Sites of the emergence of the Scarce Chaser *Libellula fulva* (O. F. Müller, 1764) (Odonata: Libellulidae) in the forest of Puszcza Notecka

Miejsca wylęgu ważki rudej *Libellula fulva* (O. F. Müller, 1764) (Odonata: Libellulidae) w Puszczy Noteckiej

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Introduction

L. fulva is a spring species (sensu Corbet 1999). Studies on the emergence of the Scarce Chaser confirm that this process is of a relatively short duration and has a characteristic, highly synchronized progress: from the period of mass numbers with a clearly isolated day of peak, through the second, milder wave of increased numbers until its gradual expiry. The duration of particular stages of emergence depends on atmospheric conditions during the emergence, but also on the conditions preceding the emergence on a given day. There is a tendency to finish the emergence as soon as possible during the course of the day. It is related to the exposition time of the dragonflies to the pressure from predators (Tatarkiewicz 2006).

During the emergence, the insects usually are vulnerable to dangers, both biotic (pressure from predators) and abiotic (unfavorable weather conditions). The manner in which the larvae locate can be crucial to their survival. The aim of the paper was to describe the places of emergence of *L. fulva*.

Area of research

The research was conducted in the years 2002–2004 near a village called Chojno (52°41'N 16°12'E), located at the southern border of the forest of Puszcza Notecka, west of the town of Wronki. The research of the emergence was focused on a part of a stream (with an adjacent low moor), located between the Chojno Lake and Chojno-Młyn.

Two research sectors were established: IIA and IIB, further in the text called stations IIA and IIB. An approximate sketch of both stations is presented in Fig.1. Station IIA was divided into smaller parts: IIA1, IIA2 and IIA3.

Stations IIA and IIB were located on opposite banks of the wide part of the stream. The mainstream flowed in the middle of the

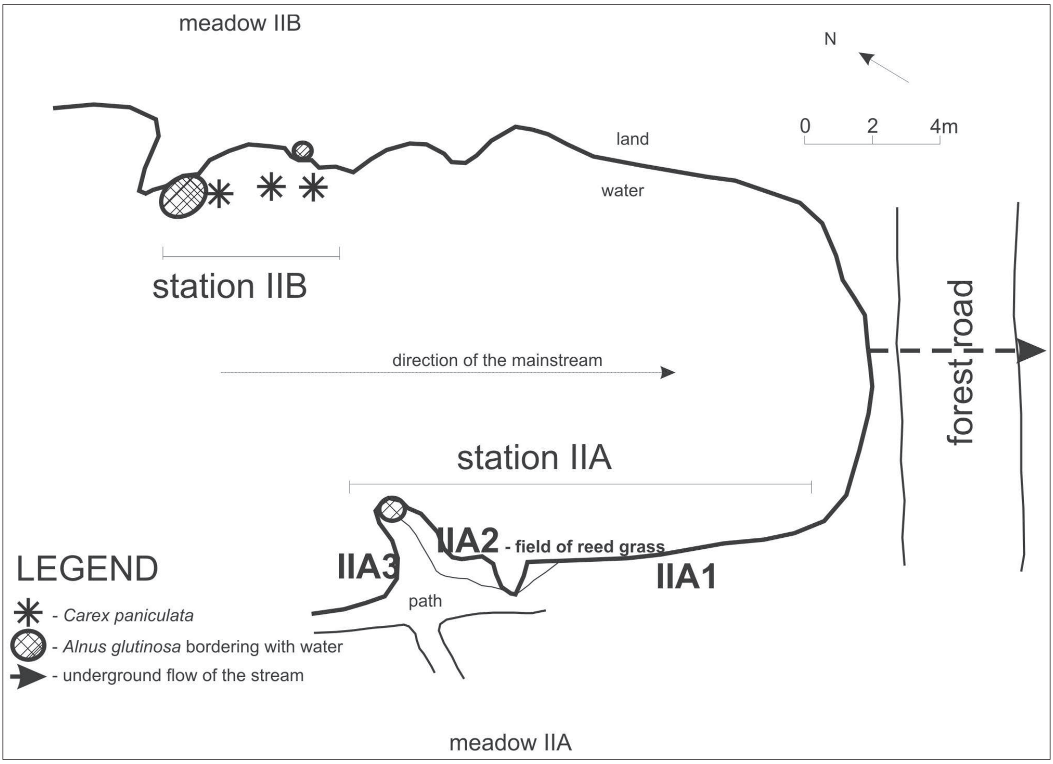

Fig. 1. The scheme of the stations allotted by the stream for the studying of the emergence of *L. fulva*.
Ryc. 1. Schemat stanowisk wyznaczonych do badania wylotu *L. fulva* nad strumieniem.

extension; the sides had a lentic character. The sandy bed, especially on the sideways was in parts clearly muddy, covered with autochthonous and allochthonous detritus. There were a few tree branches. In some places at the banks old fern leaves descended into water. Over most part of the extension, especially on the sides, there was a lot of shadow caused by the crowns of the offshore trees, and from the side of the bridge and at the mainstream it was relatively brightly (a narrow strip).

In 2003 the measurement of water depth (about 0,3 m from the shoreline) and of the deposit thickness (about 0,5-0,8 m from the shoreline) were conducted in a couple of points of stations IIA2 and IIA1. In IIA2: depth 6 cm, thickness from about 10 to 20 cm; in IIA1: depth from 4 to 12 cm, thickness from 5 to 14 cm. The measurements conducted in the distance from a dozen to several dozen centimeters from the shoreline at the station IIB showed: water depth from 2 to 6 cm, deposit thickness from 28 to 36 cm.

The plant structure in station IIA1 was designated by three species: *Thelypteris palustris* SCHOTT, *Caltha palustris* L. and *Phragmites australis* (CAV.) TRIN. ex STEUD. In IIA2 *Phragmites australis* and *Caltha palustris* dominated. In 2004 *Berula erecta* (HUDS.) COVILLE also appeared there. *Phragmites australis* and *Caltha palustris* dominated in IIA3. In the station IIA at least two species of *Carex* also grew, including *Carex acutiformis* EHRH., *Frangula alnus* MILL. and *Padus padus* L. dominated in the shrubs layer, and among the trees – *Alnus glutinosa* (L.) GAERTNER.

The station IIB was less abundant in herbaceous plants. *Carex* sp. dominated over there, and the structure was indicated by four clumps of *Carex paniculata* L. growing out of water and individual *Phragmites australis*, *Carex acutiformis* and *Lysimachia vulgaris* L. *Frangula alnus* dominated in the shrubs layer, and *Alnus glutinosa* in the trees layer.

The whole life cycle of the scarce chaser took place by the stream. So it was the stem habitat – one of a center of appearance of the population in a given year. Each year from this place the scarce chasers expanded to other areas suitable for the imagines.

Research methods

The description of the places of emergence of L. fulva each time encompassed: stations of emergence; place of appearance of the larva on the substratum (water, line of contact between water and land, land); substrate on which the larva emerged; distance of the emergence of the larva from the shoreline; altitude of emergence of the larva and height of the plant the larva had climbed; degree of concealment of the larva (covered, partially covered, uncovered).

Based on CORBET'S work (1999) the emergence was divided into four stages: I – dragonfly (an adult specimen inside the exuvia) entirely outside the water environment, but the cuticle is not yet cracked; II – the cuticle on the torso is cracked; III – abdomen is out of the exuvia; IV – wings fully developed, the specimen capable of flying.

Results

Season of 2003

The dragonflies get out of the water to a substrate suitable for emergence. The substrates are almost always plants. Among the analyzed larvae (N=258), the majority (46,5%) chose plants growing on land. Almost half of that number of dragonflies emerged on plants, whose fragments protruded from the water (27,9%). Similar number of specimens chose plants growing on the boundary of water and land (25,6%).

The most larvae were located on herbal plants (69,8%), fewer in the trees and shrubs (30,2%). However, the percentage of dragonflies emerging on trees and in the shrubs is probably higher. It is due to the fact that: a) some imagines that emerged, die as a result of praying birds (in the larval stage or at a later stage, when not yet fully developed milky-white wings moving in the wind are bait for birds); b) obtaining and description of some exuviae was impossible due to the altitude or their position.

The emergence took place both on the stems and leaves of herbal plants. In case of trees and shrubs – far more frequently in trunks and branches (87,7%) than in leaves (12,3%).

The number and percentage of dragonflies emerging on plants of the two selected categories ([1] trees and shrubs, [2] herbal plants) changed during the phenological season (Fig. 2). There is a visible tendency of a more frequent use of trees and shrubs it the first half of the emerging period. However, this phenomenon was preferential only during two days, and it was the most visible on May 20 (the day of mass emergence). A few factors influenced the phenomenon described above, however, the key fact seems to be that in the beginning of the emergence, the herbal plants were not fully developed; during mass emergence the first larvae to appear from the water climbed the highest, the next ones lower, evenly occupying the niche available for emergence.

The most dragonflies emerged on reeds (dry – from the previous year and developing in the current season) and on black alders (Tab. 1). The significant amount of

Tab. 1. The number of *L. fulva* larvae emerging on the individual plants' species in the year 2003.
Tab. 1. Liczba larw *L. fulva* wychodzących na poszczególnych gatunkach roślin w 2003 r.

Species – Gatunek	**N**	
Phragmites australis – from the previous year	33	67
Phragmites australis – developing in the current season	34	
Alnus glutinosa	61	
Caltha palustris	44	
Thelypteris palustris	29	
Carex sp.	23	
Carex paniculata	14	
Frangula alnus	7	
Equisetum sp.	5	
Lysimachia vulgaris	4	
the others	7	

the specimens also climbed *Caltha palustris* and *Thelypteris palustris*. The number of dragonflies located on each plant species reflected approximately the occurrence frequency of those plants in a given time in the environment. Two species of plants that dominated as substrates for emergence (Tab. 1), distinguished themselves from the other plants with their height.

The maximum distance that the larva covered from the water boundary to the plant growing on land, where the emergence took place, was 5,5 m (min.=8 cm, av.=0,62 m, SD=96,2 cm, N=117). In case of choosing plants growing in water the maximum distance was 2 meters from the shoreline (min.=15 cm, av.=0,65 m, SD=46 cm, N=57).

The average altitude where the exuviae were found in designated research stations was 0,95 m (min.=7 cm, max.=7,9 m – *Alnus glutinosa*, SD=115,8 cm, N=256). A relatively frequent use of trees and shrubs as substrates for the emergence in its first (phenologically) part (Fig. 2) resulted in a higher average altitude of larvae climbing in that period (1,20 m) in comparison to the second part of the emergence (0,47 m). On May 19th and 20th, outside of the designated research stations, a maximum altitude of about 9 m of the scarce chasers emerging was noted (specimens noticed in the trunks of black alders). In case of emergence taking place in the trees it was not uncommon to observe the altitude ranging from two to four meters.

Three types of larvae (or exuviae) locations on plants were distinguished: in covered places (on the underside of leaves and/or covered by neighboring plants), uncovered (on the top side of the leaves, uncovered by neighboring plants) and partially covered. In the above mentioned places there were 90 (40,7%), 93 (42,1%) and 38 (17,2%) exuviae, respectively. It indicates the lack of preference in larvae to locate in covered places.

<u>Season of 2004</u>

Many larvae getting out of water were observed in places, where large alders grew nearby. It was clearly visible on May 19 in station IIA (the day with the second largest number of emerging dragonflies, NIIA,IIB=41). Opposite an alder growing there, about 1m away from the shore, a relatively large number of larvae emerged. Close by, however, in a place where there was a visible gap in the tree stand (looking from the water in the direction of the shore) no larvae emerged.

The assumption that the trees are an indicator for the larvae choosing a section of the shore for emergence is confirmed by observations made in station IIB. The larvae got

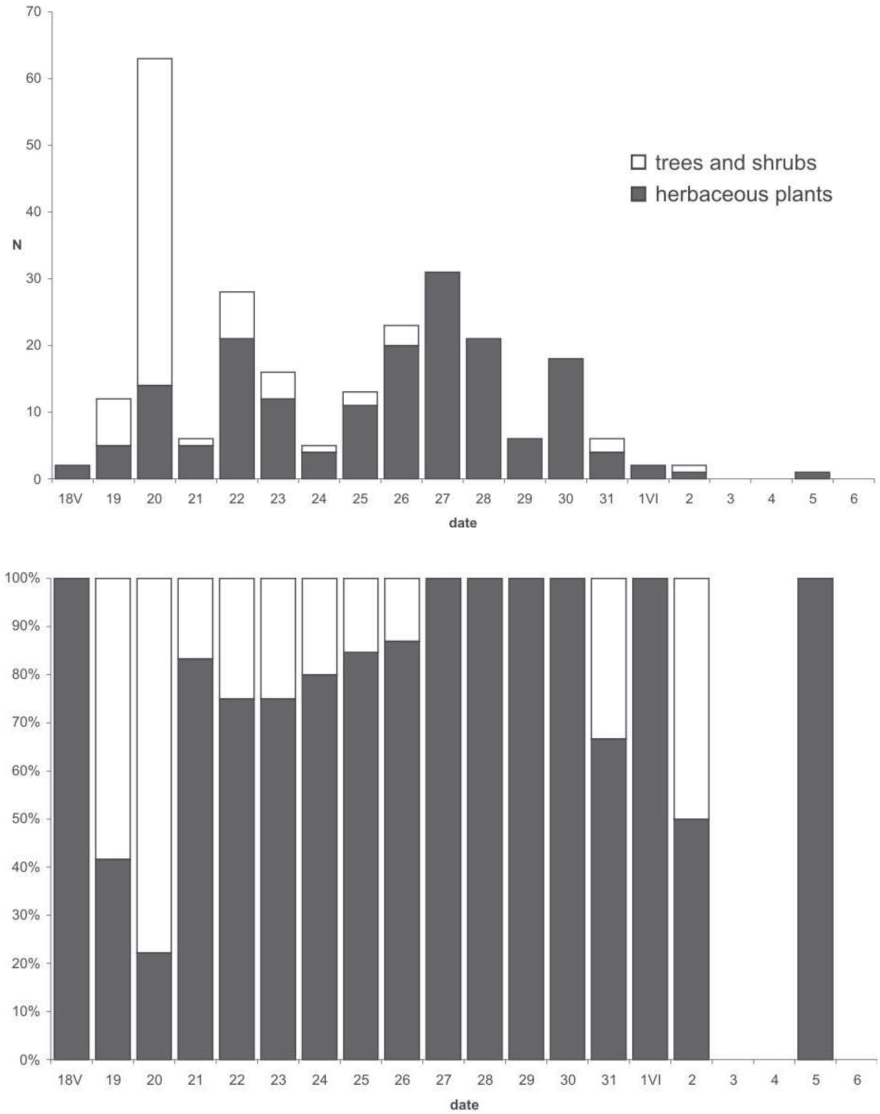

Fig. 2. The number and the percentage of *L. fulva* emerging on the separate substrata (trees and bushes vs herbaceous plants) in 2003; for each graph N=255.

Ryc. 2. Liczebność i udział procentowy *L. fulva* wylatującej na wyróżnionych substratach (drzewa i krzewy kontra rośliny zielne) w 2003r.; dla każdego wykresu N=255.

out onto a branchy alder growing by the water almost daily. Often they located in places where there were other specimens the day before. It facilitated for the birds the finding of the dragonflies. The starlings *Sturnus vulgaris* Linnaeus, 1758 regularly circulated the tree trunk in order to find newly emerged larvae.

Discussion

A numerous emergence started at dusk. The atmospheric conditions at that time enabled the larvae to climb relatively high. It is the physical conditions (wind, relative humidity, air temperature and sunrays) that can determine the length of migration of larvae, which already got out of water, directly influencing the time of drying of the cuticle. Then an even distribution of the insects in the environment would be determined by a mechanism, where the later during the day the larva appeared out of the water, the closer to water it would start getting out of the exuvia. The dependence between the air temperature and humidity in the first stage of emergence and the altitude of getting out for *Anax junius* was described by Trotier (1973).

The emergence on maximum altitude of about 9 m was observed in the research stations, while relatively often specimens that emerged in lower altitudes of a few meters were found. Until now observations indicated a maximum altitude of emergence from 1,6 m (Siebeneicher 1997) to 2 m (Sternberg et al. 2000). Corbet (1983) mentions a maximum emergence altitude of 6 m noted among the dragonflies.

Such altitude of emergence can be a result of the habitat's character (good availability of trees along with a short supply of herbal plants in the first half of emergence) and of great numbers of local dragonfly population. The altitude of getting out of the larvae may also depend on the size (length) of their bodies. Cordero (1995) demonstrated the existence of a positive correlation in this matter in the populations of dragonfly species studied by him. He also indicated four possible reasons why bigger larvae needed higher substrates for their emergence: 1) larger dragonfly species need a greater distance from the water to freely spread their wings; 2) avoiding predators; 3) finding microclimate suitable for emergence and 4) avoiding intraspecific competition.

First of the reasons (1) does not represent a full explanation of the altitudes of emerging dragonflies mentioned in this paper. The second one (2) proves correct if even dispersion of larvae in the environment hinders their detection by the birds for their nestlings fed at that time. The influence of the microclimate (3) on the altitude of emergence cannot be excluded. However, lower relative humidity noted in higher altitudes extends the stages I–III of emergence, and shortens only the duration of stage IV; higher air temperature shortens the duration of stages I–IV (Trottier 1973). Bennett and Mill (1993) note that when the numbers of the dragonfly species studied by them (*Pyrrhosoma nymphula*) were high, then a tendency for climbing higher up the trees was observed. Considering the availability of suitable substrates for the emergence in the environment, they interpret this more as a search of warmer places than as a competition for places for emergence. Maybe also in the case of *L. fulva* the larvae found warmer places in high altitude. However, in this paper high location of emerging dragonflies is interpreted differently: using the whole noted spectrum of altitudes was, above all, an element reducing the competition for limited, in this case, places for emergence (4). Thus, it reduced the probability of different anomalies appearing during the emergence of an individual specimen.

The confirmation of the adopted interpretation (4) is the fact that getting out of *L. fulva* in the trees and shrubs occurred mainly during the first wave of increase in numbers of emerging insects. In that way, since the herbal plants were not yet fully developed at that time, the dragonflies avoided overcrowding in the population. The highest percentage of coverage of trees and shrubs as substrates for emergence fell on the day of mass appearance. In the second half of the emergence the dragonflies visibly less frequently located in the trees and shrubs. The advancing development of *Phragmites australis*, *Caltha palustris* and *Thelypteris palustris*, where the emergence was concentrated, was of significant importance.

Most scarce chasers emerged on land. Maximum distance from water (5,5 meters) was 1,5 m greater than the one described by Siebeneicher (1997) and almost four times greater than the one described by Sternberg et al. (2000) for this dragonfly species.

In view of great pressure from predators, the degree of concealment of larvae (covered, partially covered, uncovered), should be of significant importance. It turned out, however, that larvae getting out on herbal plants, although theoretically safer (invisible for a human looking form above), are visible for predators. In search for the dragonflies the birds penetrated the environment not only from the tree tops. Other strategy selected by them was exploring the land directly by the shoreline and looking for insects that were located in places invisible from a different perspective. Considering the ease with which the birds penetrated the environment, it is not surprising the larvae do not have a preference for getting out in covered places.

Another measure of microhabitat's attractiveness for emerging dragonflies could be the degree of condensation of the plant cover. The higher the density the better the microhabitat, because in this way the probability of effective hiding from the predators increased. On the other hand the density could not be too high due to the need for unconstrained pumping of wings. Maybe the higher percentage of herbal plants as substrates in the second half of emergence was not only due to their high availability at that time, but also from their additional feature – their density increasing with growth.

Among the larvae appearing from the water there was a tendency for choosing plants with structure – with visible contours – on the shore. Maybe in the period preceding the emergence, the larvae concentrated near those parts of the shore where they distinguished contours of substrates for emergence. The trees, due to their sizes, could be the impulse for getting out of the water in a particular part of the shore, even though they not always became the place where the larva located. It could be due to the fact that the animals encountered other substrates on their way, which they climbed to start the emergence (Corbet 1999). Maybe the role of indicator for the larvae appearing from the water was also played by other plants, e.g. reeds or other sufficiently developed, of suitable structure, herbal plant species.

Indirectly, the possibility of such preference is also confirmed by the fact that the beginning of emergence of the majority of scarce chasers harmonized with the time of day guaranteeing at least minimum visibility (starting with dusk; such conditions would also be available on a moonlit night). Even the smallest amounts of light are sufficient to distinguish the contours of shore plants. It is possible that larvae, still in the water environment, during the day (or days) preceding the emergence, gathered around substrates suitable for emergence. Other authors (e.g. CORBET 1957) also indicate the preference of some parts of the shore during appearing.

Trees and shrubs, probably having the role of a stimulus – indicator, and surely a significant role of being a substrate for larvae appearing from the water, are an important proximate cue for imagines choosing a given water basin for reproductive activity. In turn, occurrence of herbal plants of suitable height is important not only for emerging dragonflies, but also for imagines – above all for territorial males.

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Streszczenie

Badania wylotu prowadzono w latach 2003–2004 w okolicy wsi Chojno (52°41’N 16°12’E, południowy skraj Puszczy Noteckiej), na zachód od Wronek. Koncentrowały się one nad fragmentem strumienia (z przylegającym torfowiskiem niskim), zlokalizowanym między Chojnem-Młyn a Jeziorem Chojno. Nad strumieniem zachodził cały cykl życiowy *L. fulva*. Wyznaczono tu dwa stanowiska badawcze: IIA i IIB (ryc. 1).

W 2003 roku do przeprowadzenia wylotu większość ważek (46,5%) wybrała rośliny wyrastające na lądzie. Na roślinach, których fragmenty wyłaniały się z wody, wylatywało 27,9%, a na roślinach rosnących na granicy wody z lądem – 25,6% osobników.

Na roślinach zielnych lokowało się 69,8% ważek (najczęściej na trzcinie pospolitej), pozostałe – na drzewach i krzewach (najczęściej na olszy czarnej, tab. 1). Udział procentowy ważek odbywających wylot na drzewach i krzewach był prawdopodobnie większy – niektóre wychodzące imagines ginęły w wyniku żerowania ptaków; pozyskanie niektórych wylinek było niemożliwe, ze względu na miejsce ich umieszczenia.

Liczba ważek lokujących się na poszczególnych gatunkach roślin odzwierciedlała w przybliżeniu częstość występowania tych roślin w środowisku w danym czasie. Oba wymienione wyżej gatunki roślin, które dominowały jako substraty do

przeprowadzenia wylotu (tab. 1), wyróżniały się spośród innych swą wysokością.

Wylot odbywał się zarówno na łodygach, jak i na liściach roślin zielnych. W przypadku drzew i krzewów – znacznie częściej na pniach i gałęziach (87,7%) niż na liściach (12,3%).

Liczebność i udział procentowy ważek wylatujących na roślinach z dwóch wyróżnionych klas ([1] drzewa i krzewy, [2] rośliny zielne) zmieniał się w sezonie fenologicznym (ryc. 2). Widoczna jest tendencja do częstszego korzystania z drzew i krzewów w pierwszej połowie okresu wylotu. Wymiar preferencyjny zjawisko to przybrało tylko w dwóch dniach, a najwyraźniej 20 V (dzień masowego wylotu). Na opisane zjawisko wpływało kilka czynników, jednak kluczowe znaczenie wydaje się mieć fakt, iż na początku wylotu roślinność zielna nie była jeszcze w pełni wykształcona; przy masowym wylocie pierwsze wyłaniające się z wody larwy wychodziły wysoko, kolejne niżej, równomiernie zajmując dostępne do odbycia wylotu nisze.

Odległość maksymalna, jaką pokonała larwa od granicy wody do rośliny rosnącej na lądzie, na której następnie odbyła wylot, wyniosła 5,5 m (min.=8 cm, śr.=0,62 m, SD=96,2 cm, N=117). W przypadku wyboru roślin wyrastających z wody odległość maksymalna wyniosła 2 metry od linii brzegowej (min.=15 cm, śr.=0,65 m, SD=46 cm, N=57).

Średnia wysokość, na której znajdowano wylinki na wyznaczonych stanowiskach badawczych, wyniosła 0,95 m (min.=7 cm, max.=7,9 m – olsza czarna, SD=115,8 cm, N=256). Stosunkowo częste wykorzystywanie drzew i krzewów jako substratów do odbycia wylotu w pierwszej (fenologicznie) jego części (ryc. 2) poskutkowało wyższą średnią wysokością wychodzenia larw dla tego okresu (1,20 m) w porównaniu z drugą połową wylotu (0,47 m). Dnia 19 i 20 maja, poza wyznaczonymi stanowiskami badawczymi, odnotowano maksymalną wysokość wychodzenia ważek żółtych: ok. 9 m (na pniach olszy czarnych). W przypadku odbywania wylotu na drzewach nierzadka była wysokość wychodzenia wynosząca od dwóch do czterech metrów.

Wyróżniono trzy rodzaje lokalizacji larw (lub wylinek) na roślinach: w miejscach osłoniętych (na spodniej stronie liści i/lub osłonięte przez sąsiadujące rośliny), odkrytych (na wierzchniej stronie liści, nieosłoniętych przez sąsiednie rośliny) oraz częściowo osłoniętych. W opisanych miejscach umieszczonych było, odpowiednio, 90 (40,7%), 93 (42,1%) i 38 (17,2%) wylinek. Wskazuje to na brak preferencji larw do lokowania się w miejscach zasłoniętych.

W 2004 r. wiele wychodzących z wody larw obserwowano w miejscach, w pobliżu których rosły pokaźne olchy. Wyraźnie ujawniło się to 19 V na stanowisku IIA (dzień z drugą liczebnością wśród wylatujących ważek, NIIA,IIB=41). Naprzeciwko rosnącej tam około metr od brzegu olchy wyłaniało się stosunkowo dużo larw. Natomiast tuż obok, w miejscu, w którym istniała wyraźna luka w drzewostanie (patrząc od strony wody w kierunku brzegu), nie wyłoniła się żadna larwa. Przypuszczenie, jakoby drzewa pełniły rolę swoistego wskaźnika wyboru przez larwy odcinka brzegu do wyłonienia, potwierdzają obserwacje poczynione na stanowisku IIB.

Key words. western Poland, forest of Puszcza Notecka, Chojno, the Scarce Chaser, *Libellula fulva*, Libellulidae, Anisoptera, Odonata, emergence, spring species, sites of emergence, herbal plants, shrubs, trees, height and distance of emergence