I.J.S.N., VOL. 2(2) 2011: 161-167 ISSN 2229 – 6441

INTERNATIONAL JOURNAL OF SCIENCE AND NATURE

www.scienceandnature.org

EFFICIENCY OF LIGHT-TRAPS IN RELATION THE NUMBER OF CAUGHT SPECIES

Nowinszky L. and Puskás J.
University of West Hungary, Savaria University Centre, H-9700 Szombathely, Károlyi Gáspár Square 4. Hungary

ABSTRACT
The study includes a determining method for the efficiency of light-traps. The first catching day of a particular species is called the appearance, and after the day of the last specimen caught is called disappearance. The difference of the number of species appearing and the disappearing ones means the present species. The number of caught species in the percentage of present ones is the efficiency of light- trap

KEYWORDS: Macrolepidoptera, catching, light-trap, effectiveness

INTRODUCTION

Before examining the question of the efficiency of light-traps, it is useful to define some basic concepts, it is appropriate to define some basic concepts. We must define what is meaning of the following terms: “environment” of the light-trap, “catch”, "present” species in the traps environment, and finally the "efficiency" of light-trap?

Definition of the “environment”

According to Mészáros (1990), in the field of agroecosystems, the following basic questions have primary importance: What distance does the light-trap attract moths from? What does the insect catch represent? “From what distance does the moth perceive the light of the trap, resp. how close does it have to be to the trap to unavoidably change its direction and fly to the source of light? From what distance the light-trap attracts the moths? Malicky (1987) defined the “attracting distance” (Anlockdistanz): this is where the attracting force of the light-trap takes effect. In this work we understand the environment of the light-trap the changing catching distance.

According to Nowinszky (2008) before we start to discuss the different views in scientific literature regarding the role of the collecting distance as a modifying factor, it is important to define and distinguish the concepts of a theoretical and a true collecting distance. By collecting distance, we mean the radius of the circle in the centre of which the trap is located and along the perimeter of which the illumination caused by the artificial light source equals the illumination of the environment (theoretical collecting distance).

The size of the theoretical collecting distance depends on:

- Luminous intensity of the artificial light source (candela), which is theoretically constant, but the change of voltage may modify the parameters of light (lifespan, luminous flux, total power input, and luminous efficacy).
- The continuously changing illumination of the environment (time and span of twilights, the periodical changes of the Moon, light pollution) that may be different depending on geographical position, the season of the year or during one night.

Theoretical collecting distance has been calculated by several authors, for different light-trap types and lunar phases.

According to calculations by Dufay (1964), the collecting distance of a 125 W HPL light source is 70 m at a Full Moon and 830 m at a New Moon.

Bowden and Morris (1975) determined collecting distances for 125W mercury vapour lamp: 35m at a Full Moon, 518 m at a New Moon. He described (Bowden, 1982) the collecting radius of three different lamps with the same illumination: a 125 W mercury vapour lamp, in the UV range 57 m at a Full Moon, 736 m at a New Moon, 160 wolfram heater filament mercury vapour lamp 41 m at a Full Moon, 531 m at a New Moon, 200 W wolfram heater filament lamp 30 m at a Full Moon, 385 m at a New Moon. In the view of Mukhopadhyay (1991), the collecting distance of a 100 W wolfram heater filament light-trap is 245.2 m at a New Moon and 16.7 m at a Full Moon. In our earlier works (Nowinszky et al., 1979, Nowinszky and Tóth, 1984), we determined these distances as 18m and 298 m for the Jermy-type trap working with a 100W normal bulb. The collecting distance calculated for a New Moon and a Full Moon has shown little difference at the heavily light-polluted areas since the time these papers were written (Nowinszky, 2006).

The collecting distance can be calculated with the help of the following formula:

$$r_0 = \sqrt{\frac{I}{ES + EM + EN + ELp}}$$

Where: r0 = collecting distance, I = illuminance from the lamp [candela], E = the illumination coming from the environment [lux] the latter consisting of the light of the setting or rising Sun (ES), the Moon (EM), the starry sky (EN) and light pollution (ELp).

The length of a real collecting distance is influenced by the following factors

- Abiotic factors are: The screening effect of the configuration of the terrain, objects, buildings and vegetation and the presence of disturbing lights within the theoretical collecting distance.
- Biotic factors are: Sensibility to light of species, vagiliy of certain species, and the distance of the insects' reaction to the light stimulus

Definition of the "catch" and "present"

What is the catch? We constructed in an earlier study (Nowinszky, 2003) the following hypothesis to answer the question of what a catch is. I my view, the catch represents those members of the population "present" in the vicinity that respond to the stimulus applied by the trap. First of all, however, it is necessary to clarify what the expression "present" means. The different species show varying degrees of vagility and so the various species might fly to the light-trap from different distances. The daily catch of light trapping might include individuals of species that do not belong to populations living in the direct vicinity, but have arrived from farther off, being members of the so-called "air fauna", while, as it happens in all other trapping procedures based on decoy, not including those individuals of the local populations that for one reason or another do not respond to the stimulus of the trap. Based on all that, by species "present" we mean the ones whose individuals are at a given point of time at a distance from the light-trap where they can respond to the stimulus of the trap, regardless of whether they do or do not respond. So, in my view, the expression of being "present" stands for actual distances that vary by species (Nowinszky, 2003).

Based on the experiences of authors, who have studied the question in detail and our own research; this is a brief definition of what a "catch" is. A catch is the percentage of a population that, taking its bearings by light stimuli and approaching the light-trap in the course of its migration or vagrancy, uses the light of the trap for orientation and reaching the direct vicinity of the trap, responds to the stimulus it represents by flying into the source of light and is then unable to escape.

Definition of the "efficiency"

In accordance with the definition supported by most researchers (Southwood, 1978), light-trap efficiency is understood to be the proportion in percentage of the individuals collected as compared to those actually present. In that sense the light-trap operating with a higher degree of efficiency is the one collecting more specimens of a given species. However, the degree of efficiency can also be interpreted as the proportion in percentage of the collected species as compared to the species present in the environment on any given night, regardless of specimen numbers (Nowinszky, 2003).

In principle it is possible to define the degree of efficiency of a light-trap concerning the different species by determining the modifying effect of the most important environmental factors in the case of each species, and then using these to correct the daily catch data. In this way the latter would always represent a nearly identical ratio of the number of specimen "present". Then we would express the individual numbers of the various species in the percentage of the catch associated with optimal environmental conditions and their average would amount to the degree of efficiency regarding all the species swarming at the time. It is easy to understand, however, that this is not feasible. For the majority of the species that can be light-trapped can be caught in such a small number of specimens that not even many years of observation and material from several observation post provide the mass of data that would be sufficient to define the swarming ecological requirements of these species.

Aim of our work to develop a simple method based on new theoretical bases to calculate from light-trap catch data the number of species "present" in the environment on any night of the year. And on that basis the number of aspects, their appearance in time and length of prevalence as well as the degree of efficiency regarding the individual species can be determined. Naturally, in a special interpretation, the concept of aspect refers to the light-trapped material alone.

MATERIAL AND METHODS

The collection data used in this investigation were supplied by material from the Szombathely forestry light-trap that belonging to the Hungarian national network uniformly equipped with Jermy-type traps worked in the Kámon Botanical Gardens between 1962 and 1970. We used the complete Macrolepidoptera material of this observation site to examine the efficiency of the light-trap in a way partly outlined in an earlier work (Nowinszky, 2003). We ignored the specimen numbers of the various species, examining only the question of whether the daily catch confirms the presence of the species. The different generations of multigeneration species were studied separately. However, all clearly recognizable vagile or migrant individuals turning up in between the swarming periods of two generations were regarded as separate generations. And in cases when it was not possible to draw a clear line of distinction between the two generations, we followed the procedure applied with one generation species. The catch data of the first trapped individual of the given generation was marked as 'appearance' and the day following the catch data of the last specimen of the same generation was labelled as 'disappearance'. We added up by calendar days the frequency of the appearance and disappearance of every generation of all the species and after cumulating plotted them in a graph (Fig.1 and 2). We calculated the difference between cumulated appearance and disappearance, receiving in this way the number of species "present" in the environment surrounding the trap in the function of time. We established the number trapped species by nights and represented these together with the species "present" (Fig. 3 and 4). The proportion in percentage of the trapped species in relation to those "present" was regarded as the degree of efficiency of the trap (Fig. 5 and 6).

RESULTS

These results are shown for example of the years 1962 and 1968 are presented in diagrams. The cumulative number of species appearing and disappearing is shown from the years 1962 and 1968 in Fig. 1 and Fig. 2. The present species and the caught ones are included in Fig. 3 and Fig. 4. The efficiency of the light-trap is presented in Fig. 5 and Fig. 6.

DISCUSSION

Naturally the various species appear and disappear continuously; therefore it is not possible to draw a sharp line of distinction between the different aspects. The approximate dates of aspect borders can be read from the steepness of the curves and the curves of those "present". The steepness of the curves seen in Fig. 1 and Fig. 2 provides information of periods in which many or few species appear or disappear. The coincidence of the steep phases of the two curves indicates a sudden change – at aspect switch-over time – in the composition of the species that can be light-trapped while the coincidence of flat phases expresses relative stability. Fig. 3 and Fig. 4. Show the different aspects of the Macrolepidoptera species. In early spring and late autumn in 1962 and 1968, a well recognizable aspect comprised but of a few species can be distinguished. As against that the first and second half of the summer both see the appearance of a lasting multispecies aspect separated from each other by a relatively short period of transition. In later years - with no tables included here- the two summer aspects are hardly distinct. This is the case in 1963, 1964 and 1966. In 1969, however, the two aspects are easy to separate and the early summer richness of species does not significantly lag behind that of the following aspect. In 1965 and 1970 the early summer aspect is extremely modest and in 1967 is almost completely missing. The species light-trapped in the various years and their different aspects reflect only with pronounced fluctuations and to various degrees the number of species "present". In two years, namely, in 1964 and 1965, an extremely modest winter aspect also manifested itself. Fig. 5 and 6 prove that the degree of efficiency of the light-trap becomes modified almost completely irregularly in most of the year. Only in early spring and late autumn is their increasingly significant efficiency from year to year. Further research is needed to clarify the reasons for this.

Striking that the changes in efficiency we can not see any trend. We conclude from this fact that the environmental effects are extremely important to the effectiveness of light-trap catch.

The method to establish the degree of efficiency of light-traps can also be used in ecological, cenological and faunal research. It is also possible to draw important conclusions regarding the various taxons from one year of continuous collection data at each post of observation, provided of course collection data of not just a few pestilent species are registered:

- The number of species "present" can be established on any day of the year,
- The number of aspects, their date of appearance and period of existence can be determined,
- Fast changes and relatively stable periods can be recognized,
- The actual degree of trap efficiency can be calculated expressing the proportion in percentage of the species trapped as compared to those "present" at a given point of time,
- The degree of trap efficiency is a good measuring yard to assess the effect of abiotic factors modifying the catch,
- Changes in the degree of efficiency can be compared by aspects, taxons and genders and can be a reflection of their differing requirements regarding abiotic environmental factors.

Observation data from the same sites in different years and the same annual data from different observation sites can also be evaluated on the basis of the above considerations. The differences in the number of aspects, their date and period of appearance, richness of species and the degree of light-trap efficiency can be compared with the weather and climatic differences. The use of the method could also pave the way to a more accurate understanding of the swarming ecological requirements of the species that can be trapped in great masses. For had we made daily calculations of the degree of light-trap efficiency from the material of the first decade of the existence of any light-trap network (when the complete Macrolepidoptera catch of all the observation sites was identified), it would be possible to pinpoint the species that have nearly identical main swarming periods and in most cases appear in or are absent from the daily catch together. Examining the weather and other characteristics of the nights when individuals of the various species did not fly to light, it would be possible to reveal for each species the situations that are unfavourable for light trapping. And of the course it would be possible to identify favourable conditions in the same manner. It would be possible to establish the species with similar or different swarming ecological requirements. Observation covering many years could also indicate the effects of unfavourable changes in the environment, such as a lasting drop in the number of species caused by environmental pollution. And so the method discussed could also play a role in research into environment protection.

Of course the method is burdened with all the shortcomings following from the nature of light trapping. In addition, it is also to be expected that the inclusion of species appearing in the catch but for a few days will lead to an overestimation of the degree of efficiency. The swarming of these species obviously lasts longer, but the method cannot reveal any fallback in the degree of efficiency on the rest of the days. On the other hand, we shall underestimate efficiency if we are inaccurate in separating the swarming periods of two ensuing generations or if, mislead by the specimen arriving from afar in the in-between period, we regard the complete collecting period of the species in question as one and the same swarming. However, a careful study of the phenology of the various species at the given observation site and, in the case of fresh material being identified, the separation of any recognizably migratory individuals might significantly reduce the possibility of error.

According to H. Battha and Horvatovich (1978), nearly four-fifth of the species turning up at the time of collecting can be caught while lamping, if the lamp has a strong light rich in ultraviolet rays. Investigations by Nowinszky et al. (1997) show that it is not possible to reach such a ratio by light-trap. Under the effect of several modifying factors, the degree of light-trap efficiency is modified almost completely irregularly in most of the year, but it is rarely possible to experience a ratio higher than 20-60% at most nights.

REFERENCES

Bowden, J. (1982) An analysis of factors affecting catches of insects in light-traps. *Bull.Ent. Res.* **72,** 535-556.

Bowden, J., Morris, G. M. (1975) The influence of moonlight on catches of insects in light-trap in Africa. Part III. The effective radius of a mercury-vapour light-trap and analysis of catches using effective radius. *Bull. Ent. Res.* **65,** 303-348

Dufay, C. (1964) Contribution a l'Étude du phototropisme des Lépidopteres noctuides. In: *Annales des Sciences Naturelles Zoologie*, Paris. 12. 6 281-406.

H. Battha, L., Horvatovich, S. (1978) Preparation of plants and animals (in Hungarian) Natura.

Malicky, H. (1974) Über das Geschlechterverhältnis von Lepidopteren in Lichtfallen. *Zeit. Ang. Ent.* **75,** 113-129.

Mészáros, Z. (1990) Variation of Lepidoptera populations on agricultural fields, and its forecasting (in Hungarian). Academical Thesis. Budapest. 48.

Mukhopadhyay, S. (1991) Lunation-induced variation in catchment areas of lighttrapsto monitor rice green leafhoppers (*Nephotettix* species) in west-Bengal. *Indian Journal of Agricultural Sciences*, **61** (5) 337-340.

Nowinszky, L. (1997) The light-trap effectiveness definition of concept. In Nowinszky, L. [ed.] (1997) *Light trapping of insects influenced by abiotic facors*. *Part II*. Savaria University Press. 107-116.

Nowinszky, L. (2006) Light pollution and light trapping (in Hungarian) *Dissertationes Savarienses*, Savaria University Press, 36 1-34.

Nowinszky, L. (2008) *Light Trapping and the Moon*. Savaria University Press. 170.

Nowinszky, L. [ed.] (2003) *The Handbook of Light Trapping*, Savaria University Press. 272.

Nowinszky, L., Szabó, S., Tóth, Gy., Ekk, I., Kiss, M. (1979) The effect of the moon phases and of the intensity of polarized moonlight on the light-trap catches. *Z. ang. Ent.* **88**, 337-353.

Nowinszky, L., Tóth, Gy. (1984) The formation of the light-trap catches of turnip moth (Scotia segetum Schiff.) as a function of the staying above horizon, phases and polarized light of the Moon (in Hungarian). *Kertgazdaság*. **16**, 2 83-91.

Southwood, T. R. E. (1978) Ecological methods with particular reference to the study of insect populations (Second ed.) Chapman and Hall, London.

Fig. 1
Cumulated number of appearing and disappearing Macrolepidoptera species (Kámon Botanic Garden Szombathely, 1962)

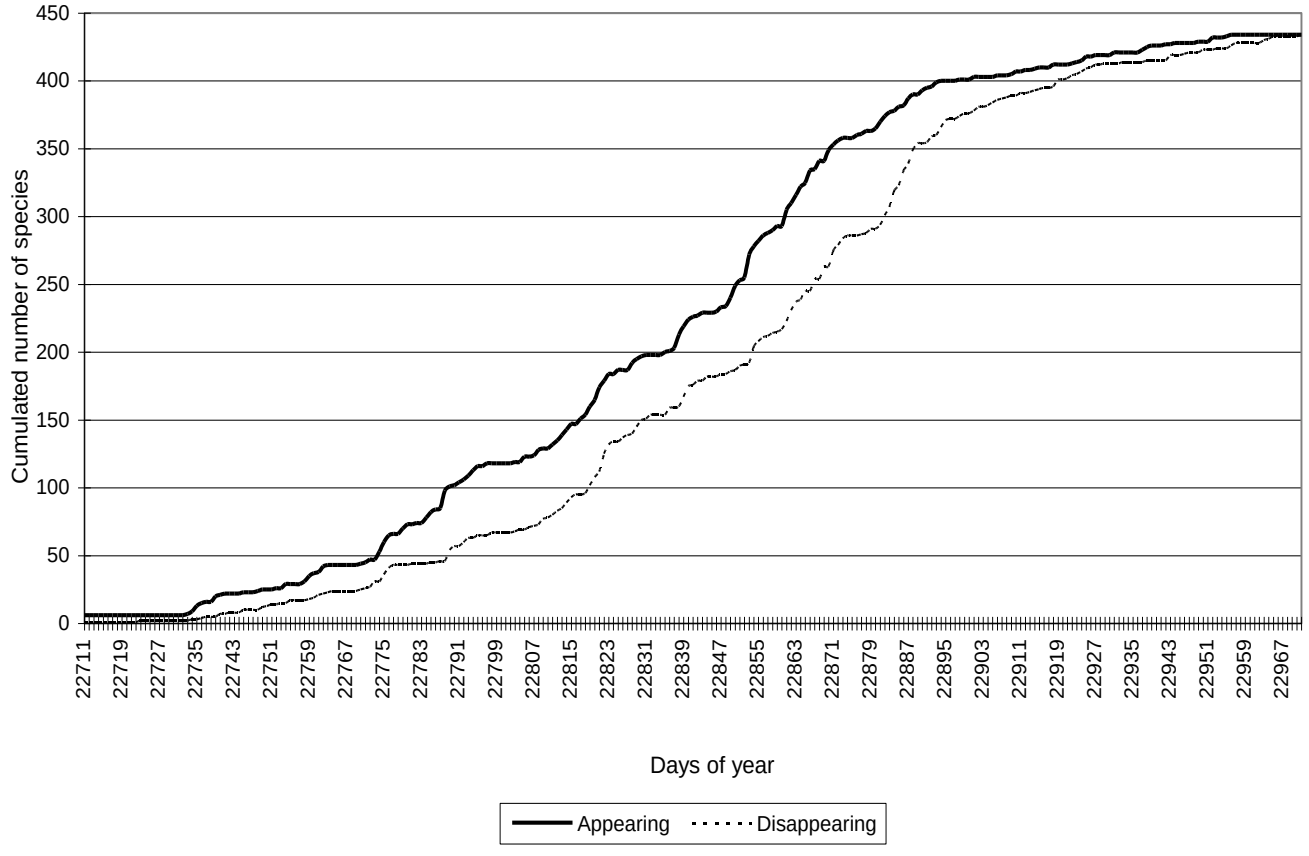

Fig. 2.
Cumulated number of appearing and disappearing Macrolepidoptera species
(Kámon Botanic Garden Szombathely, 1968)

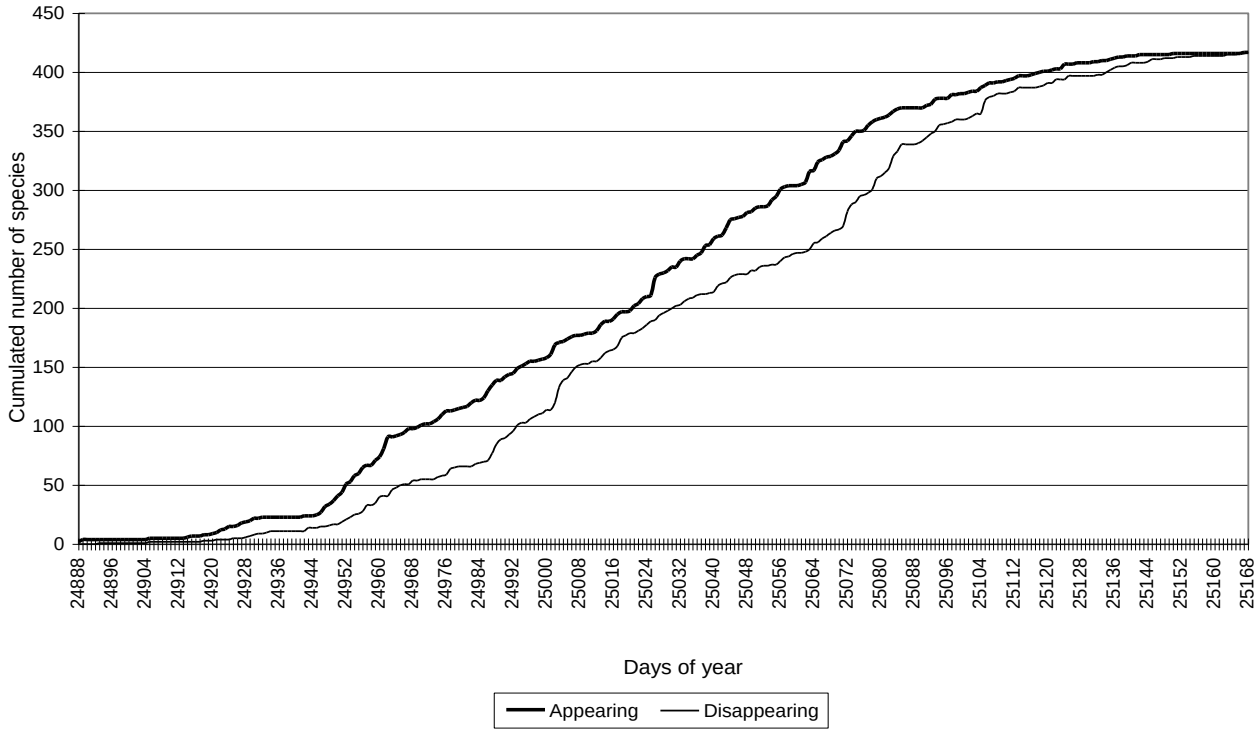

Fig. 3
The present species and the caught ones (Kámon Botanic Garden Szombathely, 1962)

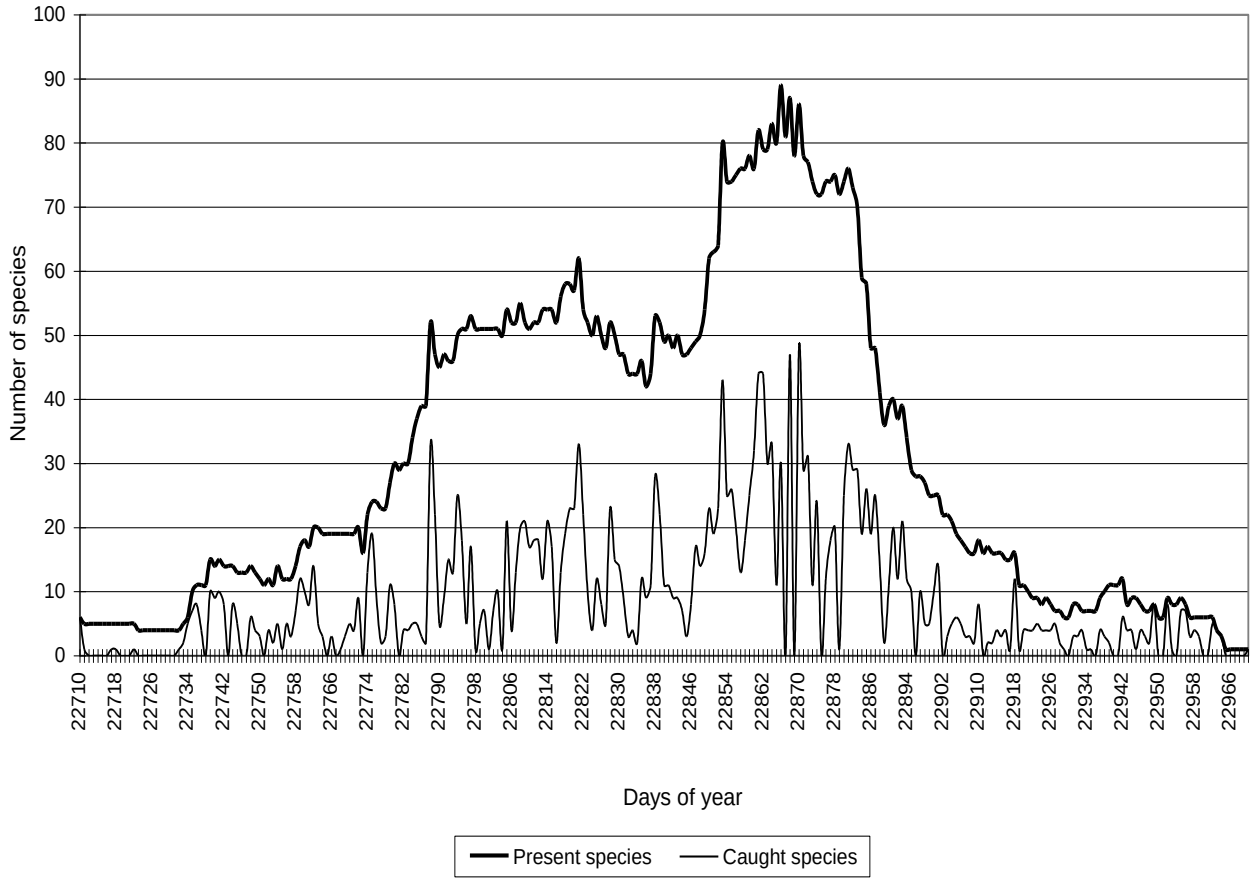

Fig. 4
The present species and the caught ones (Kámon Botanic Garden Szombathely, 1968)

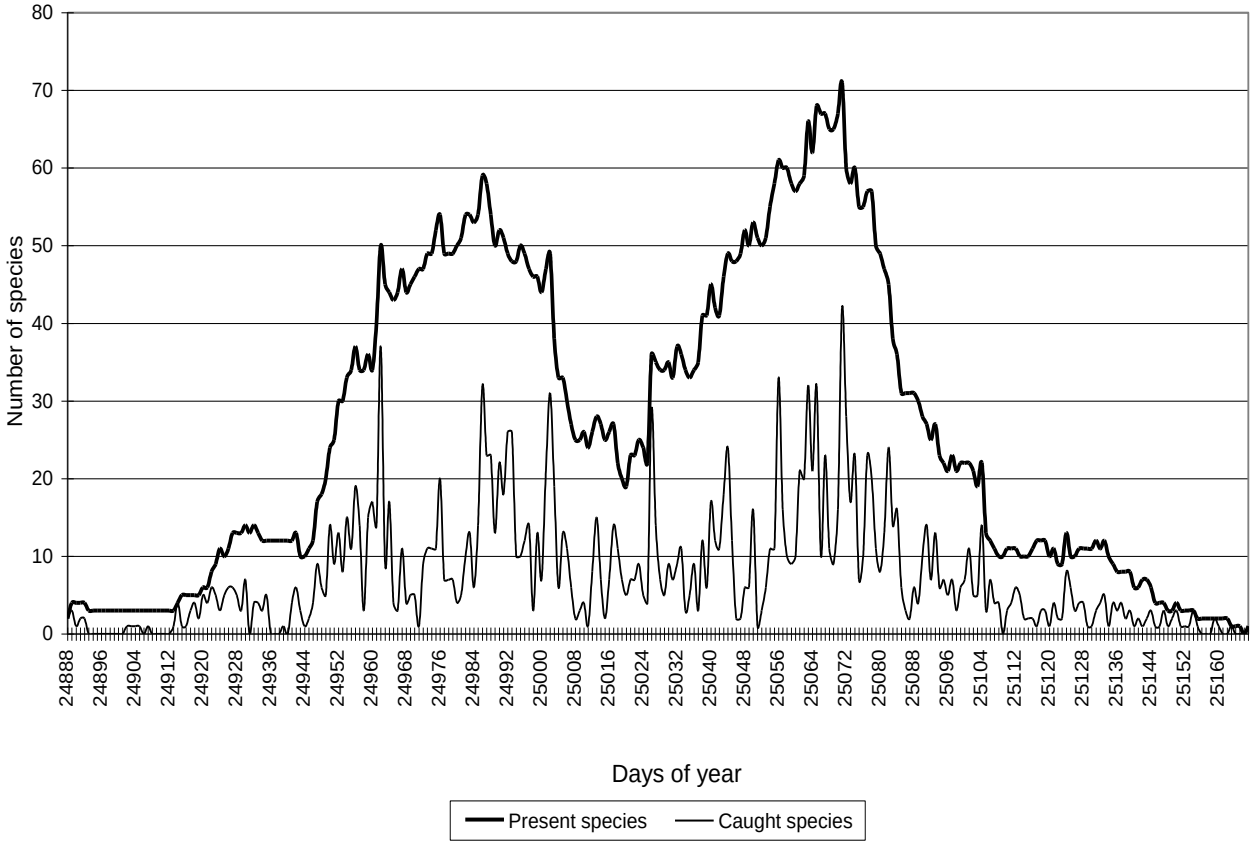

Fig. 5
Degree of efficiency of light-trap (Kámon Botanic Garden Szombathely, 1962)

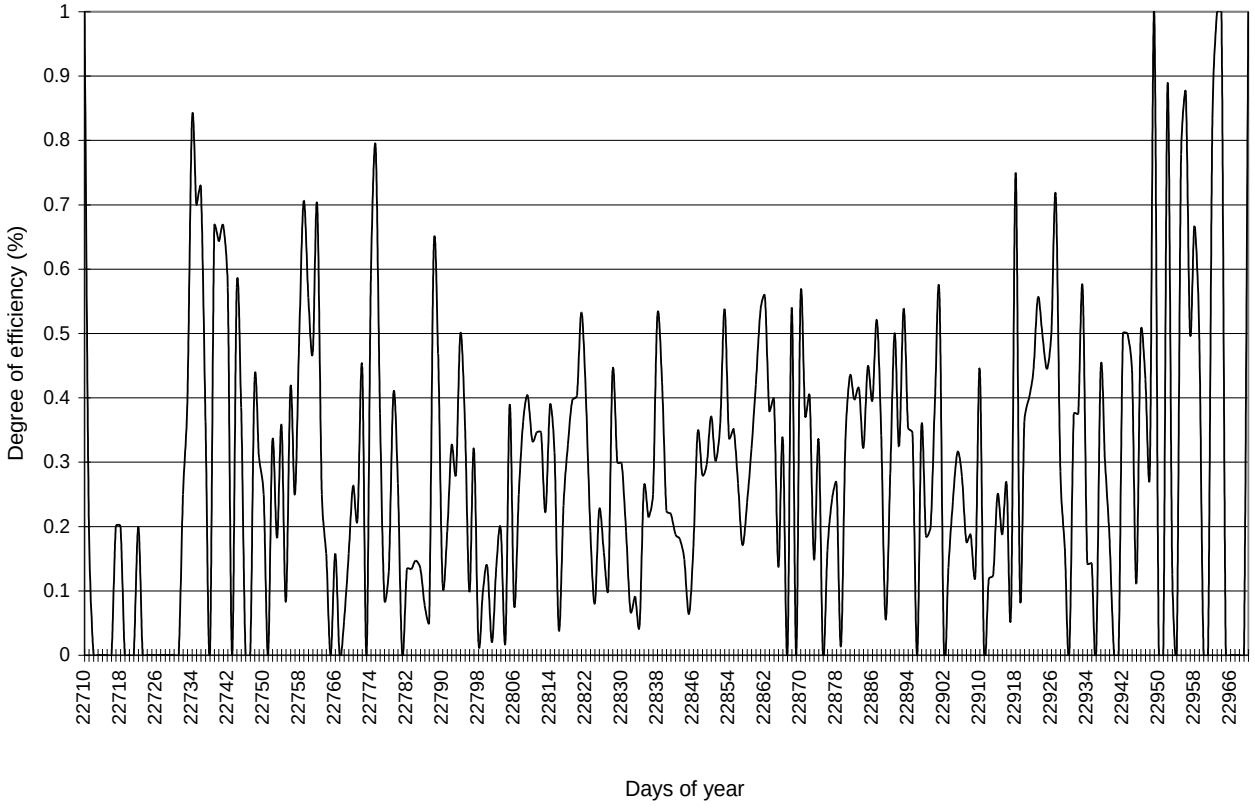

Fig. 6
Degree of efficiency of light-trap (Kámon Botanic Garden Szombathely, 1968)