# BURROWING BEHAVIOR OF *PROGOMPHUS BOREALIS* (McLACHLAN) LARVAE (ANISOPTERA: GOMPHIDAE)

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**Abstract** – Burrowing behavior was studied in the Big Sandy River (Mojave co., Arizona, USA). Observations of (1) burrowing speed and (2) trail length of different instars are discussed. *P. borealis* is shown to have the fastest burrowing speed of all larval odon. on record.

**Introduction**

Larvae in the family Gomphidae have the ability to burrow head-first into substrates using anal propulsion and leg movement, often creating characteristic "trails" by burrowing long distances just below the sediment surface (CORBET, 1999; DUNKLE, 1984; HUGGINS & DUBOIS, 1982). Burrowing speed, the time required for a larva to bury itself completely beneath the substrate, varies widely within the family. HUGGINS & DUBOIS (1982) recorded *Progomphus obscurus* and *Gomphus externus* larvae burrowing from sight under substrate in 2-5 and 40-70 seconds, respectively. *Progomphus borealis* has been described as more adapted for burrowing than any other odonate larva (KENNEDY, 1917), but details of its behavior have not been recorded. In this study we examine trail length and burrowing speed of *P. borealis*.

**Study area**

The study was conducted in the Big Sandy River at the crossing of Signal Road (34°33.935' N, 113°34.585' W, Arizona, USA: Mojave county). This is a wide flood-plain (average width 38.9±11.04 m; average depth 3.75±2.12 cm), highly braided (average underwater portion from left to right bank edges 57±14%), sandy river (substrate composition 93.7% coarse sand, 5.27% fine sand, 0.75% fine gravel, 0.21% coarse gravel, and 0.06% silt/ clay). The entire study reach was 165 meters in length. Riparian vegetation primarily includes salt cedar (*Tamarix*), willow (*Salix*), and mesquite (*Prosopis*). At the first sampling date, water temperature was 22.8°C, pH was 8.68, conductivity was 1418 µs, and dissolved oxygen was 7.54 ppm.

**Burrowing speed**

We captured 24 larvae on 21 April 2007 and measured head width, hind wingpad length, and burrowing speed (time from initial movement when directly placed on moist substrate until coverage with substrate; Fig. 1). The experiment was repeated on 3 April 2009 with 15 additional larvae. Larvae were categorized into four distinct groups which corresponded to developmental stages, as determined by body size and coloration. Groups F-2 through F-0 were progressively larger instars (average head widths 2.95±.07mm, 3.87±.07mm, and 4.93±.11mm respectively) while EF-0 larvae were close to emergence as indicated by eye and wingpad coloration. F-0 larvae had black eyes and plain wingpads characteristic of younger larvae, while EF-0 larvae exhibited cloudy eyes due to corneal detachment and visibly-folded adult wings below the wingpads (T.D. Schultz, pers. comm.).

The average burrowing speed was 2.38s (n=24; ±1.05s) on the first sampling date and 7.89s (n=15; ±3.49s) on the second (Fig. 2). The fastest burrowing time observed was 0.72s by a larva with a head width of 2.9mm and a hind wingpad length of 1.2mm, which is faster than other published dragonfly larvae burrowing speeds, the second fastest being *Gomphus externus* at 2 seconds (HUGGINS & DUBOIS, 1982).

A multifactorial fixed-effects ANOVA found a significant difference in burrowing speed between groups of larvae ($p=0.001$) and sampling date ($p<0.001$), but no significant interaction ($p=0.11$) (Fig. 2). Factors such as antecedent flow conditions of the river, time of day, or weather could affect burrowing speed. Body size had a strong effect on burrowing speed, with smaller instars generally burrowing more quickly than larger instars. Larvae near emergence (group EF-0) had significantly slower burrowing speeds than other groups including group F-0, even though individuals in groups F-0 and EF-0 were the same size. While almost all larvae in groups F-3 through F-0 began to burrow within several seconds of being placed on the substrate, individuals of group EF-0 often took more than four seconds to begin. GREVENS (1979) noted that *Cordulegaster boltonii* larvae near ecdysis were relatively inert. Larvae that are near to emergence may be expending more energy on changing body parts than on movement and growth (G.L. Harp, pers. comm.), and thus could be more vulnerable to predators.

Fig. 1. ***Progomphus borealis***: head-first burrowing and trail produced by a tunneling larva.

**Trail characteristics**

We measured 30 trails created by *P. borealis* burrowing in sandbars in or near the water. The average trail length was 1.81 m (n=49; ±1.21m). The longest trail was 6.1 m, made by a larva with a head width of 5 mm and a hind wing-pad length of 6.9 mm. This is within the range observed by KENNEDY (1917), who recorded *P. borealis* tracks that reached lengths of 3 to 15 m. The trails found on sandbars did not appear to be directional. Thirty-seven percent of the trails crossed themselves at least once. The maximum number of times a trail crossed itself was 9, and that trail was 3.86m long. The tracks ended at the edges of the sandbars, where larvae either had entered or left the water. There could be various explanations for why *P. borealis* larvae leave moving water and crawl through sandbars. Prey may be more abundant or easier to see and catch in sandbars. While predation due to other fish and other aquatic insects may be reduced by leaving the flowing water, the visibility of the tracks may make the larvae more vulnerable to predators such as frogs or birds. Burrowing, under certain circumstances, could also be a disturbance-avoidance behavior. LYTLE et al. (2008) observed high densities of *P. borealis* larvae burrowing upstream to avoid a drying reach of river.

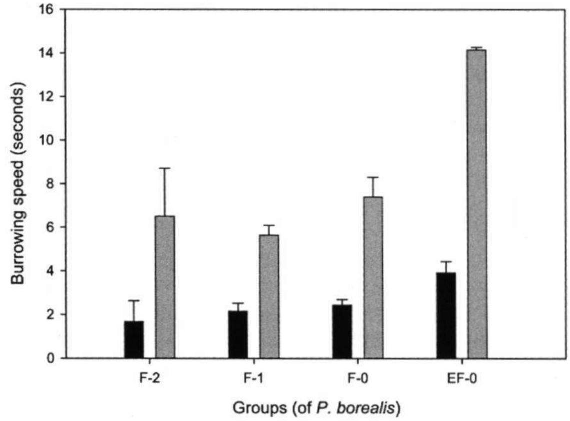


Fig. 2. *Progomphus borealis*: burrowing speed (with standard errors) from time of initial movement until coverage with substrate, for four groups of larvae. Black bars are from the first sampling date, and gray bars are from the second sampling date.

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