VERTICAL STRATIFICATION DURING EMERGENCE IN ODONATES

Emergence is a crucial event in the life of larval dragonflies. This is the only moment during their development in which larvae are immobile, and therefore are susceptible of damage or predation. Careful site selection should be expected. In his comprehensive study of the life history of *Anax imperator*, P.S. CORBET (1957, *J. Anim. Ecol.* 26: 1-69) showed that larvae prefer certain parts of the shore for emergence. This produces great concentrations of emerging individuals in some spots, to the extent that some emerging larvae can be damaged by other emerging individuals climbing on them (see pl. 2B in CORBET, 1957, *loc. cit.*). S.D. GRIBBIN & D.J. THOMPSON (1990,

Freshw. Biol. 24: 295-302) and S. BENNETT & P.J. MILL (1993, *Odonatologica* 22: 133-145) studied the emergence of *Pyrrhosoma nymphula* and found that exuviae could be very close, but never so close as to produce competition for emergence sites or damage. To my knowledge, Corbet's data are the only to indicate intraspecific competition for emergence sites in Odonata.

During field work on a man-made pond at Salcedo (Pontevedra, NW Spain) during 1985 and 1986, I noticed that the exuviae of several species seemed to be located at a characteristic height on their substrate. This fact suggested a possible case of avoidance of interspecific competition for substrates. The pond was almost rectangular, 60 × 10 m, formed at an abandoned excavation for a highroad. Due to this origin, the pond had walls of concrete 4 m high on the longer sides, with emergent vegetation only on the shorter sides. This reduced the available supports for emerging dragonflies mainly to patches of *Digitaria paspalloides*, *Cyperus vegetus* and *Typha latifolia*. During opportunistic visits to the pond I collected all the exuviae I could find and measured the height above water to the nearest cm (or the estimated distance covered by larvae that emerged on inclined substrates), and the height above the ground and the distance travelled for those exuviae found far from the water. I also measured some of the exuviae to the nearest mm (total length, excluding caudal lamellae in Zygoptera). Given the difficulty of locating enough exuviae of some species, data from measurements made during 1985 and 1986 at several other ponds (*L. virens*, *A. mixta*, *O. cancellatum*) and rivers (*P. latipes*, *B. irene*, *O uncatus*) in the province of Pontevedra are also presented.

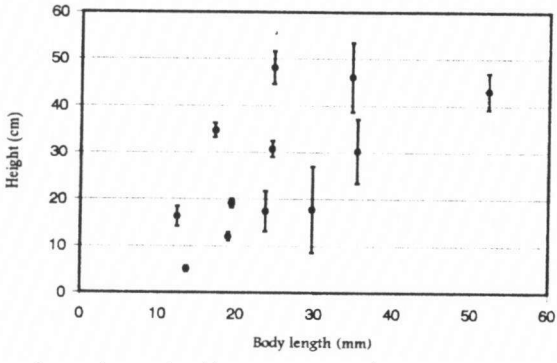

Fig. 1. The relationship between larva size and height on the substrate for the emergence in some Odonata species. – [Mean ±SE]

Figure 1 shows the relationship between mean

Table I – The localization of exuviae of some Odonata

Species	Height on the substrate (cm) mean±SE (n)	range	Distance from water (cm)* mean±SE (n)	range	Body length (mm)
Ischnura graellsii	5.09±0.59 (85)	1-46	**	–	13.61±0.25 (39)
Lestes viridis	19.12±0.91 (423)	3-132	52.36±13.49 (14)	10-175	19.37±0.21 (23)
L. virens	11.98±0.83 (103)	2-48	**	–	18.96±0.37 (5)
Platycnemis latipes	16.31±2.11 (16)	6-34	**	–	12.40±0.40 (2)
Boyeria irene	46.08±7.38 (24)	8-177	120.0 ±70 (2)	50-190	34.67±1.38 (3)
Anax imperator	43.08±3.87 (36)	10-96	35.00±8.66 (3)	20-50	52.21±0.70 (15)
Aeshna mixta	30.25±6.87 (4)	lost data	**	–	35.40±1.30 (4)
Gomphus pulchellus	17.75±9.18 (4)	5-45	**	–	29.68±0.25 (8)
Onychogomphus uncatus	17.40±4.27 (5)	11-34	**	–	23.70±0.00 (1)
Orthetrum cancellatum	48.07±3.47 (45)	10-119	134.02±9.59 (42)	20-270	24.65±0.37 (13)
Libellula depressa	30.70±1.73 (37)	14-57	45.25±11.78 (12)	5-120	24.51±0.20 (29)
Sympetrum striolatum	34.73±1.56 (146)	5-132	49.33±5.23 (40)	10-150	17.14±0.09 (141)

* Only for individuals that emerged far from the water

** All exuviae were found on emergent vegetation

larva body length and mean height above the water (or ground for individuals emerging far from the water). There is a significant positive correlation between both variables (r=0.62, n=12, P=0.033). Larger species tended to climb further on the substrate. The correlation between body length and distance covered by larvae on the ground, for the species in which some individuals emerged far from the water is not significant (r=–0.10, n=6, P=0.851). Table I shows that there is great variation within species: for instance in *I. graellsii*, some larvae climbed just 1 cm above water, but one exuviae was found at a height of 46 cm. A. CORDERO (1988, *Limnética* 4: 11-8) analysed the present data for *Lestes viridis* and showed that most exuviae were found at a height of 6-20 cm, but one was found at 132 cm. P.S. CORBET (1962, *A biology of dragonflies*, Witherby, London, p. 103), presents observations of exceptional individuals of several Odonata: the maximum distance travelled by a dragonfly larva for emergence is 45 m, and the maximum height 6 m. My data are modest in comparison with these records, but indicate that some species, specially libellulids, have a tendency to travel far from water, while others climb only on the emergent vegetation (Tab. I).

The present observations suggest that larvae select their emergence sites with care, probably testing several supports beforehand, as P.S. CORBET (1962, *loc. cit.*, p. 101) describes for *P. nymphula*. Possible explanations for the positive correlation between larva size and height of emergence site could be that larger species need to climb more to be far enough from water for wing expansion, to avoid predators or to find a suitable microclimate. Another explanation could be to avoid interspecific interference during emergence. Nevertheless this last explanation seems unlikely because it could produce intraspecific competition. P.S. CORBET (1962, *loc. cit.* p. 103) indicates that larvae of *Sympetrum striolatum* normally travel only 15-30 cm from water and climb 7-12 cm. J. d'ANGUILAR, J.-L. DOMMANGET & R. PRÉCHAC (1985, *Guide des libellules d'Europe et d'Afrique*, Delachaux & Niestlé, Neuchâtel-Paris, p. 175) indicate that *Lestes viridis* climbs 40-60 cm for emergence. Both values are very different from my observations. In the same way P.S. CORBET (1952, *J. Anim. Ecol.* 21: 206-222) found that most *P. nymphula* larvae climbed about 2 cm above the water surface, while F.C. FRASER (1944, *Ent. mon. Mag.* 80: 92) found exuviae in trees at 6-9 m from the pond and 2 m from the ground. S. BENNETT & P.J. MILL (1993, *loc. cit.*) indicate that when emergence densities were high, larvae of *P. nymphula* tended to climb more on trees (up to 3 m), but suggest that this could be more a search for warmer sites than a case of competition for emergence supports, because supports were plentiful. Probably part of the divergences between studies is due to the fact that the availability of supports of diverse heights is different between habitats. If the vertical stratification of larvae that I have found is a matter of avoidance of interspecific competition, then we can test this hypothesis comparing the range of heights for the same species at communities with different species diversity.

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