SHORT COMMUNICATION

IMPROVEMENT OF PREDATORY EFFICIENCY BY THE PADDLE CRAB *OVALIPES CATHARUS* (CRUSTACEA: PORTUNIDAE) FEEDING ON THE BLUE MUSSEL *MYTILUS EDULIS AOTEANUS*

R.J. DAVIDSON[1] & I.D. MARSDEN

Department of Zoology, University of Canterbury, Christchurch 1, New Zealand.

(Received 17 March, 1988; revised and accepted 30 October, 1989)

SUMMARY

Davidson, R.J. & Marsden, I.D. (1990). Improvement of predatory efficiency by the paddle crab *Ovalipes catharus* (Crustacea: Portunidae) feeding on the blue mussel *Mytilus edulis aoteanus*. *New Zealand Natural Sciences* 17: 81-84.

Paddle crabs (*Ovalipes catharus*) both with and without experience at opening mussels used the same 4 techniques to attack mussels (*Mytilus edulis aoteanus*, length 20 mm) in the laboratory. The mean number of attacks required to open a mussel decreased from 4.2 for naive crabs and 3.3 for experienced crabs to a minimum of 1.3 attacks after sequential exposure to 5 prey items. Experienced and naive crabs both showed an improvement in eating times following exposure to 5 successive prey items. This reduction in eating time results in increased profitability for subsequent prey items.

KEYWORDS: *Ovalipes catharus* - Portunidae - predation - learning - opening time - eating time.

INTRODUCTION

There is considerable evidence that portunid crabs, including *Ovalipes catharus,* use active behaviours to select prey (Elner 1978, Elner & Hughes 1978, Hughes & Seed 1981, Jubb *et al.* 1983, Davidson 1986). These studies have suggested that the selection of prey by invertebrate predators is affected by many factors including prey detectability and vulnerability, and predator experience with a particular prey. In a study of the shore crab *Carcinus maenas*, Cunningham & Hughes (1984) showed that during exposure to up to 6 consecutive mussels, crabs were able to reduce opening times significantly.

The role of learning in increasing predatory skills may not simply be restricted to reducing the number of attacks (or time) required to break open the prey shell. Experience gained during the eating of the prey following a successful attack may reduce the time taken to eat subsequent prey, increasing their profitability. This aspect of crab feeding behaviour has not been investigated previously.

MATERIALS AND METHODS

Ovalipes were captured off Brighton Beach, Canterbury, New Zealand (an area where the bottom fauna is known) during December 1985. The crabs' diet was determined from gut analyses (Davidson 1987, 1989). Blue mussels used as prey in experiments did not form part of the natural diet, but small bivalves less than 10 mm shell length were an important food. Male crabs (75-87 mm carapace width) were conditioned to two feeding regimes prior to experimentation. Eight crabs were fed on mussel flesh for three days (naive), while another seven crabs were allowed to feed freely on an unlimited supply of whole mussels (5-30 mm length) for three days (experienced). The two groups of crabs were then starved for three days. During experiments crabs were presented with individual whole mussels, length 19-21 mm. Mussels were presented

[1]Present address: Department of Conservation, Monro Building, Nelson, New Zealand.

individually to each crab, and opening time (time from first physical contact to the first bite of flesh), eating time (from first bite of flesh to rejection of last piece of shell) and success rates were recorded for five consecutive mussels.

RESULTS

Eight naive and seven experienced crabs attacked and consumed all five consecutive mussels. Two experienced crabs refused mussels and were withdrawn from experiments. Paddle crabs used four recognisable techniques to open 20 mm mussels in the laboratory: anterior or umbone crushing; posterior crushing; wedging; and chipping. The frequencies with which crabs used these techniques to open mussels, and the opening success rate did not differ significantly between crab treatments (Kruskal-Wallis, H value = 0.04; P = 0.6723), however the overall number of attacks required to open mussels was 14 for naive and 10 for experienced crabs (Table 1). Crabs of both groups showed considerable variation in the time required to open and eat mussel prey. Variation in these times did not appear to be related to the size of individual crabs within each treatment (naive $\bar{x}$ = 77.0 mm CW, SD = 4.0; experienced $\bar{x}$ = 77.2 mm CW, SD = 4.2). Mean eating times for both treatments showed a significant decline over five consecutive mussels (Pages L-test: L-value (naive) = 403, $P < 0.01$; L value (experienced) = 347, $P < 0.01$). Mean eating times for naive and experienced crabs are shown in Fig. 1. Lines were fitted by the least squares method to illustrate the general trends.

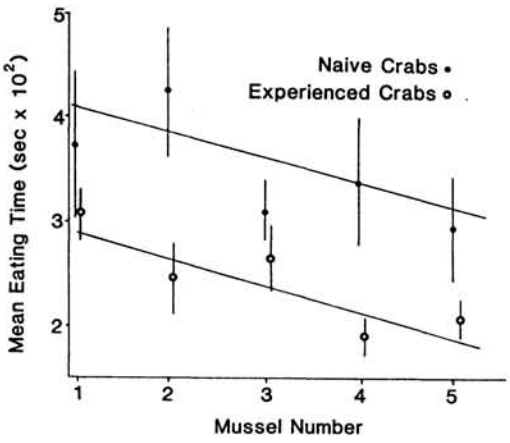

Figure 1. Mean time taken by naive and experienced crabs to eat 5 consecutive mussels. Error bars represent 95% confidence intervals.

Eating time decreased by 27% for naive crabs and 34% for experienced crabs between the first and the fifth prey. Values for the naive group consistantly exceded those for the experienced crabs, but because of the large variances a significant difference could only be demonstrated for the second mussel consumed.

The mean number of attacks required to open prey declined for both treatments (Table 2). Profitability as defined by Hughes & Seed (1981) increased as a direct consequence of declining opening and eating times (Table 2). Profit gained by experienced crabs was consistantly higher than that for naive crabs due to their reduced eating times.

Table 1. Attack and success rates of four attack methods used by paddle crabs to open five consecutive blue mussels.

Method	NAIVE CRABS (n = 8)				EXPERIENCED CRABS (n = 7)			
	All Attacks		Successful Attacks		All Attacks		Successful Attacks	
	n	%	n	%	n	%	n	%
Anterior	58	(52)	30	(75)	37	(54)	26	(74)
Posterior	45	(41)	7	(18)	29	(42)	8	(23)
Wedging	7	(6)	3	(7)	3	(4)	1	(3)
Chipping	1	(1)	0	(0)	0	(0)	0	(0)
Total	111		40		69		35	

Table 2. Summary of predatory behaviour of naive and experienced *O. catharus* feeding on 5 consecutive mussels (mean ± SD).

		Mussel Number				
		1	2	3	4	5
Opening time (s)	Naive	133±50	60±20	23±2	52±18	117±50
	Experienced	117±41	41±12	60±26	39±4	38±8
Eating time (s)	Naive	402±76	442±65	303±31	333±118	334±91
	Experienced	302±28	240±37	259±36	183±20	199±18
Profit (mg/min)	Naive	11.5±1.6	10.7±1.6	14.3±1.3	14.3±2.1	15.8±3.8
	Experienced	12.2±1.5	16.9±1.4	16.7±2.8	21.3±2	18.7±4.3
Number of attacks	Naive	4.2±1.3	2.4±0.1	1.3±0.2	2.1±0.8	3.0±1.1
	Experienced	3.3±1.0	1.3±0.2	2.1±0.4	2.0±0.3	1.3±0.2

DISCUSSION

The techniques used by paddle crabs to open mussels are consistent with those reported for other portunid crabs (Elner & Hughes 1978, Blundon & Kennedy 1982, Cunningham & Hughes 1984, Du Preez 1984, AP Rheinallt & Hughes 1985, Choy 1986). *Ovalipes* alternated attacks between anterior crushing and the less successful posterior crushing. Although posterior crushing was less successful at gaining entry into the shell it resulted in greater shell damage. This however did not result in decreased eating times. The advantage of using two methods of prey manipulation may be to detect weak spots in the shell. Posterior crushing may weaken the shell to allow subsequent anterior crushing and wedging techniques to succeed. This behaviour is likely to be important for large prey where prolonged periods of attack behaviour may be required before they are opened (Davidson 1986).

Results suggest that *Ovalipes catharus* learnt opening and eating skills while feeding on mussels. These findings also suggest that the skills learnt during preconditioning are retained for at least 3 days by *Ovalipes*. Increased profitability is a direct result of reduced opening and eating times. Such increases in profitability may advantage predators which are likely to encouter dense assemblages of bivalves such as those present in shellfish beds.

ACKNOWLEDGEMENTS

We are grateful to J.M. Davidson for assistance with laboratory experiments, and the Department of Conservation for word processing facilities. Funding for this work was provided by the University of Canterbury grant No. 574053.

REFERENCES

AP Rheinallt, T & Hughes, R.N. (1985). Handling methods used by the velvet crab *Liocarcinus puber* when feeding on molluscs and shore crabs. *Marine Ecology Progress Series* 25: 63-70.

Blundon, J.A. & Kennedy, V.S. (1982). Mechanical and behavioural aspects of blue crab *Callinectes sapidus* (Rathburn) predation on Chesapeake Bay bivalves. *Journal of Experimental Marine Biology and Ecology* 65: 47-65.

Choy, S.C. (1986). Natural diet and the feeding habits of the crabs *Liocarcinus puber* and *L. holstatus* (Decapoda, Brachyura, Portunidae). *Marine Ecology Progress Series* 31: 87-99.

Cunningham, P.N. & Hughes, R.N. (1984). Learning of predatory skills by shore-crabs *Carcinus maenas* feeding on mussels and dogwhelks. *Marine Ecology Progress Series* 16: 21-26.

Davidson, R.J. (1986). Mussel selection by the

paddle crab *Ovalipes catharus* (White): evidence of flexible foraging behaviour. *Journal of Experimental Biology and Ecology* 102: 281-299.

Davidson, R.J. (1987). Natural food and predatory activity of the paddle crab *Ovalipes catharus*: a flexible forager. M.Sc. Thesis, University of Canterbury, New Zealand.

Davidson, R.J. (1989). The bottom fauna from three subtidal locations around Banks Peninsula, Canterbury, New Zealand. *New Zealand Natural Sciences* 16: 87-95.

Du Preez, H.H. (1984). Molluscan predation by *Ovalipes punctatus* (De Haan) (Crustacea: Brachyura: Portunidae). *Journal of Experimental Marine Biology and Ecology* 84: 55-71.

Elner, R.W. (1978). The mechanics of predation by the shore crab *Carcinus maenas* (L), on the edible mussel, *Mytilus edulis* (L). *Oecologia (Berlin)* 36: 333-344.

Elner, R.W. & Hughes, R.N. (1978). Energy maximisation in the diet of the shore crab *Carcinus maenas*. *Journal of Animal Ecology* 47: 103-116.

Hughes, R.N. & Seed, R. (1981). Size selection of mussels by the blue crab *Callinectes sapidus*: Energy maximiser or time minimiser ? *Marine Ecology Progress Series* 6: 83-89.

Jubb, C.A., Hughes, R.N. & AP Rheinallt, T. (1983). Behavioural mechanisms of size selection by crabs, *Carcinus maenas* (L.) feeding on mussels, *Mytilus edulis* (L). *Journal of Experimental Marine Biology and Ecology* 66: 81-87.