Vol. 420: 273–276, 2010
doi: 10.3354/meps08899

MARINE ECOLOGY PROGRESS SERIES
Mar Ecol Prog Ser

Published December 16

NOTE

‘Personality’ in two species of temperate damselfish

A. Cecilia Eriksson[1], David J. Booth[1], Peter A. Biro[1,2,*]

[1]Department of Environmental Sciences, University of Technology, Sydney, New South Wales 2007, Australia
[2]Evolution & Ecology Research Centre, School of Biological, Earth & Environmental Sciences, University of New South Wales, Sydney, New South Wales 2052, Australia

ABSTRACT: The extent and importance of consistent individual differences in behaviour, often referred to as ‘personality’ or ‘temperament’, is a relatively recent question in ecology. It indicates that animal behaviour is much less flexible than usually assumed, and suggests that individuals consistently differ in the way they perceive and react to changes in the environment. There is evidence of animal personality in a wide variety of animal taxa, including many freshwater fish species, but there seems to be very little evidence for this phenomenon in marine fish. To address this paucity, we repeatedly measured 3 behavioural traits of 2 temperate marine damselfish species, *Parma microlepis* and *P. unifasciata*, over a 2 wk period. Consistent individual differences in boldness, aggressiveness and activity were observed in both species, but average levels of these traits did not differ between species. A correlation between personality traits was also observed, with bolder individuals also tending to be more aggressive. The existence of personality in marine fish has implications for practical issues such as sampling bias, vulnerability to harvest and links between personality and life-history traits that affect fitness.

KEY WORDS: Behaviour · Boldness · Longitudinal · Mixed model · Repeatability · Temperament

INTRODUCTION

In recent years, there has been an increased interest among ecologists in consistent individual differences in behavioural traits, often referred to as ‘personality’ or ‘temperament’. The concept of animal personality suggests that individuals consistently differ in the way they perceive and behave in a given environment, in contrast to the traditional viewpoint that behaviour is completely flexible (Sih et al. 2004, Reale et al. 2007). In addition, personality has practical implications such as for sampling methods (gear bias for bolder individuals; Biro & Dingemanse 2009), and on the selective effects of fish harvesting (Biro & Post 2008).

Although there is evidence of personality in a wide variety of animal taxa, including numerous freshwater fish species (Sih et al. 2004, Reale et al. 2007), there seems to be very little evidence for this phenomenon in marine fish with the exception of 3 studies: 1 study on stability of behavioural syndromes in rockfish (Lee & Bereijikian 2008), 1 study on behavioural correlations in Caribbean damselfish (Snekser et al. 2009) and 1 study showing personality in 2 species of tropical damselfish (Biro et al. 2010). Given the rich taxonomic, social and competitive environments of temperate marine fish communities relative to temperate freshwater fish assemblages, we might expect marine fish to exhibit greater behavioural flexibility and greater differences in behaviour among species that serve to reduce competition and predation and allow persistence. In light of these differences, and the paucity of data for marine fish, the purpose of this study was to test for evidence of personality in 2 other marine fish species to begin to assess the extent of this phenomenon in marine fish and to bring this topic to the attention of marine ecologists.

*Corresponding author. Email: peter.biro@unsw.edu.au

MATERIALS AND METHODS

In this study, we used juveniles of 2 species of damselfish (Pomacentridae), *Parma microlepis* and *P. unifasciata*. Both species are territorial temperate damselfish and are abundant on the rocky reefs of New South Wales (NSW), Australia (Buckle & Booth 2009). We collected fish using SCUBA, clove oil solution (sprayed around and over the fish to lightly anaesthetize it) and hand nets from February to April 2008 at Long Reef Beach, Sydney, NSW, on 3 different occasions due to limited fish availability on each occasion. Experiments were consequently performed in 3 blocks over a period of 3 mo. In total, 34 fish were caught and transported to the laboratory: 16 *P. microlepis* and 18 *P. unifasciata*. Although our sampling method may have been biased towards bolder individuals (see Biro & Dingemanse 2009), we nonetheless captured several fish of both species that spent almost no time moving and displayed no aggression, suggesting that any bias was not severe. Captured fish ranged in size from 19.2 to 68.2 mm total length, although as we show later, there was no effect of size on behaviour.

Fish were individually housed in rectangular aquaria (22 cm wide × 35 cm long × 22 cm deep) that were visually isolated from one another. Each tank was filled to a depth of 20 cm with sea water, and a 10 cm section of plastic PVC tube (4 cm diameter) was placed against the back wall to act as a refuge which the fish readily used. A small filter unit in each tank ensured aeration and filtration of excess nutrients. Nonetheless, we changed 80% of the water in all tanks every 4 d. An opaque, black curtain was strung up in front of the tanks, and small holes were cut to enable observations without disturbing the fish. The fish were fed ad libitum 4 times a day for the entire trial period with small (0.3 mm) Spectrum Grow pellets; uneaten food that settled to the bottom was siphoned off every other day, or more often if needed. Light conditions were kept as close as possible to ambient (lights on: ~07:00 to 18:00 h). Because even small fluctuations in temperature can have large effects of fish behaviour (Biro et al. 2010), we were careful to ensure that the temperature was kept as consistent as possible (range: 21.3 to 22.7°C), and close to ambient sea temperature at the time of collection, using a single 25 W heater placed in each tank. A thermometer in each tank was checked twice a day. The fish were acclimated to their new environment for 3 d before the commencement of the observation period on Day 4. During this period, fish were also fed 4 times daily as described above.

The observation period lasted 14 d for each experimental block. During this period, 3 personality traits (PTs) were quantified: activity, boldness and aggressiveness, with 6 repeats per trait per individual. Each PT was quantified once per day spread out over 14 d (on Days 4 and 5, 8 and 9, and 12 and 13). Each test was performed at approximately the same time each day, and fish were observed in the same order at every repeat, to ensure that repeats for each individual were carried out at roughly the same time of day. An hour was allowed to elapse between each behavioural trial for each PT to minimise any disturbance effects from the previous test.

Activity was estimated as time spent moving around in the tank, when not in the refuge, during a 3 min period; movement was defined as the fish moving more than 0.5 body lengths in any direction. Boldness was measured by the latency to leave the refuge after a simulated predator attack. A plastic rod was used to 'attack' the fish, by quickly striking towards the fish, stopping about 1 body length from the individual. If the fish was not outside the refuge at the outset, an attack into the centre of the tank was made. All individuals came out of the refuge within 3 min. Aggression was measured as the response of the fish to their own mirror images. Mirrors have been successfully used in previous studies of aggression (e.g. Karino & Someya 2007). A string was attached to each side of a mirror (10 × 12 cm), to enable it to be lowered down into the aquaria with minimal disturbance. The mirror was placed on the opposite side of the aquarium to the refuge (nearest the observer), in a corner facing the refuge. We observed fish for 5 min beginning when the fish could first be seen looking out from the refuge following the disturbance of introducing the mirror, and noted instances of aggression thereafter. Aggression was defined as time spent within 1 body length distance from the mirror, and involved movement (sometimes an initial charge) to the mirror and abruptly stopping directly in front of it, followed by displays such as tail flicks, fin flare and reversing slowly towards the mirror.

We tested for evidence of personality (consistent individual differences) using a general linear model with mixed effects (random and fixed), using Proc-Mixed in SAS. Individual identity was the random intercept effect, and initial fish mass, observation number, species identity and experimental block were specified as fixed effects to control for their effects. Thus, this statistical model generates individual-specific predictions, while also controlling for the various fixed effects. A significant random intercept effect would, in this model, indicate consistent individual differences (i.e. repeatability) in behaviour among individuals. The 'covtest' option was used to test whether the variance component associated with the random intercept effect was significant, and therefore whether there was significant repeatability in behaviour. Repeatability values were calculated as the proportion of total variance that was accounted for by variation among individuals. Degrees of freedom were calculated using the Kenward-Roger method. A saturated model was used at the beginning of the model fitting, and factors were thereafter removed one at a time if not significant ($p > 0.10$), and the model re-fitted; parameters with the largest p-values were removed first. Data for activity and aggression were arcsine square root transformed prior to the analysis to normalise the data, and the data for boldness were log transformed.

To test whether activity, boldness and aggressiveness are correlated with one another and with growth rate, we first calculated predicted values from the model, using the random effect intercept estimates for each individual (i.e. the best linear unbiased predictors), while holding any significant fixed effects constant. This procedure yielded an 'average' level of a PT for each individual, while also controlling for any other effects such as changes in behaviour over time, or mass differences. These individual-specific values were then used in regression analysis to test for correlations among activity, boldness and aggression, and between PTs and growth rate.

RESULTS

We observed consistent individual differences in all 3 PTs, after controlling for other factors that could affect mean-level behaviour. We observed large differences in activity across individuals that were consistent over time (repeatability = 0.57, covtest $p < 0.0005$; Fig. 1a). On average, activity was found to decrease with increasing body size ($F_{1,35} = 4.96$, $p = 0.0324$) and over time ($F_{1,55} = 5.34$, $p = 0.0246$). However, there were no differences in activity between species or across experimental blocks ($p > 0.05$). Analysis on each species separately yielded qualitatively identical results in terms of the fixed factors, and yielded significant (covtest $p < 0.01$) repeatability values of 0.59 for *Parma microlepis* and 0.40 for *P. unifasciata*.

We also observed large and consistent individual differences in boldness across individuals after accounting for any significant fixed effects (repeatability = 0.54, covtest $p < 0.0005$; Fig. 1b). Fish observed in the third experimental block were bolder than those observed in previous blocks ($F_{1,35} = 15.83$, $p < 0.0001$), but there were no differences in boldness between species, fish of different mass, or changes over time (all $p > 0.05$). As with activity, analyses done by species were identical, and yielded significant (covtest $p < 0.01$) repeatabilities of 0.60 for *Parma microlepis* and 0.46 for *P. unifasciata*.

There were also large consistent individual differences in aggressiveness (repeatability = 0.67, covtest $p < 0.0005$; Fig. 1c). Aggressiveness did not vary with any of the fixed effects (all $p > 0.05$). Again, separate analyses by species were identical and produced significant (covtest $p < 0.01$) repeatabilities of 0.64 for *Parma microlepis* and 0.67 for *P. unifasciata*.

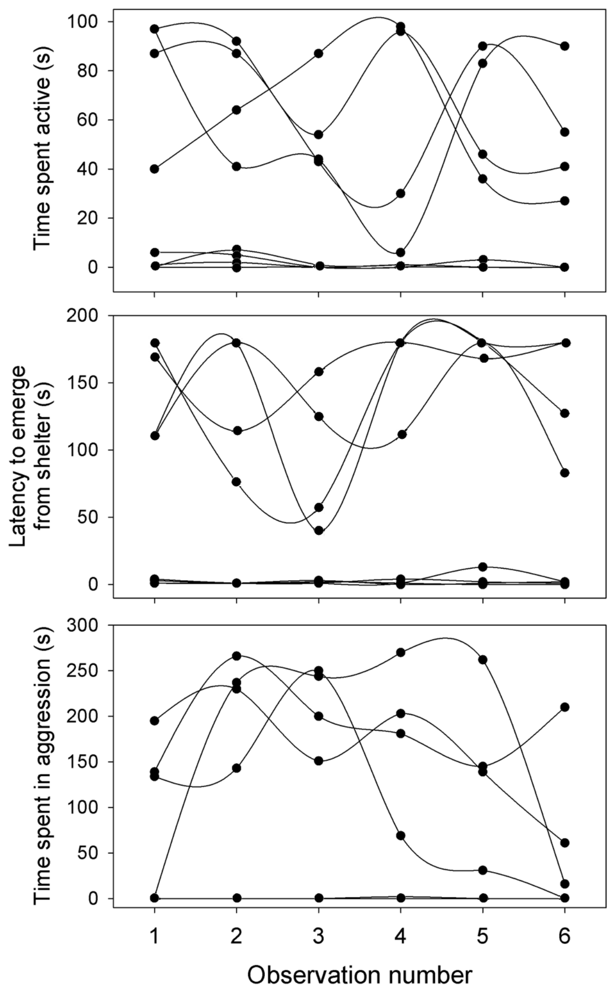

Fig. 1. Activity, boldness and aggressiveness of damselfish *Parma microlepis* and *P. unifasciata*. Shown are the successive observations over 2 wk of the 4 most extreme individuals for each personality trait. Remaining individuals are omitted for sake of clarity. All 6 observed repeats for each personality trait test are plotted for each fish. Smoothed lines join successive observations for each individual for visual clarity

Individuals that tended to be consistently more bold (lower latency to emerge) were also consistently more aggressive ($r = -0.51$, $p < 0.005$; $n = 34$; Fig. 2); however, no relationships were seen between activity and boldness or aggression (both $r < 0.20$, both $p > 0.05$).

DISCUSSION

This study provides what we believe is the first evidence for the existence of consistent individual differences in behaviour in temperate marine fish. We

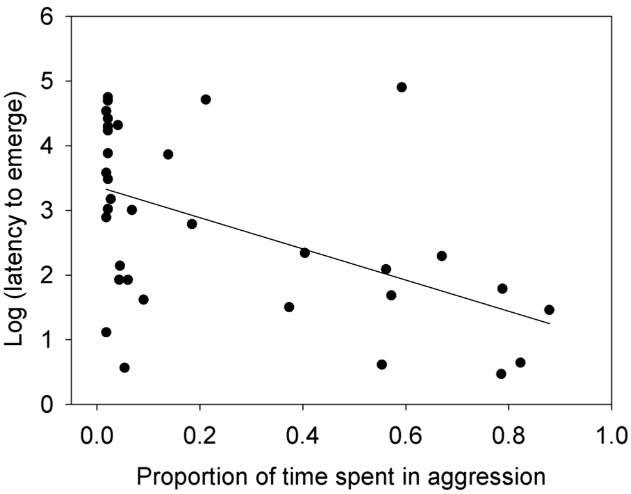

Fig. 2. Relationship between boldness (inverse of latency to emerge from shelter) and aggressiveness of damselfish *Parma microlepis* and *P. unifasciata*

demonstrated that temperate marine damselfish displayed large among-individual differences in behaviour, within-individual consistency and correlations between 2 PTs, whereby bolder individuals were also more aggressive. To the best of our knowledge, only 1 other study shows evidence of 'personality' in marine fish, having demonstrated consistent individual differences in behaviour, and correlations among behavioural traits, in 2 tropical species of damselfish from a genus that differs from the present study (Biro et al. 2010). Although Lee & Bereijikian (2008) found evidence for correlations between behavioural traits at a given point in time, they did not find within-individual consistency. Snekser et al. (2009) observed consistency over time for several behaviours when fish remained on a single type of territory, but not when they moved across territory types (artificial versus natural). The present study, along with one other (Biro et al. 2010), suggests that personality might be widespread in marine fishes, as it is for freshwater fishes. However, given that both studies were conducted on damselfishes (of different genera), future studies should expand the taxonomic base of the work.

We observed that all 3 PTs were consistent over time. However, we observed that the average level of boldness was greater for those individuals caught later in the season. We may have coincidentally caught several shy individuals in the first blocks, and several bold fish in the last block. Another possibility is that the fish in the last group were older and therefore might have more life experience, as boldness can be influenced by life experiences (Brown et al. 2007a). We also observed that activity rates were lower for larger fish and declined over time. Previous studies have shown a relationship between boldness and body mass (e.g. Brown et al. 2007b), perhaps because a smaller fish has relatively more space for movement compared to a large fish under confined conditions in the laboratory.

The reason why consistent differences in behavioural traits exist is still unclear, but they may be related to underlying differences in intrinsic metabolic capacity, growth and reproductive rates that are themselves consistent over time and across contexts (Biro & Stamps 2008, 2010, Careau et al. 2008). If so, future studies might examine fish behaviour over longer time intervals than done here, and relate behavioural differences across individuals to their growth or metabolic rates. This would provide some proximate mechanisms for why we observe this phenomenon in marine fishes and other fishes.

Acknowledgements. Thanks to J. Lee for help in the laboratory. P.A.B. was supported by a UTS Chancellors Postdoctoral Fellowship. This study was conducted under the authority of a UTS ACEC animal ethics permit. This is contribution 0046 of the Sydney Institute of Marine Science.

LITERATURE CITED

Biro PA, Dingemanse NJ (2009) Sampling bias resulting from animal personality. Trends Ecol Evol 24:66–68

Biro PA, Post JR (2008) Rapid depletion of genotypes with fast growth and bold personality traits from harvested fish populations. Proc Natl Acad Sci USA 105:2919–2922

Biro PA, Stamps JA (2008) Are animal personality traits linked to life-history productivity? Trends Ecol Evol 23:361–368

Biro PA, Stamps JA (2010) Do consistent individual differences in metabolic rate promote consistent individual differences in behavior? Trends Ecol Evol 25:653–659

Biro PA, Beckman C, Stamps J (2010) Small within-day increases in temperature affects boldness and alters personality in coral reef fish. Proc R Soc Lond B Biol Sci 277:71–77

Brown C, Burgess F, Braithwaite VA (2007a) Heritable and experiential effects on boldness in a tropical poeciliid. Behav Ecol Sociobiol 62:237–243

Brown C, Jones F, Braithwaite VA (2007b) Correlation between boldness and body mass in natural populations of the poeciliid *Brachyrhaphis episcopi.* J Fish Biol 71: 1590–1601

Buckle E, Booth DJ (2009) Ontogeny of space use and diet of two temperate damselfish species, *Parma microlepis* and *Parma unifasciata*. Mar Biol 156:1497–1505

Careau V, Thomas D, Humphries MM, Reale D (2008) Energy metabolism and animal personality. Oikos 117:641–653

Karino K, Someya C (2007) The influence of sex, line, and fight experience on aggressiveness of the Siamese fighting fish in intrasexual competition. Behav Process 75: 283–289

Lee JSF, Bereijikian BA (2008) Stability of behavioral syndromes but plasticity in individual behavior: consequences for rockfish stock enhancement. Environ Biol Fishes 82:179–186

Reale D, Reader SM, Sol D, McDougall PT, Dingemanse NJ (2007) Integrating animal temperament within ecology and evolution. Biol Rev Camb Philos Soc 82:291–318

Sih A, Bell AM, Johnson JC, Ziemba RE (2004) Behavioural syndromes: an integrative overview. Q Rev Biol 79: 241–277

Snekser JL, Leese J, Ganim A, Itzkowitz M (2009) Caribbean damselfish with varying territory quality: correlated behaviors but not a syndrome. Behav Ecol 20:124–130

Editorial responsibility: John Choat, Townsville, Queensland, Australia

Submitted: July 15, 2010; Accepted: October 26, 2010
Proofs received from author(s): December 6, 2010