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SEASONAL FLIGHT PATTERNS OF ANTLIONS (NEUROPTERA, MYRMELEONTIDAE) MONITORED BY THE HUNGARIAN LIGHT TRAP NETWORK

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Few investigations have been conducted which characterise seasonal flight patterns of antlions, because of their usual small population size, sporadic and local occurrence, and sampling difficulties. Night-active myrmeleontids are attracted to light sources, so light trapping can collect them. The authors have monitored the seasonal flight activity patterns of nine antlion species over more than 20 years using regular nightly operation of the 60 light traps of the Hungarian light trap network.

Generally, the seasonal activity of adult antlions lasted from early May to the end of September, and mass flight occurred in the period early June–late August. Time series analytical methods detected three characteristic species-groups with different seasonal flight-types. The three groups were: (a) earlier active "late spring-early summer" flying antlions (*Megistopus flavicornis, Myrmeleon formicarius*, *Nohoveus punctulatus*); (b) intermediate "early and mid-summer" flying antlions (*Distoleon tetragrammicus*, *Myrmeleon inconspicuus, Myrmecaelurus trigrammus*); (c) later "mid- and late summer" flying antlions (*Creoleon plumbeus, Euroleon nostras, Acanthaclisis occitanica*). Within groups the flight patterns were synchronised. One to four 10–day interval temporal separations were found between general activity patterns of groups. Further studies are needed to understand the ecological background to the differences between the seasonal flights of myrmeleontid species.

Key words: Myrmeleontidae, antlion adults, flight activity pattern, seasonality, temporal separation

INTRODUCTION

Imagines and larvae of antlions are predatory insects possessing natural protective value because of their unique larval foraging strategies (obligate and facultative pitmakers vs. non-pitmakers), rarity of certain species, and their aesthetic values. Antlion larvae are generalist predators. Like spiders they have a top-predator function in insect food chains on the ground surface, especially in habitats where they are represented at high density. Only few studies have described or analysed the seasonal flight patterns of myrmeleontid species (*e.g.* from Europe: CURTO & PANTALEONI 1987; from Australia: MACKEY 1988; from the Afrotropical region: HÖLZEL & OHM 1990, GÜSTEN 2001), because of their usually smaller population size, temporally sporadic and locally restricted occurrences, and practical difficulties of long-term sampling. Consequently, in order to recognise seasonality of adults, long-term, year-to-year monitoring programs with automatic collecting methods are necessary. European myrmeleontid species have positive phototaxis, so light trapping is one of the best methods for regular sampling of myrmeleontid adults. In Hungary, an extended light trap network (some 60 light trap stations at agricultural and forest habitats) has been in operation since 1958. Over seasons, daily operation of these traps offers a splendid chance to study population and assemblage level changes and trends of these insects at different time (daily – seasonal – long-term) and spatial (local – regional – countrywide) scales. In this study, the authors present and analyse the long-term data-series on the seasonal flight activity of adult antlions collected by this Hungarian light trap network.

The aims of this study

(1) To produce the general seasonal flight activity pattern of the selected myrmeleontid species based on long-term light trapping data.

(2) To describe and characterise the flight patterns of various antlion species (start, peak, and end of flight, mass flight period, length of seasonal activity, modality of seasonal activity distribution).

(3) To compare flight patterns of different myrmeleontid species in order to describe synchrony level between them.

(4) To find any characteristic antlion groups formed by similar seasonal flight patterns.

MATERIAL AND METHODS

Collecting method: light trapping

The Jermy-type trap applied in the Hungarian network has operated without baffles, using a white light source (100 Watt, tungsten filament bulb in all agricultural and some forestry traps; or 125 W mercury vapour bulb at other forestry trap sites). The light source is at a 2–metre height above the ground. Capture rate of adult antlions with light traps is usually smaller because of their lower flying speed, stronger stenotopy and lesser density. To achieve satisfying flying data on even more myrmeleontid species of a typical habitat, an experimental Minnesota-type light trap (100 W, normal white light) has been set up on a protected sand dune area near Fülöpháza in Kiskunság National Park. Capture effectiveness of this trap type is considerably greater, because it has three baffles around the light source.

Trapping sites

The stations of the regular ligth trap network were scattered in agricultural habitats such as orchards, vineyards, arable fields, parks, etc and in various forest types such as oak, beech, pine, etc. In addition to the trap on the sand dune, flight-data of adult antlions were produced in 39 agricultural and 20 forestry trap sites, respectively.

Timing and frequency of samplings

The antlion adults were identified from samples collected in agricultural areas between 1981 and 1995, and in forested habitats between 1977–1983, and since 1991. Light traps have collected flying insects each night in the period from the beginning of March or April to the end of October.

Selected myrmeleontid species

Seasonal flight characteristics of only nine myrmeleontid species could be studied. Only the following species were represented by sufficient individuals (at least 20 specimens): *Megistopus flavicornis* (ROSSI, 1790); *Distoleon tetragrammicus* (FABRICIUS, 1798); *Myrmeleon inconspicuus* RAMBUR, 1842; *Myrmeleon formicarius* LINNAEUS, 1767; *Euroleon nostras* (FOURCROY, 1785); *Myrmecaelurus trigrammus* (PALLAS, 1781); *Nohoveus punctulatus* (STEVEN, 1822) (= *Myrmecaelurus zigan* ASPÖCK, ASPÖCK et HÖLZEL, 1980); *Creoleon plumbeus* (OLIVIER, 1811); *Acanthaclisis occitanica* (VILLERS, 1789).

Data processing and statistical analyses

To produce the mean seasonal flight-patterns for the analyses, the nightly catches were summed within ten-night intervals over the season in each year. These 10-day units were counted from 1st of June forward and back in order to decrease the shifts in months caused by 31st day of May, July, and August. From all of years, catches of the same 10-day intervals were summarised and averaged. From these averaged data the seasonal distribution (%) of individuals captured per 10-day intervals was calculated for each antlion species. The latter distributions were used as the species-characteristic seasonal flight activity pattern. For assessment of interspecific synchronies (overlaps) between seasonal activity patterns, a time series analytical method, the cross correlation function (CCF) was applied (SZENTKIRÁLYI 1997, KÁDÁR & SZENTKIRÁLYI 1998). The CCF values were calculated using shifts with different number of 10–day intervals between the two seasonal activity patterns. Table 1 shows the maximal significant CCF values (*r*) at 95% confidence level, and the number of corresponding 10–day intervals as lags. Using this method, the lower the number of lags attached with a maximal significant *r* values, the greater the synchrony between two patterns compared. For similarity analysis we used more clustering methods that produced the same result. Therefore only one of them is presented in Fig. 7.

RESULTS AND DISCUSSION

In the Central European region, myrmeleontid assemblages with the greatest species-richness and population size can be found on the extended sandy area between the rivers Danube and Tisza in Hungary (GEPP & HÖLZEL 1989). Thus, monitoring must be considered to be important in their protection. Hungarian representatives of antlions are all attracted to light, and so light trapping can catch them. The majority of existing faunistic data on Hungarian antlions also came from light trapping network (STEINMANN 1963). So far 15 species have been recorded in Hungary (SZIRÁKI *et al*. 1992). However, this total includes single examples of 3 rare immigrant or vagrant species, not known to breed in Hungary and thus not considered a part of the Hungarian fauna, which is comprised of the remaining 12 antlion species. There are scattered references in earlier Hungarian literature on seasonal occurrence and flight period of antlion imagines (BÍRÓ 1885, STEINMANN 1963), but most of these refer only to the date of records and do not include detailed phenological analysis. It is understandable, since regular data collecting could start with setting up the light trap network.

Properties characterising adult antlions like stenotopy (they rarely fly outside of their biotope), low vagility level (they fly slowly and relatively weakly), low population density for several species, sporadic flight activity all contribute to the low number of captures at light traps.

Nevertheless, today there are collecting data series from several years for this group of insects, though the majority of light traps did not operate in typical antlion habitats, and so the local seasonal patterns are not represented well by these data. Therefore, a general flight pattern was attained only by superposing data. Thus in the present study, the constructed seasonal flight-activity patterns refer to a countrywide spatial-scale and a seasonal time-scale containing a mean of between-year and between-site variations.

In years and sites of our study, a total of 11 antlion species were captured at light traps, of which two were represented by only 1–2 individuals (*Neuroleon nemausiensis* BORKHAUSEN, 1791, *Dendroleon pantherinus* FABRICIUS, 1787) and were excluded from seasonality analyses. The remaining 9 species belong to the more common species of antlions in Hungary, most of which are abundant in appropriate habitat.

Characteristics of seasonal flight activity patterns

Generalised seasonality patterns of each antlion species are shown in figures 1–3, and seasonal frequency distributions of the start and end of flight are represented in Figs 4–6. Species exhibiting flight at the same period and expressing sim-

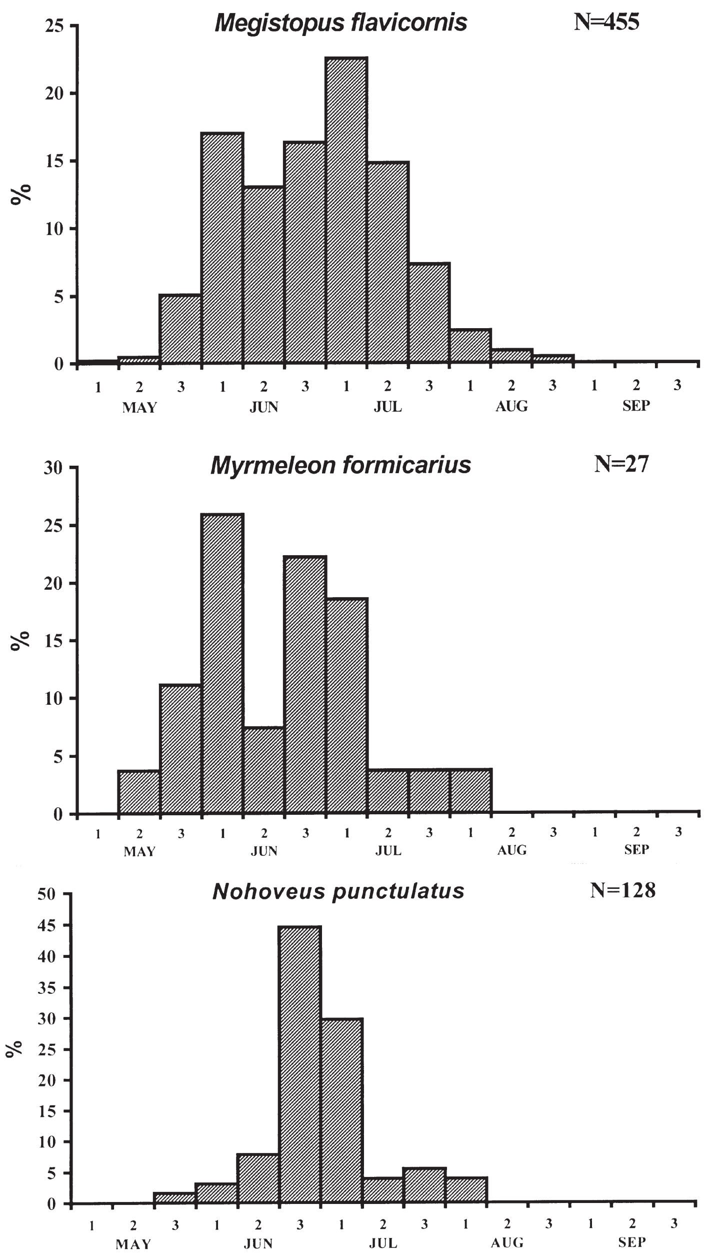

Fig. 1. Seasonal flight pattern of "late spring-early summer" active myrmeleontid species based on long-term collections of the light trap network in Hungary. (*Y-axis*: percent rates of mean number of individuals caught during the same ten-day periods over the monitoring years; N: total number of individuals)

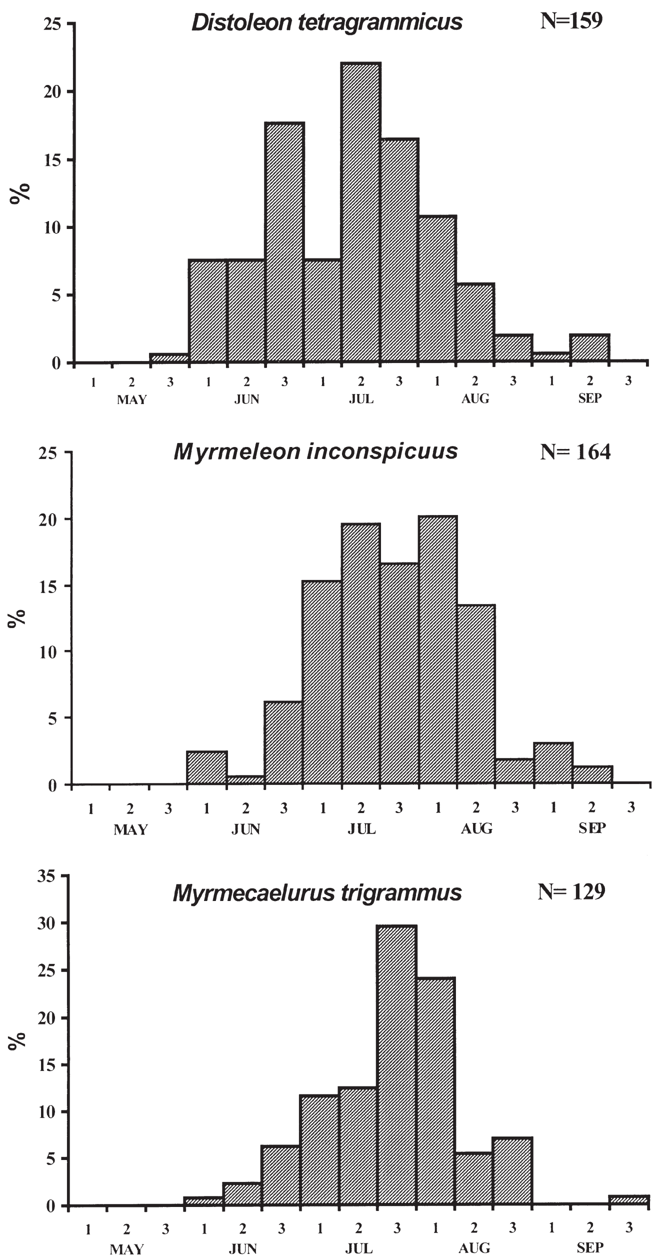

Fig. 2. Seasonal flight pattern of "early and mid-summer" active myrmeleontid species based on long-term collections of the light trap network in Hungary. (*Y-axis*: percent rates of mean number of individuals caught during the same ten-day periods over the monitoring years; N: total number of individuals)

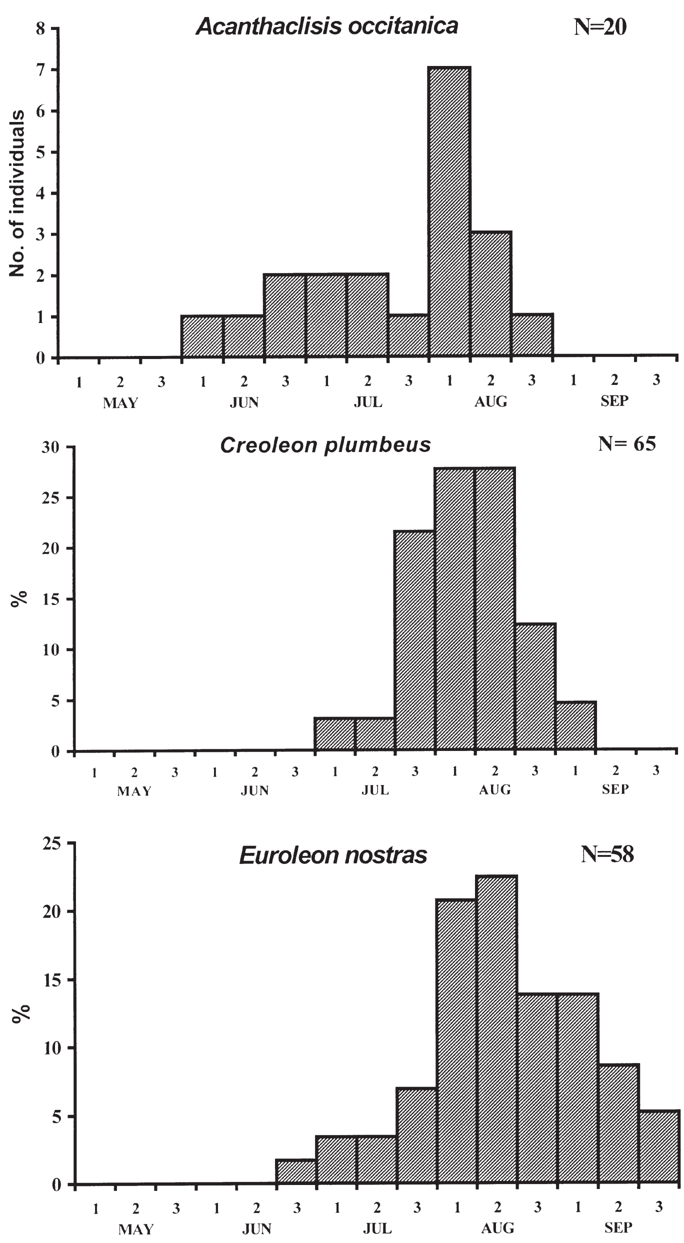

Fig. 3. Seasonal flight pattern of "mid- and late summer" active myrmeleontid species based on long-term collections of the light trap network in Hungary. (*Y-axis*: percent rates of mean number of individuals caught during the same ten-day periods over the monitoring years; the pattern of *A. occitanica* is given in individuals because of the low number of catches; N: total number of individuals)

ilar seasonality are shown in sequence, so the antlions with the earliest swarming are in Fig. 1 and latest ones are in Fig. 3. The same rank is used in Figs 4–6.

M. flavicornis – This species, one of the antlions with the earliest seasonal flights, proved to be the most dominant in light trap samples (Fig. 1). Its flight lasts

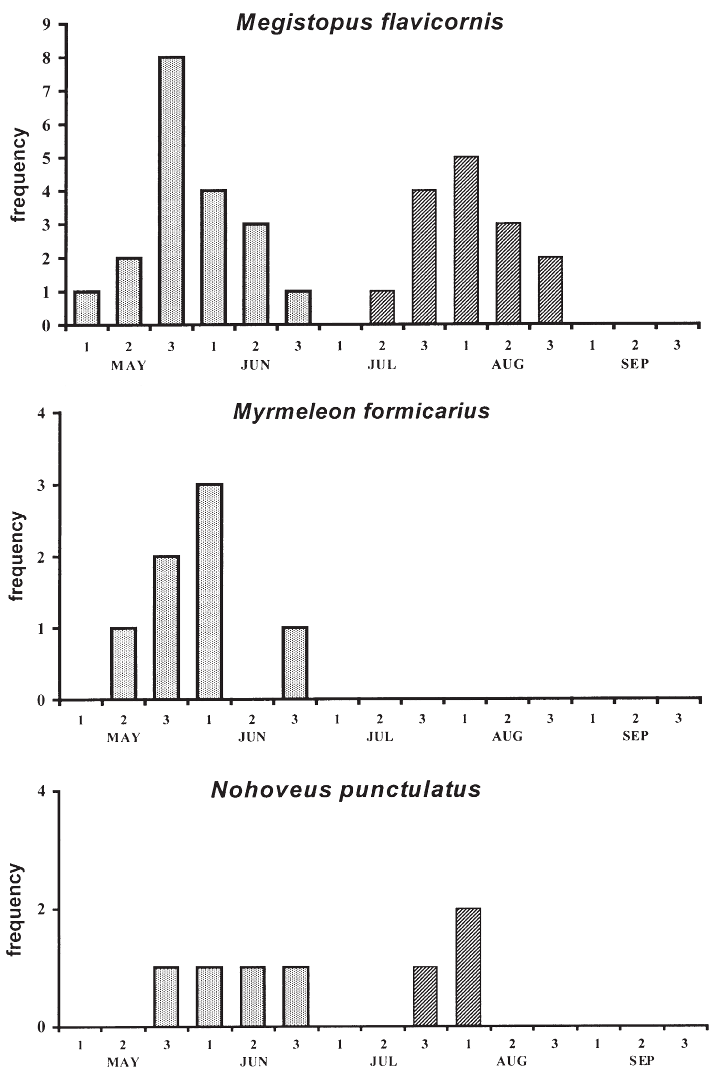

Fig. 4. Seasonal frequency distribution of the start (pointed columns) and end (striped columns) of yearly mean flight showed by "late spring-early summer" active myrmeleontid species, data based on collection of Hungarian light trap network

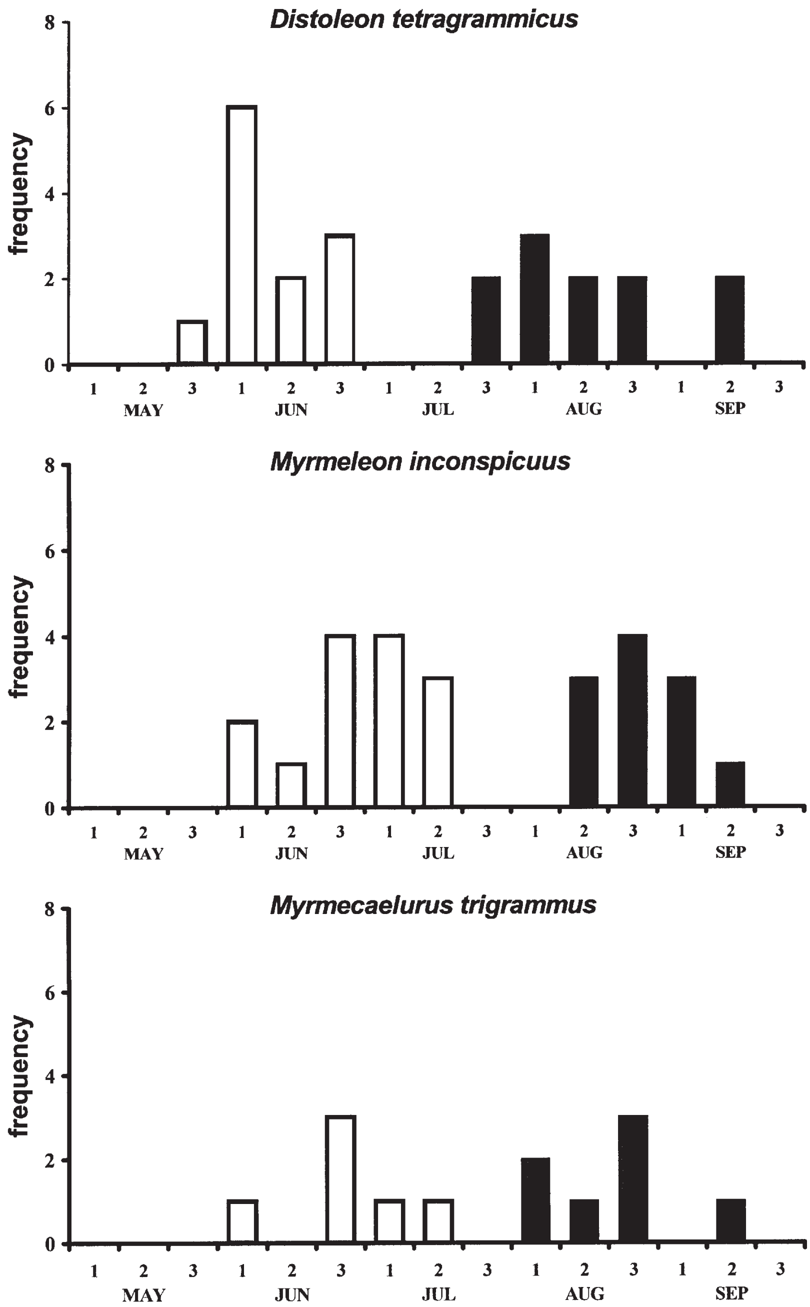

Fig. 5. Seasonal frequency distribution of the start (empty columns) and end (black columns) of flight showed by "early and mid-summer" active myrmeleontid species, data based on collection of Hungarian light trap network

from the beginning of May to the end of August. Mass flight period is allocated between the beginning June and the second ten-day period in July, with a smaller peak in early June and with a greater activity peak in early July. Such a bimodal seasonal flight-activity distribution was also expressed by *M. formicarius*, *D. tetragrammicus*, and to a lesser degree by *M. trigrammus* and *A. occitanica*. The explanation of this bimodality can be found in the phenomenon of protandry, except for *N. punctulatus* and to a certain extent *C. plumbeus* as well. The protandry is known in case of antlions. For example, in *M. bore*, *M. formicarius* and *E. nostras* it is also reported by LÖFQUIST and BERGSTRÖM (1980) and YASSERI and PARZEFALL (1996). Studying seasonal sex distribution in recent study, males emerged and flew 1–3 ten-day periods earlier than females, depending on the given species. This time lag between flights of males and females can give the first seasonal peak in number of individuals when males are still strongly active and females start to fly. Later, activity of high number of females added to still active males build up the second, usually greater peak. Seasonal activity patterns of sexes and detailed analysis of local and annual variations of these will be covered in another article.

Flight in *M. flavicornis* starts most probably in the last third of May–early June and declines at the end of July–beginning of August (Fig. 4). STEINMANN's (1963) data support the above seasonality characteristics, which suggest that imagines fly from early May to late August, and the highest frequency of this activity is during June in Hungary. BÍRÓ (1885) also mentioned records of this species only from May and early June.

M. formicarius – It occurred in captures at many light trap stations, however it was represented by only 1–2 specimens. Its seasonal activity (Fig. 1) ranges from mid-May to the first third of August; the mass flight is between early June and the first ten-day period of July. Flight pattern is bimodal, with two activity peaks in early and late June. STEINMANN's (1963) data reveal that adults of this species fly from mid-May to early August and the activity peak is formed in mid-June. Because of limited data, only the start of flight could be detected in several cases, these suggest that it takes place at the end of May and early June (Fig. 4).

N. punctulatus – Within its forest steppe belt area, this Mongol-eremial fauna element has its most western habitats in Europe on the Hungarian sand dunes. A light trap set up in such a dune (Fülöpháza) provided most of its data. *N. punctulatus* belongs to antlions with shorter flight-period. Its flight lasts from the end of May to late August. Mass flight occurs in a short, 20-day period, which is also coincident with the activity peak in the last ten-day period of June. STEINMANN's records absolutely support all the characteristics presented here.

The beginning of flight of *N. punctulatus* (Fig. 4) varies between the end of May and late June and it is finished most probably in the first ten-day unit of August.

D. tetragrammicus – This species has a wider seasonal activity (Fig. 2), flying from the end of May to mid-September. The pattern shows a considerable activity level between early June and early August with late June and mid-July peaks. Flight of this species starts during June (mainly at the beginning) and most probably it ends in August (Fig. 5). STEINMANN's (1963) records of *D. tetragrammicus* indicate a seasonality of similar length: a period between early June and mid-September. Its mass flight occurs a bit later in his data however, between the end of July and mid-August. According to BÍRÓ (1885) this antlion flies usually in July.

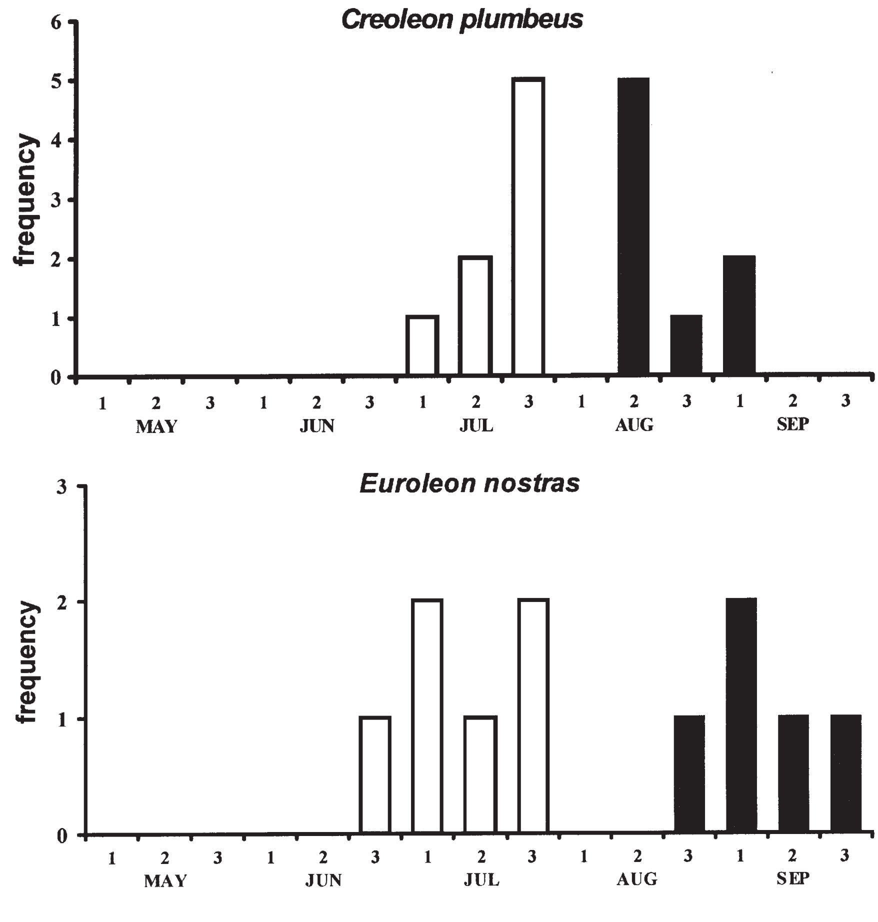

Fig. 6. Seasonal frequency distribution of the start (empty columns) and end (black columns) of flight showed by "mid- and late summer" active myrmeleontid species, data based on collection of Hungarian light trap network

M. inconspicuus – Flight activity lasts from the beginning of June to mid-September (Fig. 2), mass flight takes place from early July to mid-August. There is no definite activity peak; most individuals fly between mid-July and early August. Flight starts mainly at the end of June – early July and finishes in late August (Fig. 5). Most of records given by STEINMANN (1963) coincide with the above mass flight period that form a peak in early August. BÍRÓ (1885) stated that the flight of this species occurs in July.

M. trigrammus – The seasonal activity pattern is well distinguished from that of *N. punctulatus* (Fig. 2). Flight of *M. trigrammus* usually ranges from early June to late August, though certain individuals can be captured in September (see in Fig. 2) or even in October (STEINMANN, 1963). The more intensive flight period of imagines can be observed from the beginning of July to early August and is characterised with a sharp peak in the last ten-day interval of July. Flight often starts in late June and ends in late August (Fig. 5). According to STEINMANN's (1963) data this species is active from the end of June to early October, its major flight activity can be find in early and late July.

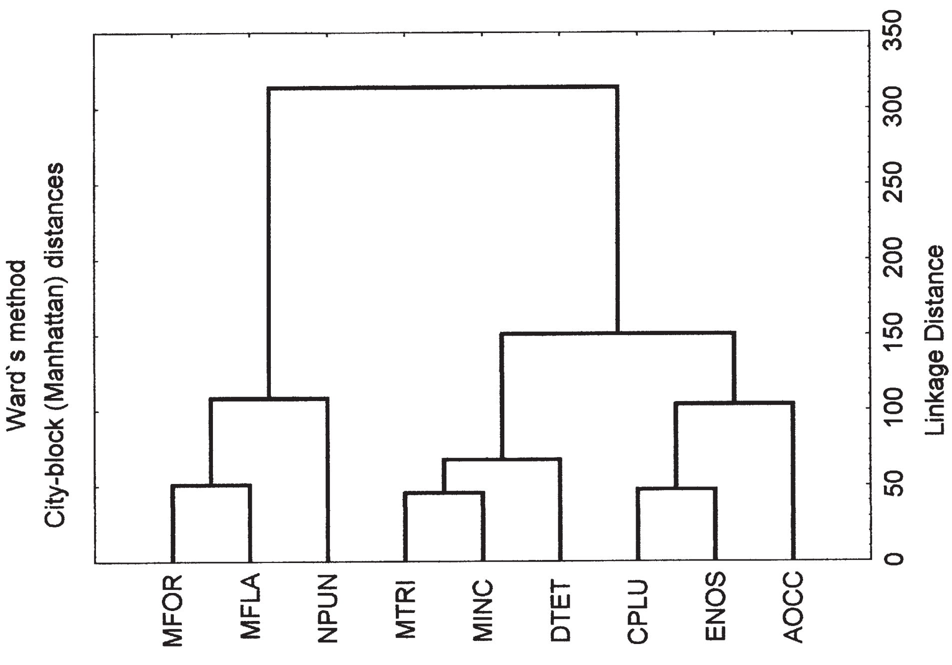

Fig. 7. Characteristic groups of antlion species with seasonally synchronised flight patterns. (The existence of three similarity groups was confirmed by various cluster analyses, e.g. Ward's method)

A. occitanica – Seasonal flight period expands between early June and the end of August (Fig. 3). Due to the low number of collected individuals, the mass flying period could not be detected, but it is likely to have an activity peak in the first ten-day period of August. Records published by STEINMANN (1963) support that it flies from early June till the end of August with an activity peak at the end of July. BÍRÓ (1885) also mentioned that adults of this antlion usually occur in August. In the case of *A. occitanica*, further light-trap samples are required in order to reveal the seasonal flight dynamics of imagines.

C. plumbeus – The flight pattern shows (Fig. 3) that this antlion belongs to those species that have a shorter seasonal activity. Imagines are active from early July to early September. Mass flight lasts from the third ten-day period of July to mid-August. The flight peak occurs in the first half of August. The start and end of flight are close to each other (Fig. 6): they are most frequent in late July and middle of August, respectively. Earlier records of STEINMANN (1963) and BÍRÓ (1885) support this phenology, mass flight of *C. plumbeus* given as between mid-July and mid-August, and peak activity taking place in the first ten-day period of August.

Table 1. Degree of temporal overlaps between seasonal flight patterns of myrmeleontid species

	MFLA	NPUN	MTRI	MINC	DTET	CPLU	ENOS	AOCC
MFOR	0 0.82	0 0.64	-3 0.71	-4 0.73	-2 0.82	-5 0.66	-6 n.s.	-4 0.67
MFLA		0 0.63	-2 0.77	-2 0.75	-1 0.81	-4 0.72	-4 0.59	-3 0.68
NPUN			-3 0.89	-2 0.69	-2 0.69	-4 0.66	-4 0.69	-4 0.82
MTRI				0 0.87	+1 0.84	-1 0.86	-1 0.79	-1 0.83
MINC					0 0.79	-1 0.89	-2 0.82	-1 0.61
DTET						-3 0.75	-2 0.62	-2 0.77
CPLU							0 0.85	+1 0.73
ENOS								0 0.66

Notes: numbers in cells: lags in 10-day intervals (upper numbers) at highest positive significant *r* values of CCF (lower numbers); The lagged seasonal patterns of antlion spp. are in columns; the greyish cells: comparisons between patterns within the same seasonality group

Abbreviations: MFOR= *Myrmeleon formicarius*, MFLA= *Megistopus flavicornis*, NPUN= *Nohoveus punctulatus*, MTRI= *Myrmecaelurus trigrammus*, MINC= *Myrmeleon inconspicuus*, DTET= *Distoleon tetragrammicus*, CPLU= *Creoleon plumbeus*, ENOS= *Euroleon nostras*

E. nostras – The seasonal activity pattern of this antlion species is shifted to the latest summer period. Imagines begin their flight in June, which lasts until the end of September (Fig. 3). Mass flight can be detected in the period from early August to early September with an activity peak in mid-August. Flight begins most frequently in July and it stops during September (Fig. 6). STEINMANN's (1963) data also show that this species flies mainly during August, and it is characterised with an activity peak in mid-August. Some individuals fly later, even in mid-October. BÍRÓ (1885) also noted one record of *E. nostras* found in September.

Level of interspecific synchrony between adult flight patterns

A look at the flight diagrams instantly illustrates that seasonal activities of all the antlion species studied are not synchronised with each other, some species fly earlier, others later, and so it seems that they can be categorised into flight-groups according to these characteristics. In order to analyse the rate of interspecific separation/overlap between seasonal activity patterns, the whole available light trap da-

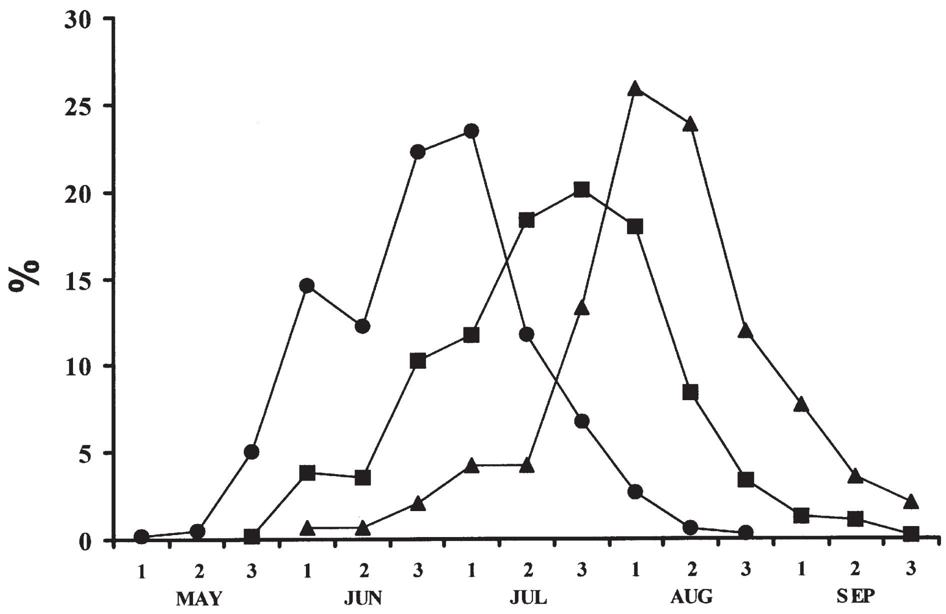

Fig. 8. Mean seasonal activity patterns of antlion groups with characteristic three flight-types based on collections of long-term monitoring light trap network in Hungary (●: "late spring-early summer" flight group *M. flavicornis, M. formicarius, N. punctulatus*; ■: "early and mid-summer" flight group *D. tetragrammicus*, *M. inconspicuus, M. trigrammus*; ▲: "mid- and late summer" flight group *A. occitanica, C. plumbeus, E. nostras*)

tabase was investigated using time series analysis. CCF functions were calculated and maximal significant *r* values with corresponding lags in number of ten-day periods were arranged in table (Table 1) by every possible comparison between pairs of species. Lag numbers indicate (regardless of the plus-minus sign) the degree of shift/separation in ten-day intervals between flight patterns of antlion species, reflecting the rate of synchrony. Data in Table 1 illustrate well that depending on different species, the values are ranged from total synchrony (no. of lags = 0) to 5–6 ten-day interval separation (a period of 1.5–2 months!). Arranging lag values it became clear that flight patterns of certain species were similar and synchronised with each other (0 lag), while they were more or less separated from others (2–6 lags).

Detection of characteristic groups of seasonal flight-patterns

In order to show from former results the expected groups gathering species with identical seasonality, cluster analyses were carried out involving various similarity methods. All the similarity analyses used on patterns of the 9 species confirmed the existence of the same 3 characteristic flight groups (Fig. 7): a well-separated earlier active antlion group (*M. flavicornis*, *M. formicarius*, *N. punctulatus*), and two more or less overlapping groups with later seasonal activity. The latter two groups consist of the species triplets *D. tetragrammicus*, *M. inconspicuus*, *M. trigrammus* and *A. occitanica*, *C. plumbeus*, *E. nostras*. Within these three seasonality groups, flight patterns are well synchronised between species (see in Table 1 the greyish cells with lag = zero or 1).

General seasonal patterns of characteristic flight groups of antlions

Table 1 shows flight activity pattern of characteristic flight groups, calculated from the total light trap catches of antlions belonging to each indicated groups. The separation of the seasonal activity patterns of the three groups and the partial overlap between them can be easily observed. According to this, the following seasonality is characteristic of the three groups.

A – The earliest active is the *M. flavicornis*, *M. formicarius*, *N. punctulatus* group with a "late spring – early summer" flight-type. Mass flight ranges from the beginning of June to mid-July with an activity peak at late June – early July.

B – Members of the "early and mid-summer" flight-type group: *D. tetragrammicus*, *M. inconspicuus*, *M. trigrammus*. Characteristic mass flight lasts from the beginning of July to early August, and the flight peak is allocated in the third ten-day period of July.

C – Group of "mid- and late summer" flight-type: *A. occitanica*, *C. plumbeus*, *E. nostras*. Main flight period of this group lasts from the end of July to late August/early September.

There is a mean lag of 2–3 ten-day periods between flight patterns of group (A) and (B), while the rate of separation between group (A) and (C) is a lag of 3–5 ten-day periods (Table 1). The lag between patterns of group (B) and (C) is usually 1–2 ten-day period. It seems that depending on latitude, there is a geographical variation in the seasonal allocation of emergence and flight periods of the same myrmeleontid species. In northern latitudes in Europe (*e.g.* LÖFQUIST & BERGSTRÖM 1980, YASSERI & PARZEFALL 1996) adults of *M. formicarius* emerge later (in July), while *E. nostras* adults emerge earlier (mainly in July) than in Hungary at more southern latitudes.

Other phenological analyses from literature also suggest that it is possible to have a shift between main flight periods of different antlion species at the same habitat. Within European antlions, CURTO and PANTALEONI (1987) in southern Italy found such partial time separation between seasonal activities. According to their published activity diagram, flight peaks of antlion species *Creoleon lugdunensis* VILLERS, *Macronemurus appendiculatus* (LATREILLE) and *Neuroleon egenus* NAVÁS followed each other in this order with a 2-week lag. This time-lag period caused an easily detectable separation in both of the start and end of flights. MACKEY (1988) in Australia (Queensland) monitored with light traps for 7 years, and recorded 13 myrmeleontid species. Although individuals of the observed antlion species occurred very sporadically over the whole year, there was a tendency that flight activity level increased in certain periods of the season (October–November and February–March). MACKEY (1988) thought that these increases in abundance indicate 1 or 2 possible annual generations, but he does not deny the chance that these are related to a longer emergence period and long adult life. HÖLZEL and OHM (1990) on Cape Verde Island reported on the seasonal activity distribution of some antlion species collected with light traps. Reviewing their data, there can be detected a noticeable tendency between the flight peaks to shift from each other. In Tunisia, North Africa, GÜSTEN (2002) carried out detailed collections of antlions with portable light traps. On the basis of his records, he detected that antlions had seasonality, certain species expressed early-season flight activity, while others were characterised with late-season activity. Early-season species were *Maracanda lineata* NAVÁS and *Macronemurus elegantulus* MCLACHLAN, while *Geyria saharica* ESBEN-PETERSEN and *Acanthaclisis occitanica* were listed among late-season antlions.

So far, the factors reasonable for partial separation between seasonal flight activity patterns of the studied Hungarian antlion groups are not known. It is unlikely that alternative foraging strategies of larvae (there are pitmakers and non-pitmakers in all the three groups), or variability of developmental period (in each groups there are species with 1 or 2 years of developmental period), or changes in size of body (smaller or larger bodied imagines are among the members of each groups) or possible competitions might explain the seasonal separations between the certain groups of antlions. In the future, the responsible factors and ecological consequences of this phenomenon should be investigated.

CONCLUSIONS

The general length of seasonal activity of antlions lasted from early May to the end of September. The mass flight of studied antlions fell into the period of early June – late August, while the start and end of flight ranged from early May to late July and from mid-July to late September, respectively. These seasonal characteristics showed between-year and species-specific variations (Figs 1–6).

Although the overlapping of the whole seasonal flight patterns of antlions are significant, there are certain separations between the species depending on temporal allocation of mass flight period and flight peaks. The shorter (*N. punctulatus, C. plumbeus*) or longer (*e.g. D. tetragrammicus*, *M. inconspicuus, M. flavicornis*) length of seasonal activities may reflect a shorter or longer emergence period or adult life span.

On basis of statistical analyses (Figs 7–8, Table 1) the studied adult myrmeleontids belong to three flight-types forming species groups with different seasonal activity pattern. These three groups are: (a) earlier flying group [EF] with "late spring–early summer" flight pattern *M. flavicornis, M. formicarius*, *N. punctulatus*; (b) intermediate flying group [MF] with "early and mid-summer" flight pattern *D. tetragrammicus*, *M. inconspicuus, M. trigrammus*; (c) late flying group [LF] with "mid and late summer" flight pattern *C. plumbeus, E. nostras, A. occitanica*.

Within these groups, the flight-activity patterns between the species were closely synchronised (Table 1), while the between-group comparisons detected lags with 1 to 6 ten-day intervals between the seasonal activities. The separation in the generalised flight patterns (Fig. 8.) were 2 ten-day intervals between [EF] & [MF], 4 ten-day intervals between [EF] & [LF], and 1 or 2 ten-day intervals between [MF] & [LF].

Similar separation was found between seasonal activity patterns of other European and tropical/subtropical antlion species. Further investigations are necessary for the ecological background to explain the seasonal differences between the flight patterns.

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