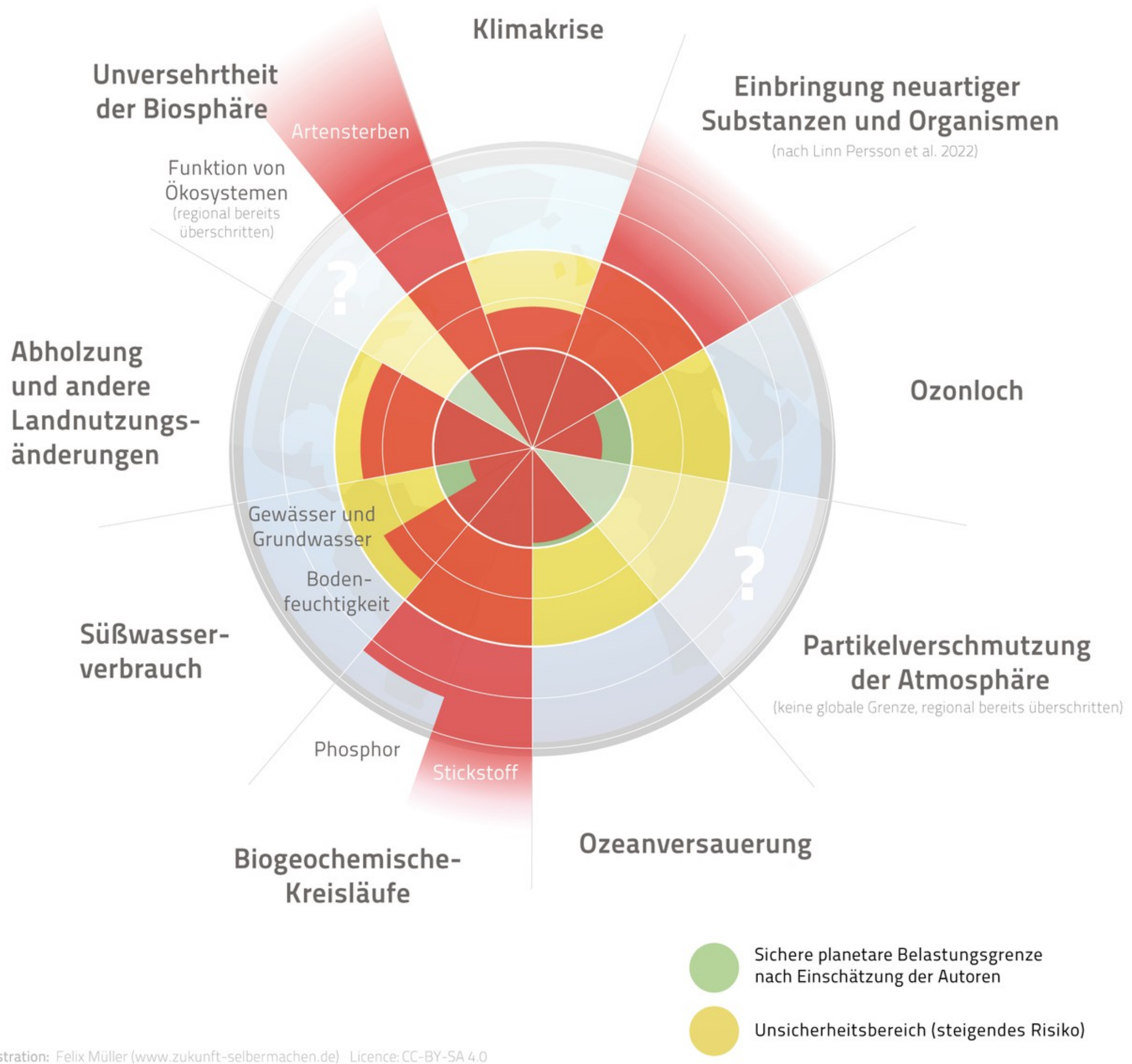
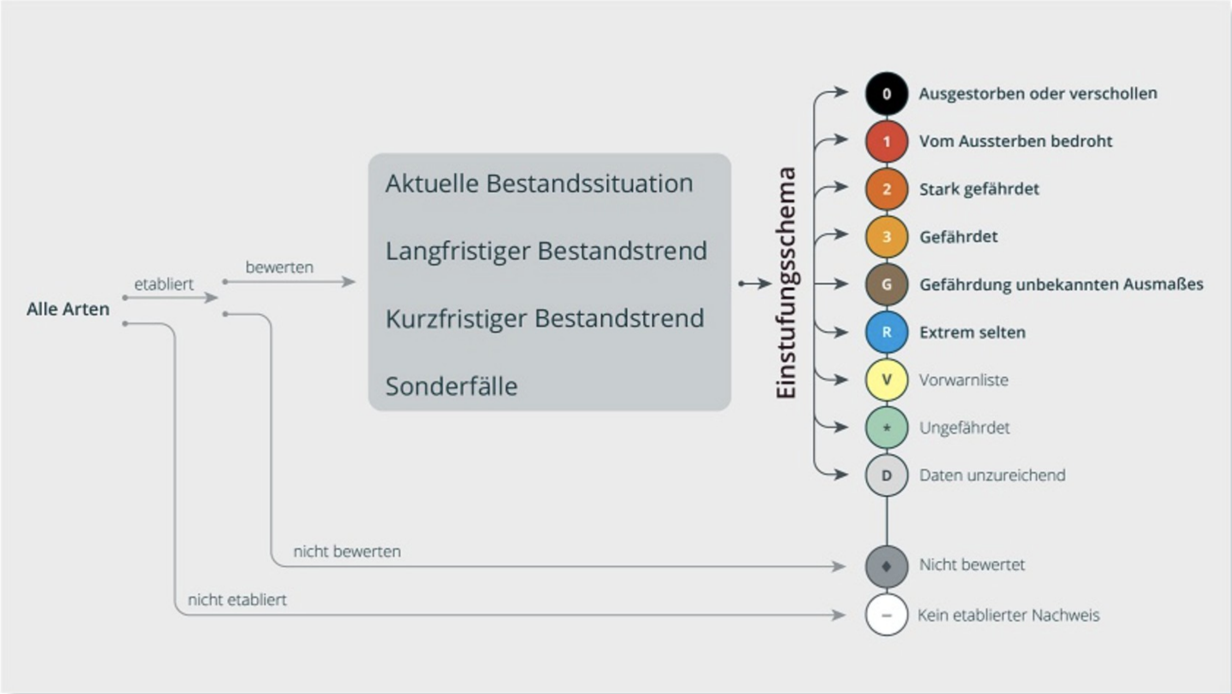

13.03.25
Hybrid
17:00 Landtag NRW
17:15 Online
Asiatische Tigermücke im Anflug?
Biodiversität und invasive Arten
Thomas Hörren
Dr. Renke Lühken
Dr. Sibylle Scharkus
Meral Thoms MdL
Dr. Volkhard Wille MdL

Foto: Werner Stapelfeld / NRW-Stiftung

Ökologische Belastungsgrenzen

nach Will Steffen et al. 2015 / Linn Persson et al. 2022 / Wang-Erlandsson et al. 2022





Die Gefährdungsanalyse mit den Kategorien der Roten Listen im Überblick.

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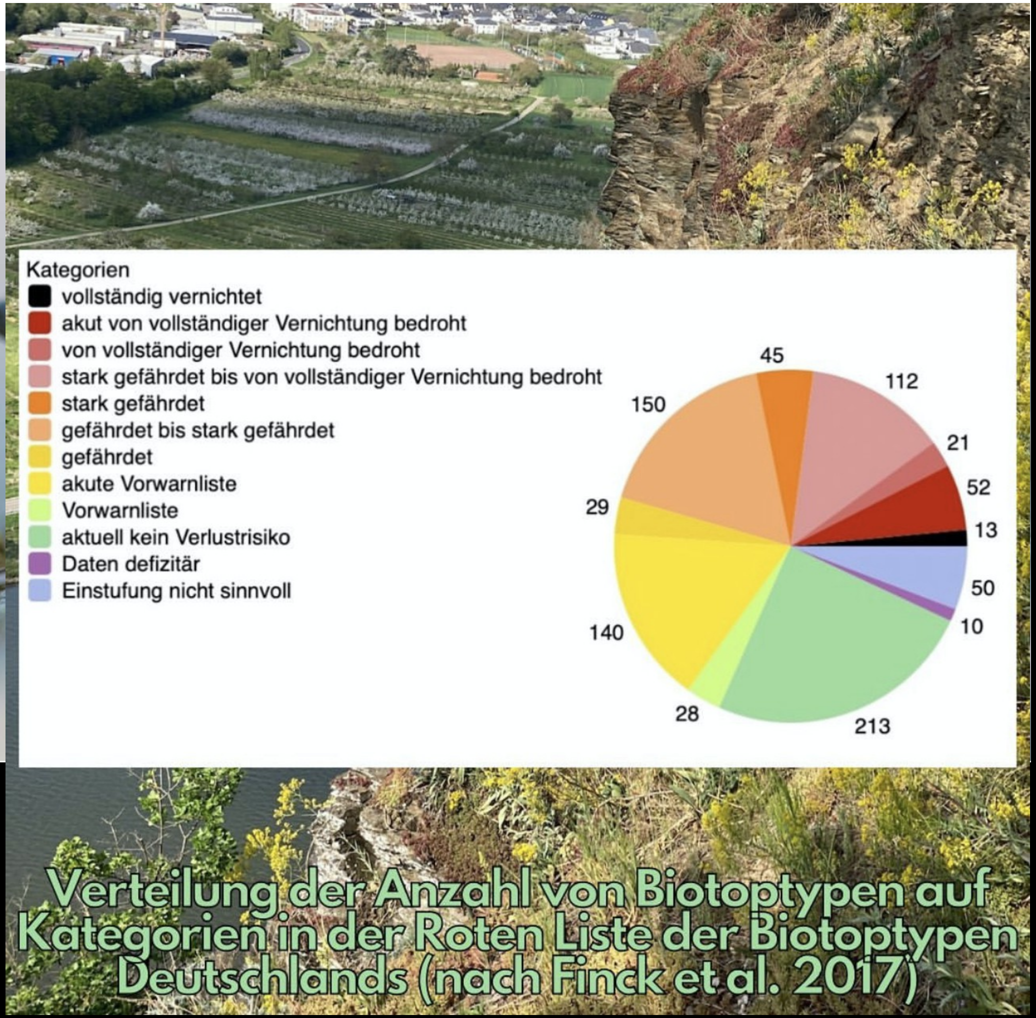

The New York Times

KREFELD JOURNAL

The German Amateurs Who Discovered 'Insect Armageddon'

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Thomas Hörren, a member of the Entomological Society Krefeld, collecting b
from a soil sample. Gordon Welters for The New York Times

By Sally McGrane

Dec. 4, 2017

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Das große Insektensterben und warum die Regierung nichts tut

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Die Kunst, sich zu entscheiden

Der Überfluss an Möglichkeiten überwältigt viele Menschen

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RESEARCH ARTICLE

More than 75 percent decline over 27 years in total flying insect biomass in protected areas

Caspar A. Hallmann[1]*, Martin Sorg[2], Eelke Jongejans[1], Henk Siepel[1], Nick Hofland[1], Heinz Schwan[2], Werner Stenmans[2], Andreas Müller[2], Hubert Sumser[2], Thomas Hörren[2], Dave Goulson[3], Hans de Kroon[1]

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Abstract

Global declines in insects have sparked wide interest among scientists, politicians, and the general public. Loss of insect diversity and abundance is expected to provoke cascading effects on food webs and to jeopardize ecosystem services. Our understanding of the extent and underlying causes of this decline is based on the abundance of single species or taxonomic groups only, rather than changes in insect biomass which is more relevant for ecological functioning. Here, we used a standardized protocol to measure total insect biomass using Malaise traps, deployed over 27 years in 63 nature protection areas in Germany (96 unique location-year combinations) to infer on the status and trend of local entomofauna. Our analysis estimates a seasonal decline of 76%, and mid-summer decline of 82% in flying insect biomass over the 27 years of study. We show that this decline is apparent regardless of habitat type, while changes in weather, land use, and habitat characteristics cannot explain this overall decline. This yet unrecognized loss of insect biomass must be taken into account in evaluating declines in abundance of species depending on insects as a food source, and ecosystem functioning in the European landscape.

Introduction

Loss of insects is certain to have adverse effects on ecosystem functioning, as insects play a central role in a variety of processes, including pollination [1, 2], herbivory and detrivory [3, 4], nutrient cycling [4] and providing a food source for higher trophic levels such as birds, mammals and amphibians. For example, 80% of wild plants are estimated to depend on insects for pollination [2], while 60% of birds rely on insects as a food source [5]. The ecosystem services provided by wild insects have been estimated at $57 billion annually in the USA [6]. Clearly, preserving insect abundance and diversity should constitute a prime conservation priority.

Current data suggest an overall pattern of decline in insect diversity and abundance. For example, populations of European grassland butterflies are estimated to have declined by 50% in abundance between 1990 and 2011 [7]. Data for other well-studied taxa such as bees [8–14]

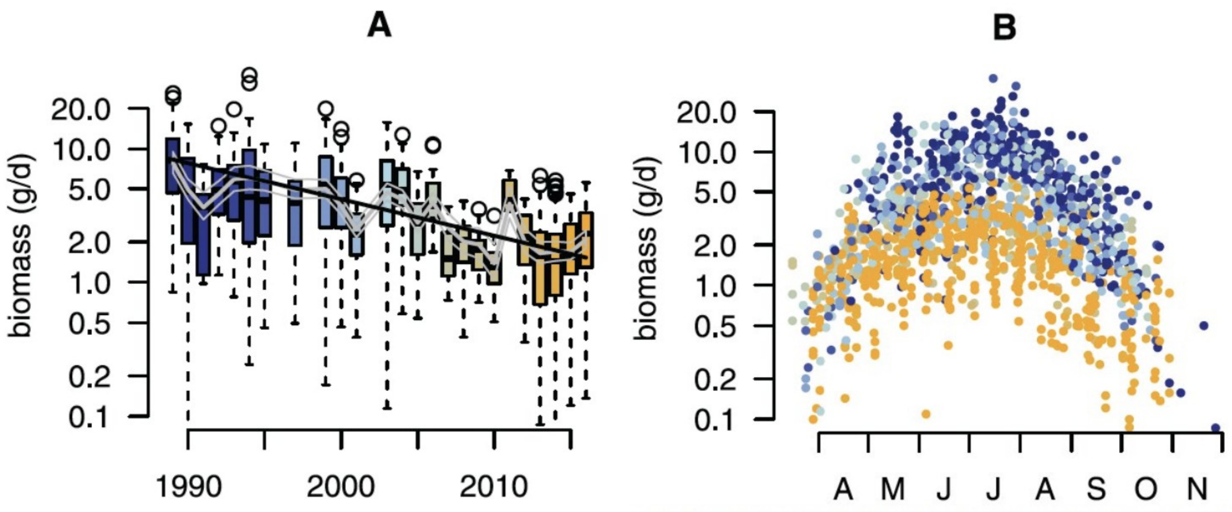

Fig 2. Temporal distribution of insect biomass. (A) Boxplots depict the distribution of insect biomass (gram per day) pooled over all traps and catches in each year (n = 1503). Based on our final model, the grey line depicts the fitted mean (+95% posterior credible intervals) taking into account weather, landscape and habitat effects. The black line depicts the mean estimated trend as estimated with our basic model. (B) Seasonal distribution of insect biomass showing that highest insect biomass catches in mid summer show most severe declines. Color gradient in both panels range from 1989 (blue) to 2016 (orange).

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Foto: Maximilian Kamps / Agentur Blumberg

Spatial, temporal and taxonomic patterns of insect extinction in Germany

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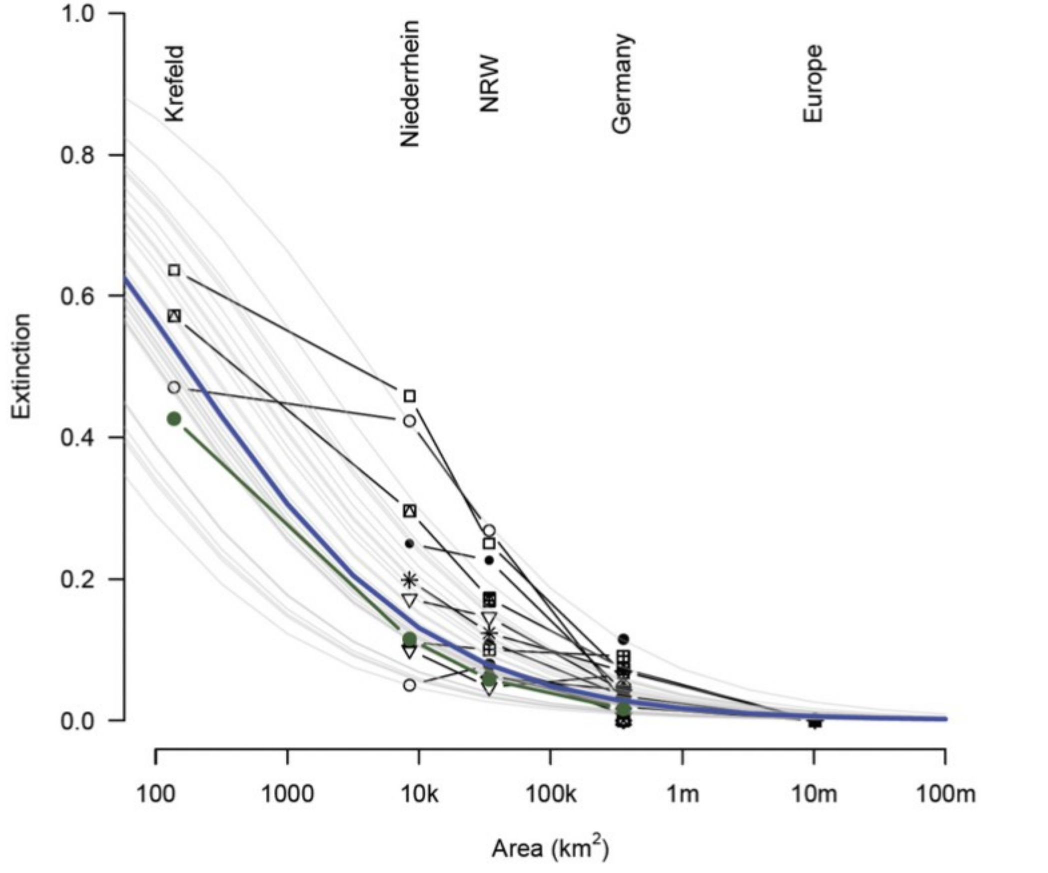
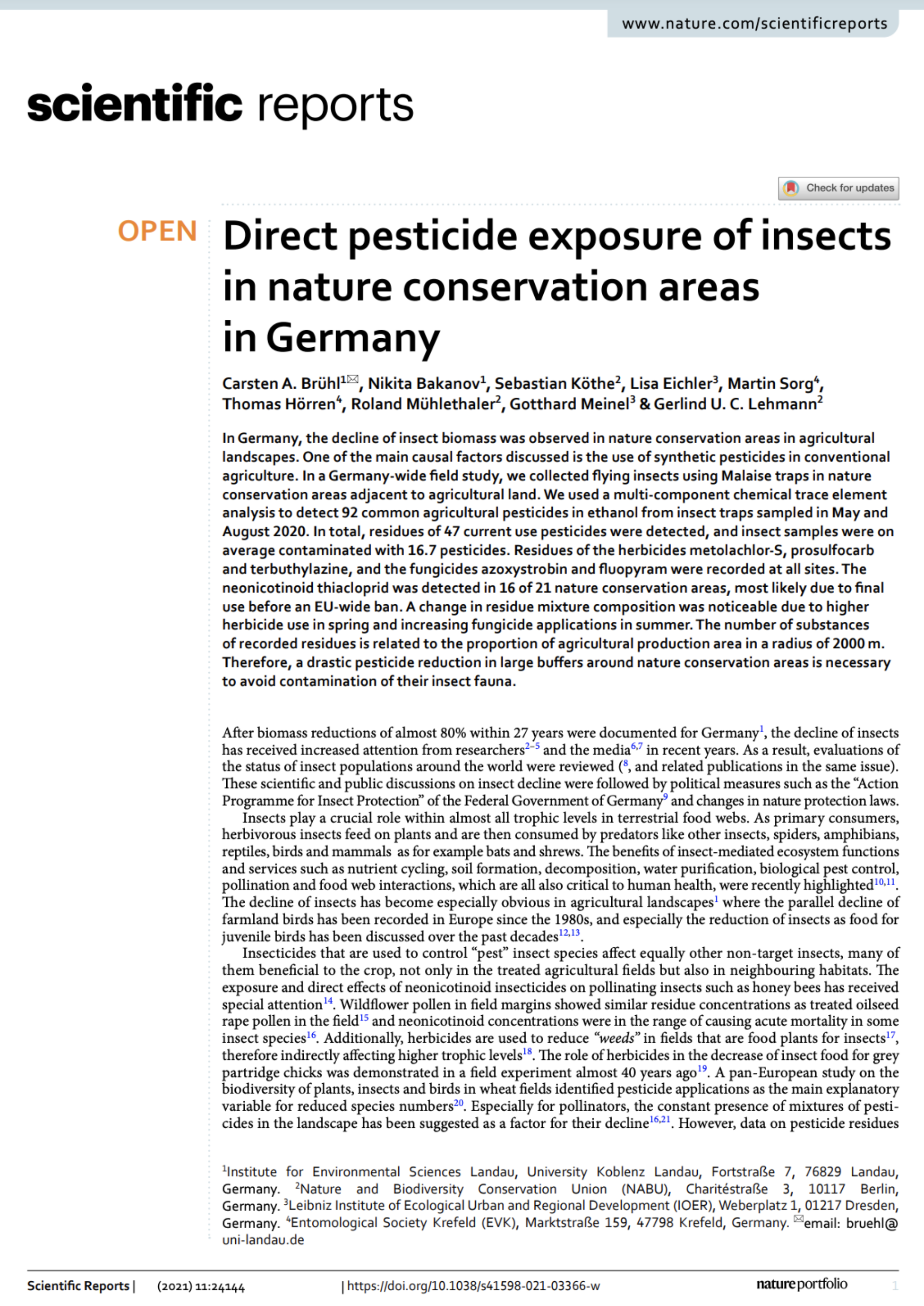


Fig. 6. Estimated mean scale-dependent extinction probability for insects.

Hallmann, C. A., Hörren, T., Ssymank, A., Sumser, H., Schwan, H., Stenmans, W., Vischer-Leopold, M., Schäffler, L. & M. Sorg (2022): Spatial, temporal and taxonomic patterns of insect extinction in Germany.- bioRxiv preprint. doi: https://doi.org/10.1101/2022.12.19.521006



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Direct pesticide exposure of insects in nature conservation areas in Germany

Carsten A. Brühl[1]✉, Nikita Bakanov[1], Sebastian Köthe[2], Lisa Eichler[3], Martin Sorg[4], Thomas Hörren[4], Roland Mühlethaler[2], Gotthard Meinel[3] & Gerlind U. C. Lehmann[2]

In Germany, the decline of insect biomass was observed in nature conservation areas in agricultural landscapes. One of the main causal factors discussed is the use of synthetic pesticides in conventional agriculture. In a Germany-wide field study, we collected flying insects using Malaise traps in nature conservation areas adjacent to agricultural land. We used a multi-component chemical trace element analysis to detect 92 common agricultural pesticides in ethanol from insect traps sampled in May and August 2020. In total, residues of 47 current use pesticides were detected, and insect samples were on average contaminated with 16.7 pesticides. Residues of the herbicides metolachlor-S, prosulfocarb and terbuthylazine, and the fungicides azoxystrobin and fluopyram were recorded at all sites. The neonicotinoid thiacloprid was detected in 16 of 21 nature conservation areas, most likely due to final use before an EU-wide ban. A change in residue mixture composition was noticeable due to higher herbicide use in spring and increasing fungicide applications in summer. The number of substances of recorded residues is related to the proportion of agricultural production area in a radius of 2000 m. Therefore, a drastic pesticide reduction in large buffers around nature conservation areas is necessary to avoid contamination of their insect fauna.

After biomass reductions of almost 80% within 27 years were documented for Germany[1], the decline of insects has received increased attention from researchers[2–5] and the media[6,7] in recent years. As a result, evaluations of the status of insect populations around the world were reviewed ([8], and related publications in the same issue). These scientific and public discussions on insect decline were followed by political measures such as the "Action Programme for Insect Protection" of the Federal Government of Germany[9] and changes in nature protection laws.

Insects play a crucial role within almost all trophic levels in terrestrial food webs. As primary consumers, herbivorous insects feed on plants and are then consumed by predators like other insects, spiders, amphibians, reptiles, birds and mammals as for example bats and shrews. The benefits of insect-mediated ecosystem functions and services such as nutrient cycling, soil formation, decomposition, water purification, biological pest control, pollination and food web interactions, which are all also critical to human health, were recently highlighted[10,11]. The decline of insects has become especially obvious in agricultural landscapes[1] where the parallel decline of farmland birds has been recorded in Europe since the 1980s, and especially the reduction of insects as food for juvenile birds has been discussed over the past decades[12,13].

Insecticides that are used to control "pest" insect species affect equally other non-target insects, many of them beneficial to the crop, not only in the treated agricultural fields but also in neighbouring habitats. The exposure and direct effects of neonicotinoid insecticides on pollinating insects such as honey bees has received special attention[14]. Wildflower pollen in field margins showed similar residue concentrations as treated oilseed rape pollen in the field[15] and neonicotinoid concentrations were in the range of causing acute mortality in some insect species[16]. Additionally, herbicides are used to reduce *"weeds"* in fields that are food plants for insects[17], therefore indirectly affecting higher trophic levels[18]. The role of herbicides in the decrease of insect food for grey partridge chicks was demonstrated in a field experiment almost 40 years ago[19]. A pan-European study on the biodiversity of plants, insects and birds in wheat fields identified pesticide applications as the main explanatory variable for reduced species numbers[20]. Especially for pollinators, the constant presence of mixtures of pesticides in the landscape has been suggested as a factor for their decline[16,21]. However, data on pesticide residues

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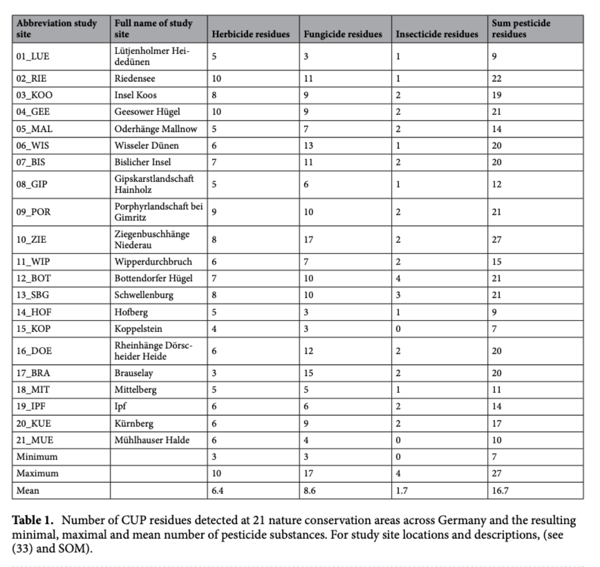

Abbreviation study site	Full name of study site	Herbicide residues	Fungicide residues	Insecticide residues	Sum pesticide residues
01_LUE	Lütjenholmer Heidedünen	5	3	1	9
02_RIE	Riedensee	10	11	1	22
03_KOO	Insel Koos	8	9	2	19
04_GEE	Geesower Hügel	10	9	2	21
05_MAL	Oderhänge Mallnow	5	7	2	14
06_WIS	Wisseler Dünen	6	13	1	20
07_BIS	Bislicher Insel	7	11	2	20
08_GIP	Gipskarstlandschaft Hainholz	5	6	1	12
09_POR	Porphyrlandschaft bei Gimritz	9	10	2	21
10_ZIE	Ziegenbuschhänge Niederau	8	17	2	27
11_WIP	Wipperdurchbruch	6	7	2	15
12_BOT	Bottendorfer Hügel	7	10	4	21
13_SBG	Schwellenburg	8	10	3	21
14_HOF	Hofberg	5	3	1	9
15_KOP	Koppelstein	4	3	0	7
16_DOE	Rheinhänge Dörscheider Heide	6	12	2	20
17_BRA	Brauselay	3	15	2	20
18_MIT	Mittelberg	5	5	1	11
19_IPF	Ipf	6	6	2	14
20_KUE	Kürnberg	6	9	2	17
21_MUE	Mühlhauser Halde	6	4	0	10
Minimum		3	3	0	7
Maximum		10	17	4	27
Mean		6.4	8.6	1.7	16.7

Table 1. Number of CUP residues detected at 21 nature conservation areas across Germany and the resulting minimal, maximal and mean number of pesticide substances. For study site locations and descriptions, (see (33) and SOM).

Brühl et al (2021)

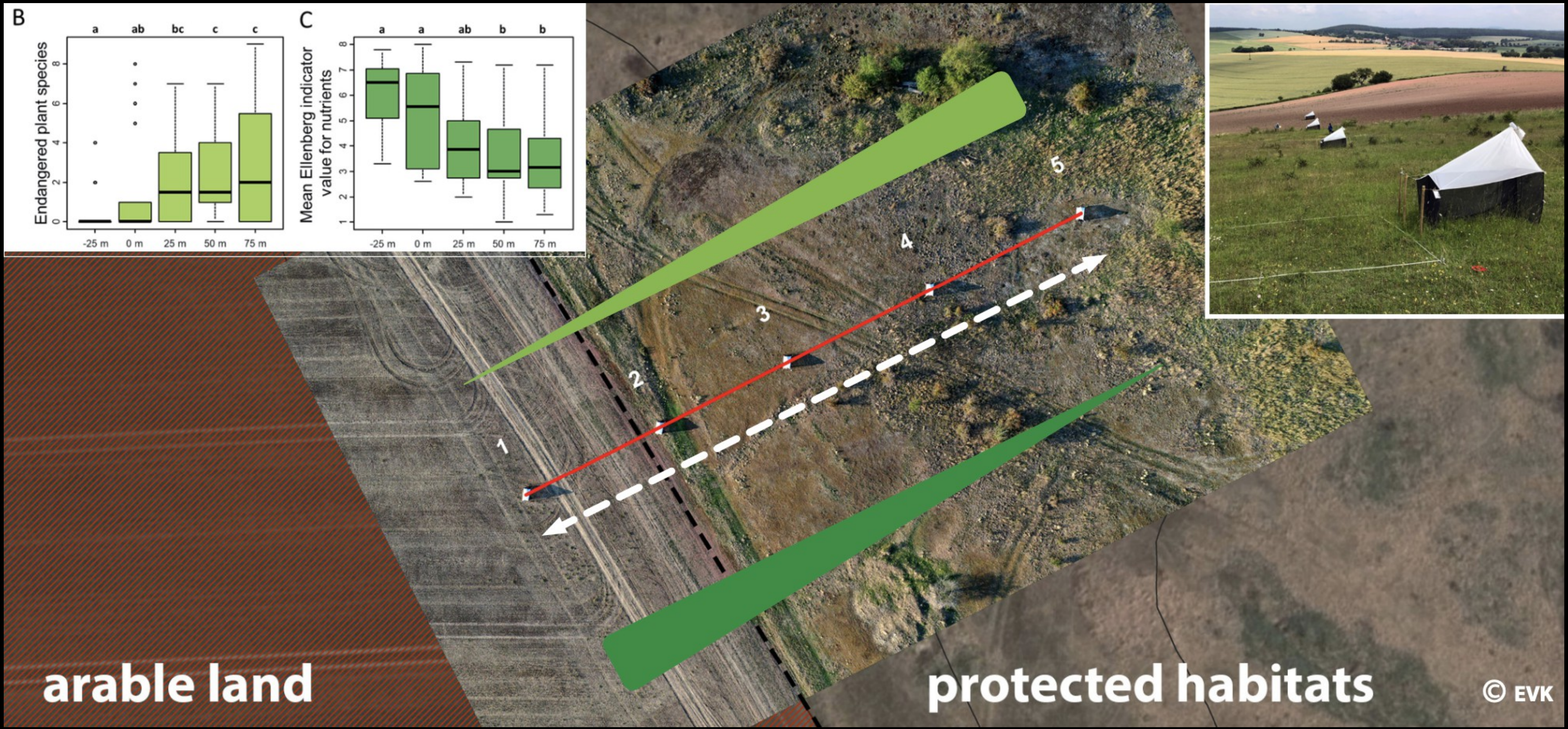
B
a ab bc c c
Endangered plant species
0 2 4 6 8
-25 m 0 m 25 m 50 m 75 m
C
a a ab b b
Mean Ellenberg indicator value for nutrients
1 2 3 4 5 6 7 8
-25 m 0 m 25 m 50 m 75 m
1
2
3
4
5
arable land
protected habitats
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Abb. 1: Malaisefalle im Naturschutzgebiet Weldaer Berg (Kreis Höxter). Foto: Entomologischer Verein Krefeld

Thomas Hörren, Sven Bodingbauer, Sarah Bourlat, Christoph Grüneberg, Matthias Kaiser, Ernst-Friedrich Kiel, Livia Schäffler, Christoph Scherber, Heinz Schwan, Andre Seitz, Werner Stenmans, Hubert Sumser, Vera Zizka, Martin Sorg

Monitoring der Biodiversität flugaktiver Insekten in NRW

Ergebnisse und Perspektiven aus der Kooperation des Entomologischen Vereins Krefeld mit dem Land Nordrhein-Westfalen

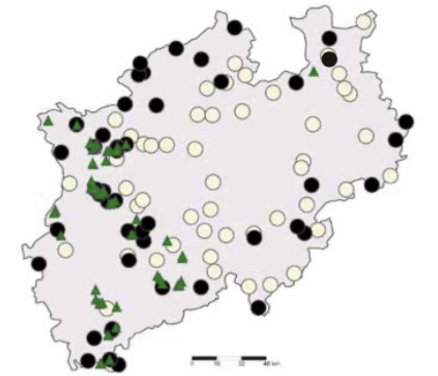
Schon im Jahr 2014 hat das LANUV Untersuchungen des Entomologischen Vereins Krefeld gefördert, um die Biomasse flugaktiver Insekten in verschiedenen Schutzgebieten zu erheben. Diese Daten flossen auch in die Publikation zu Rückgängen der Insektenbiomassen ein (Hallmann et al. 2017). In der Folge hat das LANUV ein groß angelegtes Projekt unterstützt, bei dem der Fokus auf Erfassungen in der Gesamtlandschaft lag – neben der Fortführung der Erhebungen in Schutzgebieten. Diese Untersuchungen an den zusammen 101 Standorten wurden 2022 abgeschlossen. Teile der Proben konnten in einem weiteren, vom Umweltministerium NRW unterstützten Projekt mittels DNA-Metabarcoding auf die Artenzusammensetzung hin analysiert werden.

Insekten sind von fundamentaler Bedeutung für den Naturhaushalt. Ihre extrem hohe Artenvielfalt und Individuendichte geht mit einer immensen Bedeutung für alle terrestrischen Ökosystemfunktionen einher. Der Verlust von Insektenpopulationen hätte gravierende Folgen für die Lebensräume, Pflanzen- und Tierarten. Dieser großen Bedeutung steht ein immer noch sehr geringer Kenntnisstand über die Insektendiversität gegenüber. Grund dafür ist wiederum die immens hohe Artenzahl und Individuendichte in nahezu allen Lebensräumen – der Aufwand wäre sehr groß, wollte man diese Diversität anhand morphologischer Merkmale erfassen. Zudem fehlen spezialisierte Entomologinnen und Entomologen, insbesondere für Insektenfamilien aus den mit Abstand artenreichsten Insektenordnungen in Deutschland, den Hautflüglern (Hymenoptera) und Zweiflüglern (Diptera), die aktuell zusammen über 19.000 bekannte Arten umfassen (Hörren et al. 2022c).

Das LANUV und das Umweltministerium NRW ermöglichten durch ihre finanzielle Unterstützung, den Einsatz von Malaisefallen weiter zu etablieren und die genetische Auswertung mittels DNA-Metabarcoding anzuwenden, zu evaluieren und weiterzuentwickeln. Mit diesen beiden Methoden wurde die Biodiversität flugaktiver Insekten in den Jahren 2017 bis 2022 an 101 Standorten untersucht (Abb. 2).

Erfassung mit Malaisefallen

Für die Untersuchung werden vom Entomologischen Verein Krefeld seit fast vier Jahrzehnten Malaisefallen angelehnt an den Typ von Townes (1972) verwendet (Ssymank et al. 2018), so auch in diesem



● Untersuchungsstandort in Schutzgebiet
○ Untersuchungsstandort der Ökologischen Flächenstichprobe NRW
▲ weiterer Untersuchungsstandort (1987–2022)

Abb. 2: Untersuchungsstandorte mit Malaisefallen im Zeitraum 2017 bis 2022, ergänzt um weitere Untersuchungsstandorte, die der Entomologische Verein von 1987 bis 2022 im Rahmen anderer Projekte, aber mit identischer Methodik untersucht hat.

Projekt (Abb. 1). Insekten, die in die zeltartige Falle fliegen oder laufen, treffen dort auf eine dunkle Querwand und gelangen dann nach oben ausweichend in den Gipfel des Zeltes. Dort befindet sich ein Fangkopf mit hochprozentigem Alkohol, in dem die Insekten getötet und konserviert werden.

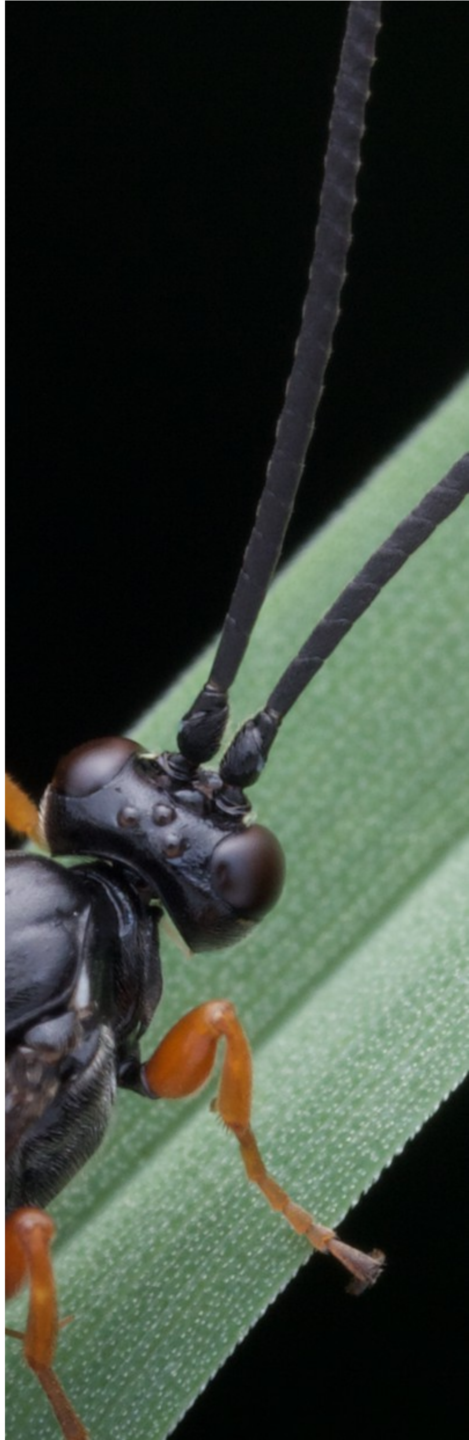
Malaisefallen können über viele Monate oder eine vollständige Vegetationsperiode hinweg betrieben werden. Dies ist ein Vorteil gegenüber anderen Nachweismethoden, die nur einzelne Tage oder kurze Intervalle einer Vegetationsperiode untersuchen. Die eingesetzten Malaisefallen erfassen darüber hinaus einen sehr breiten Ausschnitt tag- und nachtaktiver Insektenarten am Untersuchungsstandort sowie weitere Organismengruppen. In Relation zum personellen Aufwand liefern sie somit ein sehr großes Datenvolumen und sind eine besonders ökonomische Erfassungsmethode.

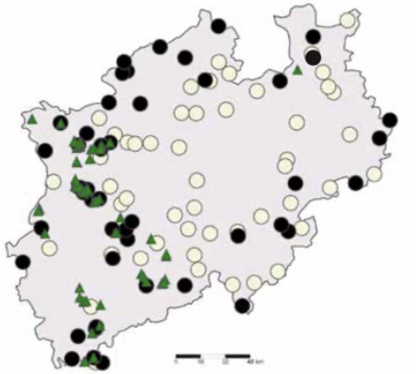
Die Freilandarbeiten werden durch standardisierte Vegetationserfassungen, pflanzensoziologische Aufnahmen und Fotografien unter anderem mit Kameradrohnen ergänzt (Abb. 3). Diese Begleitdaten ermöglichen es, die Vegetation, die visuellen Merkmale der Habitate und das Artenspektrum der Insekten miteinander in Beziehung zu setzen und ihre Veränderung zu erkennen. Alle Daten, Bilddokumente sowie Originalproben der Untersuchungen werden in den Entomologischen Sammlungen Krefeld archiviert.

Evaluation der genetischen Methoden zur Artenbestimmung

Die Möglichkeiten für die Bestimmung von Arten wurden in diesem Jahrhundert maßgeblich durch genetische Methoden wie das DNA-Metabarcoding revolutioniert. Beim Metabarcoding werden aus dem Probenmaterial bestimmte kurze Abschnitte der

Abb. 3: Drohnenfoto (oben), Malaisefalle und 3,5-mal-3,5-Meter-Quadrat der pflanzensoziologischen Aufnahme (Mitte) sowie Standortkontrolle und Probennahme mit Fangflasche und Insektenmenge nach 14 Tagen (unten). Fotos: Entomologischer Verein Krefeld





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Weather anomalies cannot explain insect decline

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Caspar A. Hallmann[1,2]✉, Eelke Jongejans[1,3], Thomas Hörren[2,4], Martin Sorg[2], Henk Siepel[1], Roland Mühlethaler[5], Gerlind U. C. Lehmann[5,6] & Hans de Kroon[1]

ARISING FROM: J. Müller et al. *Nature* https://doi.org/10.1038/s41586-023-06402-z (2023).

After a long-term study signalled a 76% drop in insect biomass in less than three decades in German-protected nature areas[1], insect declines are now assigned to a multitude of anthropogenic factors[2,3]. A recent reanalysis[4] of the insect biomass data of a previous study[1] has suggested, however, that the declines are well explained by time-lagged weather anomalies, whereas new data collected by another study[4] suggest that the declining trend has reversed in recent years (after 2016). Here we render these conclusions as invalid, on the basis of a critical review of methods and a reanalysis of the results. With evidence for insect biomass declining further, we argue for more standardized research to examine future trends and rigorous statistics to uncover the relative importance of contributing factors.

A possible trend reversal in flying insect biomass, as envisaged by a previous study[4], has profound implications on the focus of policy and conservation efforts currently planned and already underway, in Germany and beyond. A claim on trend reversal should therefore rely on sound data, obtained under the highest levels of standardization to achieve the best comparability among samples. Methodological differences (Supplementary Notes) between the original study[1] and how new data were collected[4], such as trap type, trap placement in the field, period of sampling, latitudinal differences, field and laboratory protocols altogether prohibit a direct comparison of biomass samples between the two studies, despite the efforts in ref. 4 to adjust samples by a correction factor. Hence, combining these data to derive a trend continuation (fig. 1 in ref. 4) is unwarranted and misleading.

To examine whether any insect recovery has taken place over a short time within recent years, we assessed insect biomass samples from two other projects[5–7], which included a three times larger sample size ($n = 1{,}611$ and 886 distinct samples) than ref. 4 and have meticulously followed the methodology of the original study of refs. 1,8. A formal assessment of these data can be found in refs. 5,6; here it suffices to show that no biomass recovery can be observed, neither in the federal state of North Rhine-Westphalia where the original study predominantly took place, nor across Germany. On the contrary, these results suggest an ongoing decline in flying insect biomass (Fig. 1). We therefore refute the claim that insect biomass has recovered recently.

We argue that non-standardized and inconsistent sampling between years in ref. 4 form a better explanation for the observed higher insect biomass in recent years. In 2022 — the year with the highest observed biomass — samples were predominantly taken from artificially established forest gaps aimed at increasing beta diversity and therefore insect biomass (BETA-FOR project; https://elib.dlr.de/191557/). Such small artificial gaps are well known to temporarily harbour many species and have higher abundances (for example, refs. 9–12).

Over the 4 years (2016, 2019, 2020 and 2022), factors associated with variable habitat sampling and trap placement in the field (for example, at border lines; Extended Data Table 1), resulted in a spuriously positive trend (Fig. 1). By disregarding naturally occurring variation in insect biomass between different habitat types[4], an increasing biomass trend was unintentionally constructed. Detailed habitat classification including detailed vegetation surveys should be an obligatory part of insect monitoring[8,13] and cannot be overlooked, as local habitat can have a tremendous effect on biomass catches (for example, see supplementary fig. 2 in ref. 1).

We must conclude that the newly presented data in ref. 4 have not been collected under the appropriate level of standardization (for example, ref. 8), are methodologically incomparable with the original data of ref. 1 and, therefore, do not meet the requirements to assess insect biomass trends.

Explaining trends in insect biomass in refs. 1,4 present a number of models with increasing complexity (table 1 in ref. 4). Their results show that the more complex 'weather anomaly' model (model 5) is statistically inferior (that is, less parsimonious) to the simpler 'year + sampling weather' model (model 4a), as judged by both explained deviance and Akaike information criterion (AIC). The added complexity of 12 weather anomaly covariates is unjustified by the data at hand. If we were to be advised by formal AIC model selection based on results of this table, the 'weight of evidence'[14] in support of the simpler model (sampling weather only + annual trend) is 100%, against 0% for the weather anomaly model. Despite the lack of support ($\Delta AIC = 67.3$), the authors unconventionally proceed with the unwarranted more complex model.

How then can their weather anomaly model provide a good explanation of the biomass decline over time? Replacing a single linear covariate (year) by a combination of 12 more-or-less linear covariates (weather anomaly over time; extended data fig. 2 in ref. 4) is bound to explain quite some variation in these biomass samples, purely by chance, as the data do not stem from a fully balanced longitudinal sampling scheme (table 1 in ref. 1). Such a highly parameterized model has little generality and may lead to spurious relationships. On the basis of the results of the analysis in ref. 4, there is no statistical ground for accepting weather anomalies as the major factor associated with insect decline.

Despite the incomparability of recent insect data[4] with the original data[1], as argued above, the results of the validation step presented in fig. 2 of ref. 4 show a good (60.5%) correlation between the model predictions. Upon examining the evidence for the predictive abilities of their weather anomaly model (model 5), we note that their proof depicts the combined effect of sampling weather and weather anomalies.

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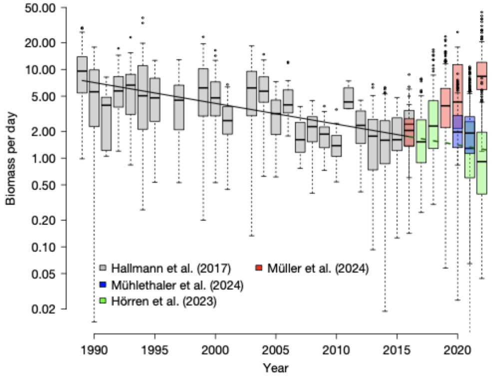

Fig. 1 | Flying insect biomass from four studies using Malaise traps in Germany. The black line depicts the average trend as given in ref. 1 ($n = 1{,}503$), extrapolated for recent years. The studies (ref. 5, blue, $n = 1{,}611$; and ref. 6, green, $n = 886$) used the same traps and protocols as ref. 1, unlike the study of ref. 4 (red, $n = 761$). Box plots: the centre line marks the median, hinges mark the 25th and 75th percentiles and whiskers extend to 1.5 times the interquartile range.

We argue that this analysis is misleading as it does not validate the weather anomaly effects separate from those of sampling weather. A plot of the validation biomass samples against predictions of their sampling weather effects only shows an improved fit (63.2% correlation) compared with the combined effect of sampling weather and weather anomaly (Fig. 2). Weather anomaly further becomes insignificant after controlling for the sampled habitat of the validation data (Fig. 2 and Extended Data Table 2). Sampling weather is thus the main reason for a good agreement between model predictions and validation data, whereas weather anomalies are confounded with sampled habitat, leaving no ground to conclude that weather anomalies explain insect biomass trends.

Confronting the way[4] selected sites and collected data incomparable with the earlier study[1] or among years within their own study, although observing no trend in insect biomass reversal in recent years based on larger datasets using the original sampling protocol[5,6], there is no evidence for insect recovery in recent years. In addition, model choices and validation in ref. 4 do not comply with current statistical practices, invalidating the assertion that lagged weather anomalies explain the temporal decline in insect biomass. In fact, it is hard to understand how weather changes in winter and early spring over decades could explain the major decline of the entire insect community, as concluded in ref. 4, whereas year-to-year fluctuations of the same weather variables contribute little to insect biomass trends over the same years[1]. We must ascertain a better understanding of the effects of long-term weather deviation on populations and communities. In that sense, we applaud attempts to link insect decline to weather anomalies under climate change[15]. However, it will require more experimental and observational studies, combined with trend analyses of suitable data,

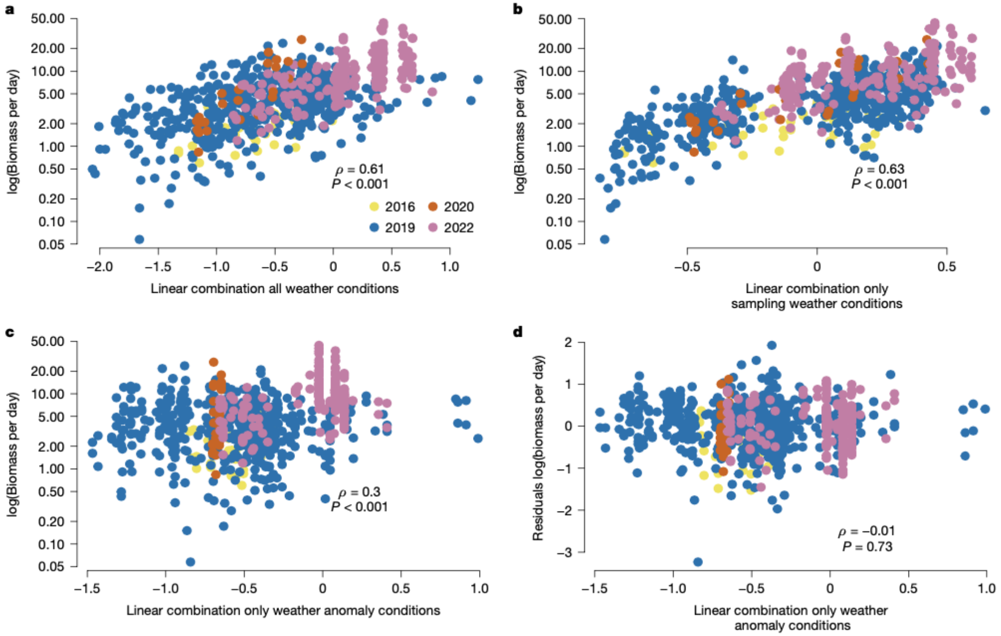

Fig. 2 | Lack of weather anomaly effects. a–c, Validation results of ref. 4 depicting the correlation between biomass and sampling weather, as well as weather anomalies (**a**), further subdivided for sampling weather only (**b**) and weather anomalies only (**c**). **d**, After controlling for sampling weather effects and sampled habitat (Extended Data Table 1), residual biomass does not correlate to weather anomalies. *P* values were determined using Spearman's rank correlation test. ρ, Spearman's rank correlation coefficient.

Vielen Dank für Ihre Aufmerksamkeit!

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