Does Wind Affect Emergence Site Selection in Odonata?

Author(s): R. Khelifa , R. Zebsa , H. Amari & M.K. Mellal
Source: African Entomology, 21(2):383-387. 2013.

Published By: Entomological Society of Southern Africa
DOI: http://dx.doi.org/10.4001/003.021.0213
URL: http://www.bioone.org/doi/full/10.4001/003.021.0213

Does wind affect emergence site selection in Odonata?

R. Khelifa[1*], R. Zebsa[2], H. Amari[2] & M.K. Mellal[2]

[1]*Département de Biologie, Faculté des Sciences Biologiques et Agronomiques, Université de Tizi Ouzou, Tizi Ouzou 15000, Algeria*

[2]*Département d'Ècologie et du Génie de l'Environnement, Faculté des Sciences de la Nature et de la Vie et des Sciences de la Terre et de l'Univers, Université 08 Mai 1945, Guelma 24000, Algeria*

All species have specific habitat preferences in which survival and reproduction are optimal. Understanding factors governing habitat selection is crucial in the field of community ecology and conservation biology (Schoener 1974; Pulliam & Danielson 1991; Morris 2003; Peterson & Dunham 2003; Johnson *et al.* 2004). Factors affecting a species' spatial distribution within a habitat are mainly the abiotic conditions, resource availability, predation, competition, and parasitism (Ricklefs & Miller 1999). During certain periods of their lifetime species are periodically vulnerable to abiotic and biotic external factors, making (micro-) habitat choice particularly crucial and producing direct and indirect demographic consequences on population and community (Cody 1985; Downie *et al.* 2004). Arthropod moulting is an example of such vulnerable life stages (Morgan & Miller 2005).

Between the aquatic larval stage and the terrestrial (aerial) adult phase, aquatic insects like Odonata (dragonflies and damselflies) pass through a critical step, which is emergence (Corbet 1999). During this stage the larva leaves the water, chooses a suitable support, and conducts the last ecdysis during which time the soft individual, vulnerable to wind damage, must remain immobile for a substantial period of time (usually from 0.5 to 2 hours) in order to complete the process and take the first (maiden) flight (Corbet 1962). Exuviae (the exoskeletons) remain at the emergence sites for some time after the adults have dispersed, signalling successful emergence (Raebel *et al.* 2010). Thus, the relative abundance (both spatially and temporally) of exuviae throughout a natural environment may be regarded as some indication of individual microhabitat selection decisions.

Wind is an important meterological factor that affects abundance (Murty *et al.* 2011), dispersal (Manoukis *et al.* 2011), food availability (Dunn 1975), foraging success (Turner 1980), and reproductive success of animal species (Weimerskirch *et al.* 2012). Jakob & Suhling (1999) have shown that strong wind can damage dragonflies during emergence. Deformity of soft wings condemns odonates to death or to lower reproductive success (Purse & Thompson 2003). One idea is that the level of wind disturbance in certain forest (similar to wetlands) would be heterogeneous, *i.e.* wind/gust intensity is more intense in open areas where vegetation is sparse and less so in highly vegetated ones (Webb 1999). Moreover, upper parts of emergent plants should also be more affected by wind than lower parts. Therefore, distribution of exuviae during windy days should be different in terms of vertical stratification and occupancy of vegetated areas.

We tested this hypothesis using the damselfly *Erythromma lindenii* Sélys as a model species because it is one of the earliest emerging odonates in North Africa, starting in late March to early April, a period dominated by windy days. The aim of the current investigation was to understand how this odonate uses heterogeneous habitat to cope with the environmental force of wind and successfully emerge from the water.

This study was undertaken in a 0.4 ha pond at 3 km northwest from El Fedjoudj province, Guelma, Algeria (36°31′54.30″N 7°22′48.08″E). Maximum water depth was 2 m and bank vegetation was heterogeneous and mainly consisted of *Typha angustifolia*, *Scirpus lacustris, Cyperus longus*, and *Paspallum distichum*.

Emergence of *E. lindenii* occurred mainly in the early morning. Exuviae were searched for and collected daily during the late afternoon (between 15:30 and 16:30 h) from 2 April (the onset of emergence season) to 1 May 2012 along 80 plots of 1 × 1 m of bank vegetation. The total number of exuviae collected in a given day was considered as the daily emerging population size.

For the rest of the paper, 'exuvia height' and 'support height' correspond to the vertical distance from the water surface to the tip of exuvia caudal lamellae and from the water surface to the tip of the plant used at emergence, respectively. Both variables were measured to the nearest cm using a 5 m decameter. Since exuviae used different emer-

---

[*] Author for correspondence. E-mail: rassimkhelifa@gmail.com

African Entomology **21**(2): 383–387 (2013)

Table 1. Pairwise Spearman correlations of five variables ($n = 425$).

	Mean wind speed	Max wind speed	Vegetation density	Exuvia height	Support height
Mean wind speed	1	0.36**	0.75**	–0.30**	–0.19**
Max wind speed		1	0.20**	–0.27**	–0.20**
Vegetation density			1	–0.23**	0.15**
Exuvia height				1	0.71**
Support height					1

**Highly significant correlation ($P < 0.0001$).

gence sites within different vegetation covers from one day to another, 'vegetation density' around exuvia was measured with a 1 × 1 m quadrate to the nearest 5 % to determine the species microhabitat choice. Exuvia head width was measured to the nearest 0.01 mm with a digital calliper. Daily mean and maximum speed of wind (m/s) were obtained from a meteorological station located at 12 km from the study pond. Beaufort wind scale was used to classify days into different categories according to wind velocity, 0: calm (0.3 m/s), 1: light air (0.3–1.5 m/s), 2: light breeze (1.6–3.4 m/s), 3: gentle breeze (3.5–5.4 m/s), etc. (Huler 2004). During the study period, only categories 1 to 3 were detected.

Statistical analyses were conducted using SPSS 17.0 (SPSS 2008). All data were tested with non-parametric tests due to departure from normality. In order to assess the effect of wind on vertical stratification and microhabitat choice, Spearman rank correlations were performed between exuviae height, support height, vegetation density, and wind speed (mean and maximum). Spearman's rank correlations were also conducted to test the relationships between the daily emerging population size, exuvia height, support height, vegetation density around exuvia and wind speed. Mann-Whitney *U*-tests were used to identify whether there were any significant differences in exuvia head width, exuvia height, support height, and vegetation density between males and females.

A total of 425 exuviae (220 males and 205 females) were collected during 30 days of sampling. No exuvia was recorded out of the pond. Mean exuvia height was 25.58 ± 22.17 cm (2–130 cm), mean support height was 45.76 ± 31.45 cm (3–170 cm), and mean vegetation density was 41.5 ± 21.51 % (5–80 %). Vertical stratification of *E. lindenii* was higher than all zygopteran species presented by Cordero (1995) including *Ischnura graellsii, Lestes viridis, L. virens*, and *Platycnemis latipes*. However, higher positions were recorded in another zygopteran *Pyrrhosoma nymphula* at 6 to 9 m further from the water climbing on trees up to 2 m above the ground (Bennett & Mill 1993).

There was a significant difference in exuvia height between males and females ($U = 19322.5$, $P = 0.01$) but no differences between sexes were noted in either their choice of support height ($U = 21288.5, P = 0.31$) or the density of the vegetation in which they emerged ($U = 21661.5$, $P = 0.53$). Females climbed higher than males (28.37 ± 23.93 cm, 22.99 ± 20.10 cm, respectively) probably because females had significantly larger head width ($U = 116$, $P = 0.02$). This differential vertical stratification of exuviae between sexes has not been investigated in previous studies. However, it might also be related to differential maiden flight between sexes, *i.e.* females might climb higher to take a longer flight while males climb lower heights and fly shorter distance. This assumption requires an independent study that takes into account both the exuvia height and maiden flight distance for each sex.

Pairwise Spearman correlations of all variables related to microhabitat choice are presented in Table 1. Exuvia height, for both sexes, was highly positively correlated with support height ($r = 0.71$, $P < 0.0001$). Over the study period, the mean and maximum wind speeds were 1.97 ± 1.25 m/s and 9.30 ± 3.03 m/s, respectively. Using Beaufort scale of wind speed, 54 % of days had light air, 26 % light breeze, and 20 % gentle breeze. Mean and maximum wind speed were significantly negatively correlated to exuvia height ($r = 0.30$, $P < 0.0001$; $r = –0.27$, $P < 0.0001$, respectively) (Fig. 1) and support height ($r = –0.19$, $P < 0.0001$; $r = –0.20$, $P < 0.0001$, respectively) (Table 1). However, mean and maximum wind speed were positively related to vegetation density where exuviae were found ($r = 0.75$, $P < 0.0001$; $r = 0.20$, $P < 0.0001$, respectively) (Fig. 2). That is, when wind speed was high

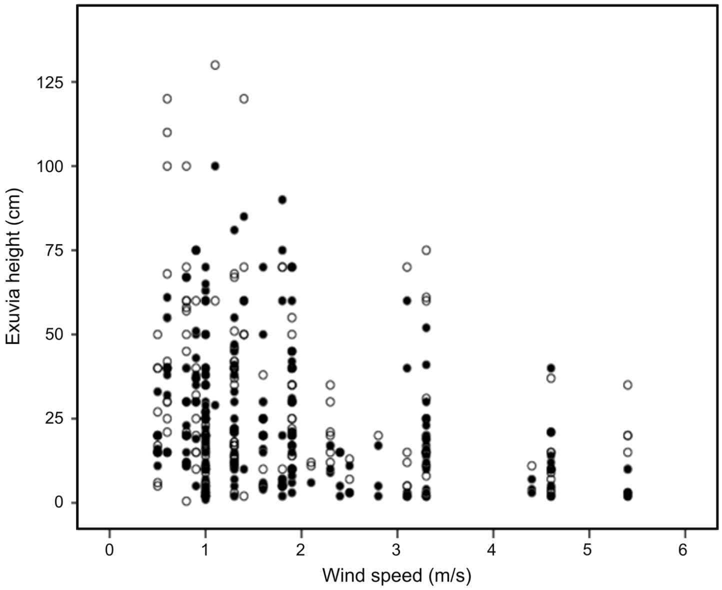

Fig. 1. Scatter plot showing exuvia height as a function of wind speed. Black and open circles represent males and females, respectively.

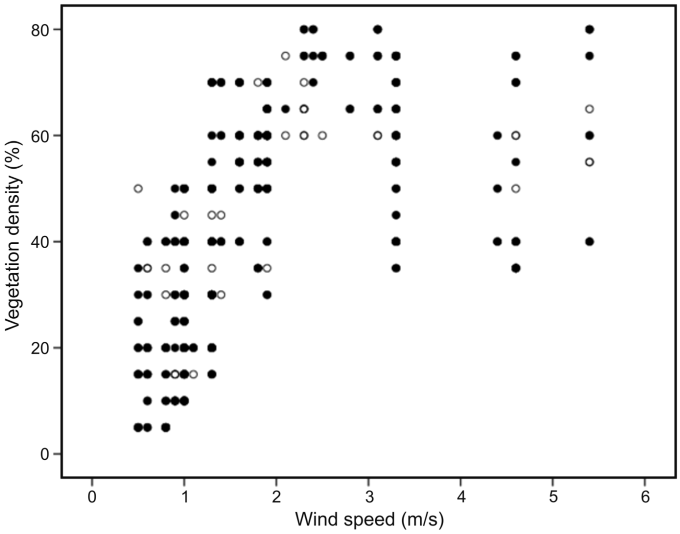

Fig. 2. Scatter plot showing vegetation density around exuvia as a function of wind speed. Black and open circles represent males and females, respectively.

larvae tended to choose lower heights, lower supports, and highly vegetated areas in order to emerge successfully without any damage. Another alternative explanation is that wind might not have behavioural effects in habitat choice but at higher wind speed the exuviae get blown off the plants if they are higher. Indeed, low vegetated sites and upper parts of emergent plants were subject to higher turbulences in windy conditions. Studies on butterflies showed that some species like *Thymelicus lineola* tended to fly nearer to the ground (Pivnick & McNiel 1987) while others occupied sheltered areas (Dover *et al.* 1997) to avoid strong wind. In another study on mosquitoes, Service (1980) showed that forest-dwelling species were less affected by wind than those inhabiting open areas.

In addition, mean and maximum wind speed were not significantly correlated to daily emerging population size (r = –0.12, P = 0.51; r = –0.14, P = 0.45, respectively). Neither the mean height of exuviae above water nor the mean height of the chosen support were significantly correlated with the daily emerging population size (r = 0.13, P = 0.49; r = –0.08, P = 0.66, respectively). Unlike Bennett & Mill (1993) who found that vertical stratification was affected by emerging larva density in *P. nymphula*, the current study did not reveal this trend. A likely reason for this is that the number of emerging individuals, including all Odonata species, was not particularly high during the study period (only three species) and the number of potential supports were abundant. Therefore, intra- or interspecific competition for emergence sites was likely to be low.

Future studies should investigate whether odonate species respond differently to wind speed during emergence according to body size. For example, at the same level of wind speed, emergence site selection of smaller species like Coenagrionidae might be affected while larger species like Aeshnidae might not.

ACKNOWLEDGEMENTS

We would like to thank A. Guebailia and N. Bouyedda for their laboratory assistance. Thanks to H. Mahdjoub for kindly helping us with data organization. We thank two anonymous reviewers for their constructive comments which helped us to improve an earlier version of the manuscript.

REFERENCES

BENNETT, S. & MILL, P.J. 1995. Lifetime egg production and egg mortality in the damselfly *Pyrrhosoma nymphula* (Sulzer) (Zygoptera: Coenagrionidae). *Hydrobiologia* **310**: 71–78.

CODY, M.L. 1985. *Habitat Selection in Birds*. Academic Press, London, U.K.

CORBET, P.S. 1962. *A Biology of Dragonflies*. H.F. and G. Witherby, London, U.K.

CORBET, P.S. 1999. *Dragonflies: Behaviour and Ecology of Odonata.* Harley Books, Colchester, U.K.

CORDERO, A. 1995. Vertical stratification during emergence in odonates. *Notulae Odonatologicae* ***4: 103***–105.

DOVER, J.W., SPARKS, T.H. & GREATOREX-DAVIES, J.N. 1997. The importance of shelter for butterflies in open landscapes. *Journal of Insect Conservation* **1**: 89–97.

DOWNIE, J.R., BRYCE, R. & SMITH, J. 2004. Metamorphic duration: an under-studied variable in frog life histories. *Biological Journal of the Linnean Society* **83**: 261–272.

DUNN, E.K. 1975. The role of environmental factors in the growth of tern chicks. *Journal of Animal Ecology* **44**: 743–754.

HULER, S. 2004. *Defining the Wind: The Beaufort Scale, and How a 19th-Century Admiral Turned Science into Poetry.* Crown Publishers, New York, U.S.A.

JAKOB, C. & SÜHLING, F. 1999. Risky times? Mortality during emergence in two species of dragonflies (Odonata: Gomphidae, Libellulidae). *Aquatic Insects* **21**: 1–10.

JOHNSON, C.J., SEIP, D.R. & BOYCE, M.S. 2004. A quantitative approach to conservation planning: using resource selection functions to map the distribution of mountain caribou at multiple spatial scales. *Journal of Applied Ecology* **41**: 238–251.

MANOUKIS, N.C., BABER, I., DIALLO, M., SOGOBA, N. & RIBEIRO, J.M.C. 2011. Seasonal climate effects aemotaxis in newly emerged adult *Anopheles gambiae* Giles in Mali, West Africa. *PLoS ONE* 6(11), e26910. doi:10.1371/journal.pone.0026910

MILLER, P.L. 1964. Notes on *Ictinogomphus ferox* Rambur (Odonata: Gomphidae). *Entomologist* **97**: 52–66.

MORGAN, S. & MILLER, R.N. 2005. *Arthropods*. Heinemann-Raintree, Mankato, MN, U.S.A.

MORRIS, D.W. 2003. Toward an ecological synthesis: a case for habitat selection. *Oecologia* **136**: 1–13.

MURTY, U.S., RAO, M.S. & ARUNACHALAM, N. 2011. The effects of climatic factors on the distribution and abundance of Japanese encephalitis vectors in Kurnool district of Andhra Pradesh, India. *Journal of Vector Borne Diseases* **47**: 26–32.

PETERSON, J.T. & DUNHAM, J.A. 2003. Combining inferences from models of capture efficiency, detectability, and suitable habitat to classify landscapes for conservation of threatened bull trout. *Conservation Biology* **17**: 1070–1077.

PIVNICK, K.A. & McNIEL, J.N. 1987. Diel patterns of activity of *Thymelicus lineola* adults (Lepidoptera: Hesperiidae) in relation to weather. *Ecological Entomology* **12**: 197–207.

PULLIAM, R.H. & DANIELSON, B.J. 1991. Sources, sinks, and habitat selection: a landscape perspective on population dynamics. *The American Naturalist* **137**: S51–S66.

PURSE, B.V. & THOMPSON, D.J. 2003. Emergence pattern of the damselflies *Coenagrion mercuriale* (Charpentier) and *Ceriagrion tenellum* (Villers) (Odonata: Coenagrionidae), two species at their northern range margins. *European Journal of Entomology* **100**: 93–99.

RAEBEL, E.M., MERCKX, T., RIORDAN, P., MACDONALD, D.W. & THOMPSON, D.J. 2010. The dragonfly delusion: why it is essential to sample exuviae to avoid biased surveys. *Journal of Insect Conservation* **14**: 523–533.

RICKLEFS, R.E. & MILLER, G.L. 1999. *Ecology.* W.H.

Freeman & Co, New York, U.S.A.

SCHOENER, T.W. 1974. Resource partitioning in ecological communities. *Science* **185**: 27–39.

SERVICE, M.W. 1980. Effects of wind on the behaviour and distribution of mosquitoes and blackflies. *International Journal of Biometeorology* **24**: 347–353.

SPSS. 2008. *SPSS Statistics for Windows*, Version 17.0. SPSS Inc., Chicago, U.S.A.

STOKS, R. & CORDOBA-AGUILAR, A. 2012. Evolutionary ecology of Odonata: a complex life cycle perspective. *Annual Review of Entomology* **57**: 249–265.

TROTIER, R. 1973. Effect of temperature and humidity on the emergence behaviour of *Anax junius* (Odonata: Aeshnidae). *The Canadian Entomologist* **105**: 975–984.

TURNER, A.K. 1980. The use of time and energy by aerial feeding birds. Ph.D. thesis, University of Stirling, Stirling, U.K.

WEBB, S.L. 1999. Disturbance by wind in temperate-zone forests. In: Walker. L.R. (Ed.) *Ecosystems of the World 16: Ecosystems of Disturbed Ground*. 187–222. Elsevier, New York, U.S.A.

WEIMERSKIRCH, H., LOUZAO, M., DE GRISSAC, S. & DELORD, K. 2012. Changes in wind pattern alter albatross distribution and life-history traits. *Science* **335**: 211–213.

Accepted 9 July 2013