Intentional partial beaching in a coral reef fish: a newly recorded hunting behaviour for titan triggerfish, *Balistoides viridescens*

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Abstract:

Coral reef fishes use a multitude of diverse feeding behaviours to increase their ability to successfully capture a wide range of prey. Here, we report a novel hunting behaviour in a coral reef fish, the titan triggerfish, *Balistoides viridescens*, where an individual was seen partially beaching itself while attempting to catch a Red Sea ghost crab, *Ocypode saratan*. This is the first report of this behaviour in the order Tetraodontiformes, and represents an astonishing capability for this species to exploit food resources outside their typical assumed ecological niche.

Keywords: *Balistoides viridescens*; beaching behaviour; coral reef; feeding ecology; Red Sea; triggerfish

Coral reefs are well-known for hosting a wide variety of fishes, with a high diversity of feeding modes and behaviours. The remarkable diversity of feeding morphologies allows coral reef fishes to consume a wide range of prey (Wainwright and Bellwood, 2002). Despite highly specialized morphologies, many coral reef fishes exhibit notable flexibility in their feeding behaviour which allows for more opportunistic or generalist diets (Bellwood *et al.*, 2005). For example, multiple species of wrasses have been reported to use tools, *e.g.*, rocks as anvils to crush hard shelled prey they would not be able to consume normally (Bernardi, 2012 and citations within). Diversity in hunting patterns and behaviour allows predators to exploit new food resources, expand their range of potential prey items, improve their odds of successful prey capture, and limit competition (Ormond, 1980; Vail *et al.*, 2014). Among coral reef fishes, triggerfishes are an ecologically important group of top invertivore predators well-known to exhibit distinct feeding behaviour across a range of their invertebrate prey (McClanahan, 2000; Young and Bellwood, 2012).

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The broad repertoire of distinct feeding modes employed by triggerfish depends on their targeted food item (Wainwright and Friel, 2000). Triggerfish will utilize suction feeding for selecting small and soft-bodied prey items, but will repeatedly bite and manipulate harder or larger prey until it is crushed into bite-sized pieces (Turingan and Wainwright, 1993). Several species are also known to use water-jetting, a behaviour where water is forcibly ejected from the mouth while closing the gill opening, to uncover invertebrates hidden in sand or to overturn large urchins (Chen *et al.*, 2001; Turingan *et al.*, 1995). At least one report also exists of triggerfish laying parallel to sandy bottoms and using rapid movements of their dorsal and anal fins to expose buried prey (Hobson, 1975). In addition to these above methods, titan triggerfish, *Balistoides viridescens* Bloch and Schneider 1801, are known to lift up and overturn rubble and break apart branching corals to expose hidden invertebrates (Ormond and Edwards, 1987). This range of behaviours across several species highlights their capability as a group to exploit resources beyond the typical capabilities of similar species with more limited feeding behaviours (Turingan and Wainwright, 1993; Turingan *et al.*, 1995). Here, we describe a novel hunting strategy of *B. viridescens*. We observed an individual feeding on semi-terrestrial prey, a previously unreported behaviour for this species.

In the afternoon of 2 May 2018, on the leeward side of Mar Mar Island (19.8375, 39.9275, Figure 1), in the south central Red Sea, an individual *Balistoides viridescens*, approximately 35 cm total length, was observed hunting a Red Sea ghost crab, *Ocypode saratan* Forskål, 1775. Video was recorded from a safe distance after observing the behaviour for a few minutes to ensure minimal or no disruption of the natural behaviour. While the *O. saratan* was foraging on algae on carbonate rocks along the shoreline, the *B. viridescens* stalked the crab in less than one meter of water and made several attempts to grab it at the water's edge while in less than 10 cm of water. Staying within several meters of the shoreline, the fish made slow approaches towards the feeding crab before rushing it in a horizontal position. The *B. viridescens* missed several times as the crab escaped towards shore. In the first attack, the fish partially beached itself in shallow water, and took several seconds to maneuver back to deeper water using its dorsal and anal fins (Supplementary video 1). In the subsequent failed attacks, the *B. viridescens* did not beach as severely, and was able to move to deeper water more quickly. After several unsuccessful attempts, the *B. viridescens* managed to securely bite the crab in several centimeters of water before dragging it to deeper water, where the crab was consumed. Figure 2 details the progression of the attack with photographs and sketches.

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This is the first report, to our knowledge, of beaching behaviour for feeding demonstrated in any tetraodontiform, and one of only a limited number for fishes that have been documented to do so. Fish feeding on terrestrial prey has been widely reported and well-documented in freshwater systems (see Kelly *et al.*, 2016; Van Wassenbergh, 2019, and citations within). Several instances also exist in marine and brackish waters including largescale foureyes, *Anableps anableps* L. (Michel *et al.*, 2015a), and mudskippers of the family Oxudercinae (Michel *et al.*, 2015b), though terrestrial prey capture mechanisms and behaviour can differ widely between species (Bressman *et al.*, 2020; Heiss *et al.*, 2018). Intentional beaching as a predatory hunting strategy is only reported for several fish species, and represents the most basal form of transitional feeding between aquatic and terrestrial habitats (Heiss *et al.*, 2018). Introduced wels catfish, *Silurus glanis* L. are known to beach while feeding on pigeons in France (Cucherousset *et al.*, 2012), and snakeheads, *Channa* spp., may utilize a similar ambush-beaching strategy to target amphibian prey (Noah Bressmen, pers. comm). The small, semi-amphibious mangrove rivulus, *Kryptolebias marmoratus* (Poey 1880), has been shown to use multiple, distinct behaviours to leave the water, some similar to beaching, to feed on terrestrial arthropods (Pronko *et al.*, 2013). Intertidal Galápagos four-eyed blennies, *Dialommus fuscus* Gilbert 1891, use terrestrial feeding behaviours similar to *K. marmoratus*, though these movements appear distinct from beaching behaviours (Nieder, 2001). In the oceans, several species of eels have been observed leaving water to capture grapsid crabs on rocky shores (Chave and Randall, 1971; Sazima and Sazima, 2004), and Wetherbee (*et al.*, 1990) report a single observation of blacktip sharks, *Carcharhinus melanopterus* Quoy and Gaimard 1824, beaching to feed on fish chased ashore. Overall, there is a limited number of marine fishes known to exhibit intentional beaching predatory behaviour, highlighting the importance of this observation.

Diverse feeding behaviours allow predators to adapt hunting strategies to best fit the resources currently available, to avoid competition, and exploit novel prey items (Dill, 1983; McFadden, 2003). Here, an individual *B. viridescens* demonstrated the capability to use a novel foraging behaviour for the species to exploit semi-terrestrial prey. Terrestrial prey items can make up an important part of the energy intake for marine species, or allow them to supplement their normal dietary requirements (Darnaude, 2005; Francis and Schindler, 2009). Several hunting tactics used by *B. viridescens*, including water-jetting and rubble flipping, often draw the attention of other fishes that may steal exposed prey before the triggerfish has a chance to feed (Ormond, 1980). As noted in eels (Sazima and Sazima, 2004), intentional beaching may be a foraging strategy for *B. viridescens* that minimizes potential competition from other marine invertivores while simultaneously exploiting a food resource inaccessible to most coral reef fishes.

This is not the only report of novel triggerfish feeding behaviour from the Red Sea. In the Gulf of Aqaba, Fricke (1971) witnessed several blue triggerfish, *Pseudobalistes fuscus* (Bloch and Schneider 1801), pick up urchins, release them high in the water column, then feed on their exposed underside as they fell. Typically, large urchins are blown over with water jets to expose their more vulnerable underside. In this instance, it is proposed that this behaviour was learned by a single individual, then replicated by others through social learning (Bshary *et al.*, 2002). Though both a different species and behaviour, it is possible that social learning may also be a factor in intentional beaching, as several triggerfishes were also seen patrolling the shallows around the island (pers. obs.) though other attacks were not observed. The presence of Red Sea ghost crabs and other shore crabs (*Grapsus* spp.) around the island could provide ample opportunity for triggerfish to supplement their diets.

Both Fricke (1971) and the present observation demonstrate the ability of triggerfishes to implement novel foraging tactics in the wild, which implies an innate capability to learn and adapt. Most studies that focus on fish behaviour and cognition focus on a small subset of coral reef fishes (Abbot, 2015; Siebeck *et al.*, 2009; Triki *et al.*, 2018; Vail *et al.*, 2013), and triggerfishes are not frequently considered. However, at least some triggerfishes are capable of learning rapidly in a laboratory setting (Cheney *et al.*, 2019). Given their capability to adopt feeding behaviours to take advantage of diverse prey resources, we posit that *B. viridescens*, and likely other triggerfishes, could serve as model systems for further investigations of learning and cognition in coral reef fish. At this time, however, coral reef fish behavioural studies remain relatively sparse, especially within the Red Sea, in part due to the historically understudied nature of the region (Berumen *et al.*, 2013). These kinds of happenstance encounters illustrate the importance of survey efforts and further observational studies, and highlight the untapped potential for behavioural studies for this and related species.

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Supporting Information:

Video files of *Balistoides viridescens* intentional beaching behaviour.

Author Contributions:

M.D.T., R.S.H., L.K.T., and A.M.H. formulated the original idea for the manuscript and made the reported observations. M.L.B provided funding for the research. M.D.T wrote the original manuscript. All authors contributed equally to the editing and revision of the final manuscript.

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Figure 1. Map indicating the location on Mar Mar Island where the *Balistoides viridescens* behavioural observation was made (red point). Inset map shows regional perspective, and the small red square indicates the location of Mar Mar Island along the Saudi Arabian Red Sea coast.

Figure 2. Images and illustrations of the beaching attack sequence of *Balistoides viridescens* (circled in white) in pursuit of *Ocypode saratan* (circled in black). The hunting progression started with (A) shallow-water stalking behaviour of *B. viridescens* as it followed *O. saratan* along the rocky coast of the island followed by (B) several partial-beaching attempts, until there was (C) successful prey capture.

Supplementary Video 1. Video footage of a titan triggerfish, *Balistoides viridescens*, intentionally beaching itself while attempting to prey upon a Red Sea ghost crab, *Ocypode saratan*. After several failed attempts, the fish grabs the crab and drags it to deeper water to feed. Video was filmed around noon on May 2, 2018.