

## The Effect of Climate Change on Light Trap Capturing Data of Lepidoptera

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**Abstract.** When examining the ecological effects of climate change those databases which contain the monitoring results of long-term time series have a key role. In our study we used the daily Lepidoptera data of the Hungarian Plant Protection and Forestry Light Trap Network within the time period between 1962 and 2006, in order to analyse the influence of the change of temperature on the ecological dynamics of Lepidoptera. As a result of the quantile regression analyses we came to the conclusion that in the examined period, regarding the total number of individuals, seasonal phenomena shifted forward, however the days with higher diversity occurred in a shorter period. The analysis of the heat sums showed that the spring warming started earlier. Although, at the same time the low quantiles of the captured Lepidoptera occurred at lower and lower heat sums over the years, while the high quantiles of those occurred at higher and higher heat sums, meaning that the active period of the Lepidoptera community grew wider. A strong correlation was observed between diversity indices and the temperature.

**Keywords:** biodiversity, quantile regression, climate change, Lepidoptera, light trap

### 1. Introduction

Since the last decades the effects of climate change on the dynamical behaviour and the size of Lepidoptera populations have become more and more obvious. Seasonal community dynamics (ecological processes) are, out of all meteorological parameters, primarily influenced by temperature. Our objective was the following: to examine the effects that the change of temperature has on community dynamics. We chose the light-attracted species assembly of Lepidoptera, which is an adequate indicator of the above ecological phenomena (Hufnagel et al. 2008). The data we needed was collected from the database of the Hungarian Plant Protection and Forestry Light trap Network. This choice had been motivated by the national coverage of the light trap network, the large number of captured Lepidoptera individuals, and also by the availability of a long-term data series (between 1962 and 2006). Various methods exist that demonstrate changes in a community: different diversity indices, gradations, species abundance models, quantile regression.

We chose quantile regression for our study, which is ideal for examining population dynamics and demonstrating changes. With the help of this method it became observable that both heat sum and the appearance of species shifted earlier and earlier over the years. Many authors agree on the seasonal dependence of community dynamics, regardless of the climate (temperate or tropical) of the area where the research was carried out. Szabó et al. (2007) used the number of species and the number of individuals for the demonstration of seasonal changes, while Fisher et al. (1943) used a diversity index. Species abundance models are also suitable for the examination of seasonal dynamics. With the help of the above methods

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different periods can be well separated. We used the traditional two-dimensional time series figures for the presentation of seasonal changes, in which the seasonal dependence of population dynamics can be seen clearly.

## **2. Material and method**

In the course of our work the database of the Hungarian Plant Protection and Forestry Light Trap Network was used, whose first light traps were installed in 1961 (Szontagh, 1975). These traps are operating all year round, except for those days when the temperature does not rise above 0 °C, or when the area is covered with snow (Nowinszky, 2003). The collection data of the Hungarian Plant Protection and Forestry Light Trap Network were analysed with data-mining methods. Due to the effects of various abiotic factors it seemed reasonable to work with the maximum number of data, so that the effects occurring at different capturing sites, modifying the number of captures, could compensate each other (Nowinszky, 2003). To produce a national time series the trap data found at different locations needed to be merged for each species. Following the work of Moon and Kim (2007) this process is called data reduction. To filter out extremes occurring in the databases and in order to reduce fluctuations in the data series the Moving Average method was used. When calculating the Moving Average we considered the 4-4 adjacent daily data as well, that is the average of 9 days (9<sup>th</sup> grade Moving Average). Number 9 was chosen, because it equals to the number of traps. After calculating the average, a 16425-line database was created containing the daily data series of 281 Lepidoptera species captured between 1962 and 2006. To create an insect data warehouse, for data filtering, and for further data processing a Visual Basic software was created. Using this programming language Excel and Access files could be managed directly. As meteorological data source the “kutdiak” database and the “KKT” database (Szenteleki, 2007 and Szenteleki et al., 2007) were used. The second one, in addition to meteorological data, contains the geographical coordinates of the Hungarian cities. For the filtering and checking of databases, data published on the website of the National Meteorological Service (2008) were used. In Hungary, the connections between captured individuals and the elements of weather have been being investigated since the late 1950s. In the scientific literature it is a generally accepted fact that flying activity, and so the number of captures is primarily influenced by temperature. Precipitation, wind and other environmental effects influence it only to a small extent and only locally. To study community changes, the method of linear quantile regression was used and for our analyses the GRET (GNU Regression, Econometric and Time-series Library) and Microsoft Excel programs were used.

## **3. Results**

One of the methods to investigate community changes is the calculation of linear quantile regression, where the changes of given ratios (10, 20, 30, 40, 50, 60, 70, 80, 90%) of the measurement data are characterized by linear quantile regression.

### **3.1. Examination of the number of captured individuals**

The days of the year, on which the number of captured individuals reached 10, 20...90% of the annual sum were investigated. Due to the fact that in the years 1972 and 1973 trapping and filling the database were uncertain, we studied the periods between 1962 and 2006 (Fig. 1), and 1974 and 2006 (Fig. 2) separately.

The steepness (coefficient) of all regression lines are negative, which shows that the captures shifted earlier and earlier. 10% of the annual sum of the number of individuals was reached 15 days earlier in 2006 than in 1962, while 90% of it was reached 26 days earlier. The ratios shifted 20 days earlier on average.

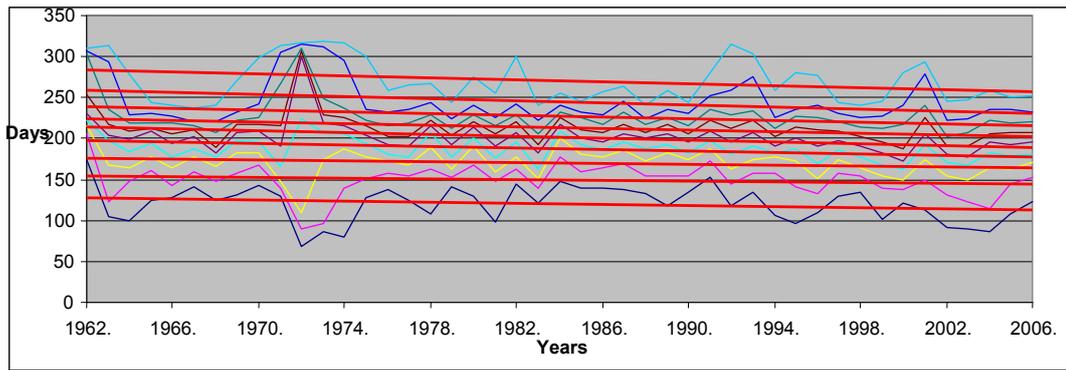


Fig. 1: The linear quantile regressions of the number of individuals between 1962 and 2006

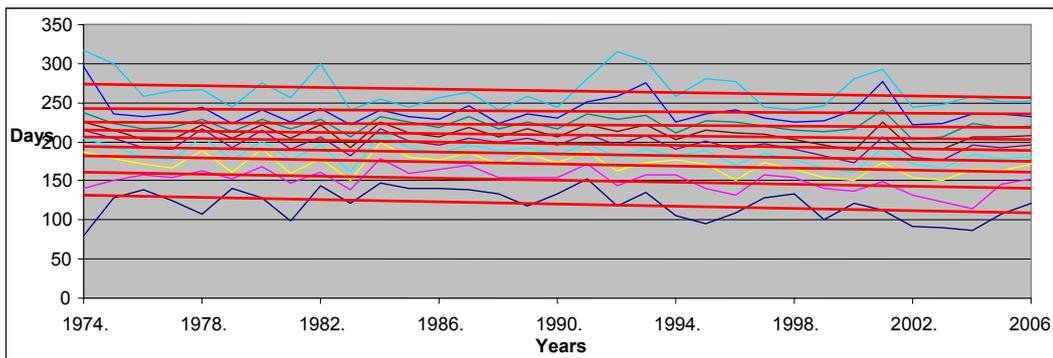


Fig. 2: The linear quantile regressions of the number of individuals between 1974 and 2006

Negative steepness (coefficient) of the regression lines can be observed here as well. 10% of the annual sum of the number of individuals was reached 21 days earlier in 2006 than in 1974, while 90% of it was reached 18 days earlier. The ratios shifted 16 days earlier on average.

### 3.2. Investigation of a diversity index

The days on which the Shannon-diversity index reached 10, 20...90% of the maximum value in the given year (between 1974 and 2006) were examined (Fig. 3).

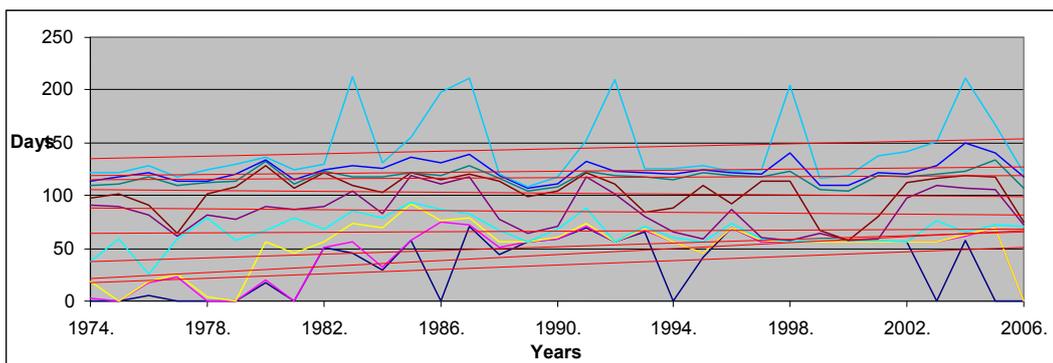


Fig. 3: The 10, 20...90% linear quantile regressions of the diversity index between 1974 and 2006

Diversity index increases until the 50 and 60% quantiles, where the steepness becomes negative indicating a decrease in the diversity index. After this an ascending tendency can be seen again.

### 3.3. Seasonal dependence

The averages of daily mean temperatures, diversity indices, the numbers of individuals and species concerning the same days of the years within the period between 1974 and 2006 can be seen in Figure 7. It

shows how different values changes as a function of the day of the year (for the sake of better visualisation values were weighted to obtain similar scaling).

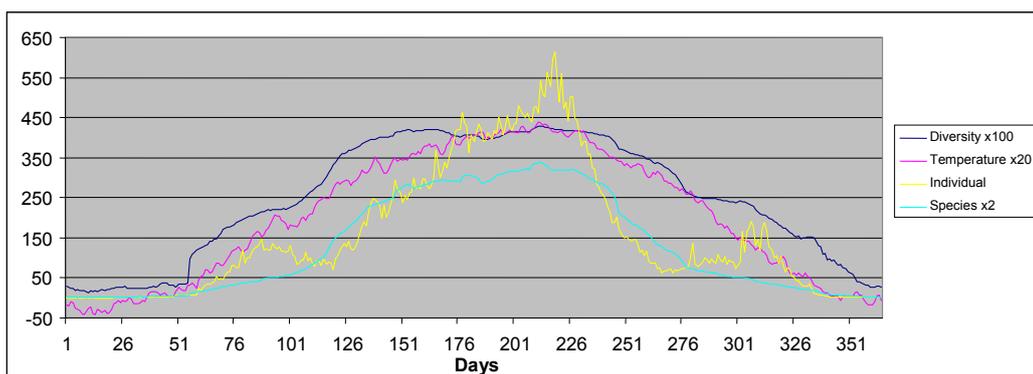


Fig. 4: The averages of temperatures, diversity indices, the numbers of individuals and species concerning the same days of the years within the period between 1974 and 2006

## 4. Discussion

The database compiled by us from the data of the Hungarian Plant Protection and Forestry Light Trap Network is suitable for application in important research areas of the national light trapping summarized by Szentkirályi (2002), for fauna, zoogeographical, taxonomic, zoocoenological, ethological, phenological, ecological, etc. examinations (Nowinszky, 2003). In our present study the long-term seasonal changes of the data were examined. Investigating the change in the number of individuals we found that the appearance of species is approximately 2-3 weeks earlier than 30 years ago. However, during the analyses of diversity indices we became aware that the increase of the different diversity index values were shifted forward. Some authors reported an increase (e.g. Bazzaz, 1975), while others a decrease in the number of individuals (e.g. Nowinszky, 2003) as a function of temperature. Taylor (1963) found that flying and, as a consequence, capturing had both lower and upper temperature threshold values. This statement was supported by our investigations (Fig. 4), i.e. that in the warmest summer period the diversity value did not increase, even a slight decrease could be observed. Relying upon these findings we came to the conclusion that as an effect of climate change, the number of Lepidoptera, and consequently their diversity, would decrease. This is also supported by the long-range model presented by Hufnagel et al. (2008).

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