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Claw removal and feeding ability in the edible crab, *Cancer pagurus*: Implications for fishery practice

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ABSTRACT

Feeding ability and motivation were assessed in the edible crab, *Cancer pagurus*, to investigate how the fishery practice of de-clawing may affect live crabs returned to the sea. Crabs were either induced to autotomise one claw, or were only handled, before they were offered food. Initially, autotomised and handled crabs were offered mussels, *Mytilis edulis*, a large part of their natural diet. After 3 days, both autotomised and handled crabs were then offered fish, a more readily handled food source. Autotomy induced crabs consumed significantly fewer mussels and less mussel mass, but ate significantly more mass of fish. This indicates that the effect of autotomy was a reduction of ability to feed on mussels rather than a general reduction of feeding motivation. The discontinuation of claw removal needs to be considered, both for the sustainability of the fishery and animal welfare concerns.

1. Introduction

De-clawing occurs in several crustacean fisheries, where live animals have their claw(s) pulled off before return to the sea. It occurs worldwide, such as in the southern Florida stone crab fishery, *Mennippe mercenaria* (Ehrhardt, 1990), the North East Atlantic deep-water red crab, *Chaceon affinis*, fishery (Robinson, 2008), and in southern Iberia, where the major claws of the fiddler crab, *Uca tangeri*, are harvested (Bennett, 1973; Oliveira et al., 2000). Around Northern Europe, an extensive fishery exists for claws of the edible crab, *Cancer pagurus* (Fahy et al., 2004; Patterson et al., 2007). This is legal in the UK since revocation in 2000 of the Crab Claws (Prohibition of Landing) Order (1986). The practice is defended because crabs may naturally autotomise (lose) and then regenerate limbs and it is thought that de-clawing provides a sustainable fishery (Carroll and Winn, 1989). Claw removal is also promoted to assist in handling of animals, and to decrease losses through entanglement in nets and cannibalism (Ary et al., 1987).

De-clawing results in a physiological stress response in *C. pagurus*, as noted by increases in haemolymph glucose and lactate and a decrease in glycogen (Patterson et al., 2007; see also Manush et al., 2005). This stress was evident both in the short term (<10 min) and the long term (24 h). Further, de-clawing was more stressful, resulted in bigger wounds and caused significant mortality compared to induced autotomy (Patterson et al., 2007). Clearly, de-clawing cannot be justified on the basis of its similarity to autotomy. However, effects of claw loss on foraging efficiency are less understood (Juanes and Hartwick, 1990; Yamada and Boulding, 1998). This is important since, if de-clawing renders crabs incapable of feeding, this poses an obvious welfare issue and a problem for claims of sustainability.

Edible crabs are predators of molluscs such as *Mytilus edulis* (Karlsson and Christiansen, 1996). Both claws may initially grasp the prey, then with one to steady the food the other crushes the hard shell (Smallegange and Van Der Meer, 2003). A problem in assessing ability to feed after claw removal is that the stress of removal may suppress

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feeding motivation. Alternatively, there may be an enhanced motivation to feed to provide extra energy for regeneration. In this case, enhanced feeding motivation may offset reduced ability to feed, making it difficult to assess ability. Here, we examine the ability of one-clawed animals to feed on hard-shelled prey when compared to two-clawed conspecifics. We concurrently test the motivation to feed by supplying easily consumed food.

2. Methods

2.1. General

Edible crabs, *C. pagurus*, were collected with baited pots from Walters Rock, Strangford Lough, Co. Down, N. Ireland, during March–June 2006. Intermoult males (120–140 mm carapace width) were retained for experiments. Animals were 'autotomy induced' or 'handled only' ($n = 12$ each) and immediately placed in individual rectangular indoor tanks (53 cm length × 38 cm width × 29 cm height), with piped seawater and constant air supply. Claw autotomy was induced by a small cut at the joint at the top of the merus, distal to the autotomy joint. Control animals were handled to a similar extent.

In March 2006, common mussels, *M. edulis*, were collected from the intertidal zone ($n = 78$) at Horse Island, Strangford Lough, N. Ireland. These were killed by immersion in fresh water near boiling point, and the shell and animal wet weight recorded. Soft tissue was dried at 50 °C for 48 h such that the animals' dry weight could be determined and used in a simple regression to assess mussel consumption by crabs ($F_{1,77} = 134.2$, $P < 0.0001$). Additional mussels were collected for feeding experiments (size classes <25 mm, 25–35 mm, 35–45 mm, 45–55 mm and >55 mm).

To assess feeding on wet fish, we first determined change in weight of fish after immersion in water. Pre-weighed samples of mackerel ($n = 44$) were placed in individual containers of seawater for 24 h and final weights determined. A simple regression of starting weight and final weight ($F_{1,43} = 749.44$, $P < 0.0001$) then served as a reference to determine amounts of fish eaten.

2.2. Experimental design

Further to capture and 'autotomy' or 'handling' on Day 1, crabs were left over night to standardise feeding. On Day 2, mussels were introduced into each tank (two each from the five size classes above) and behaviour observed for 20 min. Crab activity was recorded in terms of; rest, when the animals was observed to be stationary; activity, where the crab walked around the edge of the tank; prey interactions, when the crab contacted a mussel with its claw or legs; and general activity, which included antennule movement, claw waving or leg movement. This descriptive information on the crabs' movement was recorded to determine if claw removal rendered the animals more or less active. On Day 3, we counted the number of mussels eaten, mussel shells and remaining soft tissue were removed and 10 new mussels introduced. This was repeated on Day 4, followed by introduction of mackerel (approx. 20 g each tank) on Day 5. On Day 6, all fish was removed and re-weighed. This gave measurements of mussel consumption for a total of 3 days and fish consumption for 1 day.

2.3. Data analyses

A contingency test on numbers of crabs feeding on fish determined if autotomy affected feeding motivation. For subsequent analyses, all animals that had not fed on fish were removed, as they were deemed lacking in feeding motivation. Data were $\log_{10}(x + 1)$ transformed for normality, but untransformed means are shown in the figures for clarity. We examined mean numbers of contacts with mussels, numbers of mussels consumed, mass of mussels consumed and mass of fish consumed with respect to 'claw status' (autotomised or not) with a one-factor MANOVA, followed by individual ANOVAs.

2.4. Ethical note

No licence was required for this work, as crustaceans are not covered by the UK Animals (Scientific Procedures) Act (1986). Nevertheless, we elected to keep the numbers subject to claw removal to a minimum ($n = 12$) and to induce autotomy as this does not cause the stress response of de-clawing (Patterson et al., 2007). Crustacea have recently been shown to show responses consistent with an experience of pain (Barr et al., 2008) and, because autotomy causes no tissue damage there is little expectation of these responses. Thus, we examine here the lack of a single claw *per se* on feeding rather than having a claw removed as in fishery practice, which also induced stress.

3. Results

Crabs moved their antennules, legs and claws when mussels were offered. They then moved around the tank and often encountered a mussel. The crabs responded to contact with the mussels by either walking straight over them, standing on them, or nudging them with their claw(s) and back legs. Whilst some were observed to attempt to nip the shell no mussels were opened during the 20 min observation. The two-clawed and autotomised crabs behaved in a similar manner.

3.1. Feeding in autotomised crabs

Motivation to feed was not affected by claw removal since 8/12 clawed animals and 11/12 autotomised crabs fed on fish ($\chi^2_1 = 1.01$, NS). Claw status ('autotomised' or 'clawed') had a significant overall effect on the four variables measured ($PF_{5,13} = 7.14$, $P < 0.002$). There was no significant difference in the number of contacts made with mussels ($F_{1,17} = 1.1$, NS). Crabs with an autotomised claw predated significantly fewer mussels ($F_{1,17} = 11.30$, $P < 0.004$; Fig. 1a) and consumed a significantly smaller mass of mussel tissue ($F_{1,17} = 10.23$, $P < 0.005$; Fig. 1b). However, autotomised crabs consumed a significantly greater mass of fish ($F_{1,17} = 8.87$, $P < 0.008$; Fig. 1c). Too few autotomised crabs consumed mussels to allow for a comparison of the sizes of mussels that were actually eaten.

4. Discussion

Autotomised and intact crabs had similar contact with mussels, however, claw autotomy caused a significant decrease in the feeding of *C. pagurus* on those mussels in terms of both numbers of mussels and mass of mussel tissue. In the Dungeness crab, *Cancer magister*, damage to the chelae has a similar effect, causing animals not to feed on hard-shelled bivalves (Juanes and Hartwick, 1990). No reference was made to feeding motivation, but crabs that did not feed on clams readily consumed the tissue from shells that had already been opened (Juanes and Hartwick, 1990). The number of missing chelipeds also significantly impacted predation rates of male *Hemigrapsus sanuineus* on mussel prey, with two claws missing having the greater effect (Davis et al., 2005). Similarly, in the blue crab, *Callinectes sapidus*, animals missing two chelipeds had significantly lower foraging rates and ate smaller soft shelled clams than did intact crabs, or those crabs missing one cheliped (Smith and Hines, 1991; Juanes and Smith, 1995). Here, we only induced autotomy of a single claw, but even this virtually eliminated feeding on mussels.

In marked contrast to their responses to mussels, crabs that were induced to autotomise a claw consumed