HOOFDSTUK 21 SUMMARY

THE DUTCH BEES (HYMENOPTERA: APIDAE S.L.)

In the Netherlands, 358 species of bees have been recorded. The knowledge of their distribution and biology has greatly improved over recent years, thanks to hundreds of people who contributed their observations. This book attempts to present the accumulated knowledge on the Dutch bees in an attractive fashion, without compromizing the quality of the information. In 18 chapters, comprehensive general reviews are given of current knowledge of life history, ecology, social behaviour, evolutionary history, taxonomy, distributional trends, threats and conservation. Each species is discussed separately in its own account.

CHAPTER 1 Introduction

The importance of bees as pollinators and honey producers is widely recognized, and their biology has been studied by many. Despite the large amount of information available, little of it used to be easily accessible for Dutch amateur biologists, certainly not in their own language. The present book is the first attempt to present a summary of knowledge on bees in general, and Dutch bees in particular.

Originally, this book was conceived to present accounts of all Dutch 'sting-bearing' Hymenoptera (Aculeata). In the process of writing, however, it soon became apparent that the required number of pages for such a book would become a problem. This prompted the decision to publish two separate volumes, one dealing with wasps and ants, the other with bees. The first was published in 2004, the second lies before you now.

This introductory chapter provides a brief outline of the contents of the book, and accounts for the contributions made by each individual author. The book was written by a team of 23 Dutch bee experts.

CHAPTER 2 Bee studies in the Netherlands: a history

This chapter briefly summarizes the development of bee studies in the world, before discussing the history of bee studies in the Netherlands in more detail. A chronological account is given of people who, and institutions and organizations that made significant contributions.

The first records of bees in the Netherlands, by Goedaert and Swammerdam, date from the 17th and 18th centuries. Bennet & van Olivier (1825) mentioned eight species, a number that would rise to around 230 by the end of the 19th century, as recorded by Snellen van Vollenhoven and Ritsema.

During 1900-1945, the study of bees gained popularity thanks to publications by – among others – Oudemans, Thijsse, Heimans, Bouwman, Vuyck, Van der Vecht and Walrecht.

By 1951, according to a checklist published by Benno, the number of bee species known from the Netherlands had risen to 322. Between 1950 and the late 1970s, Benno published several important identification keys, as well as articles on biology and books aimed at popularizing the study of bees. In 1975, European Invertebrate Survey - the Netherlands was founded. In collaboration with this organization, Virgilius Lefeber started to build a faunistic database of the Dutch bees. Other important contributors to faunistic and biological knowledge of the Dutch bee fauna were Koster, Teunissen, Vegter, Wiering and Van der Zanden. At universities, researchers like Kwak, Sommeijer and Velthuis studied pollination biology and the social behaviour of bees.

After 1990, a new group of amateur entomologists founded the 'section Hymenoptera' within the Dutch Entomologists Society (NEV). This would prove to be a stimulating development for the study of bees in the Netherlands. During these recent years, bees became increasingly popular in the Netherlands, and even gained a place in Dutch nature policy and management. In 1999, a 'preliminary' atlas of the Dutch bees was published, in which distributional maps of 338 species were included. This publication launched a national recording scheme, which eventually resulted in the present book.

CHAPTER 3 The life of bees

This chapter outlines general aspects of the life of bees. The first part deals with adult bees and treats subjects like mating strategies, territorial behaviour, nest construction, foraging, oviposition, phenology and dispersal. The second part deals with the immature stages and discusses subjects like egg biology and morphology, larval development and pupation. The chapter concludes with a paragraph on the different types of life cycle found in bees.

CHAPTER 4 Bees and flowers

Approximately 80% of all Dutch plant species are pollinated by insects. Together with flies, bees are the most important pollinating insects. In their morphology, bees appear to be fully adapted for collecting pollen. Many plants are adapted to attract their pollinators. This chapter discusses these mutual adaptations of bees and plants. Some of the subjects covered are tongue length, pollen transportation, generalists vs. specialists, flower morphology, shape and structure of pollen, and pollen competition between wild bees and honeybees. A separate text box describes orchids that mimic other plants or female bees in order to attract their pollinators.

CHAPTER 5 Social behaviour in bees

Although the vast majority of bees live their lives in solitude, a few lineages have developed social life styles. Well-known examples are the highly social honeybees and bumblebees, but a range of different levels of sociality also occurs in other groups of bees, especially in the tribe Halictini (genera *Halictus* and *Lasioglossum*). This chapter describes the levels of social behaviour found in bees and discusses several examples. Possible explanations for the evolution of sociality are briefly indicated.

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CHAPTER 6 The honeybee

The honeybee is one of the most studied animal species. This is not surprising, considering its importance in agriculture, and its highly interesting social behaviour. This chapter describes several aspects of the life history of the honeybees, such as nest construction, temperature regulation, food and foraging, communication, dispersal (swarming), mating, reproduction, development of immature stages, hibernation, natural enemies and diseases. A separate text box describes the global diversity and distribution of the species of *Apis*, the genus to which the honeybee belongs.

CHAPTER 7 Parasitic bees

A considerable proportion of bee species do not build nests and do not take care of their offspring themselves. Instead, they are social parasites of other bees. Parasitic bees can be divided into intra- and interspecific parasites. Both main types of parasitism occasionally (facultatively) occur in species which usually do not live as parasites. Obligate parasites are only found among interspecific parasites. These parasitic bees are commonly called 'cuckoo bees', because of their habit to oviposit inside the nests of other bee species. In the Netherlands, this life style is represented by all species belonging to the genera *Ammobates*, *Biastes*, *Coelioxys*, *Epeoloides*, *Epeolus*, *Melecta*, *Nomada*, *Sphecodes*, *Stelis* and *Thyreus*, and by some species of *Bombus*. This chapter describes several aspects of the biology and morphology of parasitic bees.

CHAPTER 8 Relationships of bees with other insects

Bees exhibit an astoundingly large array of relationships with other organisms. Predators, parasites, parasitoids, commensals, inquilines and pathogens of bees can be found among many lineages of life on earth. This chapter focuses on the relationships of bees with other insects, most notably those occurring in the Netherlands. These insects are categorized according to the type of relationship, and brief accounts are given of their biology. Examples of covered groups are digger wasps (Crabronidae), parasitic wasps (Chalcidoidea, Ichneumonidae), conopid flies (Conopidae), bee flies (Bombyliidae), blister beetles (Meloidae) and spider beetles (Ptinidae). The chapter concludes with a discussion of possible explanations for the evolution of the remarkably large number of bee-insect relationships. Several aspects of bee-life seem to be potentially explanatory, but in general this phenomenon is hypothesized to be triggered by the successful co-evolution of bees and flowering plants, which has forced bees to lead residential lives, as they need to build nests in order to reproduce.

CHAPTER 9 Seven districts: their habitats and their bees

Based on physical and geographical properties, the Netherlands can be divided into seven main districts. For each district, characteristic habitat types can be distinguished. This chapter characterizes the bee fauna of each district and habitat type. The following districts are recognized (with habitat types in parentheses):

- marl and loess district (calcareous grassland, thicket, *Quercus-Carpinus* forest, flower rich arable field);
- higher sand district (moist grassland, dry grassland, heathland and peat moor, borders and brushwood, forest, wasteland);
- river and tidal district (grassland, moist brushwood, thicket, riparian forest, sand dunes and beaches, pioneer vegetation);
- peat bog district (bog, moist oligo-meotrophic grassland);
- dune and coastal district (wet and dry heathland, swampy thicket, dry grassland, salt marsh);
- urban district (railway yard, gardens, urban plantation).

CHAPTER 10 The Dutch bee database

Over the course of 200 years, many hundreds of people contributed their records of bees to the Dutch bee database. This resulted in the number of 186.147 records as used in the present book. This chapter describes the history, structure and contents of the database. The oldest Dutch bee record in the database concerns a specimen of *Sphecodes pellucidus*, collected in 1809. The majority of records (85%) originate from entomological collections. Recently, this percentage has drastically decreased in favour of field observations. In the years 2000-2009 the proportion of field-based records was 29%; in 2010-2011 as much as 70%. This increase in field observations is mainly caused by the increasing popularity of photographing insects. Nowadays, many field observations are accompanied by good photographs, which often allow for a reliable identification.

CHAPTER 11 Changes in the Dutch bee fauna

The Dutch bee database is used in this chapter for analyzing changes in the Dutch bee fauna over the years. Trends are calculated based on the occurrence in 5 × 5 km grid cells. Only collection-based records were used, in order to avoid possible bias caused by the strong increase of field observations in the database in recent years (presumably containing a larger proportion of common and easily recognizable species than collection-based records). The main analysis compares two periods: before 1990 and 1990-2011 (*two period analysis*). The results of this analysis are quite rough, as they are based on a comparison of the years 1990-2011 with the very long period before 1990. This is why an additional analysis was also performed, comparing three periods: before 1970, 1970-1989 and 1990-2011 (*three period analysis*). This could provide some more understanding of patterns of increase and decline over time. Each analysis only employs data from grid cells which were investigated in all (two or three) relevant periods. The results for each species can be found in Appendix 3.
The number of bee species that have declined (122) is larger than the number of species that have increased (71). So, of all species with a significant trend, 63% have declined. 34 species (almost 10% of the species recorded from the country) have disappeared from the Netherlands since 1990. On the other hand, eight 'new' species have established themselves after 1990, while some of another 15 newly recorded species are possibly also establishing themselves.

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The decline among bumblebees is dramatic: 21 of 29 species have declined, and only one (*Bombus sylvestris*) is considered to have increased.
Among ground-nesting bees, a larger proportion of species appears to have decreased (36%) than among bee species nesting above the ground (26%). This could possibly be explained by the negative effect of eutrophication on sparsely vegetated soils.
Surprisingly, no difference in trend could be found between oligolectic and polylectic bee species. Among both categories, approximately 35% of species have declined and 20% have increased. Trends of parasitic bees also appear to be comparable to those of non-parasitic bees.
In order to detect a possible effect of climate change on the bee fauna, trends of bee species which reach the northern limit of their range in the Netherlands are compared with those of other bee species. No differences in trends were found between these categories in the two period analysis. The three period analysis, however, indicated that there was an initial decline of 72% of the southern species between the first two periods (before 1970 and 1970-1989), while only 57% of the other species declined between these two periods. This decline of southern species was followed by a recovery of 67% of southern species (from 1970-1989 to 1990-2011), while only 42% of the other species increased between these two periods.
In general, the majority of species that have declined seem to have done so before 1990. After this year, the decrease in diversity seems to have stopped. It is difficult to distinguish the apparent effect of climate change (since approximately 1990) from a possibly positive effect of changes in Dutch nature policy and management. The substantial proportion of southern bee species among the species that have increased possibly camouflages a more negative development. Indeed, southern Europe is much more diverse in bee fauna than northern Europe, so shifting ranges might account for part of the results presented in this chapter.

CHAPTER 12 Conservation and habitat management

Like most other groups of organisms, bees suffer from eutrophication, acidification, desiccation and habitat fragmentation. But bees have some unique ecological traits that make them even more vulnerable to these 'usual suspects' than most other organisms: **1** specialized associations with certain flowers and certain types of nesting sites; **2** habitat differentiation (food, nesting site and nest material need to be obtained from different 'partial habitats'); **3** limited flight range (usually less than a few hundreds of meters from their nest); **4** limited phenological flexibility (flight period can hardly be adapted to changing environment). With these traits in mind, this chapter analyzes the threats and opportunities for bees in Dutch habitat management, subdivided into natural, agricultural and urban areas. Natural areas are considered very important for bees, but at present their bee fauna suffers from a lack of dynamics and small-scale variation. The bee fauna of agricultural areas has strongly deteriorated because of an excess of dynamics and a lack of small-scale variation. Urban areas are increasingly gaining importance for bees, due to a more natural approach towards managing parks and gardens. The chapter briefly discusses the effects of climate change on wild bees, competition with honey bees, pesticides and genetic modification. Concluding subjects are the international importance of the Dutch bee fauna and the position of bees in Dutch nature policy, which has improved since bees are included on the national Red List.

CHAPTER 13 Bees and humans

Bees and human share a long common history, mainly because their pollination services are indispensable for our food production. The first part of this chapter deals with the pollination of agricultural crops by bees, both wild bees and domesticated honeybees, with special attention to current research on this subject in the Netherlands. The second part of this chapter discusses the cohabitation of bees with humans in their streets, gardens and even their homes. Although some people are annoyed or alarmed by the presence of bees in their domestic territories, these emotions are rarely justified. When the right kind of information is provided, people can learn to enjoy the beauty and interesting behaviour of bees.

CHAPTER 14 Observing bees

Every year, new discoveries are made on the biology, ecology and distribution of bees in the Netherlands. Even beginners in the study of bees can contribute. This chapter aims to give practical advice for the beginner to get started, and suggestions for the advanced to spark off new ideas. Several methods of observation and research are presented, like photography, building artificial nesting sites and preparation of pollen samples. Collecting and sampling methods are also discussed.

CHAPTER 15 Morphology and function of the bee body

An overview is given of the main morphological features of bees. Special attention is paid to the function of body parts, like the sensory organs of the antennae, the specialized organs for storing pollen, different types of glands, the reproductive organs, and the sting.

CHAPTER 16 Identifying bees

This chapter presents a key to all genera of bees known from the Netherlands. In the introduction, the difference between bees and aculeate wasps is explained, as well as the difference between male and female bees. Some practical advice is provided on collecting, mounting, labeling, preserving and identifying bees. A table presents an overview of recommended literature for identifying bees to species level.

CHAPTER 17 Diversity, phylogenetic relationships and nomenclature

Worldwide, approximately 20.000 bee species have been described. These are divided into seven subfamilies, six of which occur in the Netherlands. The evolution of bees is discussed by presenting modern hypotheses on the phylogenetic relationships with other insects, as well as their

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mutual relationships. Some information on fossil bees is given. The chapter concludes with a checklist of 358 bee species known from the Netherlands. A list of species known from adjacent parts of Belgium and Germany is also given.

CHAPTER 18 Species accounts

This chapter presents summarized information for all bee species known from the Netherlands. Genus and species accounts are sorted in alphabetical order and include information on identification and taxonomy, distribution and biology. For every species, a map indicating the distribution of Dutch records is given, as well as a phenology diagram.

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