Insects nightly attracted to light at a single site in De Kaaistoep, The Netherlands. Orders, families and species identified in 1995-2011

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From summer 1995 onwards, Lepidoptera were quantitatively inventoried with a lighted white sheet at night in De Kaaistoep, a nature reserve to the west of the city of Tilburg, The Netherlands. Starting in 1997, light was also used to inventory Coleoptera. During the next years many other groups of insects were taken into account as well, including Formicidae (2002), Hemiptera-Heteroptera (2002) and Ichneumonoidea (2005). The fifteenth anniversary of the Coleoptera survey, in 2011, was a good reason to present all data collected thus far. This article describes all the orders and families attracted by light after sunset, with their numbers of species. Sometimes the species are listed too. During all the years we used the same equipment on the same spot. With the help of many entomological specialists, we were able to identify about 240,000 insects belonging to fourteen orders, 216 families and 2,180 species. In this way we made a substantial contribution to an All Taxa Biodiversity Inventory (ATBI) of De Kaaistoep, now comprising more than 7,000 species.

Introduction

Light traps are used all over the world to catch nocturnal insects. The catches do not only provide information about local diversity of insects, but also about their distribution patterns and life cycles. Often a trap consists of a lamp and a container with some fluid or vapour that kills insects attracted by the light. Many lepidopterologists, however, use a vertical white sheet with a bright lamp in front of it. The sheet is inspected regularly and insects are identified on the sheet or caught manually. Though a standard method for studying Lepidoptera (Koch 1984, Ter Haar 1924, Young 1997), it is not very popular among coleopterologists. Only Freude *et al.* (1965) recommend sampling beetles with light but on dark days before sunset.

Long-lasting studies using light to investigate night-flying insects have been rare. Almost all used some kind of continuous trap. For example, Williams (1939) studied all kinds of insects in the UK for four years. Probably one of the best long-lasting studies is the Rothamsted insect survey (RIS) which started in 1968 in Great Britain. A 40-year survey of larger moths was published recently (Fox *et al.* 2013). Bruun (1992) investigated Lepidoptera for 35 years (1954-1989) in Finland, and Wieser (1998) for at least ten years in Austria, whereas Kofler (1999, 2005) published the 'Begleitfänge' of Coleoptera. Continuous light-trapping of Trichoptera (also a RIS-study) for a period of eighteen years was reported from Great Britain (Crichton 1984) and of Ephemeroptera for fourteen years from France (Usseglio-Polatera, 1997). The record was set in Hungary with more than 50 years of light-trapping on several locations (Szentkirályi 2002). However, long-term studies using light on a white sheet and manual sampling are unknown to us.

In De Kaaistoep, our study area in Tilburg, a biodiversity inventory was set about in 1995 (Van Wielink 2010). It includes many flora and fauna elements. As a start, only Lepidoptera were studied with light on a white sheet, always at the same position. This method will be referred to in the next sections as 'with light' (see figure 2). In 1997 Coleoptera followed. Over the years more and more insect groups were included, like Heteroptera (2002), Formicidae (2002), Trichoptera (2005), Ichneumonoidea (2005) and Symphyta (2006). Other groups were studied incidentally, viz., Ephemeroptera, Auchenorrhyncha and Diptera. Many other groups were observed on the sheet as well, but only in low numbers: Orthoptera, Dermaptera, Psocodea, Psylloidea, Neuroptera and Mecoptera. The large amount of data on insects collected with light over the years, contributed substantially to an ATBI (All Taxa Biodiversity Inventory) of De Kaaistoep (Van Wielink 2010). In the current overview the data are presented at order and family level. The relative distribution over the orders of the insect numbers and the relationship with weather conditions will be dealt with in the next article. More details on specific groups (Coleoptera, Lepidoptera) will be presented in subsequent articles.

Study area

De Kaaistoep lies immediately west of the urban area of Tilburg, in the province of Noord-Brabant in the south of The Netherlands, at about 5°01'E and 51°33'N. It is owned by the Tilburg waterworks company (TWM Gronden). Since 1994 this former agricultural area has been transformed in a more

1. The study area in De Kaaistoep as seen from the east. In front is a small artificial pool. The site of the light is in the middle, just before the building, about 300 m behind the pool. In the background is a row of pedunculate oaks and other deciduous trees. Photo: Paul van Wielink
1. Het onderzochte gebied in De Kaaistoep gezien vanuit het oosten. Vooraan een gegraven poel met ongeveer 300 meter daarachter (in het midden) de plaats van het licht, vlak voor de veldwerkhut. Daarachter een rij met zomereiken en andere loofbomen.

2. Four lamps of 500 W each light a vertical white polyester sheet of 1.9 × 3.5 m. Another white sheet is positioned on the ground. Photo: Paul van Wielink
2. Vier lampen van elk 500 W verlichten een verticaal wit polyester laken van 1,9 × 3,5 m. Op de grond ligt ook een laken.

3. The authors, Henk Spijkers (right) and Paul van Wielink (left), collecting insects from the white sheet with their pooters. Photo: Ronald Peeters
3. De auteurs, Henk Spijkers (rechts) en Paul van Wielink (links), verzamelen met exhausters insecten van het laken.

Order	Group	Year(s)	Counted	Specialist
Ephemeroptera		2005	×	A. Mol
Orthoptera		1997-2011	×	E. Bouvy
Blattodea		1997-2011	×	E. Bouvy
Dermaptera		1997-2011	×	P. van Wielink
Psocodea		1997-2011	-	J.W. van Zuijlen
Hemiptera	Psylloidea	1997-2011	-	J.W. van Zuijlen
	Auchenorrhyncha	2005	×	A. Mol
	Heteroptera	2002-2011	×	B. Aukema
Coleoptera		1997-2011	×	P. van Wielink, E. Bouvy
Neuroptera		2004-2011	-	J.W. van Zuijlen
Trichoptera		2005-2011	×	B. Higler
Lepidoptera	Macrolepidoptera	1995-2011	×	H. Spijkers
	Microlepidoptera	1996-2011	-	H. Spijkers
Mecoptera		1997-2011	×	P. van Wielink
Diptera	non-Tipulidae	1997-2011	-	J.W. van Zuijlen
	Tipulidae	2008-2009	×	P. Oosterbroek
Hymenoptera	Symphyta	2006-2011	×	A. Mol
	Parasitica - Braconidae	2005-2011	-	C. van Achterberg
	Parasitica - Ichneumonidae	2005-2011	-	K. Zwakhals
	Aculeata - non-Formicidae	1997-2011	×	T. Peeters
	Aculeata - Formicidae	2002-2011	×	P. Boer

Table 1. Insect orders attracted by light always on the same spot in De Kaaistoep: years of study, counted or not, and main entomological specialist.
Tabel 1. Insectenorden die aangetrokken werden door licht, steeds op één plaats in De Kaaistoep: onderzoeksjaren, geteld of niet, en belangrijste specialistentomoloog.

natural landscape. From 1995 on, the Tilburg section of the Royal Dutch Natural History Society (KNNV) is monitoring changes in flora and fauna of De Kaaistoep (Van Wielink 1999). This resulted in one of the most extensive ATBI's in The Netherlands, with (till now) more than 7,000 species identified (Berg & Van Nieukerken 2010, Van Wielink 2011a). Our research area was the western part of De Kaaistoep. The frame with sheet and lamps was always placed at exactly the same spot, about 20 m in front of a row of pedunculate oaks (*Quercus robur*) and other deciduous trees and shrubs (figure 1). In the near vicinity (less than 100 m away) the following trees and shrubs are also present: birch (*Betula*), black and white poplar (*Populus nigra* and *P. alba*), field maple (*Acer campestre*), black locust (*Robinia pseudoacacia*), rowan (*Sorbus aucuparia*), European elder (*Sambucus nigra*), black cherry (*Prunus serotina*), common hazel (*Corylus avellana*), common hawthorn (*Crataegus monogyna*), blackthorn (*Prunus spinosa*), dog rose (*Rosa canina*), common snowberry (*Symphoricarpos albus*), blackberries (*Rubus*), Scots and European black pine (*Pinus sylvestris* and *P. nigra*), Norway spruce (*Picea abies*), European larch (*Larix decidua*), and others. To the east is open grassland on poor sandy soil, grazed by many rabbits. About 300 m to the east the grassland is bordered by another row of pedunculate oaks. About 600-700 m to the east a little canalized lowland brook flows: the Oude Leij. In 2005 and 2008 this brook was restored into a more or less natural condition. Between the Oude Leij and the light source five artificial pools are present, of which the largest has a surface area of about 1 ha. To the west and north of the light source are extensive areas of coniferous woodland (mainly Scots pine). The southern boundary is formed by the A58 motorway connecting Tilburg and Breda. A more detailed description of the site of research was published by Felix & Van Wielink (2008).

4. Ephemeroptera (mayflies) on the bottom sheet in the night of May 26th 2012, 10.30 p.m. Photo: Paul van Wielink
4. Ephemeroptera (eendagsvliegen) op het grondlaken in de nacht van 26 mei 2012, om 22.30 uur.

Methods

A light source of four mixed light lamps of 500 W each was used (Philips ML and Osram HWL, colour temperature 3700 and 4100 K, respectively). Two lamps were at the top corners and two in the middle of a vertical white polyester sheet, 3.5 m wide and 1.9 m high. Below, another white sheet was spread out on the ground (figure 2). Electricity was obtained from a nearby field cottage. The lights were nearly always switched on at sunset. The sheet was always at the same position: 51°32'25"N 5°00'37"E (RD 128.8-394.6, UTM 31u639420/5711822).

The lights were operational almost 500 times in 1997-2011, which gives an all-over frequency of less than once a week (see results). Insects were identified while they were sitting on the sheet or, if necessary, after manual collection (figure 3) and killing them with ethyl acetate or putting them directly into 70% ethanol. Specimens of various taxonomic groups were transferred to specialists, who identified them almost always under magnification. Collection, labelling, storage and transfer to specialists were organized by the authors. Of some groups, the species as well as their numbers were recorded: specimens were counted during many nights. If their numbers were too high to be counted, estimations were made by extrapolation from a sample with a known number of specimens. Table 1 gives an overview of the groups studied, the period of being under study, the specialists, and the groups studied in more detail.

Table 2. Ephemeroptera (mayflies) seen on the sheet in 2005.
Tabel 2. Ephemeroptera (eendagsvliegen) aangetroffen op het laken in 2005.

Family	Species	Nr. of specimens
Baetidae	*Cloeon dipterum* (Linnaeus)	7 ♂ +67 ♀
	Cloeon simile Eaton	3 ♀
	Procloeon bifidum (Bengtsson)	1 ♀
Caenidae	*Caenis horaria* (Linnaeus)	9 ♂
	Caenis spec. (*horaria*, *robusta* Eaton or *luctuosa* (Burmeister))	136 ♀
Ephemeridae	*Ephemera glaucops* Pictet	1 ♀
Total		**16 ♂ +208 ♀**

Table 3. Orthoptera (grasshoppers and crickets) seen on the sheet in 1997-2011.
Tabel 3. Orthoptera (sprinkhanen en krekels) waargenomen op het laken in 1997-2011.

Family	Species	Nr. of specimens
Tettigoniidae	*Tettigonia viridissima* (Linnaeus)	1
	Conocephalus discolor (Thunberg)	1
	Phaneroptera falcata Poda	4
Acrididae	*Chorthippus biguttulus* (Linnaeus)	1
Tetrigidae	*Tetrix undulata* Sowerby	4
Gryllidae	*Acheta domestica* (Linnaeus)	11
Total		**22**

Local weather conditions were recorded from 1997 onwards (temperature range from the beginning to the end of the night, wind force and direction, humidity, and presence of clouds, rain, or fog). If only a single temperature is mentioned below, it is always at 1 h after sunset.

Names and sequence of insect orders and families are in accordance with Noordijk *et al.* (2010), unless stated otherwise. Collected insects are in the private collections of the specialists or in the museum of natural history (Natuurmuseum Brabant) in Tilburg.

Results

During around 550 nights we looked for macrolepidoptera on the sheet (1995-2011), and during 494 nights for Coleoptera too (1997-2011). Other orders received much less attention (table 1) except for those incidentally seen on the sheet, i.e., Odonata, Orthoptera, Blattodea and Mecoptera. Plecoptera, Thysanoptera, Strepsiptera, Megaloptera and Raphidoptera were never encountered on the sheet, although they are known from The Netherlands (Noordijk *et al.* 2010) and, except for Plecoptera, also from De Kaaistoep.

The frequency of nightly collection with light in 1997-2011 was about 0.6 times/week (yearly variation 0.2-1.5). The average monthly frequency varied from 0 (December and January) to 6.8 (July). In July the frequency was also very variable reaching from 20 sampling days (2006) till 1 (2003). This huge variation has a great impact (see discussion).

Below, each of the fourteen insect orders found is discussed. For many orders we only mention the families seen and their numbers of species. In addition, the section on Diptera contains an overview of the distribution of specimens over the families.

Ephemeroptera (mayflies)

Some nights, Ephemeroptera were present in large numbers. On August 8th 2005 and August 6th 2006 (both nights 16 °C, no wind, high atmospheric humidity) more than a thousand (mainly *Caenis* spec.) were spotted on the ground sheet (figure 4). Ephemeroptera were collected incidentally. In the whole of 2005, 224 specimens were collected and identified. They belonged to seven species (table 2), most of them *Cloeon dipterum* and *Caenis* spec. In 2006-2007 no Ephemeroptera were collected except for the bigger ones: nineteen specimens of *Ephemera glaucops*, all females.

Odonata (dragonflies)

In fifteen years, only two dragonflies were encountered, both *Sympetrum vulgatum* Linnaeus.

Orthoptera (grasshoppers and crickets)

Twenty-two Orthoptera were drawn to the sheet, accounting for six species of four families (table 3), among them eleven specimens of house cricket, *Acheta domestica* (Linnaeus).

Blattodea (cockroaches)

Only two Blattodea were found: *Ectobius panzeri* Stephens and *E. pallidus* (Olivier). Both were nymphs, unable to fly.

Dermaptera (earwigs)

Two species of Dermaptera of two families were observed on the sheet. Some nights, tens of lesser earwig, *Labia minor* (Linnaeus) (Labiidae) were present. On August 31st 2008 (20 °C, little wind, sweltering, high atmospheric humidity, threatening thunderstorm) 48 *L. minor* were collected, of which 44% males. Common earwig, *Forficula auricularia* Linnaeus (Forficulidae) was seen in small numbers a few nights only, although a lot of them could be found in the near vicinity of the site.

Psocodea

Of the Psocodea only the Psocoptera, commonly known as booklice, barklice or barkflies, are able to fly. They were seen in low numbers on the sheet. Till now only a single species has been identified: *Methylophorus nebulosus* (Stephens) (Psocidae).

Hemiptera (true bugs and relatives)

Members of the suborders Sternorrhyncha (i.e., Psylloidea and Aphidoidea), Auchenorrhyncha and Heteroptera were seen.

Psylloidea (jumping plant lice and others) were present a few nights only. Between 50 and 100 specimens were seen in 2010 and 2011, of which 40 on September 10th 2011 (17 °C, high atmospheric humidity, gusts of wind, force 4-6). *Chamaepsylla hartigii* (Flor), *Psylla alni* (Linnaeus) (Psyllidae) and *Trioza remota* Foerster (Triozidae) were identified.

Aphidoidea (plant lice) were sometimes present in high numbers (2010-2011: 2,500 in total). Some nights they were dominant: on October 3rd 2011 (no wind, 16 °C) 68% of the 2,200 insects counted were Aphidoidea. They were not identified, not even to family level.

Auchenorryncha (cicadas) could also be present in high numbers. In 2005, 3,263 specimens were collected, of which 1,435 (mostly males) were identified (table 4), resulting in 59 species of five families (Mol 2007a). The most common species were *Euides basilinea* (Germar) (Delphacidae: planthoppers), *Aphrophora salicina* (Goeze) (Aphrophoridae: spittlebugs), and *Iassus lanio* (Linnaeus), *Oncopsis flavicollis* (Linnaeus),

Suborder/superfamily	Family	Nr. of species	Nr. of specimens
Sternorrhyncha-Psylloidea	Psyllidae	2	ca. 50
	Triozidae	1	1
Sternorrhycha-Aphidoidea	?	?	>1,000
Auchenorrhyncha	Cixiidae	1	2
	Delphacidae	12	339
	Aphrophoridae	2	69
	Cercopidae	1	1
	Cicadellidae	43	1,024
Heteroptera	Corixidae	21	4,433
	Veliidae	1	1
	Gerridae	2	3
	Saldidae	4	9
	Miridae	93	8,124
	Nabidae	6	109
	Anthocoridae	14	231
	Reduviidae	1	13
	Lygaeidae	17	693
	Acanthosomatidae	2	420
	Pentatomidae	2	166
Total		**225**	**ca. 17,000**

Table 4. Overview of Hemiptera seen on the sheet in 2002-2011.
Tabel 4. Overzicht van Hemiptera waargenomen op het laken in 2002-2011.

O. subangulata (Sahlberg), and *Populicerus nitidissimus* (Herrich-Schäffer) (all Cicadellidae: leafhoppers). Four new species for The Netherlands were discovered (Den Bieman & Mol 2010). A common and easily recognizable species was *Ledra aurita* (Linnaeus) (horned leafhopper, figure 5). It was seen every year, especially during warm, sweltering nights at the end of July or beginning of August, up to 25 specimens a night, almost all males.

Heteroptera (true bugs) were attracted to light in large numbers. Species and their numbers were recorded from 2002 onwards. Till the end of 2011, 14,202 Heteroptera belonging to 163 species and eleven families were recorded (table 4) (Aukema 2010a, 2011a, 2012). The five most common species were *Harpocera thoracica* (Fallén), *Stenodema calcarata* (Fallén), and *Lygus rugilipennis* Poppius (all three Miridae), and *Sigara scotti* (Douglas & Scott) and *S. striata* (Linnaeus) (Corixidae), with 2,379, 1,191, 914, 889, and 820 specimens, respectively. In the night of April 26th 2007 about 1,000 Miridae were counted, almost all *Harpocera thoracica* (Fallén). That night the temperature lowered from 20 to 16 °C, the wind was NE, force 3-4 but later calm, the sky was clear and the atmosphere became rather humid. Some nights many Corixidae were present, e.g., more than 1,000 *Sigara* spec. in the night of August 31st 2008 (20 °C, little wind, sweltering, high atmospheric humidity, threatening thunderstorm). Corixidae had no grip on the vertical sheet and ended at the bottom sheet (figure 6). Some interesting species were discussed by Aukema & Hermes (2009) and Aukema (2011b).

5. Horned leafhopper *Ledra aurita* (Auchenorrhyncha: Cicadellidae), a common species on the sheet from the end of July till the end of August. Photo: Paul van Wielink
5. Oorcicade *Ledra aurita* (Auchenorryncha: Cicadellidae), algemeen op het laken van eind juli tot eind augustus.

6. In the night of August 19th 2009 hundreds of small Corixidae (most of them *Sigara* spec.) were present. They could not hold on the vertical sheet and landed on the bottom sheet. Photo: Paul van Wielink
6. Honderden kleine Corixidae (de meeste *Sigara* sp.) waren aanwezig in de nacht van 19 augustus 2009. Ze konden zich niet vasthouden aan het verticale doek en vielen op het grondlaken.

Table 5. Overview of Coleoptera (beetles) seen on the sheet in 1997-2011. Family names and sequence according to Vorst (2010).
Tabel 5. Overzicht van Coleoptera (kevers) waargenomen op het laken in 1997-2011 Familienamen en volgorde volgens Vorst (2010).

Family	Nr. of species	Nr. of specimens	Family	Nr. of species	Nr. of specimens
Gyrinidae	2	34	Anobiidae	7	20
Haliplidae	8	55	Cleridae	3	7
Dytiscidae	37	1,147	Melyridae	7	722
Carabidae	87	11,397	Kateretidae	1	21
Hydrophilidae	51	19,138	Nitidulidae	14	225
Histeridae	2	3	Monotomidae	4	44
Hydraenidae	1	6	Phalacridae	5	75
Ptiliidae	3	11	Cryptophagidae	23	274
Leiodidae	18	392	Erotylidae	1	2
Scydmaenidae	2	3	Cerylonidae	1	1
Silphidae	5	266	Coccinellidae	23	8,637
Staphylinidae	149	15,566	Latridiidae	7	346
Trogidae	1	57	Mycetophagidae	3	25
Geotrupidae	3	86	Ciidae	2	2
Bolboceratidae	1	8	Melandryidae	1	4
Scarabaeidae	19	3,778	Zopheridae	2	2
Eucinetidae	1	1	Tenebrionidae	10	285
Clambidae	1	1	Oedemeridae	1	3
Scirtidae	7	675	Pyrochroidae	1	1
Buprestidae	2	4	Salpingidae	2	10
Byrrhidae	1	1	Anthicidae	4	226
Elmidae	1	1	Scraptiidae	5	19
Dryopidae	2	6	Cerambycidae	15	234
Heteroceridae	6	675	Chrysomelidae	31	559
Throscidae	5	7	Nemonychidae	1	4
Elateridae	20	1,340	Anthribidae	1	5
Cantharidae	20	2,256	Attelabidae	6	86
Dermestidae	5	33	Brentidae	9	23
Bostrichidae	1	12	Curculionidae	74	1,625
			Total of 58 families	**725**	**70,446**

Coleoptera (beetles)

In 1997-2011 the Coleoptera were studied during 494 nights, of which 291 with counts. We observed about 150,000 beetles of which 70,466 were identified, either on the sheet or under the microscope. This resulted in 725 species of 58 families (table 5), among them some species new to The Netherlands.

Some nights it was almost impossible to count or select Coleoptera because of their large numbers. Then numbers were extrapolated from a sample. We will never forget the remarkable night of July 20th 1998. After the weather changed the day before, it became >30 °C and sunny. The evening and night were cloudy, sweltering and warm (around 25 °C). More than 10,000 beetles were counted, mainly Carabidae and *Cercyon* spec. (Hydrophilidae).

Over all the years, the most numerous Carabidae were *Bradycellus harpalinus* (Audinet-Serville) and *B. verbasci* (Duftschmid) (figure 7): up to 5,000 specimens per night. Other numerous species (more than 1,000 specimens in 1997-2011) were *Oxytelus laqueatus* (Marsham) and *Philonthus quisquiliarius* (Gyllenhal) (Staphylinidae), *Helophorus brevipalpis* Bedel, *H. minutus* (Fabricius) and *Cercyon marinus* Thomson (Hydrophilidae), and *Aphodius rufus* (Moll) (Scarabaeidae). The invasive ladybird species *Harmonia axyridis* (Pallas) (Coccinellidae) was first observed on the sheet in 2003 (Cuppen *et al.* 2004). From that moment on all Coccinellidae were identified and counted. In the years 2003-2011 *H. axyridis* was seen in 207 out of 361 nights (57%), by far the highest presence of all beetles; in the night of 31 August to 1 September 2008 (20 °C, little wind, sweltering, high atmospheric humidity, threatening thunderstorm) a record number of 582 was counted in 4 h.

Neuroptera (net-winged insects)

Many species of Neuroptera are active at night and are attracted by light. We obtained fifteen species of four families, mostly Chrysopidae (lacewings, five species) (figure 8) and Hemerobiidae (seven species) (Van Zuijlen 2006, 2012). Some nights around 100 lacewings and the like were present, for instance at October 28th 2005 (19-16 °C, wind SE, force 2-3). Also Sisyridae (one species) and Myrmeolontidae (ant lions, two species) were observed. Ant lions were never on the sheet but were flying around the lamps (Van Zuijlen 2006).

Trichoptera (caddisflies)

From 2005 till May 2011, almost all Trichoptera (figure 9) were collected, identified and counted (Higler *et al.* 2008, Higler 2010a, Higler & Van Wielink 2011). Identification of specimens collected after June 2010 is not yet completed. A total of 25,781 specimens were identified, belonging to 59 species and eleven families (table 6). A thousand or more Trichoptera could be seen on the sheet during nights at the end of the summer with no wind, heavy clouds and high atmospheric humidity. The three most common species (over 3,000 specimens identified) were *Agraylea sexmaculata* Curtis (Hydroptilidae), *Oecetis ochracea* (Curtis) and *Mystacides longicornis* (Linnaeus) (both Leptoceridae). Interesting data about rare species, phenology, distribution and life-cycles were presented by Wiggers *et al.* (2006), Higler (2008), and Higler *et al.* (2008).

7. At the end of the night *Bradycellus* ground beetles (Carabidae) grouped together either at the top or at the bottom of the sheet. On August 2nd 2011 00.50 a.m. (sweltery, still, 21 °C at midnight) an estimated 2,500 *Bradycellus* specimens were present, a lot of them gathering at the top of the sheet. Photo: Paul van Wielink
7. Op het eind van de nacht verzamelen *Bradycellus*-loopkevers (Carabidae) zich óf aan de bovenrand óf helemaal onderaan het laken. Op 2 augustus 2011, 00.50 uur (broeierig, 21°C om middernacht) waren naar schatting 2.500 *Bradycellus*-kevers aanwezig, veel daarvan langs de bovenrand van het laken.

8. The lacewing *Chrysopa perla* (Linnaeus) (Chrysopidae) was fairly common on the sheet. Photo: Paul van Wielink
8. Het goudoogje *Chrysopa perla* (Linnaeus) (Chrysopidae) was tamelijk algemeen op het laken.

9. *Agrypnia varia* (Fabricius) (Limnephilidae) was a common caddisfly on the sheet. Photo: Twan Mols
9. Een algemene schietmot op het laken was *Agrypnia varia* (Fabricius) (Limnephilidae).

Lepidoptera (butterflies and moths)

Macrolepidoptera were identified and counted on the sheet, from 1995 on during more than 500 nights. Later microlepidoptera were identified too (but not counted), especially Pyralidae (snout moths) and Tortricidae (tortrix moths). From 1995 till 2011, 100,138 Lepidoptera were identified, belonging to 42 families and 795 species (table 7). About 1% of the individuals was collected to allow for a reliable identification, sometimes by examining the genitalia. Some nights moths could be seen in overwhelming numbers (figure 10). In the night of 10-11 July 2006 (windless, heavy clouds, sweltering, 24-20 °C) we estimated a few thousand moths to be present, of which more than 1,000 *Yponomeuta* spec. (ermine moths, Yponomeutidae), many more than 100 *Autographa gamma* (Linnaeus) (silver y, Noctuidae) and six *Deilephila elpenor* (Linnaeus) (elephant hawk-moth, Sphingidae). *Tyria jacobaeae* (Linnaeus) (Erebidae) was the most numerous species with more than 6,000 specimens. Some others turned up with more than 2,000 individuals like *Eilema complana* (Linnaeus) and *Phragmatobia fuliginosa* (Linnaeus) (both Erebidae), *Thaumetopoea processionea* Linnaeus (Notodontidae) and *Ochropleura plecta* Linnaeus (both Noctuidae), and *Bupalus piniaria* (Linnaeus) (Geometridae).

Mecoptera (scorpionflies and relatives)

In fifteen years about ten scorpionflies were noticed of two species, viz., *Panorpa germanica* Linnaeus and *P. communis* Linnaeus (Panorpidae).

Table 6. Overview of Trichoptera (caddisflies) seen on the sheet in 2005-2011.
Tabel 6. Overzicht van Trichoptera (kokerjuffers/schietmotten) waargenomen op het laken in 2005-2011.

Family	Nr. of species	Nr. of specimens
Hydroptilidae	6	7,798
Polycentropodidae	8	592
Goeridae	1	1
Lepidostomatidae	1	1
Ecnomidae	1	1,273
Psychomyiidae	2	25
Hydropsychidae	4	74
Phryganeidae	5	586
Molannidae	1	105
Leptoceridae	16	14,718
Limnephilidae	14	608
Total	**59**	**25,781**

Diptera (true flies)

Probably the most numerous of all insect orders were the Diptera (Spijkers & Van Wielink 2007). Many nights they were dominant on the sheet, but never counted. Usually only a selective sample was taken of individuals with conspicuous behaviour or appearance. We tried to gain insight in the number of families by taking aselective samples during four nights in 2011 (table 8). Both methods together yielded 4,150 specimens, of which 1,077 could be identified till now. They belong to 128 species of 57 families (41 Brachycera, sixteen Nematocera). Families present with more than 100 specimens in the aselective samples (2,832 specimens in total) were the Sphaeroceridae (more than 1,000), Chironomidae, Empididae, Anisopodidae, Ceratopogonidae and Ephydridae. Figure 11 shows the big differences in proportions of Diptera families in the four aselective samples. The following families were seen on the sheet, but not represented in the aselective samples: Anthomyzidae, Asilidae, Asteiidae, Conopidae, Hippoboscidae, Megamerinidae, Pallopteridae, Platipezidae, Psilidae, Rhagionidae, Rhinophoridae, Sciomyzidae, Sepsidae, Tephritidae, and Ulidiidae (all Brachycera), and Scatopsidae (Nematocera). Remarkable: in the night of April 23rd 2007 (17-15 °C, heavy clouds, hardly any wind) we counted around 250 St. Mark's fly, *Bibio marci* (Linnaeus).

In 2008 and 2009 we (selectively) collected a total of 108 Tipulidae (craneflies), belonging to fourteen species (figure 10). In 2009 we looked for Tipulidae during all nights the light was operational, and all specimens on the sheet were collected. They were present in nine out of 21 nights (spring and end of summer), resulting in 78 specimens of fourteen species (see table 9).

Till now, of 1,077 specimens of Diptera identified, one species was new to the Dutch fauna.

Hymenoptera

Members of all three suborders (Symphyta, Parasitica and Aculeata) were seen on the sheet (table 10).

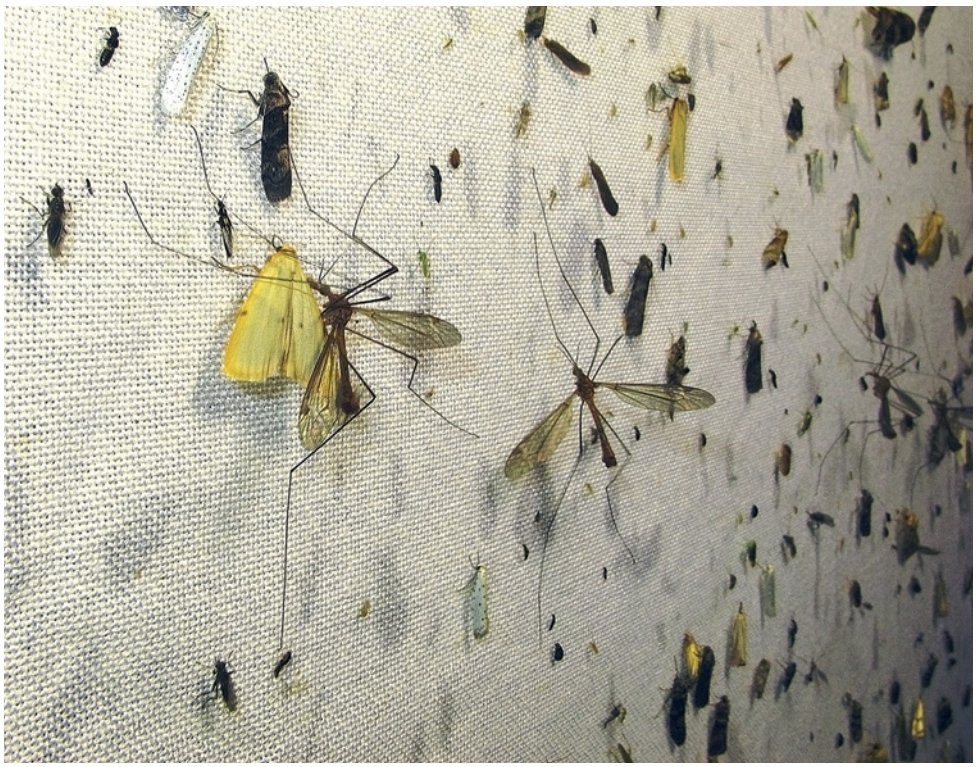
Of the Symphyta (sawflies) about 100 specimens were collected, belonging to 53 species and five families (Mol 2007b, 2008, 2009, 2010a, Mol & Cramer 2012). Only a few Symphyta were attracted to the sheet, at most six specimens per night (April 2011), substantially more females, and more than 50% in spring. The Tenthredinidae family (common sawflies) was by far the most numerous with the most species, among them *Periclista albiventris* (Klug) and *Mesoneura opaca* (Fabricius).

Table 7. Overview of Lepidoptera (butterflies and moths) seen on the sheet in 1995-2011. Family names and sequence according to Fauna Europaea.
Tabel 7. Overzicht van Lepidoptera (vlinders) waargenomen op het laken in 1995-2011. Familienamen en volgorde volgens Fauna Europaea.

Group	Family	Nr. of species	Nr. of specimens
micro-moths	Adelidae	5	8
micro-moths	Alucitidae	1	1
micro-moths	Argyresthiidae	3	6
micro-moths	Autostichidae	1	1
micro-moths	Blastobasidae	2	3
micro-moths	Chimabachidae	2	19
micro-moths	Choreutidae	1	2
micro-moths	Coleophoridae	9	11
macro-moths	Cossidae	2	212
micro-moths	Crambidae	51	459
macro-moths	Drepanidae	13	2,527
micro-moths	Elachistidae	12	28
macro-moths	Endromidae	1	2
macro-moths	Erebidae	43	19,113
micro-moths	Eriocraniidae	1	3
micro-moths	Gelechiidae	20	63
macro-moths	Geometridae	154	20,691
micro-moths	Glyphipterigidae	1	2
micro-moths	Gracillariidae	3	6
macro-moths	Hepialidae	3	224
micro-moths	Incurvariidae	2	4
macro-moths	Lasiocampidae	8	1,147
macro-moths	Limacodidae	2	285
butterflies	Lycaenidae	1	12
micro-moths	Lypusidae	1	1
macro-moths	Noctuidae	195	42,821
macro-moths	Nolidae	8	899
macro-moths	Notodontidae	25	8,255
butterflies	Nymphalidae	2	2
micro-moths	Oecophoridae	11	38
micro-moths	Peleopodidae	1	7
micro-moths	Plutellidae	1	12
micro-moths	Psychidae	2	2
micro-moths	Pterophoridae	9	35
micro-moths	Pyralidae	37	289
macro-moths	Saturniidae	1	2
macro-moths	Sphingidae	8	1,750
micro-moths	Tineidae	9	22
micro-moths	Tortricidae	133	1,058
micro-moths	Yponomeutidae	5	11
micro-moths	Ypsolophidae	5	14
macro-moths	Zygaenidae	1	91
	Total 42	**795**	**100,138**

Parasitica (parasitoid wasps) were present with many superfamilies, including Cynipoidea, Chalcidoidea and Ichneumonoidea. Cynipoidea (gall wasps) were almost exclusively found in early spring, with a maximum of 250 specimens in a night in March 2010. They were collected but not (yet) identified. Chalcidoidea (chalcid wasps, e.g., Pteromalidae and others) were seen and collected in relatively low numbers, but not identified. As from 2005 Ichneumonoidea were collected and a lot of them identified. Until now the Braconidae (braconid wasps) account for more than 500 specimens of 48 species of seventeen subfamilies, among them *Zele albiditarsus* Curtis, *Aleiodes similis* (Curtis), *Rogas luteus* Nees, and some species new to the Dutch fauna.

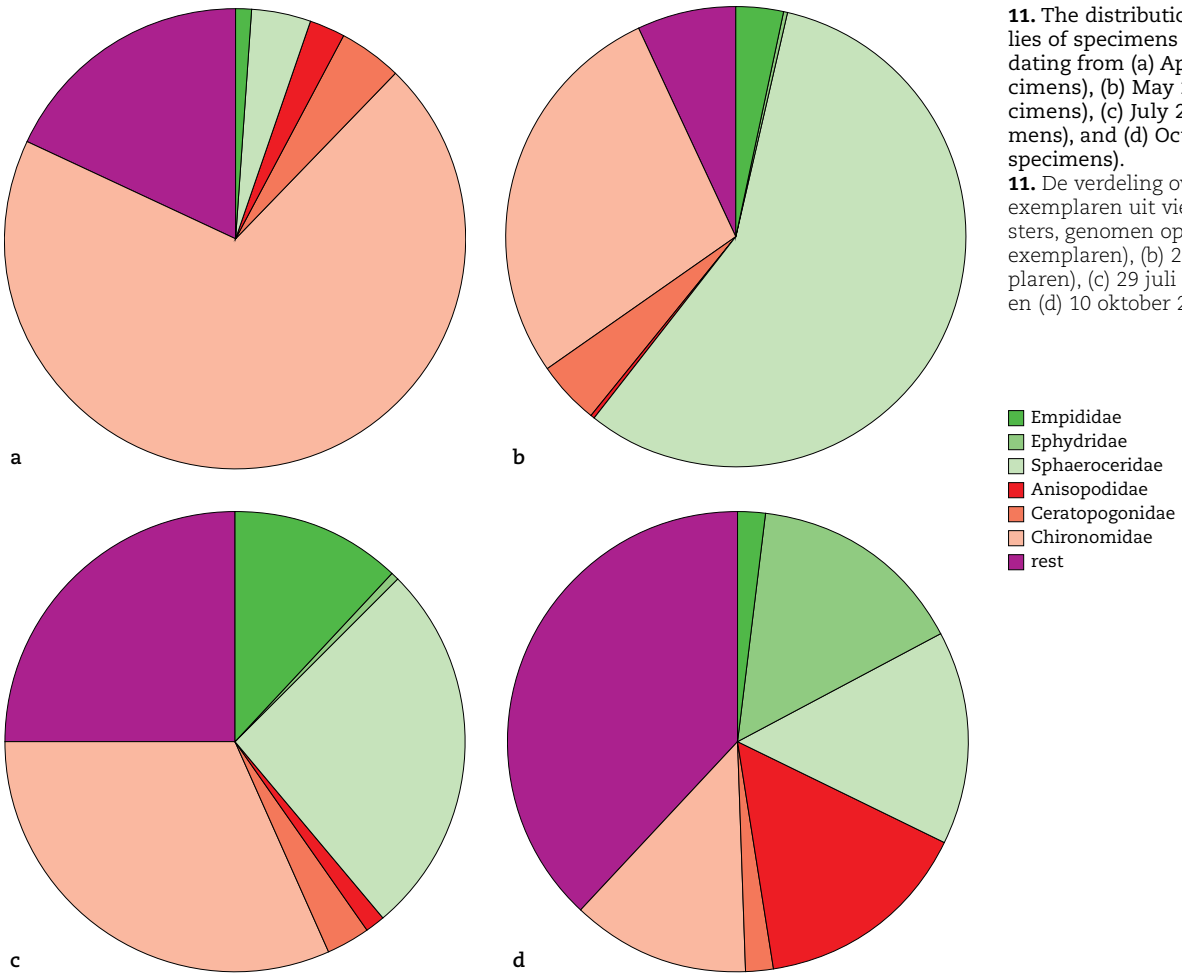
Each year thousands of Ichneumonid wasps came on the sheet. They were assigned to twelve subfamilies. Most specimens belonged to genera known to be nocturnal, like *Ophion*,



10. In the night of July 9th 2010, 00.20 a.m. (calm, 21 °C at midnight), about 2,000 moths and a lot of other insects like craneflies (Tipulidae) were present on the sheet. Photo: Paul van Wielink
10. In de nacht van 9 juli 2010, 00.20 uur (windstil, 21°C om middernacht) waren er op het laken ongeveer tweeduizend nachtvlinders en veel andere insecten aanwezig, waaronder langpootmuggen (Tipulidae).

Table 8. Overview of Diptera (true flies) seen on the sheet during four nights in 2011.
Tabel 8. Overzicht van Diptera (vliegen en muggen) waargenomen op het laken tijdens vier nachten in 2011.

Suborder	Family	11.iv.2011	29.v.2011	29.vii.2011	10.x.2011	Total
Brachycera	Agromyzidae	1	0	1	3	**5**
	Anthomyiidae	7	11	30	10	**58**
	Calliphoridae	0	0	1	6	**7**
	Camillidae	0	0	2	0	**2**
	Chloropidae	0	0	3	1	**4**
	Dolichopodidae	0	2	6	0	**8**
	Drosophilidae	0	15	4	2	**21**
	Empididae	2	53	56	13	**124**
	Ephydridae	0	2	2	98	**102**
	Fanniidae	0	1	0	0	**1**
	Heleomyzidae	0	0	0	1	**1**
	Hybotidae	0	0	0	1	**1**
	Lauxaniidae	0	2	0	0	**2**
	Lonchaeidae	0	0	1	0	**1**
	Lonchopteridae	0	0	10	47	**57**
	Muscidae	0	1	9	26	**36**
	Opomyzidae	0	0	0	28	**28**
	Phoridae	0	0	0	2	**2**
	Sarcophagidae	0	0	1	0	**1**
	Scatophagidae	1	24	10	14	**49**
	Sphaeroceridae	7	899	123	95	**1,124**
	Stratiomyidae	0	0	1	0	**1**
	Syrphidae	0	0	1	0	**1**
	Tachinidae	2	0	0	1	**3**
	Therevidae	0	0	2	0	**2**
Nematocera	Anisopodidae	4	2	7	97	**110**
	Bibionidae	3	0	0	0	**3**
	Cecidomyiidae	0	4	12	0	**16**
	Ceratopogonidae	7	72	14	12	**105**
	Chaoboridae	5	23	6	0	**34**
	Chironomidae	114	434	146	81	**775**
	Culicidae	0	0	0	4	**4**
	Keroplatidae	0	1	0	0	**1**
	Limoniidae	4	16	5	6	**31**
	Mycetophilidae	0	1	1	4	**6**
	Psychodidae	1	1	0	1	**3**
	Sciaridae	0	1	6	78	**85**
	Simuliidae	1	2	0	0	**3**
	Tipulidae	3	2	4	4	**13**
	Trichoceridae	0	0	0	2	**2**
	Total	**162**	**1569**	**464**	**637**	**2,832**



11. The distribution over Diptera families of specimens from four samples dating from (a) April 11th 2011 (163 specimens), (b) May 29th 2011 (1,570 specimens), (c) July 29th 2011 (464 specimens), and (d) October 10th 2011 (637 specimens).
11. De verdeling over Diptera-families van exemplaren uit vier verschillende monsters, genomen op (a) 11 april 2011 (163 exemplaren), (b) 29 mei 2011 (1.570 exemplaren), (c) 29 juli 2011 (464 exemplaren), en (d) 10 oktober 2011 (637 exemplaren).

Netelia and *Cidaphus*, all with a characteristic light reddish brown colour. An hour after sunset on April 23rd 2011 (relatively warm: 17.5 °C), we counted more than 1,000 specimens. Especially *Ophion minutus* Kriechbaumer was always numerous. In 2006 all specimens were counted: 256 males and 157 females came to the light trap. Over the years, about 5,000 specimens were collected altogether, and 75 species have been identified. Most of them were not really nocturnal and were represented by only a few specimens. One of them, *Metopius fuscipennis* Wesmael, appeared in 2006 in a puzzling large number of 31 specimens, all males (Zwakhals 2007).

Of the Aculeata (stinging wasps), we collected Formicidae (ants) from 2002 onwards. Vespidae, Crabronidae and Apidae were seen in very low numbers and always collected too. The night of July 19th 2002 (notes on weather conditions lacking) was spectacular because more than 10,000 ants took possession of the sheet. A sample turned out to consist of 2,975 males and 36 females of *Lasius umbratus* (Nylander) (figure 12a) (Boer *et al.* 2004). Also in the night of July 22nd 2006 (23 °C, sweltering, heavy clouds, no wind) huge numbers of ants were seen. During 1998-2011 we collected 19,204 ants (of an estimated 30,000 on the sheet) and identified them to 26 species. Among them were *L. fuliginosus* (Latreille) and *Myrmica ruginodis* Nylander (figure 12b), both with more than 1,000 specimens (Boer *et al.* 2007, 2009, 2012, Boer 2008). Some species were rather exceptional for The Netherlands (Boer 2005, 2009).

Especially during warm and sweltering nights, following warm and sunny days, Vespidae (yellow jackets and hornets) were present in low numbers. In 2011, 30 common wasps, *Vespula vulgaris* (Linnaeus) were counted with a maximum of ten a night. *Vespula saxonica* (Fabricius) and *V. rufa* (Linnaeus) were also collected. In 1999, 2002 and 2007 *Vespa crabro* Linnaeus (hornet) was seen in low numbers, in July and August. Vespidae were a nuisance because of their restlessness and unpredictable behaviour. In fifteen years only four Crabronidae and two Apidae (bees) were collected and identified, each specimen another species.

All orders

Table 11 gives an overview of all insect orders and their families, species and specimens attracted by light on the very same spot in De Kaaistoep. We identified about 240,000 specimens belonging to 14 orders, 216 families and 2,180 species.

Quantitative comparisons

A recent overview of Dutch biodiversity (Noordijk *et al.* 2010) mentions a total of 19,684 insect species. With our method with light on the single spot we managed to catch and identify 2,180 species, or 11.1%. Below we compare the results with data from The Netherlands and from other parts of De Kaaistoep, collected by other methods.

Comparison with Dutch fauna

Ephemeroptera: the seven species collected in 2005 represent 12.5% of the 57 species known from The Netherlands (Mol 2010b). It should be possible to collect more with light in De Kaaistoep. Around twelve species can be expected (Ad Mol, personal communication).

Species	Nr. of specimens	Phenology
Nephrotoma appendiculata appendiculata (Pierre)	2♂ +1♀	v+viii
Nephrotoma cornicina cornicina (Linnaeus)	1♀	v
Nephrotoma quadristriata (Schummel)	4♀	v+viii
Nephrotoma scurra (Meigen)	5♀	viii/ix
Tipula (Lunatipula) cava Riedel	8♂ +4♀	viii
Tipula (Lunatipula) vernalis Meigen	5♂	v
Tipula (Pterelachisus) pseudovariipennis Czizek	1♂	v
Tipula (Pterelachisus) truncorum Meigen	4♀	v
Tipula (Tipula) oleracea Linnaeus	2♂ +12♀	v+viii/ix
Tipula (Tipula) paludosa Meigen	6♂ +4♀	viii/ix
Tipula (Vestiplex) scripta scripta Meigen	2♀	viii
Tipula (Yamatotipula) couckei Tonnoir	1♂	viii
Tipula (Yamatotipula) lateralis Meigen	3♂ +3♀	viii/ix
Tipula (Yamatotipula) pierrei Tonnoir	4♂ +6♀	v+viii/ix
Total	**32♂ +46♀**	

Table 9. Tipulidae (craneflies) seen on the sheet in 2009 with their phenology (months in which a species was observed on the sheet).
Tabel 9. Tipulidae (langpootmuggen) waargenomen op het laken in 2009 en hun fenologie (maanden waarin een soort werd waargenomen op het laken).

Suborder	Family	Nr. of species	Nr. of specimens
Symphyta	Xyelidae	2	5
	Pamphilidae	2	2
	Argidae	1	1
	Diprionidae	4	ca. 10
	Tenthredinidae	44	ca. 100
Parasitica	Cynipidae	?	>1,000
	Chalcidoidea-Pteromalidae?	?	>100
	Braconidae	48	ca. 500-1000
	Ichneumonidae	75	ca. 5,000
Aculeata	Formicidae	26	19,204
	Vespidae	4	ca. 250
	Crabronidae	4	4
	Apidae	2	2
Total		**212**	**ca. 27,000**

Table 10. Overview of Hymenoptera seen on the sheet during various time spans.
Tabel 10. Overzicht van Hymenoptera (vliesvleugeligen) waargenomen op het laken tijdens verschillende perioden.

Odonata are diurnal. A single species was collected at night, of 29 known from De Kaaistoep (1995-2012; Heeffer 2012), and 65 from The Netherlands (Kalkman 2010).

Six species of Orthoptera were observed on the sheet, of fourteen known from De Kaaistoep (1998-2011; Bouvy 2011), and 46 from The Netherlands (Kleukers 2010a). Southern oak bush-cricket, *Meconema meridionale* Costa was not seen on the sheet, though it is known to be present in the row of pedunculate oaks at 20 m to the west of the light trap (Bouvy 2009). The observation of *Acheta domestica* on the sheet was a surprise. The behaviour near the equipment showed that the flying specimens were attracted to the white sheet.

Blattodea: two species were collected form the sheet, out of ten known from The Netherlands (Heitmans 2010). *Ectobius pallidus* was often noticed at night on oak-stems too, and *E. panzeri* on piles of wood (Van Wielink *et al.* 2009, Bouvy 2011). No other species were found in De Kaaistoep.

Dermaptera: of the six Dutch species of Dermaptera (Kleukers 2010b), two were encountered, of which only *Labia minor* was attracted by light as we clearly could see.

Psocodea-Psocoptera: in 15 years, only one species was found of the 59 known from The Netherlands (Van Zuijlen 2010). Probably some Psocoptera have been overlooked among huge amounts of Aphidoidea.

Hemiptera: three of the 61 Dutch species of Psylloidea (Den Bieman 2010a) were seen on the sheet. Many Psylloidea were probably overlooked as well among the Aphidoidea (410 species in The Netherlands; Chen 2010), which were not sampled, lacking a specialist to identify them. Auchenorrhyncha are represented in The Netherlands by 174 species (Den Bieman 2010b), of which 59 (34%) could be collected within a single year. Probably many more can be found. Of the 629 Dutch species of Heteroptera (Aukema 2010b), 163 (26%) were collected with light, whereas a total of 264 are known from De Kaaistoep (Aukema 2011a).

Coleoptera: the 725 species identified thus far equal 17.4% of those known from The Netherlands (Vorst 2010), and about 50% of all identified species in De Kaaistoep. Carabidae, Staphylinidae, and Curculionidae were present with 87, 149 and 74 species respectively, representing 23.4%, 14.1% and 13.7% of the Dutch species (Vorst 2010). A forthcoming paper will deal with the Coleoptera in detail.

Neuroptera: 64 species occur in The Netherlands (Hogenes 2010), of which 15 (23%) were lured to the light.

Trichoptera are well known to be attracted by light (Crichton 1984, Higler *et al.* 2008). The 59 species caught represent 33% of the 180 species in The Netherlands (Higler 2010b). Pitfall trapping in the vicinity of the sheet also yielded larvae of *Enoicyla pusilla* (Burmeister), the only fully terrestrial species in The Netherlands (Higler 2008). However, the imagines were never found on the sheet.

In The Netherlands occur 2,206 species of Lepidoptera (Van Nieukerken *et al.* 2010), of which we found 795 species (36%) on the sheet. In total, around 925 species are known from De Kaaistoep, including 28 species of Rhopalocera (butterflies) (Krijnen 2012) and 80 leaf miners (Van Wielink 2011b). Only fourteen butterflies (three species of two families) were seen at night on the sheet, which is less than 0.02%, illustrating the very low level of

12. Different behaviour of ant species on the sheet. (a) *Lasius umbratus* females end at the highest point of the sheet or frame and then often fly away. Photo: Paul van Wielink. (b) *Myrmica ruginodis* males gather at a spot on the sheet. Photo: Bart Horvers
12. Verschillend gedrag van mierensoorten op het laken.(a) Vrouwtjes van *Lasius umbratus* (schaduwmier) gaan naar het allerhoogste punt van het laken of frame en vliegen dan vaak weg. (b) Mannetjes *Myrmica ruginodis* (bossteekmier) komen samen op een plaats ergens op het laken.

nocturnal activity of Rhopalocera. Geometridae and Noctuidae contributed 154 and 195 species, respectively, 55.2 and 53.3% of the Dutch species (Van Nieukerken *et al.* 2010).

Diptera: in The Netherlands, 4,967 species of 110 families have been recorded (De Jong & Oosterbroek 2010), of which 2.6% of the species and 52% of the families were found on the sheet. In De Kaaistoep till now 1,232 species have been identified using all kind of methods (Van Zuijlen, personal communication). Some tens of them are new to the Dutch fauna (see amongst others Brake 2011a, 2011b, De Jong & Van Zuijlen 2003, Heller 2011) and even a species of a new family was collected (Van Zuijlen 2009). Fourteen species of Tipulidae were encountered, which is 17.5% of the 80 known from The Netherlands (Oosterbroek 2010), and 41% of the 34 species found in total in De Kaaistoep (Pjotr Oosterbroek, personal communication).

Hymenoptera: 5,315 species are known from The Netherlands (Van Achterberg 2010), of which 212 (4%) were collected from the sheet. Fifty-three species of Symphyta could be identified, 9.8% of 541 species occurring in The Netherlands (Van Achterberg 2010) and 31% of 172 known from De Kaaistoep (Mol & Cramer 2012). As for Parasitica, only Ichneumonoidea were identified: their 123 species represent 2.8% of the 4,378 known from The Netherlands (Van Achterberg 2010), viz., 48 species of Braconidae and 75 of Ichneumonidae, representing 4.4 and 4.8% of the Dutch species, respectively (Van Achterberg 2010). Although Cynipoidea from the sheet were not identified, the presence of at least 40 species could be derived from plant galls in De Kaaistoep (Buter & Van Wielink 2011), representing about 30% of the 130 species known from The Netherlands (Van Achterberg 2010). The Aculeata were represented by 34 species, 4.1% of 836 known from The Netherlands (Van Achterberg 2010). Among them were 26 species of Formicidae, about 35% of the 75 Dutch species (Van Loon *et al.* 2010) and 68% of the 38 ant species known to fly at night (Boer 2012). Of all ant species known from De Kaaistoep, only 20% were not captured with light but (only) by other methods, like Malaise traps, flight interception traps and pitfall traps (Boer 2008). A sharp contrast was formed by the Apidae: of the 350 species known from The Netherlands (Peeters 2010), only two (0.6%) were seen on the sheet, which is not surprising since Apidae are diurnal. About 85 species are known from De Kaaistoep (Theo Peeters, personal communication).

Order	Nr. of families	Nr. of species	Nr. of specimens identified
Ephemeroptera	3	7	224
Odonata	1	1	2
Orthoptera	4	6	22
Blattodea	1	2	2
Dermaptera	2	2	ca. 250
Psocodea	1	1	1
Hemiptera	18	225	ca. 17,000
Coleoptera	58	725	70,446
Neuroptera	4	15	ca. 200
Trichoptera	11	59	25,781
Lepidoptera	42	795	100,138
Mecoptera	1	2	11
Diptera	57	128	1,077
Hymenoptera	13	212	ca. 27,000
Total	**216**	**2,180**	**ca. 240,000**

Table 11. Overview of all insects identified thusfar, attracted by light on a white sheet operated on a single spot in De Kaaistoep during 1995-2011.
Tabel 11. Overzicht van alle tot nu toe gedetermineerde insecten aangetrokken door licht op een wit laken op één plaats in De Kaaistoep tijdens 1996-2011.

Discussion

This article describes the results of a long-term study of insects, making use of a single method on a single spot. Such research can provide information about changes in the insect fauna over the years, and maybe also about the nature of the changes. For instance, interventions in local nature management, introductions of exotic fauna elements, and changes in local and global weather conditions can all play a role. In this article we did not focus on those changes. Forthcoming articles will treat Coleoptera and Lepidoptera in more depth.

The method used, viz., inspection of a brightly lit white sheet and various ways of sampling, has serious shortcomings. Firstly, to be observed on the sheet, insects have to be able to fly, be nocturnal, and feel attracted to light (or hit the screen accidentally). Therefore, only a selection of all insects available in De Kaaistoep was sampled by the white sheet. Secondly, it is not a continuous collection method, covering only the period from sunset to, on average, 4 h later. Thirdly, the sampling days were chosen subjectively and almost all were restricted to March till November. Even in these months we seldom used the light during nights with temperatures below 8 °C, wind exceeding force 4, rain or fog, because we knew from experience that hardly any insects fly in such nights. Finally, manual collection probably introduces some bias, although we tried to minimalize it. The very diverse profiles of Diptera sampled on four different days (figure 11) show the huge impact of time of the year and weather conditions on the family composition. Therefore with the method used, collecting an average of 0.6 times a week, it is difficult to show shifts in abundances.

On the other hand, by using a white sheet, most macrolepidoptera and a lot of other insects can be recognized without killing them, and the time of arrival per species can be observed and related to the current weather conditions. 'Orphaned' insect groups, without specialists interested in them, can be spared. Also some behaviour of insects can be noticed, like feeding, copulating and egg depositing.

Studying insects at night on a white sheet was a pleasant, sometimes even exciting activity. Not only did we learn a lot about insect diversity in De Kaaistoep and did we find new species for The Netherlands, but, because we always used the same method on the same spot, we can also go into changes in the insect fauna over time. If it only depends on our enthusiasm we can go on for another fifteen years…

The number of insects attracted to light and their distribution over insect orders and families depend on local weather conditions and the season. The next article will be about the relationship between weather conditions and phenology of particular groups. Two other articles will give details about fifteen years of light trapping Coleoptera and Lepidoptera in De Kaaistoep.

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Samenvatting

Insecten 's nachts aangetrokken door licht op één plaats in De Kaaistoep. Gedetermineerde orden, families en soorten van 1995-2011

In 1995 startte een onderzoek met gebruik van licht en een wit laken naar nachtvlinders in De Kaaistoep, een natuurgebied in de gemeente Tilburg. Vanaf 1997 werden ook kevers onderzocht. 2011 was het 15e jaar waarin werd vastgelegd welke keversoorten in welke aantallen afkwamen op een lichtbron die steeds op één plaats stond, ongeveer 1,5 km ten westen van de bebouwing van Tilburg en 100 m ten noorden van de autosnelweg A58. In 2002 volgden mieren en wantsen, in 2005 schietmotten en sluipwespen (Braconidae en Ichneumonidae), en in 2006 bladwespen. Ook soorten van andere insectenorden werden waargenomen en zo mogelijk geïdentificeerd, zoals vliegen en muggen, eendagsvliegen, cicaden en andere (zie tabel 1). De lichtval bestond uit vier lampen van elk 500 W, die een polyester laken verlichtten van ongeveer 2 x 3,5 m. De lampen werden ontstoken op het tijdstip van zonsondergang. Aangetrokken insecten werden op het doek gedetermineerd of met een exhauster verzameld en opgeslagen in 70% ethanol. De locale weersomstandigheden zoals windkracht en –richting, temperatuur en vochtigheid werden genoteerd. Met de hulp van veel specialist-entomologen zijn tot en met 2011 ongeveer 240.000 insecten uit veertien orden op naam gebracht. Vlinders (795 soorten) en kevers (725) waren het soortenrijkst. In totaal zijn 2.180 soorten gevonden, behorende tot 216 families (voor een overzicht, zie tabel 11). Dit artikel behandelt per orde de aangetoonde families en de aantallen soorten daarvan. Regelmatig worden aangetroffen soorten genoemd, maar vrijwel alleen als ze algemeen voorkomen in Nederland. Tientallen waren nieuw voor de fauna van Nederland. Ze zijn reeds gepubliceerd of zullen meegenomen worden in toekomstige artikelen. Met dit onderzoek is een belangrijke bijdrage geleverd aan de kennis van de biodiversiteit van De Kaaistoep via een ATBI (alle taxa biodiversiteit inventarisatie), met in totaal nu ruim 7.000 geïdentificeerde soorten planten en dieren, waarvan bijna 4.700 soorten insecten. De inspanning die is verricht (16 jaar onderzoek, meer dan 2.000 uren bij het laken of ruim één uur per soort) is tamelijk inefficiënt als het alleen om soorten zou gaan. Omdat van vele groepen over lange tijd (vlinders ruim zestien jaar, kevers vijftien jaar, mieren en wantsen tien jaar) soorten én aantallen zijn vastgelegd, is het mogelijk om de fenologie van soorten en de invloed van weersomstandigheden na te gaan. Bovendien kunnen effecten op de soortensamenstelling van locale veranderingen in het terrein en mogelijk ook van weersveranderingen op lange termijn zichtbaar gemaakt worden. In een volgend artikel zal de verdeling over de orden aan bod komen, en zullen op orde- en groepsniveau de fenologie en de invloed van weersomstandigheden worden besproken.

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