist over prehistorische zoogdieren. Hij presenteert ons zijn kritische, zo niet filosofische kijk op de veranderende relatie tussen Nederlanders en de al dan niet gedomesticeerde of geïntroduceerde zoogdiersoorten. Zoals we van hem gewend zijn, is deze tekst zowel informatief als ook vermakelijk. Terecht wijst Reumer erop dat de mens als alom aanwezige en biotoopbepalende zoogdiersoort vrijwel ontbreekt in de atlas. Een kaart met de bevolkingsconcentraties, inclusief wegennet en grondgebruik zou goed verklarend kunnen werken voor het wel of niet voorkomen van verschillende zoogdiersoorten en bijvoorbeeld het gebrek aan waarnemingen in minder toegankelijke gebieden verklaren.

Het volgende hoofdstuk draagt de titel "Zoogdieren in een veranderend landschap". Hier wordt eerst in grote pennenstreken de verandering van het landschap vanaf de vroege middeleeuwen tot 1950 behandeld. De voorafgaande tijdsperiode die begint met het einde van de laatste ijstijd wordt helaas overgeslagen. Dit gebrek wordt enigszins gecompenseerd door de alinea "Prehistorie" in de soortbeschrijvingen verderop in de atlas, maar juist de samenstelling en de dynamiek van de zoogdierfauna in het hevige veranderende Nederlandse landschap is boeiend en had breed in dit hoofdstuk kunnen worden uitgemeten. De atlassen van Denemarken (Baagøe & Jensen 2007), Sleeswijk-Holstein (Borkenhagen 2011), Saksen-Anhalt (Hauer et al. 2009), Oostenrijk (Spitzenberger 2001), maar ook die van Noord-Holland (Hoogeboom et al. 2014) laten zien hoe dit aspect vorm en inhoud had kunnen krijgen. Ook de genetica, en dan met name de steeds verder verfijnde DNA-technieken, heeft de laatste twee decennia voor tal van soorten heel wat verduidelijkt over de rekolonisatie van Europa na de laatste ijstijd. Ook dit had hier mooi verwerkt kunnen worden. Verder wordt de verandering van de verschillende landschapstypes sinds 1950 behandeld.

Goed is dat het continentale plat, de stad (de bevolking van Nederland is vanaf 1500 van 1 miljoen mensen tot bijna 17 miljoen mensen in 2014 gegroeid!) en het transportlandschap (Nederland is bijzonder rijk aan infrastructuur, denk maar aan al die sloten, dijken en wegen) als aparte landschapstypen worden behandeld.

Ik mis informatie over de goed gedocumenteerde kolonisatie van de nieuwe polders – zoals de Flevopolders. Dit zijn – ook op wereldschaal – unieke processen, die heel wat vertellen over de manier waarop en de snelheid waarin verschillende zoogdieren nieuwe gebieden kunnen koloniseren.

De factoren die mogelijk van invloed zijn op de verspreiding van zoogdieren als vermesting, organische stoffen, zware metalen, licht, lawaai en het veranderende klimaat komen ook aan bod. Wel mis ik een sectie over de zure regen die in de jaren ´80 van de vorige eeuw volop in de belangstelling stond. Wat deed dit met onze zoogdieren en de biotoop waarin ze leefden?

De aan tijd onderhevige houding van de samenleving op verschillende soorten zoogdieren, inclusief de kijk op nieuwe zoogdiersoorten, wordt ook hier behandeld. Bij dit laatste gaat het onder andere over alom bekende exoten als damhert, moeflon en muskusrat, maar ook op recente ontwikkelingen rond de verspreiding van wasbeerhond, Pallas' eekhoorn en muntjak. Enige overlap met het vorige hoofdstuk was hierbij onvermijdelijk. Nederlanders staan er van oudsher om bekend dat zij het landschap naar hun hand zetten. Dit heeft op zijn minst tijdens de laatste decennia ook voor zoogdieren positieve veranderingen gebracht. De veranderende inzichten over natuurbeheer die onder andere leidden tot het ouder worden van de bossen, het inzetten van grote grazers in natuurgebieden, het (her) introduceren van zoogdieren, het verbinden van natuurgebieden door ecoducten, dassentunnels en dergelijke en het aankopen van tussenliggende stukken zijn hier goede voorbeelden van en deze worden uitvoerig beschreven.

De tabellen die voor elke zoogdiersoort aangeven wat hun status is op verschillende Rode Lijsten, hun vermelding in de Habitatrichtlijn en andere internationale overeenkomsten zijn overzichtelijk en nuttig. Jammer dat niet wordt toegelicht wat een Rode Lijst is, hoe vaak deze herzien wordt en van wanneer de Rode Lijsten dateren die in de tabel genoemd worden. Ook een verklarende tekst rond het hoe en wat van de Habitatrichtlijn mis ik. Boeiend en overzichtelijk zijn de tabellen die laten zien in welke mate de zoogdierfauna door de eeuwen heen door de verschillende zoogdierkundigen werd beschreven. Overbodig zijn echter de staafdiagrammen waarin dezelfde informatie is verwerkt.

Het is duidelijk dat de interesse voor en de kennis van zeezoogdieren lange tijd uiterst beperkt bleef. De huidige atlas is zelfs de eerste volledige atlas, dus ook de zeezoogdieren zijn integraal opgenomen. Daarbij is het van enorme waarde dat de uitgebreide en over meerdere generaties strekkende kennis van zeezoogdierenkenners Chris Smeenk en Kees Camphuysen worden gebundeld in de soortbesprekingen.

Ronduit storend vind ik de discrepantie tussen de informatie van dit hoofdstuk en de informatie van met name de soorthoofdstukken. Ik lees bijvoorbeeld dat het damhert in de duinen via ontsnapte exemplaren grote populaties heeft kunnen opbouwen, terwijl in de soortbeschrijvingen te lezen valt dat ze doelgericht zijn uitgezet. Vervolgens krijg ik de indruk dat de impact van het toenemende aantal windturbines op vleermuizen niet goed wordt ingeschat. De methodische problemen bij het vaststellen van het aantal dode dieren en de daarmee samenhangende onderschatting van het dodenaantal worden miskend. Het rekensommetje in de tekst gaat uit van 1000 in Nederland geplaatste windmolens, terwijl het daadwerkelijke aantal in 2013 al 2000 bedroeg (Anonymus 2016b). Het groeiend aantal internationale publicaties (Voigt et al. 2012, 2015, Lehnert et al. 2014, Arnett et al. 2015) dat laat zien dat de invloed op vleermuispopulaties niet onderschat mag worden, had gerust genoemd mogen worden. De in de tekst voorgestelde oplossing van het probleem (de constructie van turbinebladen die de drukverschillen klein en gelijkmatig over de bladen zou moeten verdelen) lijkt principieel onrealistisch. De reeds onderzochte en nuttige oplossingen, zoals het stilzetten van de rotorbladen bij lagere windsnelheden in herfst en voorjaar worden daarentegen niet genoemd. De bezorgdheid over het effect van windmolens op vleermuizen komt beter tot uiting in de soortbeschrijvingen van rosse vleermuis, ruige dwergvleermuis en tweekleurige vleermuis.

In dit hoofdstuk wordt verder gesuggereerd dat de boommarter en eekhoorn vooral zijn toegenomen, omdat het aanbod aan holle bomen (lees: verblijfplaatsen) is toegenomen. Deze vermeende oorzaak wordt echter in de soortbesprekingen niet genoemd. Ook wijten de auteurs van dit inleidende hoofdstuk de achteruitgang van de das vanaf de jaren '60 van de vorige eeuw aan het hoge aantal verkeersslachtoffers en de afname van regenwormen aan te hoge doses bestrijdingsmiddelen. De reden van

herstel van de populatie wordt voornamelijk gezocht in het uitrasteren van wegen in combinatie met veilige passages. De soortauteurs daarentegen leggen bij de achteruitgang de nadruk op de grote veranderingen in het agrarisch gebied en de directe vervolging door de mens, terwijl ze het stoppen van de jacht, de opkomst van de maïsteelt en de herintroductie van dassen met name verantwoordelijk stellen voor de rekolonisatie van Nederland.

Het bovengenoemde ontstaat mogelijk door verschillende interpretatie van onderzoeksgegevens, maar er zijn ook duidelijke fouten in dit hoofdstuk te vinden. De noordse woelmuis is bijvoorbeeld niet Nederlands enige endemische zoogdiersoort, maar Nederlands enige endemische *onder*soort. De evolutie van nieuwe zoogdiersoorten gaat niet zo snel! Egels worden al langer niet meer tot de insecteneters gerekend, maar vormen nu een eigen orde zoals uitdrukkelijk in de naamlijst van de atlas staat vermeld. De voor vleermuizen gevaarlijke schimmel heet al geruime tijd *Pseudogymnoascus destructans* en niet *Geomyces destructans*.

Dit hoofdstuk is te lang en te divers geworden. Het is moeilijk te verantwoorden dat de paragrafen veranderende (inter)nationale wetgeving en de historiek van de Nederlandse zoogdierkunde, inclusief het vervaardigen van zoogdieratlassen onder de gemeenschappelijke noemer "zoogdieren in een veranderend landschap vallen". Het had de leesbaarheid en de structuur ten goede gekomen als deze paragrafen in aparte hoofdstukken waren ondergebracht. De auteurs hebben blijkbaar niet de soortbeschrijvingen gezien of geraadpleegd voordat ze dit hoofdstuk schreven. Ik mis hier echter ook de doortastende hand van de redactie die dit toch informatieve hoofdstuk op orde had kunnen stellen.

In het hoofdstuk "Verandering in de verspreiding van wilde zoogdieren in Nederland" wordt een lovenswaardige poging gedaan om de verspreiding van zoogdiersoorten uit de periode van de tweede en de huidige atlas statistisch te vergelijken. Qua rastergrootte (5 x 5 km) en tijdvenster (20 jaar) zijn deze immers gelijk. Bij de eerste atlas (van Wijngaarden et al. 1971) waren gemeentes de kleinste waarnemingseenheid, daardoor zijn de gegevens hiervan slecht statistisch te vergelijken met de twee latere atlassen. Het probleem met verschil aan onderzoeksintensiteit en het beschikbaar komen van nieuwe waarnemingsmethoden (batdetectors, cameravallen, inktbedden enz.) wordt gedeeltelijk omzeild door slechts atlasblokken te vergelijken die in beide periodes redelijk onderzocht zijn, dat wil zeggen waar minstens tien zoogdiersoorten zijn aangetoond (85% van het totaal aantal atlasblokken). Bovendien wordt een logaritmische correctie toegepast voor de toegenomen waarnemingsinspanning. Eveneens worden de resultaten van het Netwerk Ecologische Monitoring (NEM) over de populatieontwikkelingen in dit hoofdstuk, tabellarisch vermeld. Ondanks deze correcties moeten de resultaten niet blindelings worden vertrouwd. Het vereiste "minstens tien zoogdiersoorten voor een atlasblok" kan bijvoorbeeld heel verschillende zoogdiergroepen betreffen al naar gelang welke diergroep onderzocht is (braakbalanalyse versus vleermuisinventarisatie bijv.). Zo is volgens de analyse zowel de zadelrob als ook de walrus uit Nederland verdwenen (beide zijn overigens dwaalgasten), terwijl de soortbesprekingen laten zien dat beide soorten in de laatste atlasperiode zijn waargenomen. Sommige inventarisatiemethodes (vangst en vondst, contra detectorwaarnemingen bij vleermuizen) zijn ook moeilijk te vergelijken. Deze problemen worden door de auteur erkend en voor veel soorten wordt aangegeven wat de (methodische) reden kan zijn van het veelal positievere verspreidingsbeeld. De kleine hoefijzerneus is de enige soort die daadwerkelijk sinds de vorige atlas is verdwenen en bij eikelmuis, grote hoefijzerneus en mopsvleermuis is de verspreiding duidelijk verslechterd. Voor veel soorten lijkt het verspreidingsbeeld sinds de vorige atlas te zijn verbeterd. Dit wordt ook grotendeels door het NEM bevestigd.

Werkwijze

De opzet van het atlasproject wordt hier uitvoerig uiteengedaan. Niet-zoogdierkundigen zal het opvallen dat men een hele reeks van uiterst verschillende inventarisatietechnieken nodig heeft gehad om alle zoogdieren in een gebied in kaart te brengen, van doodgewone zichtwaarnemingen tot het gebruik van specialistische cameravallen, grafietplankjes en batdetectors. Indrukwekkend, gezien het werk dat hier achter verborgen zit en elk jaar opnieuw verricht moet worden, zijn de kaartjes die aangeven waar winterverblijven en kerkzolders op vleermuizen zijn onderzocht. Afgezien van de open veenweide- en kleigebieden en de Waddeneilanden hebben de onderzochte rasters namelijk een goede spreiding. De rasters met vindplaatsen van braakballen van uilen dekken zelfs bijna heel Nederland! Ik had graag gelezen hoeveel prooidierresten dit bij elkaar heeft opgeleverd en of en waar al deze prooidieren zijn bewaard. Zulke verzamelingen kunnen met name nuttig zijn als bekende soorten door nieuwe taxonomische inzichten in verschillende soorten worden opgesplitst (zoals bij de gewone en tweekleurige bosspitsmuis en de woelrat en de molmuis het geval is geweest). Maar ook als men de invloed van bepaalde stoffen (zoals bestrijdingsmiddelen of zware metalen) in het milieu met terugwerkende kracht wil onderzoeken.

De digitale revolutie, waaronder de introductie van het internet, heeft het invoeren en verwerken van de grote hoeveelheid aan informatie, maar ook het motiveren van de vele waarnemers mogelijk gemaakt. Boeiend is te zien dat het aantal jaarlijkse waarnemingen van 1989 tot 2010 bijna exponentieel toenam. Dit effect van de digitale revolutie moet overigens ook worden beschouwd als de vergelijking met andere Europese atlassen (zie tabel 1) wordt gemaakt. De oudere atlassen hebben het internet nog niet ten volle kunnen benutten.

Ik vraag me af of, indien al de in Nederland beschikbare gegevens over grondgebruik, neerslag, bodemtypes, vegetatietypes etc. waren gekoppeld aan de verzamelde verspreidingsgegevens, er geen modellen gemaakt hadden kunnen worden voor een gedetailleerde voorspelling van de volledige verspreiding van een reeks zoogdiersoorten. De vorige Zwitserse atlas (Hausser 1995) heeft hier een interessante maar tot nu toe op zichzelf staande poging toe gedaan. Ook de consequenties van een warmer wordend klimaat voor de verspreiding van de zoogdierfauna zouden met zulke modellen kunnen worden berekend. Een biodiversiteitsanalyse voor de verschillende zoogdiergroepen zoals in de Deense atlas (Baagøe & Jensen 2007) is gebeurd, zou voor het aangeven van kerngebieden voor beleidsmakers van nut zijn.

Goed is dat er in dit hoofdstuk suggesties worden gegeven hoe de volgende atlas nog beter kan worden, waarbij het vergelijken van de verschillende atlasperiodes objectiever kan en de analyse van de gegevens verder kan worden verbeterd.

De soortbeschrijvingen

De soortbeschrijvingen zijn als volgt opgezet: een korte introductie met uiterlijke kenmerken, beschrijving van het gedrag en voortplantingsbiologie. Daarna volgen de paragrafen "Leefomgeving", "Voedsel" en "Areaal". Het voorkomen in Nederland wordt opgedeeld in "Prehistorie", "Historische gegevens tot 1946", "Periode 1946-1969", "Periode 1970-1988" en "Periode 1989-2012". Aansluitend volgen de paragrafen "Veranderingen en oorzaken" en "Bedreigingen en bescherming". Elke soortbeschrijving wordt afgesloten met een korte, Engelstalige samenvatting.

De teksten zijn goed en begrijpelijk geschreven. De soortbeschrijvingen variëren in lengte. Dit wordt grotendeels veroorzaakt door hoe diep de auteur in de materie is gedoken, maar ook door de hoeveelheid informatie die per soort beschikbaar is. Ook zie je dat niet iedereen even ervaren is in het schrijven van wetenschappelijke teksten. Zo wordt bij bron-

verwijzing over habitatvoorkeur of leefgedrag regelmatig naar algemene veldgidsen in plaats van naar authentieke publicaties verwezen. Toch is de kwaliteit van de soortbeschrijvingen over het algemeen goed en zijn de soortbeschrijvingen zeer informatief. Bij de Noord-Hollandse zoogdieratlas (Hoogeboom et al. 2014) liep de kwaliteit van de teksten duidelijk meer uiteen. Dit is een goede verdienste van soortauteurs maar ook van de (eind)redactie.

Anders dan in de vorige atlas (Broekhuizen et al. 1992) wordt de literatuur die over de soort in Nederland bekend is, niet volledig uitgediept. Gedetailleerde gegevens over lichaamsmaten, uitvliegtijden of habitatvoorkeuren zijn ook grotendeels afwezig. Voor zulk soort compilaties zal het heft toch in handen genomen moeten worden door een kleinere groep mensen die niet als vrijwilliger maar beroepsmatig een atlas samenstellen (zie bijvoorbeeld de atlassen van Oostenrijk, Sleeswijk-Holstein en Baden-Württemberg). Bij dergelijke atlassen haakt waarschijnlijk het bredere publiek af, maar als informatiebron voor zowel de geïnteresseerde naturalist als de bioloog zijn ze uiterst waardevol.

Wereldwijde areaalkaarten (een weergave van de globale verspreiding van een soort) zetten de Nederlandse verspreiding in een globaal perspectief. Zo blijkt de in Nederland wijdverspreide huisspitsmuis eigenlijk maar op een klein gedeelte van de wereld voor te komen en de bij ons zo zeldzame wilde kat blijkt een grote verspreiding te hebben, te weten in zowel Afrika als westelijk Azië. Het areaal van de soort wordt in de atlas weergegeven met kaartjes die voor de landzoogdieren een vaste uitsnede van Groenland tot Kamtsjatka en van Spitsbergen tot Centraal-Afrika hebben. De geboden informatie is grotendeels gebaseerd op gegevens van de IUCN (Anonymus 2016c). Helaas is ook de mercatorprojectie van deze bron overgenomen. Hierdoor worden de gebieden die dichter naar de polen liggen groter weergegeven dan ze in werkelijkheid zijn. Zo lijkt Groenland even groot als Europa en Europa groter dan Afrika boven de evenaar. Voor de zeezoogdieren is wel voor een oppervlaktegetrouwe projectie gekozen. Hier wordt een gedeelte van het noordelijk halfrond van Midden-Canada tot Midden-Siberië en van de Noordpool tot Tunesië weergegeven.

De uiteindelijke verspreidingskaartjes, de spil van de atlas, zijn helaas opvallend klein weergegeven. Er is voor de meeste soorten gekozen voor het weergeven van de gegevens van de voormalige atlas (grijze atlasblokken) én de huidige atlas (blauwe cirkels in de atlasblokken) in dezelfde kaart. Dat is voor de leesbaarheid – lees het bestuderen van de verschillen tussen de twee atlasperiodes – niet bevorderlijk. Op wat voor waarnemingen (braakbalvondsten, sporen, batdetectorwaarnemingen etc.) de verspreidingskaartjes gebaseerd zijn wordt in het hoofdstuk Werkwijze wel per soortgroep verklaard, maar voor de individuele soort wordt deze informatie over het algemeen niet gepresenteerd. Dit was bijvoorbeeld wel bij de vorige zoogdieratlas (Broekhuizen et al. 1992), de Atlas van de Nederlandse vleermuizen (Limpens et al. 1997) en bij de Noord-Hollandse zoogdieratlas (Hoogeboom et al. 2014) het geval. Bij de laatst genoemde atlas werd helaas deze informatie voor twee apart onderscheiden tijdvensters in één en dezelfde kaart weergegeven waardoor de kaartjes ook moeilijk leesbaar zijn. Voor enkele soorten (zoals das, boommarter en de walvisachtigen) worden meerdere kaartjes gepresenteerd. Dit levert beter interpreteerbare en dus inhoudelijk meer begrijpelijke kaartjes op. Zo worden bij de das losse waarnemingen en burchten gescheiden, bij de boommarter losse waarnemingen en voortplanting en bij sommige walvisachtigen losse waarnemingen en strandingen/doodvondsten. Bij de vleermuizen is alleen bij enkele soorten gekozen voor het uit elkaar houden van winter- en zomervondsten. Kraamkolonies worden bij lang niet alle vleermuissoorten apart (met rood) aangeduid. Dat is jammer.

Ik mis ook de opeenvolgende en buitengewoon illustratieve kaartjes uit de vorige atlas

voor soorten als steenmarter, das, vos, otter, ree, hamster en muskusrat waarmee de veranderingen van het areaal gedurende de laatste eeuw, zo niet de laatste 60 jaar, werden geïllustreerd. Met de huidige druk- en illustratietechnieken zouden zulke kaartjes nog mooier gepresenteerd kunnen worden. Informatief zijn de grafieken die voor enkele soorten populatietrends weergeven.

De soortbeschrijvingen zijn voorzien van bijzonder fraaie foto´s van de betreffende soort, van sporen, een typisch habitat of andere illustratieve beelden. Net zoals bij de diversiteit van de auteurs komt hier een breed spectrum van zowel beroeps- als hobbynatuurfotografen aan bod. Bij elkaar hebben 117 verschillende mensen één of meer foto´s ter beschikking gesteld. Een aparte fotocommissie heeft er zo veel mogelijk naar gestreefd om foto´s van in Nederland (en omstreken) gefotografeerde zoogdieren te gebruiken. Gezien de soms grote geografische variatie in uiterlijk binnen het areaal van een soort is dit een nobel streven. Vaak zijn fotoredacties zich niet van deze variatie bewust. De witte plekken aan het eind van de soortbesprekingen hadden her en der door meer of grotere foto´s kunnen worden opgevuld, maar over het algemeen zijn de bladzijden goed gevuld. Informatief zijn ook de habitatbeelden die vooral bij de kleinere zoogdieren zijn weergegeven. Ik mis dit soort foto´s helaas bij de vleermuizen. Jammer is ook dat er doorgaans niet wordt vermeld waar de habitatfoto´s zijn gemaakt. Dit zou voor leken, opgroeiende generaties, maar ook voor buitenlanders bijzonder informatief zijn geweest.

Engelse samenvattingen voor elke soortbeschrijving en Engelse figuur- en tabelteksten trachten de atlas voor een niet-Nederlands lezend publiek toegankelijk te maken. Voor dit doel zou het ook zeker op zijn plaats zijn geweest met inleidende kaartjes de Nederlandse topografie te illustreren. Zulke topografie- en landgebruikkaartjes werken zeer verklarend met betrekking tot het voorkomen van een reeks soorten, zoals de rosse woelmuis, het konijn of de meervleermuis. Tegenwoordig kunnen zulke kaartjes ook heel mooi als achtergrond in de verspreidingskaartjes gepresenteerd worden. Mooie voorbeelden vind je hiervan bij de zoogdieratlas van Sachsen (Hauer et al. 2009), Baden-Württemberg (Braun & Dieterlen 2005) en Oostenrijk (Spitzenberger 2001). Deze geven topografie en waterstelsels weer. Bij de Noord-Hollandse atlas (Hoogeboom et al. 2014) worden bebouwde kom en waterwegen subtiel als achtergrond gebruikt. De verklarende inleidende hoofdstukken hebben ieder een iets te bondige Engelse samenvatting, die jammer genoeg niet bij de teksten maar vrijwel helemaal achterin de atlas is geplaats. Helaas zijn de Engelse figuurteksten ook nogal summier.

Ondanks de bovengenoemde kritiekpunten is de nieuwe zoogdieratlas een mooi en waardevol boekwerk, waar we nog lang van kunnen genieten. Nu moet goed nagedacht worden over hoe de gegevens in de toekomst het best verzameld, verwerkt en gebruikt kunnen worden om de verspreiding en de dichtheid van de Nederlandse zoogdieren te monitoren en zo mogelijk te voorspellen. Bij de Zoogdiervereniging ligt de taak de vele veldactiviteiten voort te zetten, nieuwe generaties voor zoogdieren enthousiast te maken en de gegevensstroom naar de digitale databanken te stimuleren.

Literatuur

Anonymus 2007. Saksen-Anhalt, Wikipedia. URL: https://nl.wikipedia.org/wiki/Saksen-Anhalt; viewed 22 September 2016.

Anonymus 2013. Baden-Württemberg, Wikipedia. URL: https://nl.wikipedia.org/wiki/Baden-Württemberg; viewed 22 September 2016.

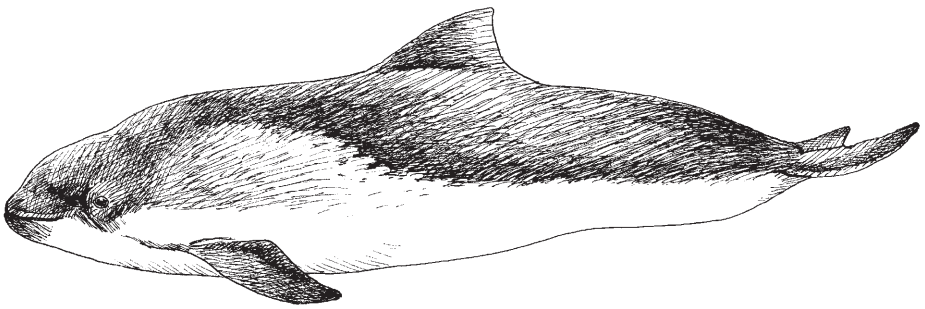
Anonymus 2014. Sleeswijk-Holstein, Wikipedia. URL: https://nl.wikipedia.org/wiki/Sleeswijk-Holstein; viewed 22 September 2016.

Anonymus 2015a. Vlaanderen. Wikipedia. URL: https://nl.wikipedia.org/wiki/Vlaanderen; viewed 22 September 2016.

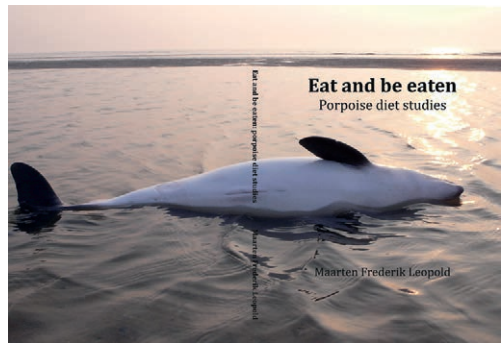
Anonymus 2015b. Denemarken, Wikipedia. URL: https://nl.wikipedia.org/wiki/Denemarken; viewed

22 September 2016.
Anonymus 2015c. Oostenrijk, Wikipedia. URL: https://nl.wikipedia.org/wiki/Oostenrijk; viewed 22 September 2016.
Anonymus 2015d. Zwitserland, Wikipedia. URL: https://nl.wikipedia.org/wiki/Zwitserland; viewed 22 September 2016.
Anonymus 2016a. List of sovereign states and dependencies by area. Wikipedia. URL: https://en.wikipedia.org/wiki/List_of_sovereign_states_and_dependencies_by_area; viewed 22 September 2016.
Anonymus 2016b. Cijfers windenergie. Rijksdienst voor Ondernemend Nederland. URL: http://www.rvo.nl/onderwerpen/duurzaam-ondernemen/duurzame-energie-opwekken/windenergie-op-land/beleid/cijfers; viewed 22 September 2016.
Anonymus 2016c. The IUCN Red List of Threatened Species. URL: http://www.iucnredlist.org; viewed 22 September 2016.
Anonymus 2016d. Nederland, Wikipedia. URL: https://nl.wikipedia.org/wiki/Nederland; viewed 22 September 2016.
Arnett, E.B., E.F. Baerwald, F. Mathews, L. Rodrigues, A. Rodriguez-Durán, J. Rydell, R. Villegas-Patraca & C.C. Voigt 2015. Impacts of wind energy development on bats: a global perspective. In: Bats in the anthropocene: conservation of bats in a changing world. T. Kingston & C.C. Voigt (eds.): 295-324. Springer-Verlag, Berlijn. Duitsland.
Baagøe, H.J. & T. Secher Jensen (red.) 2007. Danske Pattedyratlas. Gyldendal, Kopenhagen, Denemarken.
Borkenhagen, P. 2011. Die Säugetiere Schleswig-Holsteins. Faunistisch-Ökologischen Arbeitsgemeinschaft Schleswig-Holstein, Husum, Duitsland.
Braun, M. & F. Dieterlen (red.) 2005. Die Säugetiere Baden-Württembergs. Band 1 & Band 2. Eugen Ulmer GmbH & Co, Stuttgart, Duitsland.
Broekhuizen, S., B. Hoekstra, V. van Laar, C. Smeenk & J.B.M. Thissen (red.) 1992. Atlas van de Nederlandse zoogdieren. Stichting Uitgeverij van de Koninklijke Nederlandse Natuurhistorische Vereniging, Utrecht, Nederland.
Hauer, S., H. Ansorge & U. Zöphel (red.) 2009. Atlas der Säugetiere Sachsens. Naturschutz und Landschaftspflege. Sächsischen Landesamt für Umwelt, Landwirtschaft und Geologie, Dresden, Duitsland.
Hausser, J. (red.) 1995. Säugetiere der Schweiz. Verbreitung. Biologie. Ökologie. Denkschriften der Schweizerischen Akademie der Naturwissenschaften, Band 103. Birkhäuser Verlag, Basel, Zwitserland.
Hoogeboom, D., W. Ruitenbeek, F. Visbeen & J. Wondergem (red.) 2014. Atlas van de Noord-Hollandse zoogdieren 1989-2014. Landschap Noord-Holland, Heilo / Noordhollandse Zoogdier Studiegroep (NOZOS), Alkmaar, Nederland.
Lehnert, L.S., S. Kramer-Schadt, S. Schönborn, O. Lindecke, I. Niermann & C.C. Voigt 2014. Wind farm facilities in Germany kill noctule bats from near and far. PLoS ONE 9 (8): e103106.
Limpens, H., K. Mostert & W. Bongers (red.) 1997. Atlas van de Nederlandse vleermuizen. Onderzoek naar verspreiding en ecologie. Stichting Uitgeverij van de Koninklijke Nederlandse Natuurhistorische Vereniging, Utrecht, Nederland.
Spitzenberger, F. (ed.) 2001. Die Säugetierfauna Österreichs. Grüne Reihe des Bundesministeriums für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft. Band 13. Wenen, Oostenrijk.
Verkem, S., J. De Maeseneer, B. Vandendriessche & S. Yskout (red.) 2003. Zoogdieren in Vlaanderen. Ecologie en verspreiding van 1987 tot 2002. Natuurpunt Studie, Mechelen / JNM-Zoogdierenwerkgroep, Gent, België.
Voigt, C.C., A.G. Popa-Lisseanu, I. Niermann & S. Kramer-Schadt 2012. The catchment area of wind farms for European bats: A plea for international regulations. Biological Conservation 153: 80–86.
Voigt, C.C., L.S. Lehnert, G. Petersons, F. Adorf & L. Bach 2015. Wildlife and renewable energy: German politics cross migratory bats. European Journal of Wildlife Research 61 (2): 213–219.
Wijngaarden, A., V. van Laar & M.D.M. Trommel 1971. De verspreiding van de Nederlandse zoogdieren. Lutra 13: 1-41.

Jeroen van der Kooij
Rudsteinveien 67
NO-1480 Slattum
Noorwegen
jvdkooij@online.no



Eat and be eaten



Eat and be eaten - Porpoise diet studies. Maarten F. Leopold 2015. PhD thesis. Wageningen University, Wageningen, the Netherlands. 239 pp. ISBN 978-94-6257-558-5.

On 20 November 2015 Maarten Frederik (Mardik) Leopold successfully defended his PhD thesis *Eat and be eaten*. Leopold has been working on diets of fish eating bird species for about half a lifetime. These diet studies were based on the identification of remains of hard parts of prey species in birds' stomachs, mainly otoliths, the ear bones of fish. In the course of time Leopold built a reference collection that made it possible to use otoliths to not only identify the fish species but also their length and/or mass (Leopold et al. 2001).

Two events triggered the genesis of this thesis. The first was a mass necropsy of harbour porpoises (*Phocoena phocoena*) in 2006, providing a fair number of stomachs to study the diet of porpoises (Leopold & Camphuysen 2006). These stomachs were followed by tens of others in the subsequent years. The second event was the discovery in 2014 that beached porpoises supposedly mutilated by fishermen were victims of grey seal (*Halichoerus grypus*) attacks. This phenomenon made it easier to structure the PhD thesis: harbour porpoises as predator and as prey. *Eat and be eaten* was conceived.

The subtitle of the thesis, *Porpoise diet studies,* is an understatement. Not only data from diet analyses from 2006-2014 are presented, but the phenomenon of grey seal attacks on porpoises is described in full detail as well. Four chapters describe the results of diet studies. Another three chapters deal with grey seal as a predator of porpoise.

The results of diet analyses of a large sample size of porpoise confirm that *the* diet of the harbour porpoise does not exist. Though the overall diet of porpoises consists of four main fish groups (gobies, gadoids, herring-like species and sandeel), age, sex, stranding location, feeding location (estuarine, coastal or offshore, bottom or pelagic), time of year etc. are factors that influence the individual porpoise's diet. Age and size of a porpoise are important factors in discriminating differences. After weaning, a young porpoise starts feeding on gobies, which are small low-energetic fish. To sustain itself a young animal needs ca. 2000 gobies a day. An adult would need ca 5000 gobies a day, i.e. an average of more than three gobies per minute, round the clock. Physically this seems impossible. Thus, whilst growing, porpoises are supposed to switch to larger prey of a higher energy density. And that's exactly what Leopold found: clupeids and sandeels were the most abundant prey species in older and bigger porpoises.

Another interesting result Leopold found is that many porpoises are emaciated. Stomachs of these animals often contained food remains. Compared to the diet of well-nourished individuals the emaciated animals had fewer prey remains, and prey of lower quality (less fatty fish) in their stomach. On the extreme end of this range several animals had empty stomachs; they were most often found in summer. The author concludes that life is not easy for a porpoise in the southern North

Sea in summertime.

In Dutch coastal waters, the life of a porpoise is not easy either. From incidental observations it was known that grey seals can attack porpoises (i.e. Bouveroux et al. 2012). This phenomenon was never quantified. Until DNA in fresh supposedly grey seal induced wounds of three porpoises was analysed and identified as grey seal, constituting definitive evidence that grey seals attack porpoises and not only incidentally. Characteristics of the bite wounds and other mutilations of these three animals were used to conduct a retrospective study using photographs of dead porpoises necropsied in the Netherlands from 2003-2013. It turned out that ca. 25% of the dead porpoises were victim of a grey seal attack. The grey seal victims showed two different patterns. Porpoises containing bottom dwelling prey species (thus feeding near the seafloor) had zigzag wounds, whilst porpoises containing pelagic or surface prey species (thus feeding in the water column) showed wounds on the throat or cheek. The relationship between the attack wounds and attack-specific diet strengthened the idea that grey seals attack living porpoises while feeding. Stomach content as circumstantial evidence. Stomach content was shown to aid in identifying bycatch by bottom-set gillnets as well. Presumed bycatch victims fed on bottom dwelling species.

Though analysis of stomach contents can provide answers to many questions, caveats in knowledge remain, amongst others: diet of porpoises further offshore (e.g from bycaught animals) and differences between diets in the North Sea and in estuaries. I would encourage the author to investigate how the diet found by stomach content analysis (last meal) reflects diet on the longer time scales found by fatty acid analysis and stable isotope analysis (cf. Janssen 2013). As Leopold states in his thesis, there are plenty of topics to be addressed in the future. I can only hope that he finds time, funding, and new so-called *maagmeisjes* ('stomach girls', male or female) to assist in analysing many more porpoise stomachs.

References

Bouveroux T., J.J. Kiszka, M.R. Heithaus, T. Jauniaux & S. Pezeril 2014. Direct evidence for gray seal (*Halichoerus grypus*) predation and scavenging on harbor porpoises (*Phocoena phocoena*). Marine Mammal Science 30: 1542–1548. DOI: 10.1111/mms.12111.

Jansen, O.E. 2013. Fishing for food. Feeding ecology of harbour porpoises *Phocoena phocoena* and white-beaked dolphins *Lagenorhynchus albirostris* in Dutch waters. PhD thesis. Wageningen University, Wageningen, the Netherlands.

Leopold, M.F. & C.J. Camphuysen 2006. Bruinvisstrandingen in Nederland in 2006. Achtergronden, leeftijdsverdeling, sexratio, voedselkeuze en mogelijke oorzaken. IMARES Rapport C083/06 / NIOZ Rapport 2006/5. Available from the internet: http://library.wur.nl/WebQuery/wurpubs/fulltext/19160.

Leopold M.F., C.J.G. van Damme, C.J.M. Philippart & C.J.N. Winter 2001. Otoliths of North Sea fish: interactive guide of identification of fish from the SE North Sea, Wadden Sea and adjacent fresh waters by means of otoliths and other hard parts. CD-ROM, ETI, Amsterdam.

Steve C.V. Geelhoed
Wageningen Marine Research
Ankerpark 27
1780 AB Den Helder
The Netherlands

‘De Wolf terug’ - antwoorden op vragen

De Wolf terug, eng of enerverend? D. Klees, E. van Maanen, L. Linnartz, M. Drenthen & M. van der Weide 2015. Kosmos, Utrecht. ISBN 978 90 5210 986 2.

Eind februari 2015 verscheen het boek ‘De Wolf terug, eng of enerverend?’, geschreven door de mensen van het initiatief en website ‘Wolven in Nederland’. Dat was twee weken voordat op 7 maart 2015 de eerste zekere wolf op eigen kracht Nederland bereikte, na een afwezigheid van meer dan een eeuw.

De vijf auteurs, op verschillende wijze betrokken bij het (toekomstig) wel en wee van de wolf in Nederland, verschaffen met dit boek een goed beeld van de huidige stand van zaken rond de terugkeer van de wolf in Nederland en de mogelijke consequenties die dat in de toekomst zal kunnen hebben.

Zij gaan ook in op de geschiedenis van het voorkomen van de wolf in Nederland. Uiteraard behandelt het boek daarbij ook de laatste, gedocumenteerde Nederlandse wolven. Heeze in Noord-Brabant wordt weer eens het laatste geval genoemd, zij het met het jaartal 1879, terwijl elders meestal voor Heeze het jaartal 1897 wordt genoemd. Voor zover ik kan nagaan, is Heeze een slecht gedocumenteerde rondgezongen waarneming. Ik vind deze waarneming voor het eerst genoemd in de Nederlandse bewerking (2000) van het wolvenboek van Okarma. Opmerkelijk is dat in het hier besproken boek het laatste, wel goed gedocumenteerde geval, namelijk Schinveld 1869, niet genoemd wordt. Het zou goed zijn als iemand de meldingen van wolven in Nederland in de negentiende eeuw nog eens kritisch zou onderzoeken, bijvoorbeeld door kranten uit die tijd er op na te pluizen.

Spannend is de foto van de vermoedelijke wolf langs de A12 bij Duiven in 2011. Op de foto in het boek staat het dier helaas erg klein. In andere bronnen wordt dit dier op grond van het uiterlijk een mogelijke Italiaanse wolf genoemd. Inderdaad lijkt het niet op een Poolse wolf (zie onderstaand). Dat een wolf van de Italiaanse stam Nederland bereikt is niet uitgesloten. De wolf die per abuis in het Westerwald geschoten is werd in genetisch onderzoek toegeschreven aan de Italiaanse stam. Het Westerwald is hemelsbreed maar 100 kilometer van Zuid-Limburg. In deze Lutra opperen Lelieveld et al. overigens de mogelijkheid dat de mogelijke wolf van Duiven een jakhals is geweest. De relatief tengere bouw en de roodachtige vacht passen inderdaad niet alleen bij een Italiaanse wolf, maar ook bij een jakhals.

Het boek geeft een realistisch beeld van het perspectief van de wolf in Nederland. Zo wordt er niet overdreven hoog op gegeven van de goede rol die wolven zouden kunnen gaan spelen in de Nederlandse natuur. Heel nuchter staat er dat wolven waarschijnlijk niet zo'n groot ecologisch effect zullen uitoefenen in het Nederlandse en Vlaamse landschap, waar de mens zo'n dominante invloed heeft. We zijn hier niet in Yellowstone.

Heel nuchter is ook de constatering dat wolven andere roofdieren doden als ze kans krijgen. Zelf zag ik in Yellowstone hoe een wolf probeerde een coyote te pakken te krijgen. Als wolven zich echt in flinke aantallen, waarbij je zou kunnen denken aan een honderdtal, in Nederland gaan vestigen, zal de vos het mogelijk moeilijk krijgen, zoals ook de hermelijn heeft geleden onder de komst van de vos in de duinen (Mulder 1990). De natuur is geen zoet sprookje.

Het boek laat duidelijk zien dat de mens de wolf zijn terugkeer toestaat, na een dieptepunt in Europa omstreeks 1950. Betere bescherming tegen vervolging was cruciaal. Daarbij komt een beter voedselaanbod, met name in de vorm van veel meer hoefdieren. De enige serieuze beperkende factor voor vestiging van de wolf in Nederland lijkt het autoverkeer. Kan een populatie de sterfte door aanrijdingen aan? Dit is een serieus probleem, in grote delen van Nederland lijkt het bijvoorbeeld de otter door aanrijdingen niet definitief te lukken om een populatie op te bouwen (Kuiters & Lammertsma 2014). De das redt het door vele voorzieningen, maar dat is een tunneldier (Dekker & Bekker 2010, Vreugdenhil & Bekker 2015). Het boek wijst er op dat wolven slim zijn en zich goed aanpassen aan nieuwe omstandigheden. Ik heb in deze ook meer vertrouwen in de wolf dan in de das.

De vormgeving van het boek is eenvoudig en de bladspiegel maakt een volgepropte indruk. Hoeveel mooier zou het geweest zijn als het was uitgegeven in de kleine reeks van de KNNV Uitgeverij over zoogdieren: steenmarter, konijn, das en wild zwijn.

Het hoofdstuk van hoofddocent filosofie Martin Drenthen van de Radboud Universiteit over onze omgang met de wolf zet aan tot nadenken. Zo constateert hij dat het verwijzen naar de wettelijk beschermde status ons niet veel helpt bij het beantwoorden van de morele vraag of en waarom we de wolf zouden moeten beschermen. Juridische argumenten zijn te gemakkelijk, het zijn vaak dooddoeners. Ook gaat hij in op het onjuiste beeld van de wolf als metafoor voor de wildernis.

De eerste recente wolf in Nederland heeft het wildernisbeeld al enorm afgezwakt door zijn gedraaf dwars door dorpen, maar dat was na het verschijnen van dit boek. Die wolf heeft door meteen maar een aantal schapen te doden ook voor een zekere ontnuchtering gezorgd. Nogmaals: zie het artikel elders in deze Lutra. Al met al is het boek een gedegen en nuchter verhaal over de wolf vanuit verschillende invalshoeken.

Literatuur

Dekker, J.J.A. & G.A. Bekker 2010. Badger (*Meles meles*) road mortality in the Netherlands: the characteristics of victims and the effects of mitigation measures. Lutra 53: 81-92.

Kuiters, A.T. & D.R. Lammertsma 2014. Infrastructurele knelpunten voor de otter. Overzicht van verkeersknelpunten met mate van urgentie voor het nemen van mitigerende maatregelen. Rapport 2513. Alterra, Wageningen.

Mulder, J.L. 1990. The stoat *Mustela erminea* in the Dutch dune region, its local extinction, and a possible cause: the arrival of the fox *Vulpes vulpes*. Lutra 33: 1-21.

Vreugdenhil, S. & H. Bekker 2015. Infrastructuur en verkeer. In: F. van Bommel, S. Vreugdenhil & M. La Haye (red.). De Das: 80-93. KNNV Uitgeverij, Zeist.

Johan B.M. Thissen
Mansberg 7
NL-6562 MA Groesbeek
Nederland

Contents of Volume 59 (2016)

Editorial

Thissen, J.B.M. & J.P. Bekker. A mammal atlas for the Anthropocene. 1

Research Papers

Bekker, J.P., M.E.J. Bosselaers & G.R. Heerebout. Supposedly lost syntype of the rough-toothed dolphin (*Steno bredanensis* (Lesson, 1828)) traced back at the Ghent University Museum. 65

Bos, D., F. Timmerman & R.C. Ydenberg. Muskusrattenbestrijding tijdens de MKZ-crisis in 2001. 33

Hüppop, O. & R. Hill. Migration phenology and behaviour of bats at a research platform in the south-eastern North Sea. 5

Keijl, O.G., L. Begeman, S. Hiemstra, L.L. IJsseldijk, P. Kamminga & Seal Centre Pieterburen. Cetaceans stranded in the Netherlands in 2008-2014. 75

Kuijper, W.J., I.K.A. Verheijen, A. Ramcharan, H. van der Plicht & T. van Kolfschoten. One of the last wild brown bears (*Ursus arctos*) in the Netherlands (Noordwijk). 49

Lelieveld, G., B. Beekers, J. Kamp, D. Klees, L. Linnartz, E. van Norren, E. Polman & R. Vermeulen. The first proof of the recent presence of wolves in the Netherlands. 23

Mulder, J. & R. Janssen. Tail defects in two Daubenton's bats (*Myotis daubentonii*). 109

Suzuki, K.K., T. Shimamoto, R.G. Furukawa & H. Yanagawa. Diurnal activity of juvenile Russian flying squirrels recorded by camera trapping. 115

Book Reviews

Geelhoed, S.C.V. Eat and be eaten. 131

Thissen, J.B.M. 'De Wolf terug' - antwoorden op vragen. 133

van der Kooij, J. De derde atlas van de Nederlandse zoogdieren – een nieuwe mijlpaal in de zoogdierkundige geschiedenis. 121