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# FIFTY-YEAR-LONG INSECT SURVEY IN HUNGARY: T. JERMY'S CONTRIBUTIONS TO LIGHT-TRAPPING

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## INTRODUCTION

The use of different trapping methods has an important role in field samplings of insect populations and assemblages. Taking into consideration that the majority of insect species are active at night, a regular and quantitative survey of their abundance may only be conducted with traps operating automatically. Light trapping is one of the most frequent and most popular sampling methods. Hundreds of light traps are working around the world mainly to forecast agricultural and forest pests. The possible uses of data on the identified species from these collections are wide ranging, and may serve taxonomic-faunistic, zoogeographic or insect-ecological studies to name a few. In most cases, only a single light trap is operated at or near the observed crop field or forest stand. There are only a few places, where several (5–15) light traps are operated simultaneously in order to produce pest forecasting generally on a smaller area. Only two countries are known worldwide where there is an existing national light trap network, >50 stations, that has been operating for decades. One of these is in the UK (Rothamsted Insect Survey: R.I.S.), the other one is in Hungary (Hungarian Light-trap Network). Simultaneous samplings with such networks of light traps can be carried out according to landscape, or even at a larger spatial (regional, national) scale to forecast insect pest densities. In addition, they are able to make synoptic monitoring of spatio-temporal dynamics of complete insect assemblages. Such survey systems are fundamental to modern research fields, e.g., for the study of effects of climate change on habitats and communities, or for the long-term monitoring of biodiversity changes and their trends.

Hungarian entomology celebrates two important events in 2002: Professor JERMY's 85th birthday and the 50th anniversary of the installation of the light trap type, which was designed and first operated by him in 1952 and has been used by the National Light-trap Network ever since. After a 6-year-experience of trapping and managing the caught insect material from six different sites in the country, JERMY launched a widespread use of his traps. At his suggestion, a national-wide network of light traps started to operate in Hungary in 1958. The network, established with the intention of forecasting for plant protection purposes, grew to more than 100 traps a decade later, and even today about 60 stations are operating. Below I review the birth of the so-called "JERMY-type" trap; how and at what degree JERMY has contributed to the development and current knowledge of the use of light trapping in Central Europe with the establishment of this long-term-operating network, unsurpassed so far.

## ESTABLISHMENT OF THE "JERMY-TYPE" LIGHT TRAP

To understand the need for JERMY's splendid idea, i.e. the development and long-term operation of a continuous sampling device, we need to cast light on the circumstances 50 years ago: requirements of plant protection practice, the available literature on foreign light trapping experiences, and last the professional and economical background of the times.

### *Necessity for countrywide forecasting of pests*

In the late 1940s and early 1950s, before the use of light traps, post-war Hungarian plant protection was faced with the countrywide outbreaks and heavy damage by serious insect pests. These were either the recently introduced invader species, like Colorado potato beetle (*Leptinotarsa decemlineata*), and the American fall webworm (*Hyphantria cunea*), both spreading in Hungary from 1947. On the other hand, outbreaks of endemic noctuid species (cutworms) between 1948–1950 caused extensive damage in arable field crops. The outbreaks of these important pests begged for countrywide forecasting of pests. In that period, JERMY investigated both under field and laboratory conditions the control of these pests. He also studied the behaviour and the ecological characteristics of these pests. He clearly saw that the foundation of a forecasting system, with greater spatial scale and different temporal scales, was needed to prevent insect damage at the national or regional level. Having an extensive knowledge of literature, he knew about the results of foreign studies reporting that light traps are capable of collecting a high number of individuals, especially noctuid moths. These results suggested him the use of light traps for monitoring. But what could be found in the foreign literature at that time?

### *Experiences on light trappings in the first half of the 20th century*

The phenomenon that night-active insects are attracted toward artificial light sources was probably familiar to our ancestors who built fire. According to descriptions between 1st century BC and 4th century AD, the first primitive light traps operating with oil lantern were used by Roman beekeepers to protect against wax moths (STEINER 1991). Engravings illustrating beekeepers or people with oil lamps or burning torches killing moths with persist from the 17th and 18th centuries (HOBERG 1682). Hungarian forestry literature in the 19th-century also advises that great fires must be lit at forest edges to suppress moth pests (like *Lymantria dispar, Operophtera brumata, Malacosoma neustria* or *Euproctis chrysorrhoea*) causing defoliation, because many of them would be attracted and burnt by the flames. A generally applied insect collecting method was 'lamping' with the aid of a white sheet placed in front of a light source (KOVÁCS 1958, LÖDL 1989). The first electronic lamps appeared around the turn of the century. In the second half of the 1910s, a wider availability of electricity made possible the development of several trap types with this light source that allowed automatic insect collection. From that time until the end of WWII, an increasing number of studies were published annually throughout the world on light trapping in the international agricultural entomology literature. These revealed that the improvement and operation of traps were restricted mainly to plant protection in agriculture, the control of major pests of the most important economic crop plants. These agricultural cultivated plants included sugarcane, tea, jute, rice, palms, tobacco, cotton, maize, fruit trees, vine and vegetables. From the list of these crop plants, it is evident that a considerable proportion (35%) of these light trap experiments took place in subtropical-tropical colonial areas of European countries. Most studies were conducted in USA and Canada (51%), while only a smaller proportion (14%) of the light trapping was published in European literature. Pioneer investigators of light trapping analysed thoroughly the catching efficiency of the traps, because in most cases the aim of this collecting method was to strongly decrease pest population level in stands of the crop plant. The large number of individuals, especially in the case of moths (mainly noctuids) and beetles, captured by light traps within a relatively short period of time, encouraged these researchers. These numbers often meant captures of hundreds of individuals per night or even 500 000 individuals per year in case of certain species (cutworms, vine moths, leaf rollers, sugarcane beetle, cockchafers). Efforts to use light traps to eliminate pest insect populations from plant stands (orchards, arable fields) were doomed to failure, and by the 1950s it became obvious that the light trap method is not suitable for pest control. Nevertheless, these experiments greatly contributed in the development of different trap types: several constructions were tested; furthermore, capture changes due to different spectral composition of light sources were also discovered and comparative studies were made on the light sensitivity of different insect orders. During trapping of different target pests, it was discovered that from nearly all winged insect orders, a huge number of species flies toward light, e.g. moths, beetles, leafhoppers, flies, mosquitoes, crickets, hymenopteran parasitoids, etc. Identification of all collected materials, especially from the macrolepidoptera, often yielded hundreds of species from a given locality. So by the middle of 20th century light trapping had become one of the most preferred insect sampling methods, producing both quantitative and qualitative data on individuals and species in a relatively short period of time. In the literature published by the end of the 1930s, most of the issues regarding insects light trapping had already been discussed, and these issues have appeared in studies of light trapping or are of concern to us until today. For example, effects of weather elements on daily flight activity, effects of moonlight and moon phases, characteristics of night flight behaviour, changes of male:female ratio, seasonality characteristics, nocturnal flight distribution, relationship between egg-laying and flight to light, effect of light trap location and surrounding habitats on captures, etc.

In relation to the identification of complete moth assemblages, being even nowadays an issue, the effect of climate fluctuation was also revealed. It was reported that in the 1920s in the State of Montana (USA), within the noctuid moth assemblages collected with light traps, the proportion of prairie (xerothermous) species had increased during years of strongly dry weather.

During the four decades before 1950, more than 600 papers referring to light trapping were published. Was JERMY familiar with the results of these investigations before he devised his light trap? The answer is yes, because his collection of articles includes numerous reprints and photocopies referring to light trap experiments from that period. These and the conversations I had with him suggest that he was very familiar with the literature on light trapping, published in English, German, French, and Russian, thanks to his extensive knowledge of foreign languages. He was most influenced by the works of C. B. WILLIAMS, inventor of the famous type Rothamsted light trap. WILLIAMS' articles published from the mid-1930s have been among the most cited works of light trap literature until today. Regular investigations of light trap catches with modern, statistical evaluation started with C. B. WILLIAMS' activity. In the 1910s and 1920s, WILLIAMS light-trapped several important economic pests (froghopper, cotton and pink bollworm) in tropical areas (Surinam, Trinidad and Egypt, respectively), and during this work he developed a new type of light trap design which he continuously kept modifying to increase its efficiency. This was the precursor of the famous Rothamsted type light trap (WILLIAMS 1948), which is still in operation at R.I.S. These experiments led him to the important observation that successful light trapping should be carried out over a long-term period with continuous record and under standard conditions. WILLIAMS accomplished two famous trapping series, the first one between 1933–1936 and the other one between 1946–1949 in the experimental field of

Rothamsted Experimental Station. During these continuous collecting periods he used his above-mentioned self-constructed light trap type. His results were published in a series of articles (Williams 1935, 1936*a*, 1939, 1940, 1948, 1951, 1953, 1964). From the captured insect materials, he identified the complete macrolepidoptera group, so his analyses mainly refer to moths, especially the family Noctuidae. The aim of his light trapping experiment series was to indicate the rate of all potential environmental effects influencing captures (meteorological factors, moonlight, and electricity of the atmosphere). The true importance of these works, in my opinion, is that he was the first one who introduced the statistical methods (e.g., correlation and regression analyses, ANOVA) and species diversity ( -diversity) for the analyses of light trap data (Williams 1936*b*, 1953, 1964). Information in Williams' articles had a major role in forming Jermy's favourable opinion about light trapping methods. The question was, however, whether he should completely apply the same Williams-type light trap under the conditions in Hungary?

### *Technical background and the construction of "Jermy-type" trap in 1952*

In the early 1950s, following the Soviet examples, a socialist planned economy was introduced in all branches of production in Hungary. A characteristic of this type of productions was that only a few kinds of industrial goods were made, but in enormous quantities. So the assortment in light bulbs was also limited. As Jermy intended his light trap to forecasting of insect pests, his idea was to operate it in a long-term national network. His great technical talent, which he has proved many times with his experiments, helped him to make a very clever selection of all the materials and tools: all of them could be bought then and were expected to remain commercially available for decades. So, as a light source, he chose a 100 W incandescent, tungsten filament light bulb for his trap. (This bulb type is still available in Hungary.) Due to network operation, in case of malfunction or bulb exchange, all the components must have been quickly purchasable at any point of the country. Our network is still operating with the "Jermy-type" traps, being the best proof of the grandiosity of this conception. Although minor technical modifications on the trap have been made based on experience while running the network (Benedek *et al.* 1974), its main structure, the arrangement of technical elements determining the way and level of catches has remained.

In 1952, Jermy constructed his light trap from very simple components, while taking into consideration practical point of view. As a part of the trap, there is a circular roof made of aluminium with a diameter of 1 meter fixed to a column at two meters above ground level. The light source (light bulb and lamp-holder) is hung on the lower side of the roof. The function of the roof is to protect of the lamp and captured insect material from rain. Below the light source is a metal funnel placed 40 cm below the roof. The upper end of the funnel is 50 cm in diameter and it tapers to 5 cm in diameter, and then it continues in a 10-cm-long tube, leading to the killing jar. The funnel directs the attracted insects flying around the light bulb to the connected killing jar. Balls of cotton wool are placed on the floor of this glass jar, to prevent damage to the insects as they fall into the jar. Chloroform (sometimes carbon tetrachloride) has been used as poison in the traps, because it proved to be less dangerous to the operating personnel than the formerly applied hydrogen-cyanide. In addition, since its vapour is heavier than air, a sufficient concentration stays in the glass to produce a killing effect. JERMY provided detailed descriptions and drawings of each structural components of his trap, with the intention of standardising construction and manufacturing. He also preferred a light source with white light, because he knew from published data that other light sources with shorter wavelength (e.g., UV light) attract high numbers of insects (JERMY 1961). Processing large numbers of individuals caught by more efficient light sources would have required a lot more labour and costs, and it often could have resulted in less valuable scientific material because large bodied species would damage more delicate ones (JERMY 1961, 1974, KOVÁCS 1962). This was aptly demonstrated, when more traps were experimentally operated with UV light source at stations of the Hungarian Plant Protection Service in 1963 (MÉSZÁROS 1966*a*). JERMY did not install boards (baffles) around the bulb, resulting in a further reduction in the amount of collected material. Baffles were used in several trap types (e.g., Minnesota type) in order to increase level of catch through increasing collision of insects with these boards.

### *Outlining light trap operation*

Besides structure, use or operation also had to be standardised to insure that operators would work the same way at each station of the national network, and that the traps would produce the same quality of insect material required for identification. The thoroughly detailed directions for the operation of the light trap (JERMY 1961) were developed based on a 6-year trial period (1952–57) in close association with a team of taxonomic specialists for identification.

### *Experimental period of material handling and network operation (1952–1957)*

Manufacture and testing of the prototype of light trap in 1952 was conducted in the Department of Zoology in the Plant Protection Institute, Budapest. The trap was placed and operated in the garden of a rural experimental laboratory of the Institute located at Keszthely, Western Hungary. After the favourable results of the first year, another four traps began operation in 1953. In 1957, the test operation of six light traps was running through the whole season. JERMY was well aware of the fact that light traps would probably collect a large number of individual insects (hundreds of thousands), especially in case of a network with many stations working continuously. Identifying this huge collected material requires a team of taxonomic experts. As a practical man, JERMY probably would not have started the light trap network, if there had not been suitable taxonomic expertise available at that time. He managed to convince several colleagues at the Department of Zoology of the Hungarian Natural History Museum to participate in this extraordinary task. Among others, he recruited the two most exceptional lepideptorologists of that time, L. KOVÁCS (Macrolepidoptera) and J. SZŐCS (Microlepidoptera). JERMY clearly saw that the success of his forecasting network depended on the complete and reliable identification of moth assemblages collected annually with individuals numbering in the hundreds of thousands. The scientific knowledge of the above mentioned taxonomists matched the grandiosity of the task. LAJOS KOVÁCS worked fanatically on the huge moth collection until his death. They gradually perfected the national light trapping method (JERMY 1961, KOVÁCS 1958) as they were continuously communicating with each other. The fact that JERMY, while co-operating with others, examined the possibilities and efficiency of his trap through a test period of six years, demonstrates his incredibly persistent and experimenting personality, observing and recording even tiny details. Thanks to their co-operation, they had all the necessary experience by the end of 1957 to start the extension of the light trap network at the stations of the Plant Protection Service in 19 counties.

### *Development of light trap network*

The plant protection stations were state-controlled and they were distributed all across the whole country. Therefore, they seemed ideal for the extension of the light trap network. In 1958, two stations, and in 1959 all plant protection field stations were supplied with light traps. The number of light traps working in agricultural areas suddenly increased until the late 1960s, because from 1963 onwards, additional regional light traps were set up (4–6 traps/county) for local forecasting. From 1963, the collected insect material of nearly 30 traps operating at the stations and institutes was processed centrally in the Department of Zoology of the Hungarian Natural History Museum by its Identification Group, which included younger taxonomic experts as well. In 1961–62, a forest light trap network with 12 stations was also established under the direction of PÁL TALLÓS and PÁL SZONTÁGH (LESKÓ & SZABÓKY 1998). The Plant Protection Identification Group had also processed catches of these forest traps until 1971. By this time 25 forest traps had been operating. With this rate of extension of the forecasting network, JERMY's dream had been fulfilled by the end of the 1960s. Following the death of L. KOVÁCS in 1971, identification of the forest and agricultural light trap materials was separated locally also. Experts of Forest Protective Monitoring-forecasting Service in the Forest Research Institute processed the collections of the forest light trap network with the aid of outside professional and amateur entomologists. The complete Lepidoptera collection was processed again from the mid-1970s (for some years following the death of KOVÁCS, only major forest pest species were identified regularly). There were some fluctuations in the number of forest traps in the 1970s and 1980s. Today there are 25 traps operating.

From the agricultural light traps, the material of so-called central traps that work at plant protection stations (one trap per county), was processed in a centralised forecasting system from the 1970s, but only major moth and beetle pests were identified. The number of all the agricultural traps is recently around 50.

History, structural changes, and managing materials of the Hungarian light trap network have been reviewed in detail by several authors. For information about the initiation, development, and later periods of the network and a thorough review of the history of the forest light trap network in Hungary, see the works of JERMY (1961), KOVÁCS (1962), MÉSZÁROS (1966*b*), MÉSZÁROS and VOJNITS (1968), VOJNITS (1968*b*), BENEDEK (1970), HERCZIG (1983), NOWINSZKY (2000), LESKÓ and SZABÓKY (1998).

## JERMY'S DIRECT AND INDIRECT CONTRIBUTIONS TO LIGHT TRAPPING

### *The technical development*

It is obvious from the above review that one of the most important direct contributions of JERMY to this traditional and popular insect sampling method was that, by recognising the conditions and requirements, he devised a simple, but efficient light trap type for practical use, which is still successfully operated today. In addition, in collaboration with taxonomic experts, he also developed the still valid standard sampling methods in detail.

## *The network development*

From the very first moment, JERMY intended to use his trap as part of a nation-wide network, with the aim of forecasting insect populations. After a trial period of six years, he gradually increased the number of light trap stations and gathered information about possible operational errors, and laid the foundation for the successful long-term operation of a forecasting network.

## *His publications about light trapping*

JERMY had only a few publications specifically on light trapping. The reason for this is that the study of other entomological problems was in the focus of his broad-ranging scientific activity, as is illustrated by the list of his publications in this book.

In 1961, he published the description of his successfully tested light trap type, its directions for use, and the short history of the 10-year-long development of the network (JERMY 1961). In 1974, at an international symposium on the use of light traps, held in Budapest, he reviewed the results that had been reached so far and discussed the importance and utility of traps in faunistic, ethological, ecological, forecasting and migration investigations (JERMY 1974). In spite of the small amount of publications, he has always paid attention to the smooth functioning of the light trap network. He referred to the importance of analyses of light trap data series in numerous writings and lectures on plant protection studies, and he warned about the necessity to preserve the light trap network. It was evident to him that the data series, with decades-long observation, are eventually becoming more valuable in monitoring such large-scale processes as effects of climatic change on insects or bioindication of species and diversity changes. He also published his views on this (JERMY 1998).

## *Foreign reception of Jermy's light trapping improvements*

Scientists abroad also took notice of the results obtained by the "JERMY-type" light trap. During the 1960s, there were numerous light trapping experiments and developments performed, especially in Germany (e.g., CLEVE 1964), where a trapping had already been going on for 10 years by the time JERMY began testing his model (HAEGER 1957). JERMY's light trap type was tested mainly in the surrounding countries, e.g., in Austria (MALICZKY 1965), but was also used in France (GAGNEPAIN 1974), and it was thoroughly described and compared with other traps in Germany (MESCH 1965). L. RÉZBÁNYAI, who applied this method for his Hungarian lepidopterological investigations (RÉZBÁNYAI 1974), introduced Hungarian light trapping techniques to Switzerland and applied this method for his investigations there (RÉZBÁNYAI 1974). Meanwhile, JERMY's (JERMY 1961, 1974) and other Hungarian scientists' work and publications on light trapping were frequently referred to by several outstanding foreign scientists using the method (e.g., WOLDA 1978, 1981).

### *Jermy's influence on Hungarian light trapping investigations*

JERMY's careful, critical but always encouraging thoughts and his demands on himself and of others, inspired a number of studies on light trapping in the case of scientists who had personal contact with him. There are few publications about data of Hungarian light trap networks that would not refer to "JERMY-type" traps. The important direct influence of the trap constructed by JERMY and the long operation of the initiated network on light trap studies would be difficult even to estimate. On the basis of publication lists (e.g., LESKÓ & SZABÓKY 1998, MÉSZÁROS & VOJNITS 1968, NOWINSZKY 1994, 1997, 2000, 2001) and other literature surveys, there are at least 600 publications that were written by Hungarian researchers using data collected by "JERMY-type" light traps. In my opinion, the greatest impact of JERMY and his light trap is documented in this large public undertaking. It is impossible to entirely present now the 50 years of the Hungarian light trap studies with all its diverse fields based on the study of insect samples and data series produced by the successful trap type and the well-working networks. So I only illustrate this with some examples from more important light trap studies, without striving for completeness. Literature search of the themes referring to light trapping illustrated the tremendously wide ranging, countless potential groupings that exist (LÖDL 1987). Data produced by the Hungarian light trap network may be analysed at different temporal and spatial scales. Data coming from the method of light trapping might aid the analyses of daily (e.g., influence of weather elements on night activity), seasonal (e.g., flight pattern of insects from catches summed weekly), and long-term year-to-year (e.g., fluctuations in population dynamics, biodiversity) temporal changes. Data might be spatially analysed at local (1-trap-station), regional, or national scale. As for sampled insects, light trap data may refer to a given species or groups of species (e.g., taxonomic or ecological assemblages). From a combination of the above points of view, many studies of new fields of light trapping were created. I mention these briefly to attempt to arrange in chronological order and by topic the light trapping studies of past decades.

## MAJOR RESEARCH FIELDS AND RESULTS OF THE HUNGARIAN LIGHT-TRAPPING

### *Faunistics*

Even in the very first years of light trapping, our lepidopterologists discovered several moth species new to the Hungarian fauna and new to science (KOVÁCS 1962, MÉSZÁROS & VOJNITS 1968, 1974). With the accumulation of data, description of a moth fauna within a larger region became possible (LESKÓ & SZABÓKY 1997). Processing the light trap materials proved to be useful in the case of other insect taxa besides Lepidoptera. In the 1960s, Neuroptera (STEINMANN 1963, ÚJHELYI 1968), Heteroptera and Homoptera (JÁSZAINÉ 1964–66) were also identified in light trap catches. Since 1969, J. TÓTH identified the major portion of the collected Coleoptera from the traps operating in the forest, and he also produced valuable faunistic data (TÓTH 1972, 1973). Large numbers of species from the order Trichoptera were also found among the light trap caught species. Trichopterologists frequently used the light trap method of collecting to gather faunistic data (e.g., KISS 1984, KISS & SCHMERA 1997, 1999, NÓGRÁDI 2000, NÓGRÁDI & UHERKOVICH 1988, 1990, 1994, SCHMERA 1999, 2000, UHERKOVICH & NÓGRÁDI 1990).

### *Forecasting of pestiferous moths*

Even during testing phase of light trap network, flight pattern analysis of certain moth pest species began, in order to solve its forecasting as soon as possible. Some of the earliest similar works were done on the cutworms (*Heliothis maritima*, *H. dipsacea*) (NAGY 1957), on the European corn borer (NAGY 1960), and on *Loxostege sticticalis*, *Homoeosoma nebulellum* and *Etiella zinckenella* (REICHART & SZŐCS 1961). Experts at the Identification Group needed to do the pioneering work in working out the forecasting methods built on the network. It is necessary to emphasise here the name of ZOLTÁN MÉSZÁROS, who published his results on forecasting in a series of articles (e.g., MÉSZÁROS 1963–1965, 1966*a, b*, MÉSZÁROS & VOJNITS, 1967, 1974). He grouped moths according to their characteristics of life history, and he invented new indices on the basis of population dynamics according to generation number, which had a predictive value of possible outbreaks for the following year. With these characteristics, he prepared the first long-term population dynamics analysis of some noctuid species (MÉSZÁROS *et al.* 1979). Parallel with this, flight dynamics, characterising the seasonality of most studied moth species, were described. According to network catches, first forecasting maps were also drawn, which supported the preparations for landscape level forecasting with the aim of protection (MÉSZÁROS & VOJNITS 1967, KOVÁCS & DRASKOVITS 1967). Transformation of numerical data to distribution maps was useful in the analysis of spreading and migration of species (KOVÁCS 1971, MÉSZÁROS & VOJNITS 1967, VOJNITS 1966, 1968*a*), and even in the study of biogeographical analysis of outbreaks (VARGA & UHERKOVICH 1974). It must be mentioned, however, that besides moths, light trap data of other representatives of insect orders were used to temporally characterise their flight activity. Light traps provided useful information for seasonality description of Heteroptera (JÁSZAINÉ & BENEDEK 1968, BENEDEK & JÁSZAI 1973, ERDÉLYI & BENEDEK 1974), cockchafers (HOMONNAY 1977), and certain leafhopper species (*Macrosteles* spp.) (JÁSZAINÉ 1977).

Forecasting results of light trapping concerning agricultural pests were summarised by MÉSZÁROS & VOJNITS (1968, 1974), and NOWINSZKY (2000). Finally, these early forecasting methods became part of the every day practice in plant protection (BENEDEK *et al.* 1974).

### *Forecasting of forest pests*

From the establishment of the network (1961–62), light trap catch data played an important role in the yearly forecast of forest pests (LESKÓ & SZABÓKY 1998). Those research results, which were based upon the simultaneous analyses of light trap and damage data series of forest defoliating moth pests, were usually built into the yearly published forecasting works (e.g., SZONTAGH 1974, 1976, 1980, 1987, LESKÓ *et al.* 1994, 1995, 1997–1999). In this respect, at landscape level, light trap catches did indicate outbreaks of several important pests generally a year earlier.

### *Abiotic environmental factors influencing light trap catches*

Even in the beginning phases of light trapping, the study of abiotic factors started using data series of daily captures of traps. From foreign studies, the different effects of weather elements or moonlight phases on flight activity of insects had been known by the 1950s. In Hungary, it was WÉBER (1959*a, b,* 1960) who, for the first time, studied the effects of weather elements on light trap catches, and many others followed him (NOWINSZKY 1994, 1997, 2000, 2001). The pioneer WÉBER was also the first to demonstrate the changes in light trap captures occurring as the weather fronts passed by. Later, it was shown by the light trapping data of KÁDÁR & SZENTKIRÁLYI (1984, 1992) that an increase in flight activity of ground beetles preceded cold fronts, whereas it decreased before the onset of warm fronts. Impacts of various types of weather fronts on moths flights were analysed in detail by NOWINSZKY and his colleagues (NOWINSZKY 1997, 2000, 2001, PUSKÁS *et al.* 1997) as well as by LESKÓ *et al.* (1998). Using Hungarian light trap data NOWINSZKY (1994, 1997, 2000, 2001) together with an interdisciplinary team, achieved new noteworthy results in demonstrating the effects of major abiotic factors in the environment as follows: weather factors, moon phases, intensity of polarised moon light, periodic solar activity, solar flares, geomagnetic disturbances, ionospheric disturbances, cosmic radiation, atmospheric electricity, macrosynoptic weather situations, thunderstorms, twilight polarisation phenomena, interplanetary magnetic field sector boundary, gravitational potential by the Moon and Sun, and earthquakes (NOWINSZKY 1994, 1997, 2000, 2001).

### *Long-term monitoring of insect population and the climate change*

Long-term monitoring systems can be used for studying the impacts of global and regional environmental changes on living organisms. The several decades long data sets collected by the Hungarian light trap network were used to monitor changes in insect populations (SZENTKIRÁLYI 1999, SZENTKIRÁLYI *et al.* 2001).

The biological effects of climate change have an increasing importance since 1980s (TRACY 1992). There are numerous predictions for expected influences of the increasing temperature ("global warming") on abundance, life cycle and phenology of insects, interspecific relationships in food chains of insects, and geographical distribution of some pests (WATT *et al.* 1990, HARRINGTON & WOIWOD 1995). According to the possible scenarios, the climate would become drier associated with more frequent droughty years in Hungary. Various hypotheses regarding direct and indirect effects of arid, warm climate on insects (Plant Stress Hypothesis, Climate Release Hypothesis, Plant Vigour Hypothesis) exist that may explain the insects' outbreaks (MARTINAT 1987, MATTSON & HAACK 1987, PRICE 1991). In particular, lepidopterous forest defoliator species produce damaging outbreaks for time to time in Hungary whose fluctuations can be monitored sufficiently by light traps. Different climate elements and aridity indices were used in time series analysis of data sets of yearly moth catches by LESKÓ *et al.* (1994, 1995, 1997–1999) and SZENTKIRÁLYI *et al.* (1995, 1998). They detected decreasing tendencies of yearly amount of precipitation in climatic data series. A series of stronger droughty years has been detected since early 1980s until the mid-1990s. The outbreak patterns of each studied species were synchronised at a nation-wide scale and those were recorded in drought years. In the analysis of time series of moth pests, no significant periodicity was detected.

Increase in the abundance of *Lygus* species caused by arid years could be proved by long-term light trapping (RÁCZ & BERNÁTH 1993). The spatial spreading of an invader moth pest (cotton bollworm) was extended in dry and warm years also in Hungary as it was confirmed by light trap catches (SZABÓKY & SZENTKIRÁLYI 1995). KÁDÁR and SZENTKIRÁLYI (1997) demonstrated the emigration of hygrophilous species by flight from the drying habitats in arid seasons by long-term fluctuation patterns of carabids.

The long-term data series of light trappings can be implemented not only in the analysis of population dynamics but also in the description or characterisation of seasonal flight patterns of less abundant, rarer species. In this way over many years of trapping sufficient number of data could be collected for seasonality analysis of certain ground beetles (KÁDÁR & SZENTKIRÁLYI 1998), brown lacewings (SZENTKIRÁLYI 1992, 1997) and antlions (SZENTKIRÁLYI & KAZINCZY 2001).

### *Long-term monitoring of insect biodiversity by light trapping*

Adverse trends of biodiversity changes are experienced all over the world. For this reason, their long-term monitoring possibilities have a great importance. The National Biodiversity-monitoring System (LÁNG & TÖRÖK 1997) also includes numerous light trap stations to obtain data on species diversity changes through the identification of entire collected materials of some insect orders. The fluctuations of diversity patterns of insect assemblages sampled by light traps may indicate the changes in habitat conditions.

LESKÓ *et al.* (2000) and SZENTKIRÁLYI *et al.* (2000, 2001) analysed the changes and long-term trends in time series of yearly number of individuals, richness of species, and species diversity statistics of macrolepidopteran assemblages sampled by light traps located in various forests over four decades. Their results proved that there is a definitive, significant decreasing trend of moth assemblages in time series of each structural character at certain trap stations. According to similarity analyses, sudden changes and transformations happened in the species composition and structure of moth assemblages from time to time (during a 5–10-year period). For instance, data series of a trap station from lowland region with sandy area characterised by xerothermous habitats can be read in Figure 1. The fluctuations and decreasing trends of number of individuals and number of species could be explained by changes in environment at trap site, such as forest settling, disappearance of natural grassland, increase of arable fields, drainage, droughty years, decreasing water tables and the decline of old-growth oak forests.

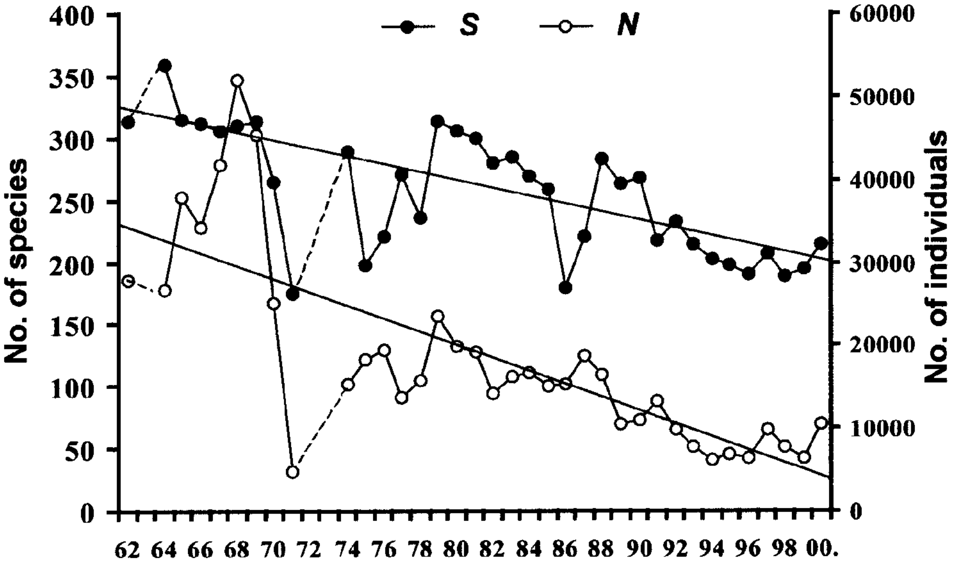

Fig. 1. Long-term fluctuation pattern and trend of the yearly total number of species (*S*) and number of individual (*N*) of macrolepidopteran assemblage sampled by a forestry light trap in southern part of Hungary (near Tompa) between 1962 and 2000. (Equation of trend for *S*: y = 326.50 – 3.30x, and for *N*: y = 34920.43 – 789.67x) (after SZENTKIRÁLYI *et al.* 2001)

Since 1981, a long-term light trap monitoring has been going on some predatory insect groups (lacewings, antlions, ground beetles) at the Department of Zoology of the Plant Protection Institute. It was found that the level of species diversity of green and brown lacewings strongly depended on the vegetation at the light trap sites. The long-term time series of species richness and abundance level significantly fluctuated depending on winter mean temperature and summer drought levels (SZENTKIRÁLYI 1992, 1998). Only the carabids produced fluctuations with smaller amplitudes in structural characteristics of assemblages (KÁDÁR & SZÉL 1999).

Another long-term insect monitoring has been operated by R.I.S. light trap network in Great Britain (TAYLOR 1986). TAYLOR *et al.* (1978), TAYLOR (1986) and WOIWOD (1987) informed us that the land-use changes (mechanization of agriculture, increase of intensity of farm practice, “hedging and ditching”, forest clearing, intensive field margin management, widespread use of pesticides) reduced the total number of moths by about 60 percent between 1950 and 1960. In parallel, the -diversity of the moth assemblages was also decreasing.

## CLOSING WORDS

I hope that I have illustrated how the established Hungarian light trapping system has provided various experimental opportunities for many researchers for decades. Allow me to close this overview with sentences from a manuscript prepared by JERMY in 1993. "The Hungarian light trap network – due to its spatial density of traps, time period of data series, as well as to the number of insect groups under taxonomic identification – is unique all over the world. There can be only in a few countries, such as in Great Britain found a system more or less similar to it. For many reasons we must do all our best in order to maintain the network for the future."

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