

MODIRISK: Mosquito vectors of disease, collection, monitoring and longitudinal data from Belgium

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Abstract

The MODIRISK project aimed at studying biodiversity of mosquitoes and monitoring/predicting its changes, and hence actively prepares to address issues on the impact of biodiversity change with particular reference to invasive species and the risk of introducing new pathogens. This is essential in the perspective of the ongoing global changes creating suitable conditions for the spread of invasive species and the (re)emergence of vector-borne diseases in Europe. The main strengths of the MODIRISK project in the context of sustainable development were the links between biodiversity and health-environment and its contribution to the development of tools to better describe the spatial distribution of mosquito biodiversity. MODIRISK addressed key topics of the global initiative Diversitas, which was one of the main drivers of the 'Research programme Science for a Sustainable Development' from the Belgian funding agency Belspo (www.belspo.be). Three Different MODIRISK datasets were published on GBIF (1) [The collection dataset](#), which contains the Culicidae collection in the Museum of Natural History RBINS in Brussels. (2) [The inventory dataset](#), which holds the data of the MODIRISK inventory effort and (3) [the longitudinal dataset](#) holding experiment data used for risk assessments.

Rationale

Mosquito-borne diseases are prime candidates as (re)emerging vector-borne diseases in Europe. Knowledge of the taxonomic and functional biodiversity of both endemic and invasive mosquito species as well as the factors driving changes was missing in Belgium. Acquiring this knowledge is an essential step towards understanding the current risk and preparing action plans for future threats. Therefore, the objectives of MODIRISK were (1) to inventorize endemic and invasive mosquito species in Belgium considering environmental and taxonomic elements of biodiversity (Collection dataset), (2) to assess the population dynamics of selected endemic and invasive mosquito species and their interrelationship (Longitudinal dataset) (3) to model mosquito biodiversity distribution at a 1km resolution, (the Inventory) and (4) to disseminate project outputs. The three datasets, originated during the MODIRISK project (Figure 1), were standardised to Darwin Core (Wieczorek, 2012) and published by the Royal Belgian Institute for Natural Sciences (RBINS) through the Integrated Publishing Toolkit or IPT (Robertson, 2014) of the Belgian GBIF node.

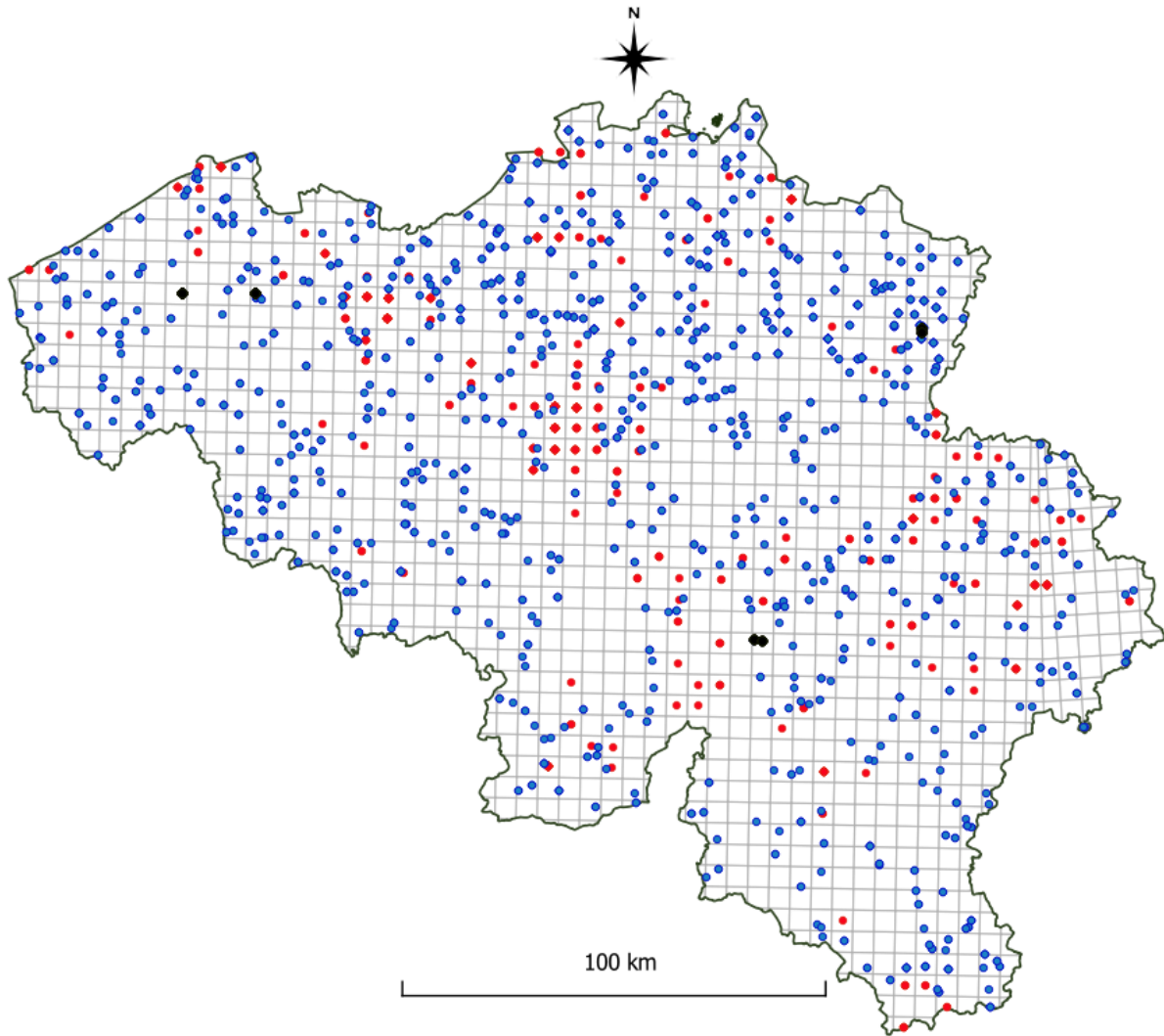


Figure 1: Overview of the MODIRISK data, with red dots: RBINS Culicidae collection; blue dots: Inventory and black dots: Longitudinal Study

During the first phase (years 2007-2008), the project focused on the inventory activities; setting-up laboratory experiments for studying life history traits of *Culex pipiens* in relation to temperature and the first selection of models based on the field results. Whilst during the second phase of the project (years 2009-2010) the focus was on the spatial model building and validation, the longitudinal study and dynamics of selected indigenous and invasive species that were found during the inventory of the first phase and on more population genetic driven research.

The collection dataset [1^], dealing with both historic and recent Culicidae specimens, the Inventorydataset [2], dealing with the current inventory of Culicidae in Belgium and the longitudinal study dataset [3], dealing with questions about risk assessment, outbreaks, and possible distribution are three different datasets developed in the MODIRISK project.

These three datasets are closely linked, but are published as three different Darwin Core Archives. The Inventory dataset: "MODIRISK: Monitoring of Mosquito Vectors of Disease (inventory)" was first published in 2013 (occurrence core) while the Collection dataset (occurrence core) and the longitudinal study (event Core) were published in 2017.

The project was coordinated by the Institute of Tropical Medicine, Antwerp (<http://www.itg.be/E>).

Datasets

The Collection dataset

In the beginning of the past century many mosquitoes were collected all over Belgium by M. Goetghebuer and M. Bequaert who built up the most representative and rich collections of Belgian Diptera, preserved at RBINS (Grootaert et al., 1991). In the Belgian Culicidae collection of RBINS four subcollections are present: a general Belgian collection, two subcollections (Goetghebuer and Bequaert), and a subcollection of unidentified specimens i.e. the supplements (figure 2). The subcollection Bequaert was mainly collected between 1912-1958 and counts 135 voucher specimens. The subcollection Goetghebuer was collected between 1909-1946 (mainly between the period 1910-1930) and counts 269 specimens. In the general Belgian collection 241 specimens are present, all of them collected between 1878-1967 (mainly between 1880-1925). The supplements are the largest subcollection with 737 specimens collected between 1892-2005 (mainly during 1920-1960).

All 1381 specimens (24 species) in RBINS collections were re-identified and digitised during the MODIRISK project. Further, all voucher specimens from the available collections were re-identified at the species level using Schaffner et al., 2001. Seventy seven percent of the specimens were collected between 1910 and 1960, with most of the specimens collected between 1940 and 1950. The intensity of research and mosquito-sampling fluctuated during this period, as revealed by the number of voucher specimens per decade (figure 3). The oldest specimens (collected in 1878) are deposited in the general Belgian collection. In this collection 16 species were discovered, in the subcollection Bequaert, the subcollection Goetghebuer and in the supplements respectively 18 species, 21 species and 20 species were counted. *Culex pipiens* and *Culiseta annulata* were the most abundant recorded species present in the collection (figure 4), as were many voucher specimens of *Aedes punctor*.

Curatorial units

- RBINS-Entomology Collection: M. Bequaert (135 voucher specimens - 1912-1958)

- RBINS-Entomology Collection: M. Goetghebuer (269 voucher specimens - 1909-1946)
- RBINS-Entomology Collection: Supplements Collection (737 specimens - 1892-2005)
- RBINS-Entomology Collection: RBINS Insect Collection (241 specimens- 1878-1967)

For more information on the RBINS collection we refer to Dekoninck et al, 2011 and 2013.

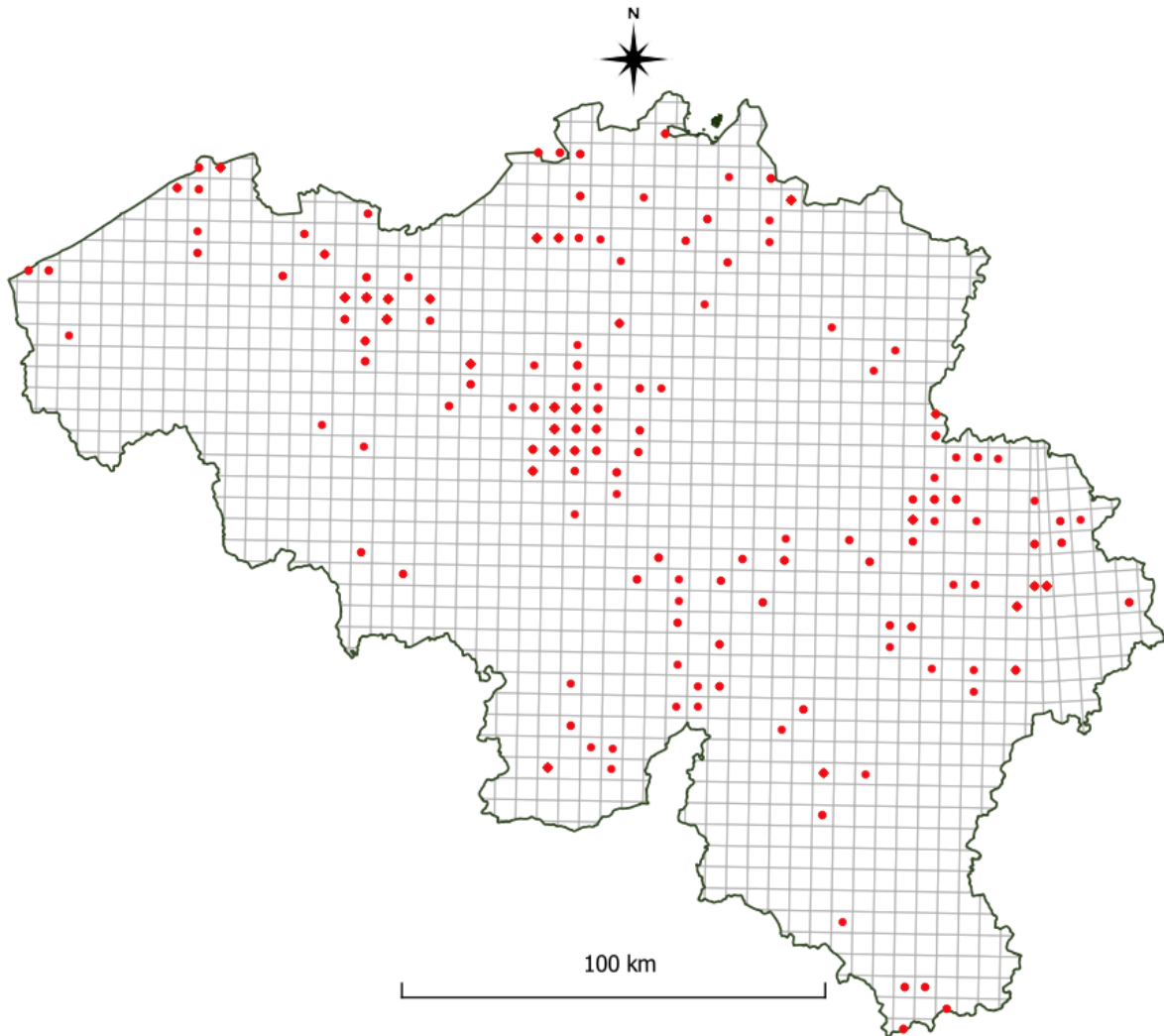
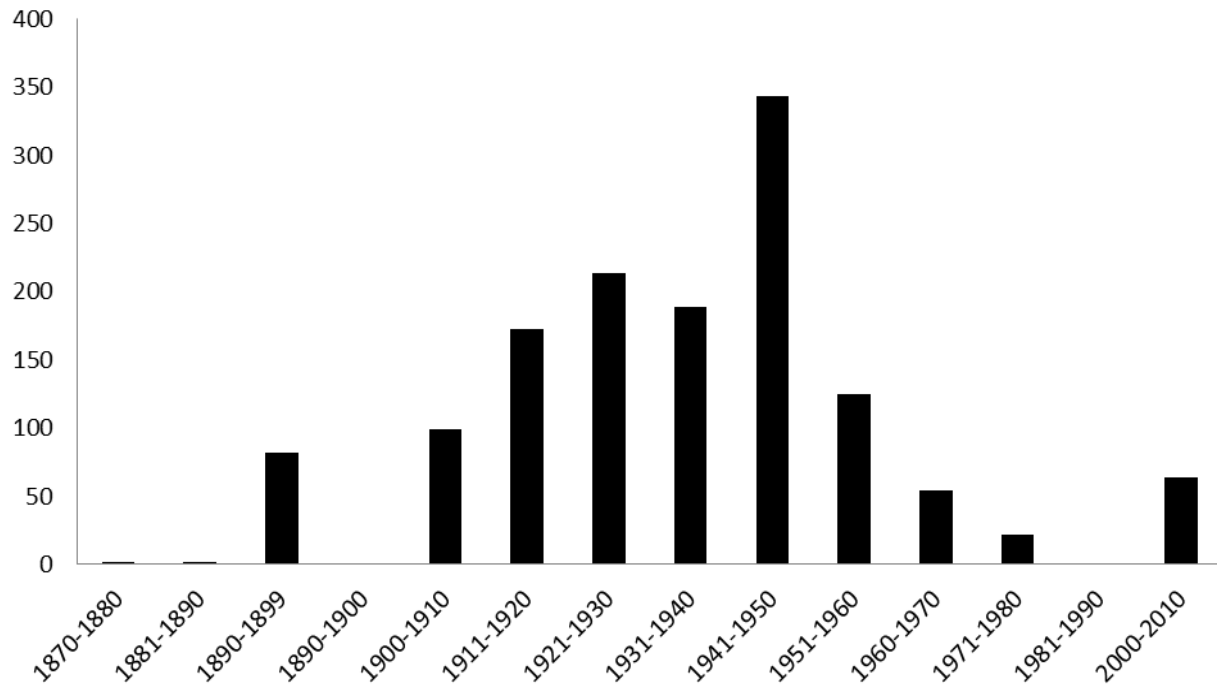


Figure 2: The RBINS Culicidae collection.



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Collection List

Royal Belgian Institute of natural Sciences

- Entomology
 - Acari
 - Araneae
 - Coleoptera
 - Diptera
 - Belgian Ceratopogonidae Collection
 - Belgian Culicidae Collection
 - Algemeen
 - Collection M. Bequaert
 - Collection M. Goetghebuer
 - Supplementen

Figure 3: RBINS collection: distribution of voucher specimens through time

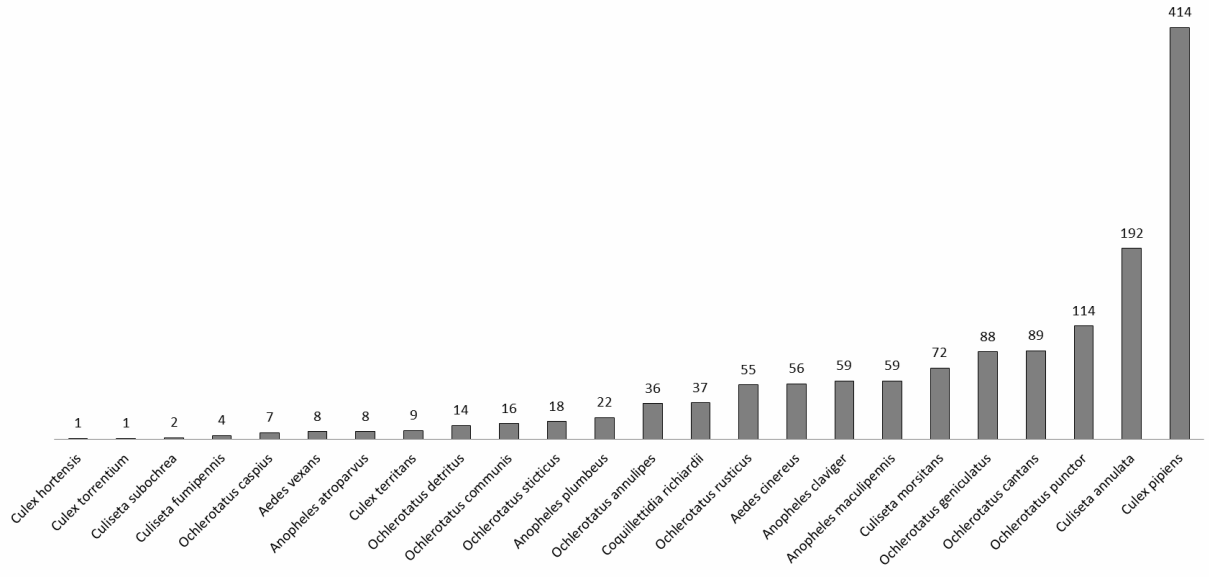


Figure 4: RBINS collection: species and the number of specimen available

MODIRISK:RBINS Diptera: Culicidae Collection Source:

<http://ipt.biodiversity.be/resource?r=modirisk-rbins-culidae-collection>

GBIF: <https://demo.gbif.org/dataset/3331bcd4-f85e-4252-8e92-3aaa6fdc3eca>

The Inventory dataset

The Culicidae inventory [dataset](#) (figure 5) was created during a cross-sectional field survey in 2007 and 2008, using a network of CO₂-baited Mosquito Magnet Liberty Plus traps throughout Belgium in three key habitats (urban, agriculture and nature) (Versteirt et al., 2013). Each location was sampled only once for one week. Twenty-nine mosquito species were identified to the species level (figure 6).

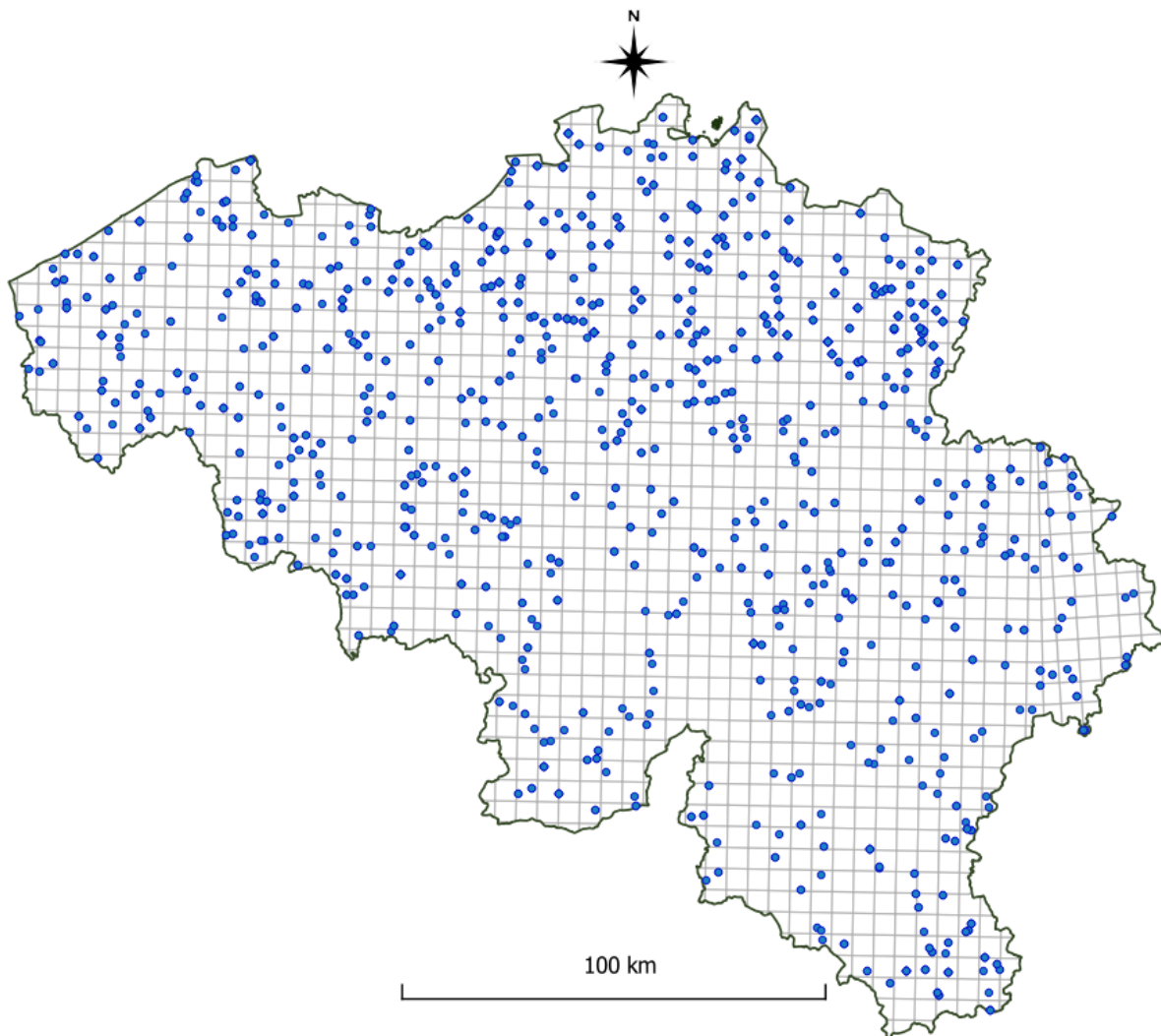


Figure 5: The inventory dataset

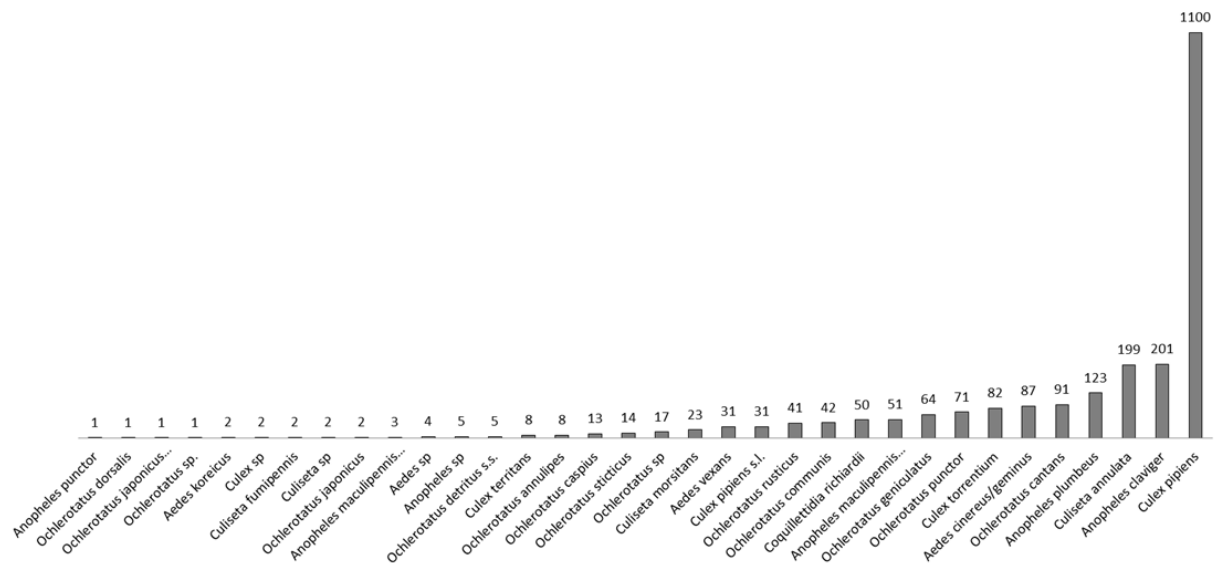


Figure 6: The species and the number of observations available in the Inventory dataset

For more information on the Inventory data set we refer to: Versteirt 2009, 2011, 2012, 2013, 2015.

MODIRISK: Monitoring of Mosquito Vectors of Disease (inventory) Source:

<http://ipt.biodiversity.be/resource?r=modirisk-longitudinal-culicidae-study>

GBIF: <http://www.gbif.org/dataset/6679952f-649b-4888-bd97-00daca4b8cc1>

The Longitudinal dataset

During the longitudinal study, three sites (Maasmechelen, Ruiselede and Torhout, Natoye) were sampled thoroughly, with preferably each study site consisting of different subsites (figure 7). Each of this subsite was sampled with a minimum of six traps (3 types, 2 of each type) using Mosquito Magnet Liberty Plus (MMLP), BG Sentinel and CDC Gravid (CDC, J. Hocke model) traps . MMLP traps were used during the inventory, BG Sentinels were used specifically to attract invasive *Aedes* species and Gravid traps for *Culex* species. The sites were sampled fortnightly during 14 visits every two weeks from April 20 until the 5th of October 2009. In total 33682 adult mosquitoes (individualCount) were collected in 606 occurrence records at the four sites (figure 8).

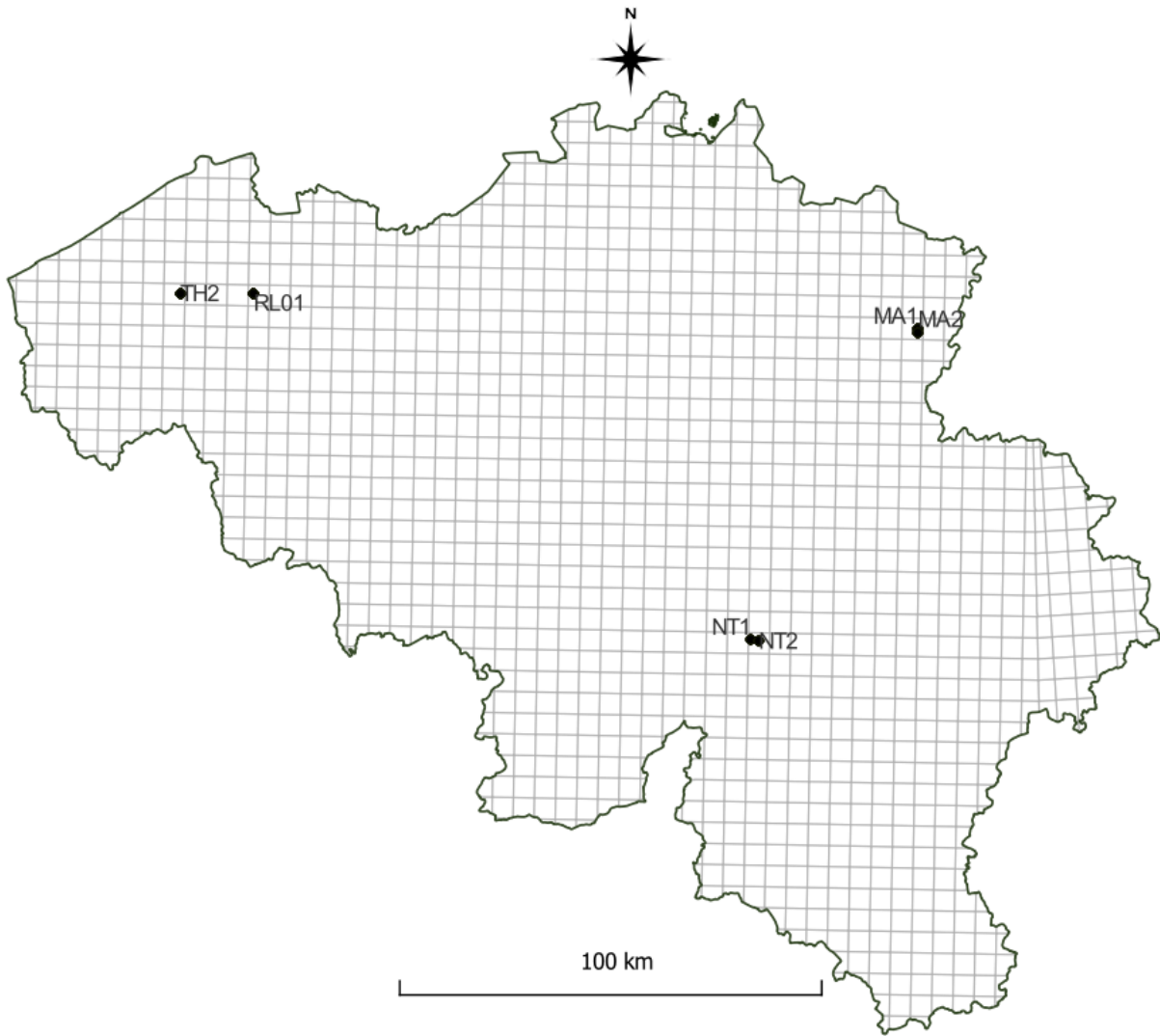


Figure 7: Longitudinal monitoring

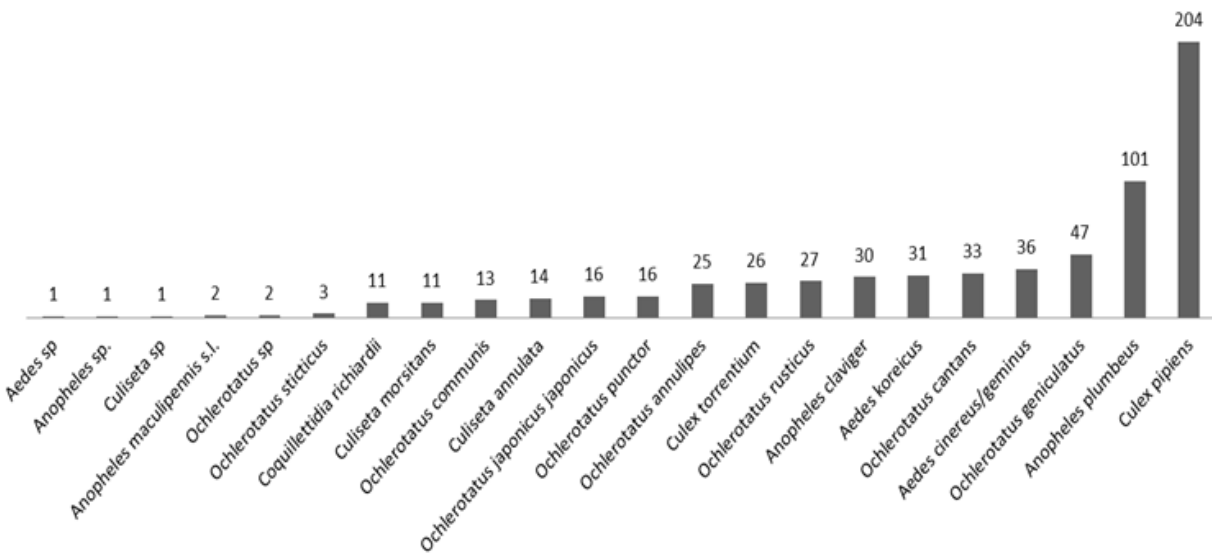


Figure 8: The species and the number of observations available in the longitudinal study dataset

Study site Maasmechelen (MA). The area surveyed was an old sand quarry near the national park Hoge Kempen and the industrial park of Maasmechelen, which harbours several recycling companies. One site was the initial reference site, a small mixed forest fragment with birch, oak and pine next to the industrial zone (MA1). The other subsite (MA2) was situated on the opposite of the road, in a narrow strip of mixed forest adjacent to a large nature reserve (heath). Land cover consists largely of mixed small forest, moorland, sand quarry and a large industrial zone.

Study site Natoye (NT). The population of *Aedes japonicus* at Natoye was surveyed by UCL. Two Belgian second-hand tire companies located in the village of Natoye (Namur) were surveyed. Sites were named Natoye1 and Natoye2. The companies import mainly tires for trucks and heavy vehicles originating from various countries (only from Europe). Tyres are stacked outside, and many are exposed to rainfall and therefore often contain water and organic material like decomposing leaves. Landcover consists largely of deciduous forests, gardens, cultivated fields around Natoye1 and gardens, cultivated fields and meadows around Natoye 2.

Study site Ruiselede and Torhout. Study Site Ruiselede (RL) & Study Site Torhout (TH): We sampled mosquitoes at two different localities in Western Flanders in the same ecoclimatic region, during one complete active season from May until October: - an urban-rural landscape was sampled: 2 sites at Torhout near Groenhove forest complex (TH01 and TH02) - a natural landscape was sampled: 2 sites at Ruiselede, Vorte Bossen (RL01 and RL02)

For more information on the longitudinal data set we refer to: Damiens et al. 2014; Dekoninck et al. 2011, Versteirt et al. 2012.

MODIRISK: Monitoring of Mosquito Vectors, Longitudinal study Source:

<http://ipt.biodiversity.be/resource?r=modirisk-longitudinal-culicidae-study> GBIF:

(<http://www.gbif.org/dataset/9ee09033-8aab-4813-8c2b-db6d54d9817b>)

Keywords

Occurrence, Voucher Specimens, Culicidae, vector disease, mosquito, malaria, Eco-climatic changes, taxonomy, spatial distribution models, population genetics, ecology of invasive species

Taxonomic coverage of the three datasets

Morphological identification of the Culicidae was done mainly using the electronic identification key of Schaffner et al. (2001) and the paper key of Becker et al. (2010). In the period 2000 - 2009 substantial changes were proposed for the Aedini Tribe taxonomy, which resulted in almost tripling the number of genera in the entire Culicidae family. A recent publication from Wilkerson et al. (2015) proposed to return to the taxonomy from before 2000, restoring a classification system useful for the operational community. This dataset was built during the 2000 - 2009 period, using the available taxonomies at that time, resulting in the consequent use of the genus *Ochlerotatus* (Now *Aedes*) in the dataset.

Taxonomic ranks

Kingdom: *Animalia* **Class:** *Insecta*, **Orders:** *Diptera*, **Families:** *Culicidae* **Subfamilies:** *Anophelinae* & *Culicinae*

Geographic coverage of the three datasets

Belgium is a small country in Western Europe. To the west, its 70 km coastline fronts the North Sea; to the north lies the Netherlands; to the east, Germany, and to the south, France and Luxembourg. Biogeographically, the fauna of eastern Belgium belongs to the Central European Province of the Eurasian (Palearctic) region. By contrast, the rest of the country primarily consists of an Atlantic fauna plus a few Central European relict species (Figure 9).

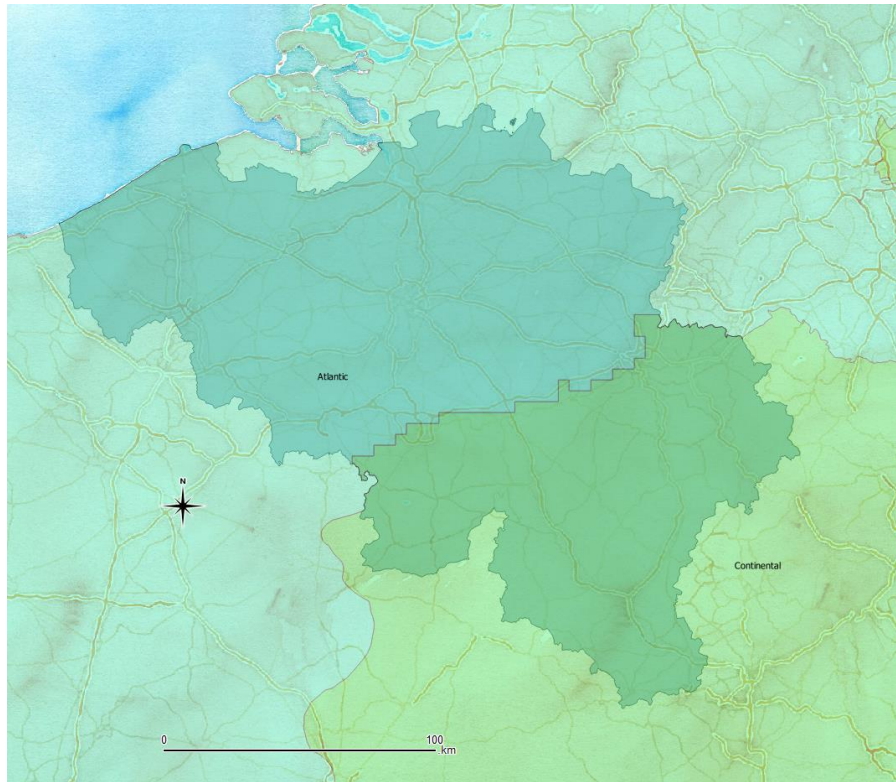


Figure 9: Biogeographical areas of Belgium

Politically and geographically, the country is divided into three parts: Flanders, Wallonia and the Brussels Capital Region. In Flanders (13, 522 km² and population about 6 million people), to the north, soils are mainly sandy to loamy. Here, the most important habitats for ants are heathlands and dry grasslands. The Brussels Capital Region is a small region (162 km²) entirely situated in the sandy loam area. In Wallonia (17, 006 km² and about 3, 5 million people), to the south, soils and habitats are more diverse, ranging from forests to rocky and calcareous grasslands on loam and chalky soils. Eastern Wallonia, near the German border, includes the Hautes Fagnes, a large area of bogs and peat with some typical ant species.

Belgian has a temperate maritime climate that is influenced by the North Sea and the Atlantic Ocean with substantial precipitation in all seasons. The summer is moderate and the winters are mild.

Geographical method

Collections Dataset

The Universal Transverse Mercator Projection (UTM), an adaptation of the standard Mercator projection, uses a two-dimensional Cartesian coordinate system to identify locations on the surface of the Earth (Wikipedia).

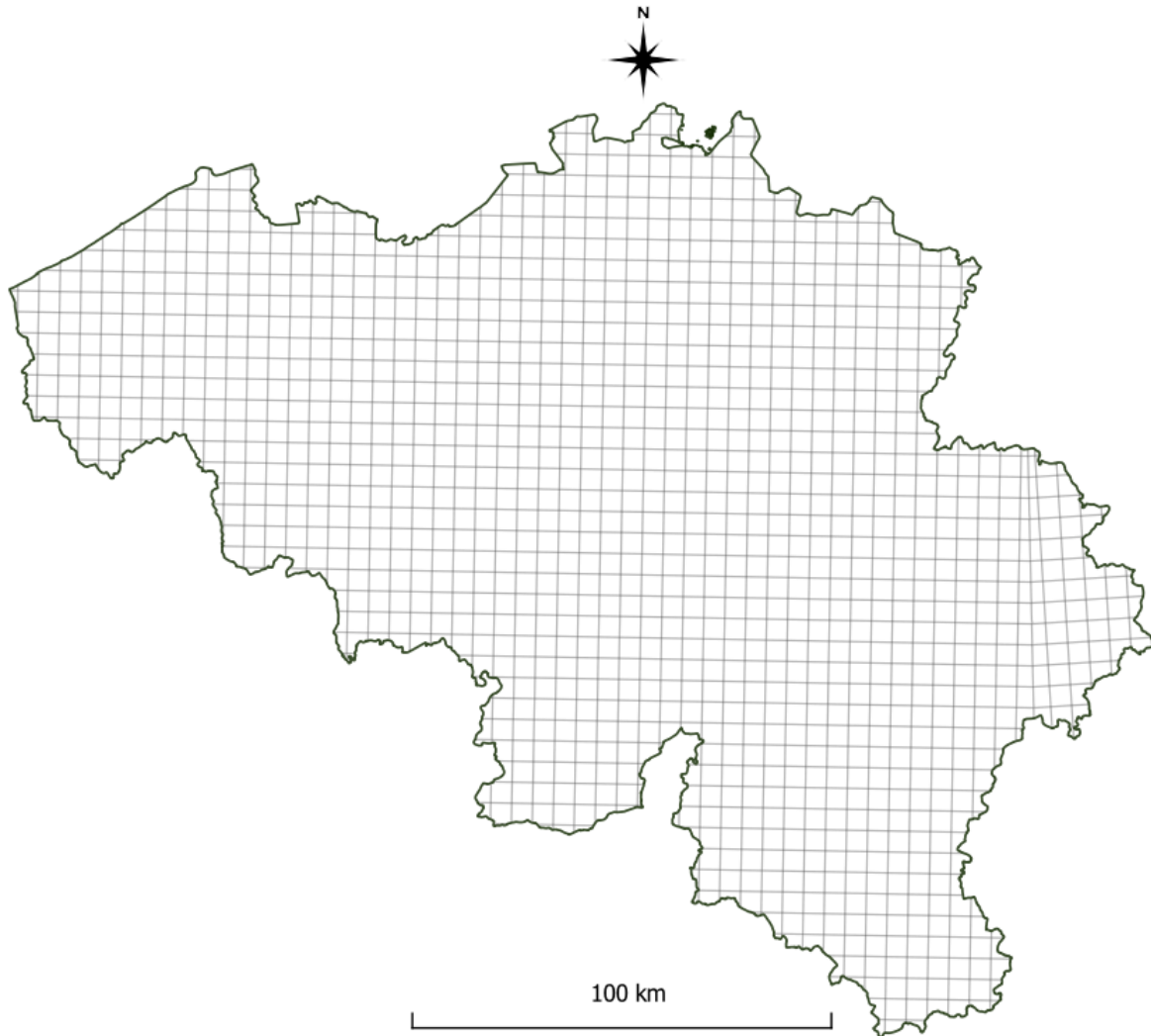


Figure 10: The UTM 5km grid of Belgium

The Inventory

The 971 selected sample sites have exact GPS coordinates. Cross-sectional field surveys were conducted during the first phase of the project to inventorize Culicidae. Using the Corine Land Cover

(2000) classification (NGI, 2004) three strata were aggregated: urban, rural and natural. In each stratum random points were assigned adding up to 971 selected sampling points in total. The number of points assigned for each Corine land cover aggregated class was proportional to its total surface in Belgium. Details of the sampling design can be found in Versteirt et al. 2011 & 2013.

The Longitudinal Study

All the selected sampling sites have exact GPS coordinates

Bounding coordinates

50° to 51,51° latitude, 2.54 to 5.92 longitude.

Temporal coverage

The Collection dataset (1812-2005), **The Inventory** (2007-2008) and **The Longitudinal dataset** (2009-2010). The overall distribution of the mosquito records over time is illustrated in figure 11.

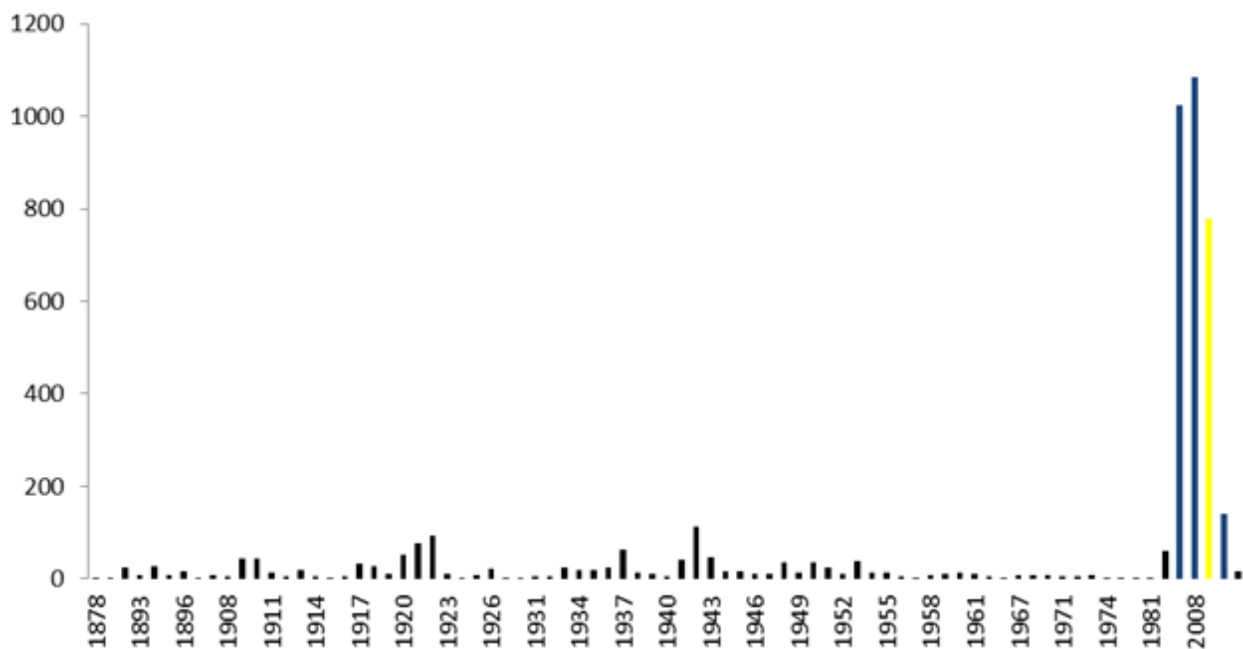


Figure 11: Distribution of occurrences of all three datasets through time (black = Culicidae collection, blue = inventory, yellow = longitudinal study)

Quality control of the three data sets:

To assure quality of morphological identifications, a random sample (10%) of the identified mosquitoes collected through the MODIRISK project (Inventory and Longitudinal data set) was re-identified by an external expert. The re-identification of the RBINS collections done during the MODIRISK project was also checked by an external expert.

Members of the *An. maculipennis* complex were further identified to species using a PCR of the ITS2 region (Marinucci et al. 1999).

Dataset description

The occurrence data from the MODIRISK database are extracted, standardised, and published as three separate Darwin Core Archives: The Collection, the Inventory and the longitudinal study. The main rationale behind this is that these different datasets are built for their own specific purpose and differ in sampling protocols and methods. Together these datasets represent a complete overview of the data collected during the MODIRISK project.

The Darwin Core terms (<http://rs.tdwg.org/dwc/terms/>) in the dataset at the time of publication are:

Collection Dataset

Occurrence Core

Id; type; language; license; rightsHolder; accessRights; institutionCode; collectionCode; datasetName; ownerInstitutionCode; basisOfRecord; occurrenceID; catalogNumber; recordedBy; sex; lifeStage; preparations; disposition; eventDate; year; month; day; countryCode; stateProvince municipality; locality; verbatimCoordinates; verbatimLatitude; verbatimLongitude; decimalLatitude; decimalLongitude; geodeticDatum; georeferenceRemarks; identifiedBy; scientificNameoriginalNameUsage; kingdom; genus; specificEpithet; nomenclaturalCode

- **Object name:** Darwin Core Archive MODIRISK:RBINS Diptera: Culicidae Collection
- **DOI:** <https://doi.org/10.15468/3in3fb>
- **Character encoding:** UTF-8
- **Format name:** Darwin Core Archive format
- **Format version:** 1.12

- **Distribution:** <http://ipt.biodiversity.be/archive.do?r=modirisk-rbins-culidae-collection>
- **Last Publication date of data:** 2021-03-25
- **Language:** English
- **Licences of use:** CC0 1.0 Universal (CC0 1.0) Public Domain Dedication
- **Metadata language:** English
- **Date of metadata update:** 2022-02-27

Hierarchy level: Dataset

Inventory Dataset

Occurrence Core

id; type; license; institutionCode; basisOfRecord; dynamicProperties; occurrenceID; individualCount; sex; samplingProtocol; eventDate; year; verbatimEventDate; habitat; continent; country; countryCode; stateProvince; municipality; locality; locationRemarks; decimalLatitude; decimalLongitude; geodeticDatum; identifiedBy; scientificName; genus; specificEpithet

- **Object name:** Darwin Core Archive MODIRISK: Monitoring of Mosquito Vectors of Disease (inventory)
- **DOI:** <https://doi.org/10.15468/4fidg2>
- **Character encoding:** UTF-8
- **Format name:** Darwin Core Archive format
- **Format version:** 3.6
- **Distribution:** <http://ipt.biodiversity.be/archive.do?r=modirisk-monitoring-2>
- **Last Publication date of data:** 2022-02-28
- **Language:** English
- **Licences of use:** CC0 1.0 Universal (CC0 1.0) Public Domain Dedication
- **Metadata language:** English
- **Hierarchy level:** Dataset

Longitudinal study

Event Core

id; type; language; license; rightsHolder; accessRights; datasetIDinstitutionCode; datasetName; ownerInstitutionCode; eventID; parentEventID; samplingProtocol; eventDate; year; month; day; verbatimEventDate; eventRemarks; countryCode; municipality; locality; verbatimLatitude; verbatimLongitude; decimalLatitude; decimalLongitude; geodeticDatum

Occurrence Extension

Id; type; language; license; rightsHolder; accessRights; institutionCode; datasetName; ownerInstitutionCode; basisOfRecord; occurrenceID; individualCount; eventID; parentEventID; samplingProtocol; eventDate; verbatimEventDate; eventRemarkscountryCode; municipality; locality; verbatimLatitude; verbatimLongitude; decimalLatitude; decimalLongitude; geodeticDatum; scientificName; kingdom; genus; specificEpithet; nomenclaturalCode

- **Object name:** Darwin Core Archive MODIRISK:Monitoring of Mosquito Vectors, Longitudinal study
- **DOI:**<https://doi.org/10.15468/rwsozv>
- **Character encoding:** UTF-8
- **Format name:** Darwin Core Archive format
- **Format version:** 1.1
- **Distribution:** <http://ipt.biodiversity.be/archive.do?r=modirisk-longitudinal-culicidae-study>
- **Last Publication date of data:** 2022-02-28
- **Language:** English
- **Licences of use:** CC0 1.0 Universal (CC0 1.0) Public Domain Dedication
- **Metadata language:** English
- **Hierarchy level:** Dataset

The data are published under a Creative Commons CC0 waiver and we kindly ask you to notify the corresponding authors of the respective dataset if you use the data, especially for research purposes.

Additional information

This data paper is linked with three MODIRISK mosquito related datasets; (1) the collection dataset, (2) the Inventory data set, (3) the Longitudinal study data set. The database server uses Windows Server 2003 SBS R2 as operating system, and is running IIS with PHP for site development, MS SQL Server for database development and SQL Server Mobile Tools to allow remote access from a PDA. Three types of MODIRISK forms were prepared by the MODIRISK coordinator and adapted during a group session at Project SD/BD/04 - Mosquito vectors of disease: spatial biodiversity, drivers of change, and risk “MODIRISK” SSD-Science for a Sustainable Development - Biodiversity 19 ITM: (1) Field form, (2) Morphological identification form, (3) Mosquito storage form. Based on these, relevant tables were developed by Avia-GIS, implemented in the database, and transferred to the web server.

Project data

Project title: Mosquito vectors of disease: spatial biodiversity, drivers of change, and risk

Funding: Belspo, Science for Sustainable Development- Project SD/BD/04D

(<http://www.belspo.be/belspo/ssd/science/prbiodiversityen.stm>) Study area descriptions/descriptor:

Project fiche: http://www.belspo.be/belspo/ssd/science/projects/MODIRISK_en.pdf Project

report:http://www.belspo.be/belspo/ssd/science/Reports/FinalReport_MODIRISK%20ML.pdf

- **Principal investigators:** Wouter Dekoninck; Wim Van Bortel; Veerle Versteirt
- **Resource contact, resource creator, point of contact:** Wouter Dekoninck; Wim Van Bortel; Veerle Versteirt
- **Metadata provider:** Dimitri Brosens
- **Content providers:** Wouter Dekoninck; Wim Van Bortel; Veerle Versteirt
- **Processors:** Dimitri Brosens

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