Insect Declines Essay Condensed Plan

Insect population trends: why should we care, what do we know, and where do we go next?

**Why do we care? - 100**

Lots of insect groups – unique and overlapping functions.

Homburg, 2019 – insects are most diverse taxon on Earth in terms of species numbers

Sanchez-Bayo, 2019 – Lepidoptera: pollination, natural pest control, prey items. Hymenoptera: bees for pollination and economic value. Diptera: pollinators, natural enemies of agricultural pests. Coleoptera: pest control and recycling of organic matter. Hemiptera: true bugs. Orthoptera: grasshoppers, locusts, crickets. Odonata: dragonflies and damselflies. Control mosquitos and agricultural pests.

Habel, 2019 – pollination has high economic value, and significant impact on crop yields.

Specific risk in global south where high diversity of insect pollinated crops are grown Dicks, 2021.

Powney, 2019 - Without these, we risk ecosystem health and global food security.

What we lose?

Cardoso, 2020 – lose major part of tree of life, along with all their services, leaving us with a less diverse, more homogenized group.

Montgomery, 2020 - Have enough info to justify immediate action.

**Key drivers - 100**

2 drivers that come up most – habitat change (including land use change/agricultural intensification, but also pollution, urbanization, industrialization, alien species) and climate change.

Habitat change – Sanchez-Bayo, 2019, Powney, 2019, Habel, 2019

Land-use change – Newbold, 2014 – prob that species occurred at site strongly related to major land-use type (PREDICTS), Newbold, 2016b – strong impact of land use (PREDICTS), Millard, 2021 – land-use, but different in tropics to non-tropics. Gray, 2016 – protected areas most effective when minimize human-dominated land use.

Climate – Lister, 2018, Soroye, 2020, Deutsch, 2008

Can be specific to specific groups e.g. CCD in honeybees Van Engelsdorp, 2009

BUT often these are all interlinked and can act additively, synergistically, or antagonistically (Wagner, 2021a). Outhwaite, 2022, Cardoso, 2020.

**Comparing studies on insect trends – what do we know? – 300**

Increase in studies since first reports of major insect declines.

Lots of variation in studies – different insect groups, at different taxonomic levels, different locations and scales of location, dates data collected and over what period, method used to assess trends.

Alarming findings by certain studies

* Hallmann, 2017 – flying insect biomass declined by 76% 1989-2016 Germany.
* Sanchez-Bayo, 2019 – claim global rates of decline that could see extinction of 40% of species over next few decades. BUT see Simmons, 2019.
* Hallmann, 2020 - reduction in total biomass of approximately 61% for macro-moths as a group and at least 42% for ground beetles, by extrapolation over a period of 27 years in Netherlands
* Seibold, 2019 – 2700 arthropod species, Germany 2008-2017 - Grasslands - biomass, abundance and number of species declined by 67%, 78% and 34%, respectively. BUT forest - biomass and species number—but not abundance—decreased by 41% and 36%, respectively.

Some studies have less severe findings

* Earlier study by Biesmeijer, 2006 - Bees - Signif decreases in richness observed in 52% and 67% of British and Dutch cells. Increases in 10 and 4%. Hoverflies - No signif directional change for hoverfly richness in UK, but increases in 34% and decreases in 17% of Dutch cells.
* Powney, 2019 – wild bees and hoverflies in GB from 1980-2013 using occupancy models. 1/3 species decreased, tenth increased.

Or even positive findings

* Outhwaite, 2020 – Terrestrial insects show 5.5% increase in occupancy in the UK 1970-2015.
* Van Klink, 2020 – meta-analysis over 41 countries 1925-2018. Decline of terrestrial insect abundance by ~9% per decade and an increase of freshwater insect abundance by ~11% per decade.

Although many studies done in Westernized countries, some have looked at other areas in recent years

* Lister, 2018 – sustained declines across all 10 major arthropod taxa biomass 1976-2012 in Puerto Rico rainforest.
* Gillespie, 2020 – declines of muscid flies 1996-2014 in arctic
* Loboda, 2018 – decrease of 80% total muscid fly abundance Greenland 1996-2014

Some studies just focused on specific taxa

* Homburg, 2019 – carabids – decline in species richness, but not biomass or abundance. Germany
* Brooks, 2012 – carabids – ¾ species declined. UK
* Van Strien, 2019 – butterflies, Netherlands 1890-2017 – strong decline in grassland, woodland, heathland, though stabilized over recent decades in grassland and woodland
* Wepprich, 2019 – butterflies, Ohio, 1996-2016. 33% reduction in abundance.
* Soroye, 2020 - bumblebees - Probability of site occupancy declined on average by 46% (±3.3% SE) in North America and 17% (±4.9% SE) in Europe in recent period (2000–2014) relative to the baseline period (1901–1974)

*Main conclusion is that there is a lot of variation.* ***150***

Across space, time, and taxonomic lineage Wagner, 2021b, Outhwaite, 2020, Hudson, 2017

Any one driver at one time depends on the specific driver at a particular time. Habel, 2019

Certain traits and nature of threat influence extinction risk – Cardoso, 2020, De Palma, 2015, Habel, 2019, Dirzo, 2014

* Nature of threat – seibold, 2019 - Sites embedded in landscapes with a higher cover of agricultural land showed a stronger temporal decline

Across time

* Ollerton, 2014 – Britain pollinators. From 1920-50s – lost 3.41-3.46 species per decade. From 1960s – 0.98 species per decade

Across habitat type

* Powney, 2019 – 55% decrease species associated with uplands, 12% increase in dominant crop pollinators
* Brooks, 2012 - 48.4% declines in northern moorland and western pasture, to 50% increases in southern downland. More stable in woodland and southern hedgerow. BUT even when stable in these sites, same taxa were often declining elsewhere.

Rare vs common, common may have bigger effect (Cardoso, 2020).

* Depends on method e.g. Hallmann, 2020 – abundance – ground beetles – abundant worse BUT biomass – rare worse.
* Losses concentrated in rare Powney, 2019, Outhwaite, 2020
* Seibold, 2019 – grasslands – mainly rare. Forest – abundant and rare
* Loboda, 2018 – number of common species also decreased

Specialists vs generalists – in general, generalists win, but not always the case

* Biesmeijer, 2006 – declines more frequent in specialists (habitat or food)
* Boyes, 2019 – majority of winners are generalists

Size, dispersal ability, univoltine, flight season.

* Smaller species showed stronger decline (Homburg, 2019), maybe also explaining why they observed decrease in species richness, but not biomass.
* Shorter flight season best at explaining occurrence and abundance patterns – De Palma, 2015
* Univoltine species had more negative pop trends (Wepprich, 2019)

Some studies fail to find links

* Hallmann, 2017 – decline regardless of habitat type, weather, land-use etc
* Loboda, 2018 – some links between summer temp and composition of muscid flies in Greenland, but at species level, most relationships between abundance and climate predictors were not signif.

*And not all insects are declining.* ***50***

Wagner, 2021b, Boyes, 2019.

Always some taxa which show positive or non-signif trends, even if overall trend in negative (Wagner, 2021a, Saunders, 2020)

Crossley, 2020 study showed no net declines. BUT see Welti, 2021.

**Where do we go next? Gaps in knowledge/limitations - 300**

Despite increase in number of papers, inverts are still understudied compared to vertebrates in terms of long-term BD change studies Outhwaite, 2020. Wagner, 2021b

Not enough replication Hallmann, 2017. Need more long-term time series data because of highly dynamic nature of insects and large annual variation. Fox, 2019, Didham, 2020, Montgomery, 2020

Geographically restricted Hallmann, 2017– mainly westernized countries. Tropics especially lacking, where most BD is Wagner, 2021b, Lister and Garcia, 2018 and highest risk is Dicks, 2021.

Taxonomically restricted Hallmann, 2017. E.g. ants Sanchez-Bayo, 2019. Butterflies, bees, moths overrepresented Hallmann, 2020. Only small fraction of insects have had any substantial pop monitoring Montgomery, 2020. Most insects remain undescribed Montgomery, 2020

Temporal bias, more records in recent years (Powney, 2019). What should historic baseline be seeing as historical pop abundance is rarely available? Didham, 2020. Van Strien, 2019. Shifting baseline syndrome? Outhwaite, 2020

Harder to quantify rare species Cardoso, 2020

Study species in isolation? Or as a whole? Wagner, 2021b, Brooks, 2012

Drivers very unclear Hallmann, 2017, Boyes, 2019

Data often collected without standardized protocol Powney, 2019

Publication bias - Publish positive/stable trends as well as negative to overcome publication bias and aid meta-analyses. Montgomery, 2020

Many datasets remain unanalyzed Wagner, 2021b. Urgent need to mobilize existing data and interrogate them with modern, rigorous analysis tools Outhwaite, 2020. Minimize problems with existing data by taking advantage of multiple datasets Cardoso, 2020. Use of large data sets and sophisticated statistical analyses Habel, 2019.