Supplementary information for

Behavioral variation in the pygmy halfbeak *Dermogenys collettei*: comparing shoals with contrasting ecologies

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# Equal contribution

Supplementary Table S1. Sample sizes of shoals in different ecologies at the three water bodies: Jurong Lake Gardens (lake), Springleaf Nature Park (river) and Windsor Nature Park (stream).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  | Location | | |
| Environmental characteristic | **Classification scheme** | **Jurong Lake Gardens** | **Springleaf Nature Park** | **Windsor Nature Park** |
| Canopy cover | Absent | 6 | 4 | 0 |
|  | Average | 2 | 3 | 3 |
|  | Full | 3 | 0 | 5 |
|  |  |  |  |  |
| Aquatic vegetation | None | 8 | 1 | 2 |
|  | Present | 3 | 6 | 6 |
|  |  |  |  |  |
| Water depth | Shallow (<30 cm) | 3 | 4 | 3 |
|  | Deep (>30cm) | 8 | 3 | 5 |
|  |  |  |  |  |
| Water flow | Still | 10 | 0 | 3 |
|  | Moving | 1 | 7 | 5 |

Supplementary table S2: The summary of the principal component analysis used to describe the shoal’s behavior is reported together with the standard deviation, the loading factors and each behavioral index used. Principal components with an eigenvalue smaller than 1 (PC4 and PC5) have been dropped.

|  |  |  |  |
| --- | --- | --- | --- |
| Behavioral measurement | PC1 | PC2 | PC3 |
| Total duration of sexual interactions | -0.489 | -0.492 | 0.001 |
| Total number of sexual interactions | -0.460 | -0.380 | -0.270 |
| Total number of agonisticbehaviors | -0.214 | 0.103 | 0.922 |
| Total duration of swimming behaviors | -0.306 | 0.730 | -0.276 |
| Total duration of stationary behaviors | 0.640 | -0.266 | -0.017 |
|  |  |  |  |
| Standard deviation | 1.46 | 1.16 | 1.00 |
| Proportion of variance explained | 0.43 | 0.27 | 0.20 |

Supplementary table S3. The average value of the behaviors recorded in the study is reported together with S.E. and range. The sum of courtship, agonistic and locomotory behaviors are also shown. All behaviors are standardized to one minute of observation. \* = performed behavior for males, received behavior for females.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Behavior | | | Male behaviors  Mean ± SE (range) | Females behaviors  Mean ± SE (range) | |
| a) Sexual interactions | | |  |  | |
|  | *i) Courtship duration data* | |  |  | |
|  | | Following females (s)\* | 16.18 ± 1.74 (0.48 – 42.55) | | 10.06 ± 1.68 (0 - 30.04) | |
|  | | Swimming under (s)\* | 2.06 ± 0.54 (0 – 10.43) | | 1.23 ± 0.33 (0 - 5.29) | |
|  | | **Total duration of courtship behaviors\*** | **18.24 ± 1.94 (0.68 – 44.96)** | | **11.30** ± 1.72 (**0 - 30.57)** | |
|  | | |  |  | |
|  | *ii) Courtship count data* | |  |  | |
|  |  | Approaching an individual of the other sex | 0.17 ± 0.08 (0 – 1.62) | | 0.01 ± 0.01 (0 – 0.16) | |
|  |  | Being approached by an individual of the other sex | 0.02 ± 0.01 (0 – 0.24) | | 0.21 ± 0.05 (0 – 1.01) | |
|  |  | Circling a female\* | 0.41 ± 0.13 (0 – 2.97) | | 0.13 ± 0.043 (0 - 0.90) | |
|  |  | Checking a female\* | 0.06 ± 0.02 (0 – 0.36) | | 0.05 ± 0.022 (0 - 0.41) | |
|  |  | Switching to new female\* | 0.27 ± 0.09 (0 – 1.78) | | 0.002 ± 0.002 (0 - 0.06) | |
|  |  | Mating attempt\* | 0.04 ± 0.02 (0 – 0.51) | | 0.002 ± 0.002 (0 - 0.06) | |
|  |  | **Total number of courtship behaviors\*** | **0.97 ± 0.19 (0 – 3.49)** | | **0.43** ± 0.08 (**0 - 1.64)** | |
|  |  |  |  | |  | |
| b) Agonistic behaviors | | |  |  | |
|  |  | Chasing | 0.85 ± 0.26 (0 – 6.28) | | 0.15 ± 0.08 (0 - 1.97) | |
|  |  | Being chased | 0.47 ± 0.14 (0 – 3.75) | | 0.04 ± 0.02 (0 - 0.45) | |
|  |  | Displacing | 0.10 ± 0.03 (0 – 0.65) | | 0.004 ± 0.004 (0 - 0.10) | |
|  |  | Being displaced | 0.06 ± 0.02 (0 – 0.51) | | 0 ± 0 (0 – 0) | |
|  |  | Frontal threatening with female | 0.03 ± 0.02 (0 – 0.46) | | 0.02 ± 0.01 (0 - 0.31) | |
|  |  | Frontal threatening with male | 0.15 ± 0.05 (0 – 1.13) | | 0.01 ± 0.01 (0 - 0.37) | |
|  |  | Biting | 0.09 ± 0.04 (0 – 0.73) | | 0.003 ± 0.003 (0 - 0.09) | |
|  |  | **Total number of agonistic behaviors** | **1.78 ± 0.30** (**0.10 – 6.85)** | | **0.23 ± 0.10** (**0 - 2.42)** | |
|  |  |  |  | |  | |
| c) Locomotor behaviors | | |  |  | |
|  |  | Stationary duration (s) | 14.63 ± 2.26 (0 – 37.83) | | 32.18 ± 2.69 (2.87-54.13) | |
|  |  | Swimming duration (s) | 19.75 ± 2.31 (0.56 – 50.47) | | 14.03 ± 2.49 (0.55-48.71) | |
|  |  | **Total duration of locomotor behaviors** | **34.38 ± 2.14** (**9.94 – 52.25)** | | **46.22 ± 1.81 (28.57-60.00)** | |

Supplementary Table S4. Behavioral scores are not affected by the time of day that behavioral observations were performed. Time of day was divided into three categories across schoals: morning (9:00 – 11:30, n = 8 shoals), mid-day (11:31 – 14:00, n = 11), and afternoon (14:01 – 17:00, n = 7). For six shoals, behavioral observations spanned two time categories, although the majority of behaviors fell into a single time category in each case. In these cases we classified the time category based on where the majority of obsrevations were performed. In each model we included sex (males and females) as a fixed effect. Interaction terms bewteen time of day and sex were not significant in all models and were therefore removed. Simplified models are presented. All models included shoal identiy as a random effect to account for the fact that males and females shared the same shoal.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Response | Predictor | df | χ2 | p |
| PC1 | Time of day | 2 | 0.09 | 0.96 |
|  | Sex | 1 | 48.15 | **<0.001** |
| PC2 | Time of day | 2 | 4.43 | 0.11 |
|  | Sex | 1 | 0.37 | 0.54 |
| PC3 | Time of day | 2 | 1.69 | 0.43 |
|  | Sex | 1 | 12.33 | **<0.001** |

Supplementary Figure S1. The pictures are representative of observation sites with different environmental characteristics as reported in the main text. Red arrows point to water sections where halfbeaks were observed. Panel A), a site in Seletar river with no canopy cover is shown. Panels B) and C) show two sites in Jurong Lake Gardens with respectively average and full canopy cover, whereas panel D) shows a site in Windsor Nature Park with full canopy cover. In E) a shallow site in Windsor National Park and in F) a site with deep water in Seletar river. In panel G) a site with no aquatic vegetation as seen in Jurong Lake Gardens can be compared with a site H) with aquatic vegetation in Seletar river.

