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EMERGENCE AND ADULT BEHAVIOUR OF
MACROMIA SPLENDENS (PICTET)
IN GALICIA, NORTHWESTERN SPAIN
(ANISOPTERA: CORDULIIDAE)

A. CORDERO RIVERA¹, C. UTZERI² and S. SANTOLAMAZZA CARBONE¹

¹Departamento de Ecoloxía e Bioloxía Animal, Universidade de Vigo, E.U.E.T. Forestal,
Campus Universitario, ES-36005 Pontevedra, Spain

²Dipartimento di Biologia Animale e dell'Uomo, Università "La Sapienza",
Viale dell'Università 32, I-00185 Roma, Italy

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Exuviae were found in sheltered places, most commonly in small cavities under the river banks. The species is able to breed in hydroelectric reservoirs that show marked changes in water level and where riverine vegetation is completely absent. At these places exuviae were found on dead trunks and big rocks, usually in a horizontal upside-down position. In the laboratory, emergence followed the typical aeshnid sequence. Adult, full coloured males showed no yellow spots on abdominal segments 5 and 6, while the spots on segments 4 and 7 were widely variable. 37 adult males of a natural population at the river Lérez were marked. Of these, 12 were resighted 1 to 14 days after marking. Males patrolled over 50-150 m of the river, usually flying straight about 30 cm above the water. Females were observed at the river on 21 occasions, and in 19 cases oviposited as soon as they arrived at water. However, mating was recorded only once during 52 h of observation over 18 days. Two more matings were obtained with a tethered female. Since matings at the oviposition sites seem to be rare, it is suggested that copulation is performed mainly at the feeding places. Eggs were scattered by the unaccompanied female by dipping the abdomen 3-10 times for no more than 2 min, in spots of the river as far as 1 m from each other. The importance of forested areas for conservation of this species is discussed.

INTRODUCTION

Macromia splendens is one of the rarest European dragonflies (ASKEW, 1988; DOMMANGET & GRAND, 1996). For this reason our knowledge of its ecology and behaviour are fragmentary, especially in the Iberian Peninsula. For instance, there are no reports on copulation in this species, and oviposition behaviour has been

described only briefly (LIEFTINCK, 1965; BELLE, 1983; DOMMANGET & GRAND, 1996; SCHÜTTE & SUHLING, 1997). In Galicia, northwestern Spain, *M. splendens* was first recorded by CORDERO (1996) from a hydroelectric reservoir; probably an atypical habitat. Following this finding, during 1996-1998 the species was further recorded from nine rivers in the same region, in which some dense populations have been recorded (A. Cordero, unpublished). Herewith we present the results of some observations on the emergence of *M. splendens* in the field and laboratory, and some behavioural observations of marked adult males and females.

METHODS

During 1996-1998 we searched for populations of *M. splendens* in Galicia, by visiting 20 rivers and travelling more than 10,000 km. Exuviae of this species were found at the rivers Tambre, Lézé, Tea, Avia, Cabe and Limia. The entire emergence process was recorded in the laboratory.

Observations on adult behaviour were carried out both at the above rivers and at the rivers Miño and Deza. In 1998 we concentrated on an intensive field work study on the river Lézé at Castiñeira, Cotobade, Pontevedra province (UTM 29TNH3500). From 11 June to 28 July the river was visited on 18 days, totaling 52 h of observations. Observations were carried out by one to four observers, starting at 7-9 h and ending at 12-16 h (solar time; in Spain, local time is two hours later). 40 males and 1 female were captured. The dragonflies were measured (abdomen and hind wing length, using digital callipers) and photographed, and 37 of them were marked with different positioned colour dots on their wings (the remaining three were damaged by capture). Because this marking method permitted the identification of flying individuals, the marked dragonflies were never netted again.

LARVAL DEVELOPMENT, EMERGENCE AND ADULT FLIGHT PERIOD

Larvae of this species were very difficult to find. We were unable to find a single larva in the rivers Valdeiras, Tambre and Umia. Despite intensive searching between the shore line and the river bottom

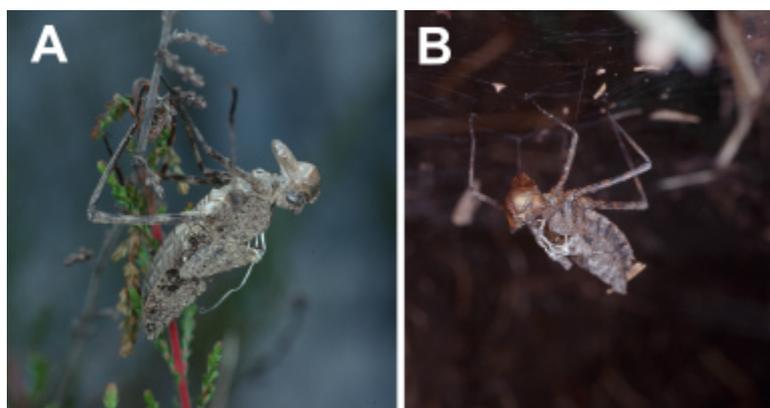


Fig. 1. Exuviae of *M. splendens* in northwestern Spain: (A) on *Erica* sp, at the Albarellos reservoir; (B) below a spider web at the river Lézé.

of the river Lézé, at a depth of 1.5 m, only four larvae were collected, between 17 and 24 May, 1997. Of these, two were close to emergence, and the other two were 5.8 mm in length. Kept in the laboratory, at about 20°C, and fed *ad libitum* with aquatic oligochaetes, these latter reached their final size in November and were released at the place of capture. The larvae were found at a depth of 0.3-1 m, where the river bank was rich in tree roots, dead leaves and branches (one was observed resting on a tree root). Together with *Macromia* larvae, larvae of the dragonflies *Onychogomphus uncutus*, *Gomphus sp.*, *Cordulegaster boltonii*, *Boyeria irene* and *Oxygastra curtisii* were also usually found, along with the water bug *Ranatra linearis*, a typical pond species. We searched the muddy bottom of the river, up to 1.5 m depth, but never found larvae.

In natural rivers, exuviae were found mainly in dark and sheltered places, usually under the fern *Osmunda regalis*, or on tree trunks, but sometimes also on very thin perches (Fig. 1A). In most cases exuviae were found in a horizontal upside-down position (Fig. 1B), which seems characteristic of this species. Cavities under the river banks were commonly used for emergence. In one such cavity, an exuvia was found perched on a spider web, a very unusual perching site for an emerging dragonfly (Fig. 1B).

In hydroelectric reservoirs, in which the water level changes markedly and larvae have no shore vegetation to climb up (Fig. 2), exuviae were mainly found perched on dead trunks and big rocks. For example, at the Lindoso reservoir, river Limia, we found six exuviae of *M. splendens*, most of which were attached to the roof of the same small cavity in a granite rock. Thus this species can accomplish larval development and emergence in the complete absence of shore vegetation.



Fig. 2. A view of the Albarelos reservoir in June 1995, where a large population of *M. splendens* was observed from 1995 to 1998. Exuviae were found on dead trunks (arrow) or on big stones. Note the very low water level.

A quantitative search for exuviae carried out in the river Cabe on 12 July, 1998, yielded three exuviae of *M. splendens*, 67 of *Oxygastra curtisii* and 13 of *Boyeria Irene*.

In the field, in different years, emergence probably started on different dates. In the places that we monitored continuously, we found the first exuviae on 13 June 1995, 15 May 1997 and 13 June 1998. Since adults were recorded on the wing up to the end of July, the entire flight period probably lasts about 6-10 weeks.



Fig. 3. Some phases of the emergence of a *M. splendens* male in the laboratory. Pictures were taken at 5:00, 5:32, 5:33, 6:07 h local time.

Figure 3 shows some phases of the emergence in the laboratory. In two cases, it took place during the night. The entire process needed two hours and was very similar to that of other large anisopterans (cf. e.g., fig. 6 in ASKEW, 1988).

MORPHOLOGICAL
VARIABILITY

The abdomen length of 40 males from the Lérez population averaged 53.11 ± 0.15 mm (range: 51.08-54.59), while the hind wing length was 44.90 ± 0.12 mm (range: 43.14-46.83). The lengths of the only female measured were 51.65 mm and 45.88 mm, respectively.

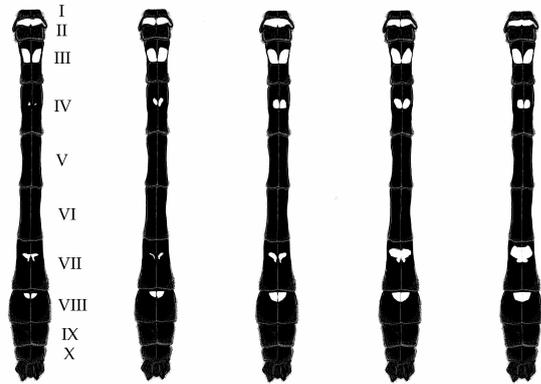


Fig. 4. Variability in the extension of yellow spots in males from the river Lérez, northwestern Spain.

Males showed great variability in the size of the abdominal yellow spots, particularly of those on segments 4 and 7, while segments 5 and 6 showed no spots at all. Some examples of such variability are shown in Figure 4.

ADULT BEHAVIOUR

In 1998, at the river Lérez, adult, full-coloured *M. splendens* were on the wing from 22 June to 17 July. Of the 37 marked males, 12 (32%) were resighted between 1 and 14 days after marking (Fig. 5). The maximum population density was recorded between the end of June and early July, when up to 15 males were observed patrolling along the river. The marked individuals reappeared at the same river starting from 8 July, and represented a large fraction of the total number of males observed daily.

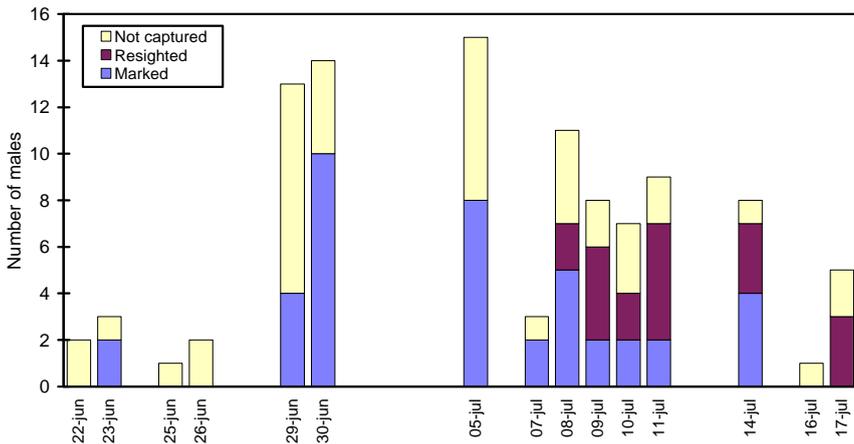


Fig. 5. The number of males marked and resighted at the river Lérez, together with an estimate of the unmarked males recorded.

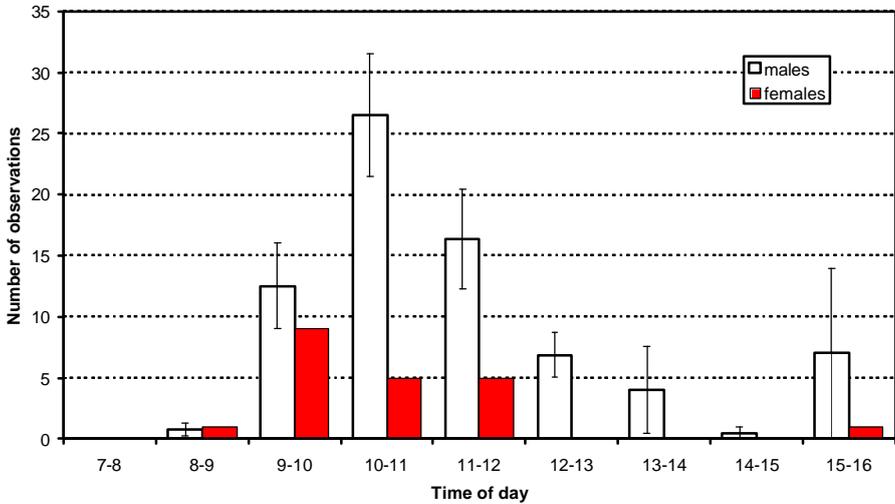


Fig. 6. Daily activity of male and female *M. splendens*. For males, the mean number of individuals crossing our observation point during each hour is presented. For females, given the scarcity of records, all individuals observed on different days have been grouped together.

This suggests that the river Lézé population was fairly small.

Males patrolled the river flying fast and straight, about 30-50 cm above the water surface. The activity of 16 marked males observed in different days, showed that, if undisturbed, the male patrols up and down 50-150 m of the stream. Males remained for an average of 16 ± 3.7 min at the stream (range: a brief visit to 56 min). Males usually avoided shaded areas, but in the river Deza some flew in a completely shaded area, inspecting the banks in a similar way to that of *Boyeria irene* males.

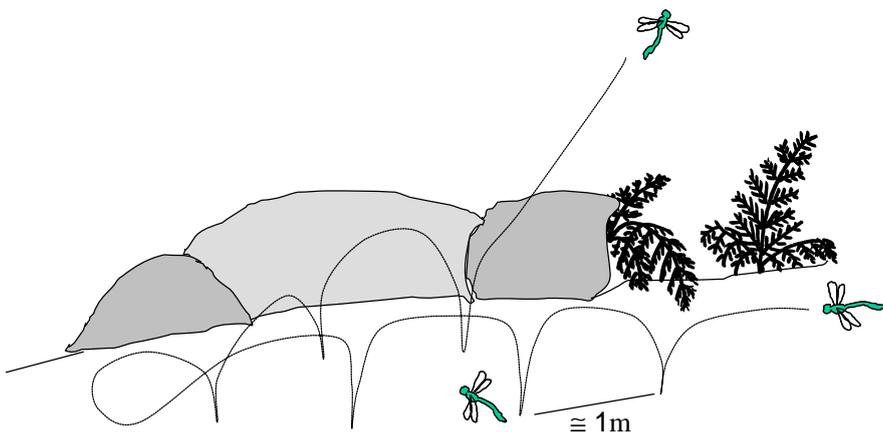


Fig. 7. Schematic representation of oviposition behaviour in *M. splendens*.

Males and females were observed at the river between 8:00 and 16:00 h, but the maximum number of ovipositing females did not coincide with the maximum number of patrolling males (Fig. 6). Also, in the first four days of observation, the first individuals to appear at the river were females, while the first males appeared up to one hour later than the first female. Between 10:00 and 12:00 h, usually three or four males patrolled the river simultaneously. Generally, when two males came into visual contact, rapid aggressive behaviour took place, but apparently neither male was firmly displaced, since usually both returned to the river. Similar interactions were observed between males *M. splendens* and *Oxygastra curtisii*.

At the river, females were observed 21 times. Nineteen of these immediately started to lay eggs (first oviposition recorded on 23 June) (Fig. 7), apparently scattering them by single dips of the abdomen at a distance of

about 1 m from each other. Oviposition bouts never exceeded 2 min, females touching the water 3 to 10 times and then quickly disappearing over the trees. The preferred oviposition sites were either near a big rock (exactly the same water spot was used in both 1997 and 1998, and by several females in the latter year) or under the shore ferns. Females oviposited close to either the sunny or the shaded bank of the river, as was also observed at the rivers Tea and Cabe. Ovipositing females were apparently unnoticed by passing males, and only once was one pursued by a male, but this did not end in seizure.

Two females did not oviposit upon arriving at the water. One of these was immediately mated by a marked male, after which the pair flew up to the tree canopy in copula. The other female was netted and presented to patrolling males by means of the fishing line technique (ST. QUENTIN, 1934). One male captured this female and mated for 10 min (Fig. 8). Soon after, another male also mated with her, but copulation lasted only 2 min, probably due to disturbance by the observer. Since the pre-copula tandem flight was very fast and short-lasting, it was not possible to determine whether or not intra-male sperm translocation took place between seizure and copulation (for a comment on sperm translocation in corduliid dragonflies, cf. UTZERI et al., 1998).



Fig. 8. A copulating pair *M. splendens*, obtained by the fishing line technique.

DISCUSSION

EMERGENCE

In Galicia, we have found exuviae of *M. splendens* either on shore vegetation, including very thin plants (*Erica* sp.), or rocks, frequently in small cavities, often in sheltered, nearly inaccessible places. The same was reported by DOMMANGET & GRAND (1996). Apparently, in both the French and Spanish populations, the last moulting takes place in a horizontal upside-down position.

Our records indicate that populations of *M. splendens* keep stable also in artificial reservoirs which lack aquatic vegetation. Therefore, the presence of riverine vegetation is not indispensable for the maintenance of a population.

Even though the very few larvae collected in spite of the great search effort suggest that larvae may be just secretive, the small number of exuviae found probably means that the number of individuals in our populations was actually low. In fact, in the same places, exuviae of *B. irene*, that has a body size similar to *M. splendens* s, were four times as numerous as those of the latter, and those of *O. curtisii* were 22 times more abundant. Furthermore, *M. splendens* larvae have not been found in previous studies of benthic macroinvertebrates of Galician rivers.

The dates on which the smaller larvae were collected were too early, relative to oviposition dates, to make us think that they had hatched from eggs laid in the same year; instead, they had probably hatched in the preceding year. Although they were richly fed in the laboratory, these larvae did not become fully grown until November, indicating that probably in the field they would have been unable to complete development in their second year, thereby suggesting a three years larval period.

MORPHOLOGICAL VARIABILITY

The main populations of *M. splendens* are in northwestern Spain and southeastern France, and these are separated by a considerable distance (DOMMANGET & GRAND, 1996). Even though the species might have been distributed over a wider area in the past, some differentiation between the present Spanish and French populations may be expected. Drawings of *M. splendens* male coloration have been provided by BILEK (1969), who reports some variability in the dorsal yellow spots: 30% of the males lacked the spot on abdominal segment 5 and several also on segment 6. LIEFTINCK (1965) indicated that, out of eight males from southeastern France, three (37.5%) lacked the yellow spot on segment 5 and all on segment 6. Galician males never have spots on segments 5 or 6 (Fig. 4), this resulting in a darker pattern than that reported in the literature (AGUESSE, 1968; BILEK, 1969; SANDHALL, 1987; ASKEW, 1988). This suggests the existence of some differentiation in the colour pattern between Spanish and French populations. However the individual represented in D'AGUILAR et al. (1985) strictly resembles a Galician male. On the other hand, as far as body size is concerned,

Galician males are very close to both those from France (LIEFTINCK, 1965; AGUESSE, 1968; D'AGUILAR et al., 1985) and from Extremadura (central Spain, BENÍTEZ & GARCÍA, 1989).

ADULT BEHAVIOUR

M. splendens males make patrol flights of 50-150 m along the river, showing a peak of flight activity between 9:00 and 12:00 h. In this period they probably search for females, since they were not seen feeding (see also DOMMANGET & GRAND, 1996; SCHÜTTE & SUHLING, 1997). However, even though we observed a relatively dense population over many hours, we recorded only one mating. Oviposition behaviour is very inconspicuous, as also in other *Macromia* species (WALKER & CORBET, 1975), and on several occasions males did not seem able to detect ovipositing females. On only one occasion did a male pursue an ovipositing female but he was unable to seize her. In this species, mating at the water seems extremely rare. GRAND (in press) observed the tandem formation only once, but this did not end in copulation, whereas DOMMANGET (1995) recorded only a few matings in ten years of observation. These reports suggest that most matings take place far from the water. Mating very far from water has been observed on one occasion in the corduliid *Somatochlora meridionalis* (UTZERI et al., 1998). It is possible that males patrolling the river are those that were unable to mate at common rendezvous sites or those that had already mated but continued searching for females at the river. Adults disappeared from the river at about 12-13 h, although some returned at 15-16 h. A similar daily activity was reported also for southeastern French populations (GRAND, in press).

In southeastern France, *M. splendens* males patrol the rivers in the morning, but fly along roads (BILEK, 1969) or among trees in the afternoon (GRAND, in press). At the Albarellos reservoir both males and females started to make obvious feeding flights along a path in the middle of an oak forest at about 13:00-14:00 h. We speculate that mating may occur at these places, which could explain why females start to oviposit as soon as they reach the water.

The choice of forested areas, or at least tree lines, for feeding sites has important implications for the conservation of *M. splendens*. Such an association with tree lines, as at the side of forest roads, is also reported in *M. illinoensis*, in Canada (WALKER & CORBET, 1975) and in *M. urania* and *M. katae*, in Hong Kong (WILSON, 1995). If this is true, *M. splendens* could be negatively affected by the substitution of native trees with *Eucalyptus* plantations, a very widespread occurrence in northwestern Spain. Where this occurs, insect abundance is very much reduced, thereby possibly producing food limitation.

In conclusion, even though *M. splendens* is a rare species, our observations suggest that it has several behavioural adaptations which make allowance for some optimism concerning to its long-term conservation. In Galicia, hydroelectric reservoirs are being built in most of the river valleys

inhabited by the species; however it seems able to survive even in these reservoirs. This ability clearly depends on its behavioural flexibility.

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