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Preliminary Farming Trial of *Tapes dorsatus* (Lamarck) in Four Estuaries in New South Wales, Australia

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Abstract

A pilot farming trial conducted over 48 weeks in four estuaries along the coast of New South Wales (NSW), Australia, investigated the farming potential of the native clam *Tapes dorsatus* (Lamarck). Four experimental sites contained clams stocked at 750/m^2 in intertidal ground plots characterized by sandy substrate and high salinity. Clams held at Brisbane Water achieved the greatest growth (shell length and live weight), attaining market size (~38 mm) in 48 weeks of grow-out. This was attributed to warm water, a slightly lower growing height and the occurrence of two growing seasons in this estuary. Clams at Wagonga Inlet recorded the second highest growth over the 48 weeks and the highest survival (74.3%). High numbers of predatory molluscs and crabs at Wallis Lake resulted in low survival at this site. Predators might have altered the feeding behavior of *T. dorsatus*, contributing to reduced growth. Clams cultured in Merimbula Lake also re-corded relatively slower growth, attributed to lower temperatures. The growth of *T. dorsatus* was comparable to related species of commercial importance cultured overseas.

Introduction

Tapes dorsatus (Lamarck) is a sub-tropical estuarine clam endemic to Australia. It is found in seagrass beds and sand flats, where it grows to a maximum shell length of 100 mm. The species occurs throughout the Indo-West Pacific. In Australia, it is found from Houtman and Abrolhos Islands, Western Australia to Queensland (Wells and Bryce 1988), with isolated populations as far south as Victoria (Robinson and Gibbs 1982).

In 1996, 134 t of clams/cockles were commercially harvested from the wild in Australia. *Katelysia scalarina*, a clam similar in appearance to but smaller than *T. dorsatus*, is harvested in Tasmania and currently retails at AUS $8-10/kilo at a size of about 38 mm (shell length). It is anticipated that such a shell length will also be an acceptable market size for *T. dorsatus*. Currently, there is no commercial clam farming industry in Australia, although fourteen NSW oyster farmers had their aquaculture permits endorsed for clam farming in 1997.

T. dorsatus was chosen as a potential species to farm because it is endemic to NSW, local stocks could provide broodstock for hatchery propagation and spawning of this species is relatively easy. In addition, its shape, color and firm, well-textured meat are similar to that of clams that already have a high market acceptance in Australia.

Our earlier work on *T. dorsatus* at Port Stephens Research Centre (PSRC) (Paterson and Nell 1997) indicated that the species grows better when farmed in the sediment rather than in hanging culture. It also performs better in a sandy-shell substrate than in a muddy substrate. *T. dorsatus* cannot tolerate salinities < 20% and the optimum salinity range for growth is 30-40‰ (Nell and Paterson 1997). Based on these findings, sites falling within existing commercial oyster farming leases along the NSW coast were selected for this first cooperative clam farming trial in Australia. The aim of this trial was to evaluate the technical feasibility of clam farming on existing oyster leases in NSW, Australia.

Materials and Methods

Experimental sites, characterized by sandy sediment, were selected in four estuaries along the NSW coast: Wallis Lake, Brisbane Water, Wagonga Inlet and Merimbula Lake (Fig. 1). The tidal heights of each of these experimental sites were 0.3 m, 0.2 m, 0.3 m and 0.3 m, respectively, above zero tide datum (the tidal range for NSW is 0.1 - 2.0 m). Temperature and salinity data for each site were obtained from nearby oyster depuration plants. Four sediment samples were taken from each experimental site at week 48. Sediments were sieved with de-ionised water into six grades (Table 1) using the Wentworth Scale (Folk 1974). The total

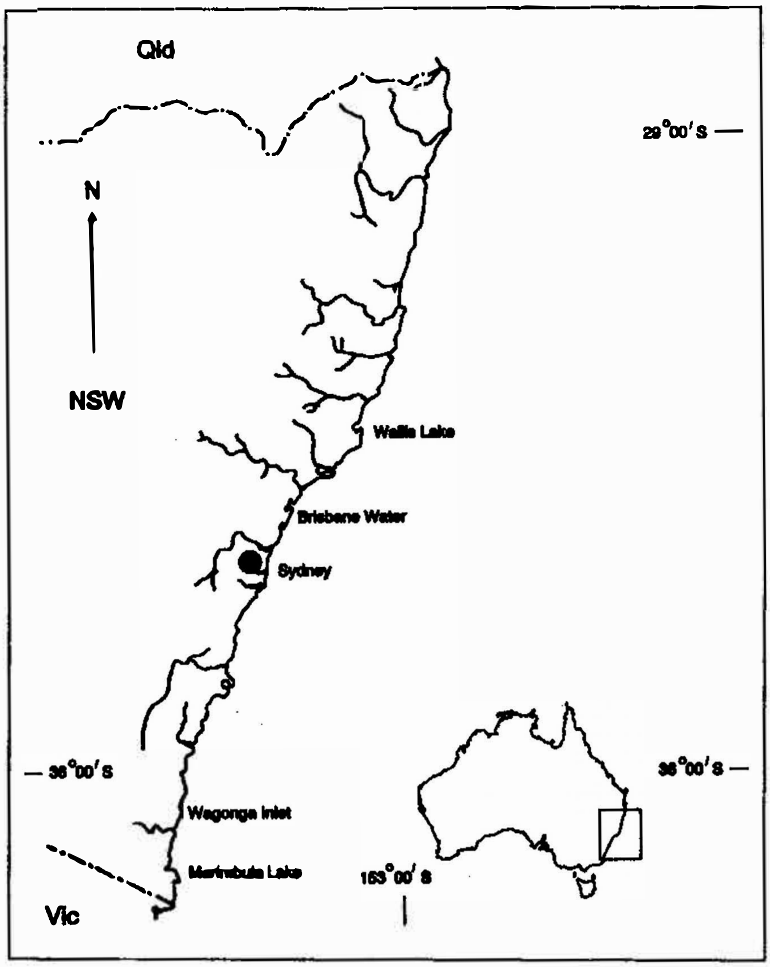

Fig. 1. Location of experimental sites on the NSW coast.

Table 1. Sediment characteristics[1] and organic content[1] at experimental sites used in the semi-commercial farming trial.

Size class	Mesh size	Phi	Weight (%)			
	(μm)	(Ø)	Wallis Lake	Brisbane Waters	Wagonga Inlet	Lake Merimbula
Very coarse sand	>1000	0	0.5±0.17	0.8±0.07	0.5±0.14	0.6±0.13
Coarse sand	>500	1	2.1±0.35	5.5±0.23	9.5±0.85	8.4±0.56
Medium sand	>250	2	75.8±1.58	29.0±0.95	78.8±0.48	54.0±0.44
Fine sand	>125	3	12.6±0.28	29.6±0.96	9.0±0.66	33.7±0.29
Very fine sand	>63	4	0.8±0.03	26.8±1.07	0.4±0.06	0.9±0.13
Silt/Clay	<63	5-14	8.1±1.62	8.3±1.32	1.8±0.09	2.6±0.13
Total organic matter (TOM)			1.5±0.31	1.7±0.21	0.7±0.06	0.8±0.06

[1]Data are mean ± s.e. (n=4).

organic matter (TOM) was determined by drying sediment samples for 24 h at 100°C, then ashing at 475°C for 5 h (Walne and Millican 1978). TOM was percentage dry weight lost after ashing (Table 1). Sites at tidal heights of 0.2 and 0.3 m were exposed to the air for 3% and 4%, respectively, of the time over the experimental period. Clams were stocked in 1.44 m^2 plots at a density of 750/m^2 in all four estuaries. This density was determined on the basis of the number of market size shells (shell length ~38 mm) that could be fitted edge to edge within a 1 m^2 area. This density is consistent with related species that are commercially cultured (Mitchell 1992). The perimeter of each plot was formed by four 1.2 m x 0.2 m sheets of galvanized steel driven approximately 0.15 m into the substrate. The plots were covered with 6 mm polyethylene 'protection mesh' to exclude small boring gastropods and crabs plus a layer of 9 mm polyethylene mesh to protect against rays and octopus. There were six replicate plots at each site.

The experiment was conducted from March 1996 to February 1997. At the start of the experiment, the mean ± s.e. live weight and shell length of *T. dorsatus* were 0.66±0.01 g and 15.33±0.05 mm, respectively (n=700). Sampling was undertaken every 12 weeks at which time the mesh was cleaned of fouling or, if necessary, replaced and any overlying sediment was removed to prevent suffocation. All measures of live weights were obtained after air drying clams on tissue paper for 0.5 h and shell length was determined using digital calipers along the clam's longest axis. Clams were held in hanging baskets in the experimental estuary after weighing and sizing and were returned to the experimental plots on the next low tide. Survival was calculated as the number of live clams/total number of clams recovered within a quadrant (0.24 m x 0.24 m) randomly positioned in each replicate plot. Final adjusted survival value was determined on week 48 and calculated as the number of live clams/expected number of clams (i.e. stocking density of 43.2 clams or 750/m^2) within the quadrant. Small holes in the empty clam shells were used as evidence of predation by boring whelks. Predation by crabs was determined from the number of empty shell hinges recovered that were broken or chipped. Oyster farmers involved in the pilot farming trial made regular checks to ensure experimental plots remained intact. Biomass was calculated as the % survival of clams after 48 weeks x the live weight (g) of the clams after 48 weeks.

Results and Discussion

Salinities recorded remained above the lower tolerance limit (20%) and within the range recorded as optimum for growth (30-40%) of *T. dorsatus* (Nell and Paterson 1997) at all experimental sites (Table 2). Temperature changes followed similar trends at each site, with the highest temperatures from November through to March and lower temperatures from June to September. The highest mean temperature over 48 weeks was at Wallis Lake (19.6°C), followed by Brisbane Water (19.0°C), Wagonga Inlet (17.6°C) and Merimbula Lake (16.9°C) (Table 2).

Sediment at the Wallis Lake and Brisbane Waters sites contained slightly higher percentages of organic material and silt/clay particles than those in

Wagonga Inlet and Merimbula Lake, but all sites were characterized by a firm sandy consistency. Sediments at the Wallis Lake, Wagonga Inlet and Merimbula Lake sites were mainly comprised of medium sand (range of values: 54.0-78.8% weight) while at Brisbane Water, the sediment was composed almost equally of medium, fine and very fine sand (between 26.8-29.6% weight) (Table 1).

Clams in Brisbane Water had higher mean shell length and live weight increases than clams cultured at other experimental sites at the end of the semi-commercial farming trial (Table 3). The fact that these clams attained market size (~38 mm shell length) in 48 weeks supports the future commercialization of this species. Unlike the other three estuaries, Brisbane Waters showed an extended growing season from spring to summer that resulted in a larger final mean size. The marginally lower tidal height of the experimental site at Brisbane Water (3% versus 4% exposure to air at other sites) may also have contributed to this result (see Anderson and Chew 1981).

Table 2. Temperature[1] (°C) and salinity[1] (‰) from March 1996 to February 1997 recorded in close proximity to each experimental site.

	Sites							
	Wallis Lake		Brisbane Water		Wagonga Inlet		Merimbula Lake	
Months	°C	‰	°C	‰	°C	‰	°C	‰
March '96	22.9	32.5	21.5	35.0	22.3	34.0	20.0	34.1
April	21.3	32.0	21.4	35.0	19.9	32.8	16.7	34.6
May	18.7	31.7	19.4	34.3	16.8	34.3	17.0	34.7
June	17.4	31.0	16.4	32.1	15.5	33.9	14.7	34.0
July	16.3	31.8	13.8	33.0	12.2	35.6	10.7	33.2
August	16.7	31.0	14.5	32.2	12.7	34.4	12.0	33.1
September	17.8	31.7	16.4	30.4	15.0	32.7	14.0	33.8
October	19.1	32.8	19.5	33.7	16.5	34.0	19.0	35.1
November	19.9	32.3	19.5	34.4	18.5	35.6	19.5	34.8
December	20.9	32.6	22.1	34.8	19.0	37.6	20.7	34.5
January '97	22.2	33.9	21.7	35.7	21.0	36.1	17.0	32.1
February	22.5	32.1	22.3	34.4	22.0	36.4	21.0	35.8

[1]Data is represented as means where n ranges from 1-35 temperature and salinity readings.

Table 3. Shell length[1] (SL in mm), live weight[1] (LW in g) and total biomass[1] of *Tapes dorsatus* farmed in four estuaries along the NSW coast from March 1996 - February 1997.

	Sites							
	Wallis Lake		Brisbane Water		Wagonga Inlet		Merimbula Lake	
Weeks	SL	LW	SL	LW	SL	LW	SL	LW
12 weeks	18.5±0.2	1.1±0.0	21.4±0.3	1.6±0.1	24.8±0.3	2.5±0.1	18.3±0.2	1.1±0.0
24 weeks	18.9±0.2	1.2±0.0	22.8±0.3	2.0±0.1	26.1±0.4	3.1±0.2	18.1±0.3	1.1±0.1
36 weeks	20.6±0.3	1.5±0.1	30.0±0.5	4.5±0.2	26.9±0.5	3.5±0.2	20.3±0.7	1.5±0.1
48 weeks	27.6±0.4	3.6±0.2	37.3±0.5	8.6±0.3	29.9±0.5	4.6±0.2	27.0±0.5	3.4±0.2
Total Biomass*	82.5±112.2		11.6±343.1		35.0±117.6		74.6±123.3	

[1]Data are mean ± 95% confidence limits (n = 30 x 6 replicates at each site).
*Biomass was calculated as live weight x survival at 48 weeks.

Clams cultured in Wagonga Inlet recorded the second largest final mean shell length and live weight. The growth of clams over autumn was considerably higher than in any other estuary in any season. This differs from other estuaries where summer was the predominant growing season for *T. dorsatus* (Fig. 2).

While higher temperatures are known to be conducive to faster growth (Bourne 1982), other factors such as food availability (which was not investigated here) may override the effects of temperature. The highest water temperature regime was recorded at Wallis Lake but clams cultured there attained a final mean ± s.e. shell length of only 27.56±0.25 mm, compared to 37.27±0.27 mm for clams at Brisbane Water.

The slower growth recorded by clams held in Merimbula Lake probably reflected the cooler water temperatures at this site, particularly over winter when no growth was recorded. Their growth in summer, however, was comparable to that of clams cultured in the other estuaries (Fig. 2).

Survival was highest for clams cultured at Wagonga Inlet (Table 4). Over the 48 weeks of the pilot farming, the total number of clams found (alive + dead) within quadrants decreased (i.e. empty shells had been crushed and were difficult to find), resulting in overestimates of survival. Hence, adjusted survival values were calculated as described above. A high abundance of predatory gastropods (*Conuber* sp.) and hermit crabs on the experimental plots at Wallis Lake was reflected in a high incidence of mortality of clams at this site (Table 4). As reported by Nakaoka (1996) for mussels, not only are predatory whelks responsible for increasing mortality, but their presence is also known to suppress growth of the bivalves even if they are physically separated by netting. Such suppression of growth

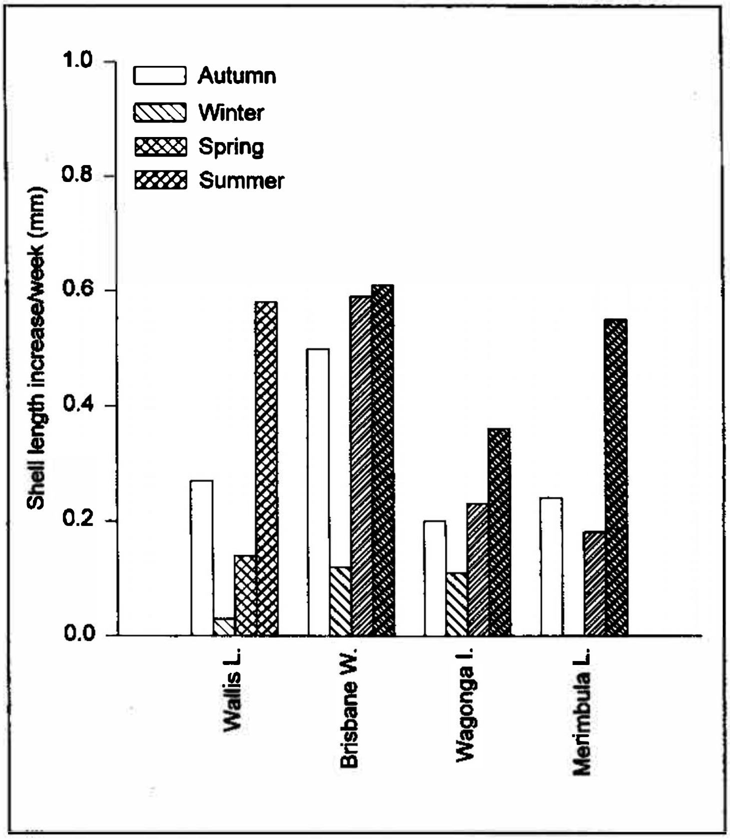

Fig. 2. Seasonal growth rate of *Tapes dorsatus* farmed in four NSW estuaries from March 1996 (autumn) - February 1997 (summer).

Table 4. Survival[1] (S) and total mortality (%) attributed to predatory gastropods[2] (Pg) and crabs[2] (Pc) of *Tapes dorsatus* farmed in four estuaries* along the NSW coast from March 1996 - February 1997.

Weeks	Sites											
	Wallis Lake			Brisbane Water			Wagonga Inlet			Merimbula Lake		
	Survival (%)	Pg	Pc	Survival (%)	Pg	Pc	Survival (%)	Pg	Pc	Survival (%)	Pg	Pc
12 weeks	97.9±1.6	16.7	na	78.9±13.5	2.4	16.7	99.3±0.9	na	na	96.4±3.7	na	na
24 weeks	81.8±18.7	2.8	13.9	67.1±19.2	na	na	98.1±2.6	na	na	86.8±4.7	3.3	na
36 weeks	40.5±37.1	9.1	19.7	40.2±17.9	20.7	na	86.2±9.6	25.0	na	66.6±21.7	na	na
48 weeks	23.1±29.1	12.7	19.4	73.0±20.3	7.9	6.4	74.3±19.8	1.5	2.9	61.7±18.4	2.8	4.17
48 weeks[3]	17.6±22.5			69.1±3			76.0±31.9			48.2±21.0		

[1]Survival data is mean ± 95% confidence intervals, n=6 plots. Survival was calculated as the number of live clams/total number of clams recovered within a quadrant (0.24 m x 0.24 m) randomly positioned in each replicate plot.

[2]Predation attributed to crabs and gastropods is expressed as a percentage of the total mortality.

[3]Adjusted survival calculated as the number of live clams/expected number of clams (i.e. stocking density of 43.2 clams or 750/m^2) within the quadrant.

*na - no data available.

is presumed to be caused by chemical cues (Nakaoka 1996). The prevalence of predatory animals may, therefore, have contributed to reduced growth in clams at this site.

The growth of *T. dorsatus* in the four study estuaries, was comparable to the Manila clam *Ruditapes philippinarum* commercially cultured elsewhere (e.g. Bourne 1982; de Valence and Peyre 1990; Spencer et al. 1991; Mitchell 1992). This study demonstrated that clam farming on highly saline oyster leases with firm sandy sediment is technically feasible. The commercial viability of clam farming in NSW still requires assessment.

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