Year to year fluctuations in the abundance of true bugs

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If you have a love for bugs then you are probably familiar with the joy it gives to observe changes in distribution patterns. Observing and especially understanding the rapid spread of invasive species, the expansion of warm-loving bugs or the increase of species profiting from nature management gives a certain satisfaction. There is even a kind of grimm joy when you observe and understand patterns of decline caused by human mismanagement. In addition to the long-term trend of species there are also clear fluctuations from year to year. For the individual observer these are more difficult to observe as it is difficult to know if an observation of high numbers in a certain year is caused by a genuine increase or is just a case of being on the right moment on the right spot. Only by combining the observations of a large number of observers it becomes possible to detect and study fluctuations in abundance between years. Here we use data collected during the Dutch bug mapping scheme, which was conducted in 2017 and 2018. This project coincided with two years with exceptionally warm summers, with the second year being also exceptional dry. This allows us to get some insight in year to year fluctuations (hereafter called short term trends) of Heteroptera.

Methods

The data used was collected during the Dutch bug mapping scheme conducted in 2017 and 2018. This project focussed on ten Heteroptera families, but for some of these the number of taxa and/or the number of observations where small for which reason they are discarded in this study. Here we use data on Coreidae, Rhopalidae, Cydnidae, Scutelleridae, Pentatomidae and Acanthosomatidae. The data was collected throughout the Netherlands and the geographical distribution of the recording intensity was largely the same between both years. In the two years of the project 81 species belonging to these families were recorded, however, species for which less than 20 records in either of the two years were available, were removed from the dataset so that the analysis is based on 42 species in total. For these species 14,048 records (a species on a day on a location) were available for 2017 and 17,935 records for 2018. If the abundance of species would be the same in 2017 and 2018 than we would expect an increase in records between 2017 and 2018 for each species by 128%, as the total number of records increased from 14,048 to 17,935. We therefore calculated the expected number of records in 2018 based on the number of records in 2017 and compared this with the actual number of records in 2018. If the number of records in 2018 was less than 80% of the predicted number we considered the species to have declined, and if the number of records in 2018 was more than 120% of the predicted number, we considered the species to have increased. When the number of records in 2018 was between 80-120% of the predicted number we considered the species to be stable. Readers should bear in mind that the fluctuation we observe is relative to the total number of bugs observed. This means that it is theoretically possible that all species declined, in which case the species with the lowest decline still could show a positive short-term trend in our analyses as they declined less compared to the other species.

Most species included in our analyses spent the winter as adult and reproduce in spring with larvae of the new generation being found during the summer. Differences between 2017 and 2018 could therefore be caused by either good/bad reproduction in the summer 2017 or low/high survival during winter. We were therefore interested to see if differences in short-term trend could be observed between the different parts of the year. For this we applied the same method as described above but divided the years in two periods: January to June and July to December.

Results

Table 1 presents the short-term trend of the species between 2017 and 2018. Fourteen species showed an increase and fourteen a decline. For many species the short-term trend was rather strong with five (*Aelia klugii*, *Acanthosoma haemorrhoidale*, *Picromerus bidens*, *Arenocoris fallenii* and *Eysarcoris venustissimus*) species for which the number of records was less than 50% than expected, based on the number of records in 2017. Also, the short-term trend shown by the increasing species is in many cases very pronounced with three species (*Leptoglossus occidentalis*, *Legnotus limbosus* and *Stictopleurus abutilon*) for which the number of records in 2018 was twice as high as predicted based on the records of 2017. Table 2 shows the short-term trend between the first half of 2017 and the first half of 2018 and between the second half of 2017 and the second half of 2018. This table shows that there are not only strong variations in abundance between the years, but that there are also strong fluctuations in trends within the year. A very marked example of this is *Elasmostethus interstinctus* of which the number of records in the first half of 2018 were only 20% of that of the first half of 2017, while the number of records in the second half of 2018 were almost twice as high as in 2017.

Discussion

It is likely that the main factor determining the strong year to year fluctuations is the weather. Both 2017 and 2018 were warm and are among the top ten warmest years on record. The year 2017 experienced a very warm May period and was slightly wetter than normal. The year 2018 experienced a very warm and dry May to August period, resulting in water shortages in gardens, agricultural areas and also in nature reserves.

From Table 1 it is clear that many species indeed show strong year to year fluctuation in abundance, with 14 of the 42 species being clearly more common in 2018 and 14 of the 42 of the species being clearly rarer in 2018. These strong fluctuations are found in all included families and in species of different habitats and life styles. The main difference in weather between 2017 and 2018 is the latter experiencing even higher temperatures and especially being much dryer. We would expect that species found in dry and hot habitats would profit from this. However, *Aelia klugii*, one of those species, instead showed a decrease of over 50%. It is, however, possible that this is not due to a genuine decrease but is simply the result of the species evading the high temperatures and staying below ground where they escape attention of heteroptologists. In contrast *Stictopleurus abutilon*, another species found in dry, often hot grasslands, did show an increase being almost three times as abundant in 2018 compared to 2017. This is a southern species which was still scarce in the Netherlands at the start of the century. The weather in 2018 seemingly resulted in a very high reproduction for this species.

Table 2 shows for the 42 included species the short-term trend in different parts of the year. Most striking from this table is the fact that trends between parts of the year show strong differences. There are seven species which fall in the increase category in one part of the year and in the decrease category in the other part of the year. In addition, there are another 16 which show a increase or decrease in one part of the year, while being stable in the other part of year. For groups like breedings birds or plants it makes sense to measure the reproductive success in calendar years however for bugs in which a new generation starts halfway the calendar year this not necessarily makes sense. Table 2 shows that low numbers in spring, either due to poor reproduction in the preceeding year or due to low survival during winter, not necessarily results in low numbers in the second part of the year as a high reproductive success can easily result in a recovery of the population. Likewise, high numbers in spring, due to high reproductive success in the preceding year or high survival during winter, can easily be undone by low reproductive success resulting in low numbers in the second half of the year. Like in the fluctuation between the years the strong fluctuation between different parts of the year is found in all included families and in species of different habitats and lifestyles. One pattern is rather evident and that is that the four included species of Acanthosomatidae are also the four species showing the strongest decline when the first half of 2017 is compared to the first half of 2018. This indicates that for this family either reproduction in 2017 was very low or survival in winter 2017-2018 was very poor. Remarkably enough, three of these four species recovered strongly with numbers found in the second half of the year being on average 150 to 240 percent higher than in the second half of the preceding year, indicating a very high reproductive success during the hot and dry summer of 2018.

Conclusion

This paper is not meant as thorough analysis of short-term trends (fluctuations) in Heteroptera and for this a more detailed analysis of a series of three or more years would be necessary. However, some preliminary conclusion can be drawn from this exercise. First of all, it shows that, as all readers were probably already aware, bugs show strong year to year fluctuations in numbers. More surprising might be the strength of these fluctuations. Also surprising might be the strong fluctuations in numbers between different parts of the year and that the fact that these fluctuations in different parts of the year can have different directions. At least two notes of caution are necessary. First of all, people should, when reading the tables in this paper, be aware that they are looking at relative and not absolute numbers. Readers should also be aware that a lower number of observations might not necessarily mean that a species declined, as it also could indicate a change in behavior due to which a species is less likely to be observed (e.g. species staying below ground).

The number of records submitted on bugs in the Netherlands remains high and by the end of 2020 we will have four years with 14,000 or more records of the 42 species included in this study. An analysis of that dataset will allow to determine the impact of weather condition in different parts of the year on the fluctuation in numbers of different species in different parts of the year.

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Table 1. Short-term trend between 2017 and 2018 of 42 species of Heteroptera.
The colour indicates the trend of the species. Green: increase; yellow: decrease; grey: stable.

Taxon	Records 2017	Record 2018	Trend 2017/2018
Aelia klugii	35	16	35,8
Acanthosoma haemorrhoidale	349	177	39,7
Picromerus bidens	213	119	43,7
Arenocoris fallenii	31	19	48,0
Eysarcoris venustissimus	83	51	48,1
Arma custos	283	202	55,9
Eurygaster testudinaria	339	255	58,9
Eysarcoris aeneus	30	23	60,0
Troilus luridus	66	51	60,5
Pentatoma rufipes	1.251	979	61,3
Tritomegas bicolor	169	138	63,9
Piezodorus lituratus	339	295	68,1
Palomena prasina	1.898	1.756	72,4
Zicrona caerulea	67	63	73,6
Chorosoma schillingii	73	77	82,6
Coreus marginatus	1.577	1.695	84,2
Sciocoris cursitans	48	56	91,4
Gonocerus acuteangulatus	619	718	90,8
Elasmostethus interstinctus	402	473	92,1
Rhopalus parumpunctatus	152	179	92,2
Peribalus strictus vernalis	330	398	94,4
Elasmucha grisea	479	597	97,6
Syromastus rhombeus	71	90	99,3
Alydus calcaratus	32	41	100,3
Cyphostethus tristriatus	198	257	101,6
Rhopalus subrufus	187	249	104,3
Pyrrhocoris apterus	651	936	112,6
Stictopleurus punctatonervosus	204	306	117,5
Aelia acuminata	324	514	124,2
Neottiglossa pusilla	29	48	129,6
Chlorochroa pinicola	51	86	132,0
Myrmus miriformis	138	234	132,8
Rhaphigaster nebulosa	586	1.026	137,1
Eurydema oleracea	291	525	141,3
Graphosoma italicum	520	953	143,5
Carpocoris purpureipennis	137	256	146,3
Dolycoris baccarum	780	1.476	148,2
Coriomeris denticulatus	58	112	151,2
Corizus hyoscyami	213	412	151,5
Leptoglossus occidentalis	609	1.578	202,9
Legnotus limbosus	21	72	268,5
Stictopleurus abutilon	115	427	290,8
TOTAL of 42 species	**14.048**	**17.935**	

Table 2. Short-term trend between 2017 and 2018 of 42 species of Heteroptera in different part of the year.
The colour indicates the trend of the species in a that part of the year. Green: increase; yellow: decrease; grey: stable. The fourth column indicates whether the trend in one part of the year is different from that in the other part of the year: ** indicates that in one half of the year the species increased while it decreased in the other half of the year; * indicates that in one half of the year the species showed a increase or decrease while it was stable in the other of the year.

Taxon	Trend period 1	Trend period 2	Difference in trend between periods
Elasmostethus interstinctus	20,0	239,5	**
Cyphostethus tristriatus	35,5	252,5	**
Elasmucha grisea	37,4	153,1	**
Acanthosoma haemorrhoidale	38,1	41,8	
Aelia klugii	45,5	33,1	
Arma custos	53,2	51,7	
Picromerus bidens	58,2	37,1	
Eysarcoris aeneus	61,8	54,6	
Arenocoris fallenii	66,9	39,7	
Eysarcoris venustissimus	68,8	37,8	
Gonocerus acuteangulatus	77,1	103,3	*
Alydus calcaratus	81,1	89,8	
Palomena prasina	83,0	66,6	*
Syromastus rhombeus	85,9	112,6	
Troilus luridus	87,3	49,6	*
Pentatoma rufipes	91,6	49,2	*
Piezodorus lituratus	94,3	57,5	*
Tritomegas bicolor	94,9	9,4	*
Leptoglossus occidentalis	96,7	205,5	*
Rhopalus parumpunctatus	100,4	84,2	
Sciocoris cursitans	101,7	113,4	
Eurygaster testudinaria	101,7	43,0	*
Coreus marginatus	105,1	76,4	*
Stictopleurus punctatonervosus	105,7	109,0	
Graphosoma italicum	119,8	156,6	*
Chlorochroa pinicola	121,6	128,5	
Peribalus strictus vernalis	130,6	79,7	**
Dolycoris baccarum	132,2	150,4	
Rhopalus subrufus	132,4	95,9	*
Rhaphigaster nebulosa	135,5	142,8	
Aelia acuminata	136,2	119,6	*
Stictopleurus abutilon	148,6	286,4	
Carpocoris purpureipennis	155,2	135,0	
Pyrrhocoris apterus	159,0	94,0	*
Coriomeris denticulatus	159,0	170,9	
Corizus hyoscyami	167,9	141,9	
Myrmus miriformis	168,9	114,8	*
Zicrona caerulea	192,2	41,8	**
Chorosoma schillingii	204,2	62,0	**
Eurydema oleracea	221,9	105,7	*
Neottiglossa pusilla	342,3	83,4	*
Legnotus limbosus	432,4	66,1	**
TOTAL of 42 species			