

Growth history and intrinsic factors influence risk assessment at a critical life transition for a fish

O. M. Lönnstedt · M. I. McCormick

Received: 23 August 2010 / Accepted: 11 May 2011
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Abstract Making the appropriate decision in the face of predation risk dictates the fate of prey, and predation risk is highest at life history boundaries such as settlement. At the end of the larval phase, most coral reef fishes enter patches of reef containing novel predators. Since vision is often obscured in the complex surroundings, chemical information released from damaged conspecific is used to forewarn prey of an active predator. However, larvae enter the reef environment with their own feeding and growth histories, which will influence their motivation to feed and take risks. The present study explored the link between recent growth, feeding history, current performance and behavioural risk taking in newly settling stages of a coral reef damselfish (*Pomacentrus amboinensis*). Older and larger juveniles in good body condition had a stronger response to chemical alarm cues of injured conspecifics; these fish spent a longer time in shelter and displayed a more dramatic decrease in foraging behaviour than fish in lower body condition. Feeding experiments supported these findings and emphasized the importance of body condition in affecting risk assessment. Evidently, larval growth history and body condition influences the likelihood of taking risks under the threat of predation immediately after settlement, thereby affecting the probability of survival in *P. amboinensis*.

Keywords Chemical alarm cues · *Pomacentrus amboinensis* · Body condition · Risk assessment

Communicated by Biology Editor Dr. Stephen Swearer

O. M. Lönnstedt (✉) · M. I. McCormick
ARC Centre of Excellence for Coral Reef Studies, and School of
Marine and Tropical Biology, James Cook University,
Townsville, QLD 4811, Australia
e-mail: oona.lonnstedt@jcu.edu.au

Introduction

The dynamics of predator–prey interactions are central to the evolution of the astounding diversity of coral reefs. Extensive studies of freshwater systems, and a limited number of marine studies, suggest that prey, which make the correct behavioural decision under the threat of predation, will have an enhanced probability of survival (Ferrari et al. 2009). Prey must constantly balance vigilance and conservative antipredator behaviours with behaviours that enhance growth and fitness, such as feeding and mating. Prey balance risk with respect to their current requirements, such that individuals that have a high motivation to feed or mate are expected to take greater risks (e.g. Ferrari et al. 2005). Individuals that in this way alter their avoidance response in a manner that reflects the magnitude of risk present will successfully balance the trade-off between defensive and fitness promoting behaviours (threat-sensitive predation hypothesis; Helfman 1989). It has been suggested that predator avoidance is based on the level of energy reserves a forager has; individuals with a poor feeding history accept greater predation risks than individuals that have accrued a greater amount of energy reserves (asset protection model; Clarke 1994). The decisions individuals make at a particular point in time will be a function of an innate decision-making framework, a learned behavioural repertoire and proximate factors (e.g. feeding history and growth) that will influence the context-specific response. Research on freshwater fish suggests that the response of individuals to predation threats is influenced by the size and body condition of the prey individual (Reinhardt and Healey 1999; Brown et al. 2004; Pollock et al. 2006; Carreau-Green et al. 2008). To date, little is known of the mechanisms that underlie these important behavioural interactions in complex coral reef ecosystems.

Studies of freshwater systems highlight the pivotal role that chemosensory cues play in risk assessment (Brown 2003; Brown and Chivers 2006). All major groups of aquatic organisms, from protists to vertebrates, include taxa that have evolved chemical alarm cues (CAC) (Wisenden 2003). These alarm cues are present in specialized cells in the epidermis and when released warn nearby individuals of imminent danger in responsive conspecifics and heterospecifics (Brown 2003; Carreau-Green et al. 2008). Both field and laboratory experiments have demonstrated that the detection of this alarm cue leads to the increased survival of forewarned conspecifics (Chivers et al. 1996; Mirza and Chivers 2000) as a result of heightened awareness (Mathis and Smith 1993; Brown 2003). It has been suggested that chemical cues are likely to be important for benthic fishes on coral reefs because of the high surface topography that may assist cryptic predators and limit visual cues despite the often good underwater visibility (Larson and McCormick 2005; Holmes and McCormick 2011). In addition, the high abundance and diversity of cryptic predators suggests that prey should have evolved sophisticated antipredator mechanisms that efficiently minimize predation risk (Larson and McCormick 2005; McCormick and Holmes 2006).

The dispersive larval phase exhibited by most coral reef invertebrates and fishes means that individuals newly entering the reef community bring with them unique feeding and growth histories. Studies that have examined the levels of variability in life history and behavioural traits at metamorphosis and settlement have found extremely high levels of variability, particularly in behavioural attributes (e.g. McCormick and Molony 1993; Kerrigan 1996; Searcy and Sponaugle 2000; Sponaugle et al. 2006). Fuiman et al. (2010) found high levels of variability (CV 52%) in behavioural traits associated with space use (boldness) that predicted survival in the field for a recently settled damselfish. This finding together with the high and variable levels of mortality found in the days following settlement (Almany and Webster 2006) emphasize the importance of understanding the link between previous growth history and behavioural decisions made under the risk of predation and survival.

The objective of the current study is to determine how natural levels of variability in body condition affects whether a settlement stage damselfish (*Pomacentrus amboinensis*) responds with an antipredator behaviour to damage-released alarm cues of conspecifics. It is the first study to explore the link between previous history and current risk decisions made by prey in marine species. We expect that fish with a poor feeding history may not show a typical antipredator response. To further investigate the connection between intrinsic factors and risk-taking behaviour, the feeding history of individuals was manipulated, which allowed us to examine how different levels of

variability in body condition influence the strength of the antipredator response of fish to chemical alarm cues from conspecifics. Fish in low body condition were predicted to take more risk to feed and be less responsive to chemical cues once in the vicinity of damaged conspecifics (i.e. potential predators).

Materials and methods

Study species

Pomacentrus amboinensis is a common pomacentrid in the northern Great Barrier Reef, Australia. *P. amboinensis* was chosen as our model species as they are known to settle in large numbers at our study site and are readily collected with light traps at the end of their larval phase. In addition, they are sufficiently large at settlement to get accurate size and weight measurements and hardy enough to withstand handling (McCormick and Holmes 2006). This species of damselfish is a demersal spawner with a bipartite life history, their pelagic larval phase lasting between 15 and 23 days (Kerrigan 1996). They settle to a wide range of habitats but are found in highest densities in shallow sandy areas around coral or rock outcrops. The newly settled fish are between 10.3 and 15.1 mm standard length (SL) (Kerrigan 1996). *Pomacentrus amboinensis* mainly feed on algae, but are also known to take zooplankton.

Fish collection and maintenance

All *P. amboinensis* used in this experiment were caught around the fringing reef at Lizard Island, (14°40'S, 145°28'E), northern Great Barrier Reef (GBR), Australia, using light traps that had been moored overnight in November 2008 (see Meekan et al. 2001 for design). Light traps catch damselfishes at metamorphosis, as they come into the vicinity of the reef to settle. Fish were transported back to the research station at dawn in covered containers and were placed overnight in 30 l aerated flow through seawater holding tanks (12L:12D photoperiod) at 26.52–27.15°C (information from data loggers confirmed that these were similar temperature ranges that fish on the reefs around Lizard Island were exposed to during this time period). Following the initial acclimation period, test fish were transferred to experimental aquaria. *Apogon cyanosoma* (Apogoniidae) were used as a control for the effect of adding the scent of any damaged fish into the treatment tank. They were chosen as they are phylogenetically distant and ecologically very different from the focal species; *A. cyanosoma* is a nocturnal planktivore living in large schools at the base of reefs, while *P. amboinensis* is a diurnal planktivore inhabiting small patch reefs in sandy

areas at the periphery of reefs in small social groups of up to 10 individuals (Hobson 1974). Thus, it is highly unlikely that *P. amboinensis* would innately respond with an antipredator response to the chemicals released from the apogonid epidermis. *Apogon cyanosoma* were collected on SCUBA using clove oil and hand nets in November 2008. All fish were fed newly hatched *Artemia* sp. (ad lib) twice a day.

Observation tanks

All experiments and behavioural observations were conducted in transparent 28 l aquaria (30 × 40 × 25 cm) with a constant flow of seawater until the commencement of trials. A single air stone was placed at the back corner of each tank with a 1.5-m long plastic tube (for stimulus injection) fixed to the airline with the end attached approximately 1 cm above the air stone allowing for rapid dispersal of extracts in the aquaria. Dye trials showed that it took approximately 57.2 ± 2.9 s for the extract to disperse through the tank after the injection. Artificial branching *Acropora* corals (moulded resin; item no. 21505; Wardleys/TFH, Sydney; dimensions: 14 × 11.5 × 5 cm) were placed along the opposite side of the aquarium creating a vertical shelter ca. 12 cm high. The substratum consisted of a 2 cm thick layer of sand. After each 20-min trial, the fish were removed and the aquaria, tubing, shelter, substratum and air stone were thoroughly cleaned.

Stimulus preparation

Donor fish were euthanized by cold shock and were subsequently placed into a Petri dish. A clean scalpel blade was used to make superficial vertical incisions (minor flesh damage) along each flank of test fish. The muscle surface area of an average recruit was 66.2 ± 6.6 mm² (mean ± SE). Two damselfish of a similar size were used for each conspecific skin extract (6 incisions along each flank) to standardize for differences in body size, due to their large size (surface area of 123.7 ± 9.3 mm², mean ± SE) a single apogonid was used for each heterospecific skin extract (12 incisions along each flank). Each prepared skin extract was rinsed in 15 ml of seawater and filtered through filter paper (47 mm Ø) in order to remove any solid matter prior to being drawn up into a disposable 60 ml syringe for injection into the test aquaria. All skin extracts were prepared within 20 min of preparation as extracts may lose potency if frozen or stored for longer periods of time (Smith 1989).

Experimental protocol

Prior to experimentation, test fish (one individual per tank; 11.9 ± 0.5 mm² mean SL ± SE) were acclimated in the

flow through seawater test aquaria for 24 h to allow for recovery from the stress of capture. To minimize the effect the observer had on the test fish, observations were conducted from behind a black plastic barrier. Prior to the start of the trial, the water flow was stopped and 20 ml (approx. 132,000 nauplii/l⁻¹) of extra *Artemia* sp. was added to the aquaria to stimulate feeding. After food had been injected, test fish were left to feed for 2 min prior to starting the experiment, as fish will feed more when food is first introduced. To remove any stagnant water from within the stimulus injection tube, 60 ml of water was drawn out and discarded. An additional 60 ml of saltwater was drawn out and kept within a disposable syringe. The behaviour of a single naïve *P. amboinensis* within each test aquarium was recorded for the 10-min prestimulus period. Immediately following the prestimulus period, 15 ml of the experimental stimulus (conspecific skin extract, heterospecific skin extract or a saltwater control) was injected into the tank, followed by 60 ml of the previously obtained saltwater (to ensure that all the stimulus cue had been flushed into the tank). The behaviour of the fish was then recorded for a further 10 min. After each 20-min trial, the fish were removed and euthanized by cold shock in a slurry of crushed ice and seawater for body measurements. For each stimulus, we conducted 20 different replicates.

Experiment 1: effect of previous history on the response to CAC

The behavioural response (see later for measurement) of recently metamorphosed *P. amboinensis* to 3 different test stimuli was tested: extracts from the damaged skin of conspecifics; extracts from the damaged skin of a heterospecific (*Apogonid* sp.); and a saltwater control. To examine the link between risk assessment and previous growth history, each *P. amboinensis* that had been tested for a response to conspecific skin extracts had their growth history assessed using otolith microstructure. Otoliths (sagittae) were extracted from fish, and transverse sections through the nucleus were prepared as per Wilson and McCormick (1999). Otolith increment width was used as a proxy for growth (as per Gagliano et al. 2007a). Daily increment deposition has been previously validated for this species (Pitcher 1988). A visible settlement mark in the otoliths allowed us to determine the day of settlement (Wilson and McCormick 1999). Morphometric measurements and otolith analysis enabled us to calculate several different growth history variables: age, size at hatching, size at settlement, initial growth rate (0–3 days), linear growth rate (linear growth phase that occurs ~6–10d after hatching), maximum growth rate, day of maximum growth and their overall larval growth maximum (as per McCormick and Meekan 2010).

Experiment 2: effect of body condition on the response to CAC

To manipulate previous growth and feeding history, we carried out a 5 day feeding experiment. Newly metamorphosed *P. amboinensis* was placed into 30-l aquaria and fed different densities of 36–48 h old *Artemia* sp. nauplii. Fish were fed 3 times per day, at three different levels equivalent to high (ad libitum, 1,600 nauplii l⁻¹), medium (960 nauplii l⁻¹) and low (320 nauplii l⁻¹), resulting in well-fed, moderately fed and poorly fed fish. Fish from each treatment were then tested for a response to skin extracts prepared from conspecific that had been fed ad libitum (1,600 nauplii l⁻¹). In addition, two control treatments were conducted: skin extracts from a heterospecific fish (*A. cyanosoma*; Apogonidae) and a saltwater control. To examine the influence of the feeding levels on body condition, all fish were euthanized by cold shock prior to measurement of body condition (weight (g), SL (mm)). Body condition was then quantified as the residuals of an overall length weight regression.

Quantification of behaviour

The behavioural response to experimental stimuli was quantified by recording a total of four different behavioural traits for each fish during the trials: number of feeding strikes; time spent in shelter; number of movements in and out of shelter; and distance from shelter. Feeding strikes were recorded as the total number of strikes (successful or unsuccessful) made by the individual during each 10-min observation period. At 15-s intervals, the fish's horizontal and vertical distance from shelter was recorded. Test aquaria had been divided up into a series of zones, both vertical and horizontal. The first zone was set at the outside edge of the branching coral shelter and they continued at 50 mm intervals away from shelter. This allowed us to calculate the average distance from shelter. The number of times a test fish moved in and out of shelter was recorded, and the total time (s) the test fish spent in shelter was taken during each observational period.

Statistical analyses

The four behavioural variables were analysed as changes in the magnitude of each behaviour between 10-min pre and poststimulus periods. A one-factor multivariate analysis of variance (MANOVA) was used to test for differences in behaviour among stimulus treatments. One-factor ANOVAs were then performed to identify significant differences within individual behaviours. A Bonferroni correction was employed to account for nonindependent tests (adjusted alpha = 0.0125). Significant differences were further

examined using Tukey's HSD means comparison tests. The assumptions of normality and homogeneity of variance were examined prior to MANOVA and ANOVA. Body condition was quantified as the residuals of an overall length weight regression. To test for a significant effect of the different feeding treatments on body condition, a one-factor ANOVA was carried out.

Otolith analysis and morphometric measurements allowed us to calculate several aspects of growth history: age, size at hatching, size at settlement, initial growth rate (0–3 days), linear growth rate (linear growth phase that occurs ~6–10d after hatching) and maximum growth rate, day of maximum growth, their overall larval growth maximum and an index of body condition. Body condition was calculated as the residuals of a length (mm) by weight (g) least squares regression. The influence of these variables (9 independents) on the strength of antipredator behaviours (dependents) was then examined using a multiple regression. Analyses were undertaken on the change in magnitude between pre and postinjection of the conspecific skin extract for each of the behaviours measured (i.e. feeding rate, shelter use, time spent in shelter (s) and distance from shelter). Variables were checked for collinearity using correlation, and the variables weight and initial growth (calculated from the regression) were dropped from multiple regression analyses due to correlations >0.9 with other variables. The variables included in the model were, therefore, age, size, size at hatching, size at settlement, linear and maximum growth rate, day of maximum growth, overall larval growth maximum and body condition. The 'best subsets' was used to produce an optimum predictive model. The best models were selected based on the Mallows's CP selection statistics.

Results

Experiment 1: effect of previous history on the response to CAC

The overall behaviour of *P. amboinensis* between pre and poststimulus periods differed among the three stimulus treatments (MANOVA, Pillai's Trace_{8,110} = 0.7, $P < 0.0001$). ANOVAs showed that there was a significant difference in each behavioural trait after the introduction of the conspecific skin extracts. For all the treatments, individuals swam around the majority of the tank during the prestimulus period, fed on *Artemia*, and only entered shelter infrequently and for short periods of time. In both control treatments, this behaviour did not significantly change after the injection of either experimental stimulus (heterospecific cue or saltwater). However, after injection of the conspecific skin extract, there was a significant

reduction in feeding strikes ($F_{2, 57} = 44.4$, $P < 0.0001$), individuals moved closer to shelter ($F_{2, 57} = 7.42$, $P < 0.001$), entered shelter more frequently ($F_{2, 57} = 11.9$, $P < 0.0001$) and spent significantly more time hiding in shelter ($F_{2, 57} = 22.4$, $P < 0.0001$).

The multiple regression analysis suggested that growth history and body condition were correlated with the anti-predator behaviour of *P. amboinensis* (Table 1). The regression model for feeding strikes identified that only body condition had a significant influence on the change (accounting for 24%) in the foraging behaviour of *P. amboinensis* in response to conspecific skin extracts (Table 1; $R_p = -0.43$). In this way, fish in better body condition decreased feeding more intensely in response to alarm cues (Fig. 2a). Standard length and maximum overall growth accounted for 32% of the variability in shelter use under a perceived risk (Table 1). The number of times fish moved in and out of shelter was negatively correlated with standard length ($R_p = -0.53$) and growth maximum ($R_p = -0.50$) of fish. In contrast, body condition and age at settlement accounted for 41% of the variation in time the fish spent in shelter in response to alarm cues (Table 1), with both variables showing positive relationships with total time fish spent in shelter (Body condition, $R_p: 0.67$; age, 0.40; Table 1, Fig. 1b). No significant relationship was found between body condition, growth history and distance from shelter.

Experiment 2: effect of body condition on the response to CAC

There was a significant difference in body condition of fish between the three feeding treatments (ANOVA $F_{2, 57} = 72.4$, $P < 0.0001$). Fish that had been fed the two higher concentrations were heavier for any given length compared to the poorly fed fish. There was a significant difference in the behavioural response of fish from the different feeding treatments to damage-released conspecific chemical alarm cues (MANOVA, Pillai's Trace_{16,380} = 0.903, $P < 0.0001$, Fig. 2). Both well-fed and moderately fed *P. amboinensis* responded with a significant decrease in the number of feeding strikes ($F_{4, 95} = 108.11$, $P < 0.001$, Fig. 2a) and

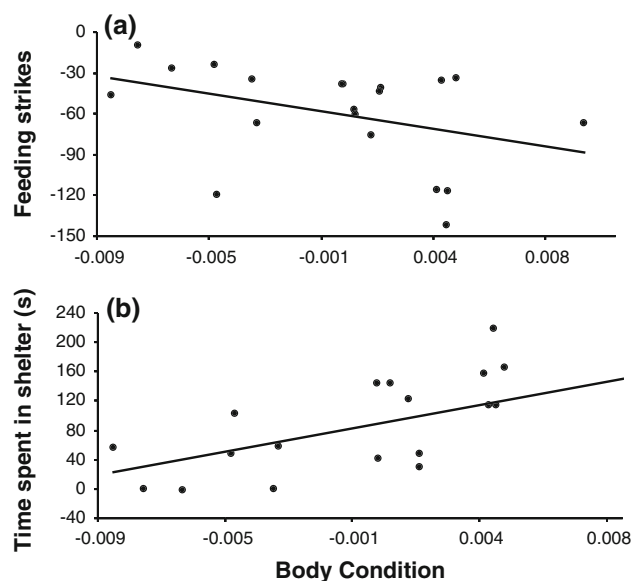


Fig. 1 The **a** negative regression relationship between feeding strikes and body condition and the **b** positive relationship between time spent in shelter (s) and body condition of newly settling *Pomacentrus amboinensis* exposed to conspecific skin extracts

distance from shelter ($F_{4, 95} = 10.13$, $P < 0.0001$, Fig. 2b), and a significant increase in shelter use ($F_{4, 95} = 24.93$, $P < 0.0001$, Fig. 2c) and time spent in shelter (s) ($F_{4, 95} = 8.74$, $P < 0.0001$, Fig. 2d). In contrast, there was no significant change in behaviour between the pre and poststimulus period for poorly fed fish compared to the two control treatments (Fig. 2). Poorly fed individuals swam around the majority of the tank feeding on *Artemia*, even after the introduction of the conspecific alarm cue (Fig. 2).

Discussion

These results clearly demonstrate that damage-released chemical cues from settlement stage *P. amboinensis* alert conspecifics to the presence of predation risk. Individuals appear to balance cautious or risky behaviours with the relative benefits of energy intake under potential threats.

Table 1 Summary of results of multiple regression analysis that compared growth history and behavioural change in response to conspecific skin extracts in *Pomacentrus amboinensis*

Dependent variable	Mallow's Cp	R_{adj}^2	R^2	P (F test)	Independent variables	R_p	P (t test)
Feeding strikes	-1.26	0.24	0.32	0.036	Body condition	-0.43	0.049
Shelter use	-3.44	0.32	0.40	0.014	Standard length	-0.53	0.015
					Growth maximum	-0.50	0.019
Time spent in shelter	-2.89	0.41	0.47	0.0059	Body condition	0.67	0.0025
					Age	0.40	0.048

P (F test) tests the significance of the overall regression model, while P (t test) tests for the significant contribution of the variability in the dependent variable of the partial correlation (R_p) variable (s)

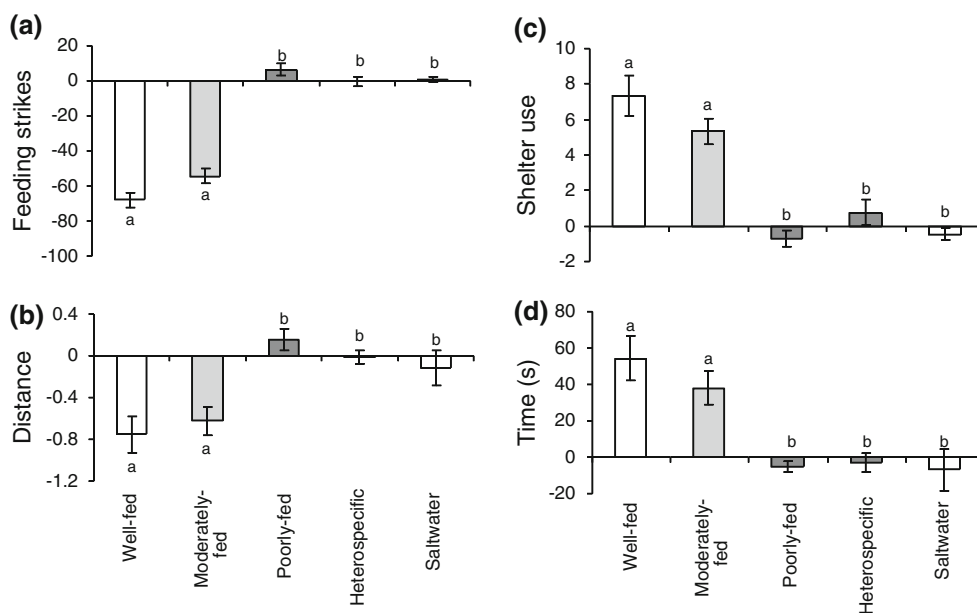


Fig. 2 Mean change (\pm SE) in **a** feeding strikes, **b** distance from shelter, **c** number of times going in and out of shelter and **d** time spent in shelter (s) by *P. amboinensis* from the different feeding treatments between the 10-min pre and poststimulus period for fish exposed to:

chemical alarm cue of a conspecific; chemical alarm cue of a heterospecific; and a saltwater control. Letters above or below bars represent Tukey's HSD groupings of means

Furthermore, our study indicates that the strength of the antipredator response is correlated with the previous growth and feeding history of the fish. Younger fish with lower than average body condition appeared to take higher risks in the face of a predation threat. This result was further supported by experimental manipulations showing that a poor feeding history eliminated any behavioural response to alarm cues from injured conspecifics.

The context and timing of predation threats are important (whether it be in the form of a visual or chemical cue), and individuals that adjust their response to the level of threat present will be more likely to make a well-informed decision (Helfman 1989). Prey that recognizes potential threats early in life should immediately gain an advantage as they reduce the probability of being captured by predators hunting in the area (Carreau-Green et al. 2008). Many piscivores inhabit topographically complex coral reefs and many target juvenile reef fishes as an important source of food when available, leading to high rates of mortality (Beukers and Jones 1997; Stewart and Jones 2001). Because of the diversity of foraging tactics used by predators, ranging from ambush to pursuit, the most reliable indicator of the activity of a predator will be the odour emitted from a damaged prey. Indeed, responding to extracts from damaged skin has been demonstrated to be an effective way of increasing the survival in a freshwater fish, the fathead minnow (*Pimephales promelas*) (Mathis and Smith 1993). Similarly, a combination of visual and olfactory experience with predators has also been shown to

increase the survival of newly settled *P. amboinensis* in the field (McCormick and Holmes 2006).

Size and relative body size has been shown to influence behavioural decisions in the face of a predation threat. Juvenile coho salmon (*Oncorhynchus kisutch*) display size-dependent risk taking; smaller individuals are more willing to risk predation to obtain food than their larger conspecifics (Reinhardt and Healey 1999). Reinhardt and Healey (1999) suggested that larger juvenile coho take less risk in order to protect their higher accumulated energy reserves. Our results demonstrate that older and larger newly settled fish, in good body condition (i.e. heavier for any given length), showed a stronger antipredator response to alarm cues from injured conspecifics, thus being consistent with both the asset protection model and the threat-sensitive predation hypothesis. Hunger is likely to be the intrinsic driver underlying this finding, as it is expected that hungry individuals will take greater risks in the face of predation while foraging, and likely to trade-off safety for energy gain (Helfman 1989). It has been found that juvenile fish of low body condition have a higher probability of being preyed upon (Hoey and McCormick 2004), suggesting that the shift in balance between risky behaviours and energy intake associated with hunger might underlie this finding. Evidently, larval growth history and body condition influences the likelihood of taking risks under the threat of predation immediately after settlement, thereby affecting the probability of survival in *P. amboinensis*. Mortality in the first 24 h after settlement has been shown to be high

(upwards of 50%) and selective for previous growth history and body traits (Shima and Findlay 2002; Gagliano et al. 2007b; Holmes and McCormick 2009; McCormick and Meekan 2010). This initial selective mortality is important, since it influences the distribution of traits in subsequent life stages and can even influence fitness (McCormick and Gagliano 2009; McCormick et al. 2010). Recent research on freshwater fishes has also shown that intrinsic factors, such as feeding history and hunger, affect the risk taking in prey (Brown et al. 2004; Pollock et al. 2006). The present study provides additional support for the hypothesis that feeding history alters the balance between risky behaviours and vigilance. It is interesting to note that newly settled fish, which are largely naïve to reef based predators, already have well-developed chemosensory and behavioural strategies that help them avoid their predators.

Although starved fish failed to respond to the alarm cue, they may still have detected it and deliberately disregarded the warning signal that predators were present and active in the vicinity. Brown and Smith (1996) found that food deprived predator-naïve minnows did not respond with antipredator behaviours to conspecific skin extracts that had been mixed with cues of an unknown predator (predatory pike). Yet, once supplied with abundant food, the same minnows reacted with a typical antipredator behaviour when exposed to the pike cue. Their results indicate that although minnows did not respond to skin extracts from conspecifics, they did detect the alarm substance and memorized the cue of the unknown predator. Clearly, learning still occurred even in the absence of an overt alarm response.

It might seem surprising that poorly fed individuals did not react to the alarm substance despite several studies showing that responding to alarm cues during a predator encounter improves survival. *Pomacentrus amboinensis* live and forage in a topographically complex environment, with numerous opportunities to dash into shelter when a predator is in the immediate vicinity. The fact that individuals in low body condition ignore the cues of injured conspecifics may indicate that they trade-off predator avoidance behaviour in order to satisfy their energetic requirements. It is plausible that hungry damselfish, although forewarned by the chemical alarm cue, wait for more direct signs of a predator threat, such as a visual cue. McCormick and Manassa (2008) reported that a coral reef goby elicited a stronger antipredator response when visual cues of a natural predator and conspecific skin extracts were present together.

Prey species have evolved to cope with the ever present threat of predation and they continually balance risky, fitness promoting behaviours with the safer options. It is these decisions that determine the fate of individuals and the genes they hold.

Understanding the behavioural mechanisms that underlie selective survival during the early life stages of coral reef fish may help us understand population/community level responses, which in turn, is fundamental to developing a mechanistic understanding of ecosystems. Our study demonstrates the importance of larval history in influencing the behaviour of the settled stages of fish and that these behaviours are likely to have repercussions for survival. Fish that are in poor body condition at settlement are likely to exhibit more risky behaviour. Previous research shows that cohorts of fish may differ markedly in their body condition and larval growth, and these intrinsic factors may impact population dynamics at a local scale through their influence on behaviour and risk assessment.

Acknowledgments We thank L. Vail and A. Hogget for logistic support. J. Maddams processed the otoliths used in this study. This study was funded through an Australian Research Council Centre of Excellence for Coral Reef Studies. Research was conducted under JCU ethics approval A1067.

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