BIOLOGY AND ECOLOGY OF THE FRESHWATER MUSSEL *VELESUNIO ANGASI* (BIVALVIA:HYRIIDAE) IN THE MAGELA CREEK, ALLIGATOR RIVERS REGION, NORTHERN TERRITORY

PART I

(TEXT)

by

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I certify that the substance of this thesis has not already been submitted for any degree and is not being currently submitted for any other degree.

I certify that any help received in preparing this thesis, and all sources used, have been acknowledged in this thesis.

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SUMMARY

The biology and ecology of the freshwater mussel, Velesunio angasi, were investigated from March 1980 to May 1981, in waterbodies of the Magela Creek - a seasonally flowing stream of tropical northern Australia. Features of the biology and ecology of the mussel studied included shell shape and environment, distribution, abundance, population dynamics, reproduction, food ingestion, physiological condition, production, and seasonal changes in any of these.

Three shell forms of V. angasi in lateral outline and obesity were recognisable in the Magela Creek: a winged, billabong or true angasi form, and two ecophenotypic variants - (1) a non-winged and dorsally arched form, and (2) a high, moderately winged and swollen Creek form. Both ecophenotypes appeared to be functionally adapted to maintenance and survival against swift flowing waters, and for aestivation over the Dry season in the braided, sandy creek channel above Mudginberri billabong, respectively. The dorsally arched shells were present only in Mudginberri billabong; progressive dorsal arching culminating in a distinct arcuate form was found at sites of increasing Wet season stream velocity. This trend was accompanied by a decline in relative shell height.

Relative height and obesity were correlated broadly among the billabongs with environmental factors of decreasing eutrophy and increasing depth respectively. Neither correlation, however, could be interpreted in terms of functional morphology and both relative height and obesity were found to be more closely associated with ontogeny;

relative height declined with increasing growth rate and obesity increased with increasing age of mussels. There was some evidence to indicate that shells were more obese on silty, unconsolidated sediments which is otherwise suggestive of adaptive morphology.

Young shells (< 1 year old), as yet relatively unaffected by environment, were always typically angasi in form throughout the Magela Creek, i.e. posteriorly winged and truncated.

Differences in distribution and abundance of V. angasi for both microhabitat and between-billabong, were clearly evident and quantified in terms of morphometry, hydrology and physicochemical limnology of the billabongs.

Distributional patterns within billabongs were readily quantified in terms of optimal depths or subregions for mussels, delineated mainly by: (1) local seasonal dissolved oxygen concentrations, sufficient levels of which are required for successful recruitment and subsequent development of populations; and (2) suitability of substrates - stable, and firm but yielding sediments are required for maintenance of individuals.

Among all billabongs of the Magela Creek, a correlation was found between mean dissolved oxygen concentration averaged over the seasons, and mean densities of the mussel populations. Apart from dissolved oxygen, no other physicochemical parameter studied was related to mussel distribution and abundance. Between billabongs nevertheless, distributional patterns clearly fell into two categories, those for

billabongs lying on the mainstream channel of flow (channel and floodplain), and backflow billabongs. For both billabong types, mean abundances of the mussel populations were related to mean dissolved oxygen concentrations and billabong morphometry. Certain dimensional relations of the latter are argued to be useful indicators of the Wet season flow regime, important for mussel recruitment in billabongs of the through-flow type, or of the amount of water remaining in the backflow billabongs at the end of the Dry, equally critical to the survival of mussels.

Features of the population dynamics of mussels investigated included age and growth, population structure, mortality and mussel movements.

Dark growth rings on the shells of mussels from all waterbodies were shown to be annular in nature, and resulted from late Dry season stresses. These could, therefore, be used to age mussels and to determine other population parameters. von Bertalanffy growth equations were used to describe growth in length of V. angasi. No dimorphism in size (and shell shape) was noted between the sexes. Growth rates of mussels between different waterbodies varied widely, being clearly correlated with mean food availability as measured by surface chlorophyll concentrations. Differences in growth rates of mussels within billabongs were accounted for by local differences in food and/or oxygen availability.

Population structures of mussels were compared both within and between waterbodies. Within-billabong patterns in size and age structure were quantified in terms of depth and different subregions. Both size and

age of mussels generally increased with increasing depth in the billabongs, and declined only in the deepest waters of the floodplain billabongs. These patterns are the result of littoral recruitment, instability of the shallows, and oxygen depletion in the deepwaters of the floodplain billabongs.

Recruitment of juvenile, newly metamorphosed mussels onto the sediments of the Magela Creek waterbodies was distinctly seasonal, occurring during the Wet-early Dry seasons. A feature of the age structures of mussel populations between waterbodies, was the irregular nature of those from the floodplain billabongs. Significant proportions of the variation in year class strenth, however, were accounted for by variation in annual stream discharge. This relationship added credence to evidence from distributional studies as to the importance of dissolved oxygen, as manifested through Wet season flow, to juvenile recruitment in these populations.

Age specific mortality rates were estimated for the mussel populations from three billabongs - Georgetown, Mudginberri, and Nankeen which represent backflow, channel, and floodplain types respectively. Longevities of mussels recorded between the different waterbodies were variable with determinations ranging from 11 to 35 years. Maximum ages of mussels among the billabongs were significantly correlated with mean dissolved oxygen concentration. Thus, from known longevities and age specific mortality rates of mussels, the stress imposed by low dissolved oxygen concentrations was believed to be a major cause of mortality of mussels in the Magela Creek waterbodies. Females appeared to be more susceptible than males to mortality by

this cause.

Regular seasonal movements of mussels were observed onto the shallow, flooded banks of Georgetown, a backflow billabong, each Wet season. Annual movements in Buffalo, a deeper channel billabong, however, were negligible, with only some slight evidence of displacement downstream by Wet season flooding.

The reproductive biology of V. angasi investigated in the Magela Creek included structure of the breeding population, gonadal development, larval production, and glochidial release and parasitism.

The sexes of V. angasi examined in the Magela Creek were separate; hermaphroditism was very occasional and was confined to less than 2% of each of the populations investigated. Gonads of the smallest individuals (< 1 year old) from most populations, appeared to function initially as males. Other than this early protandry no evidence of sex reversal in the adult population was found. The sex ratios of mussels in all environments were biased in favour of males. This was attributed to differential mortality of the sexes; males outlive females in many of the waterbodies. Gonadal maturation was found to be size dependent and was reached by mussels during their first year, at a range in length between 25.0-29.9 and 30.0-34.9 mm. First gravidity of females was found similarly to be size dependent and occurred at a length of approximately 40 mm. This size was attained on average within an age span of from 0.6 to 1.5 years depending on the waterbody. A long and gradual decline in reproductivity with increasing age occurred for female mussels at least in most of the

Magela Creek populations.

The timing of spermiogenic and oogenic activity of V. angasi was the same, and both sexes, therefore, were assumed to spawn simultaneously and at a similar intensity. Spawning and larval production were immediate responses to the intensity of gametogenesis. Larval development of mussels in the Magela Creek, from spawning to glochidial maturation, was rapid and during the warmer Wet season months at least could be completed in well under 12 days.

The ubiquity of mature primary oocytes and sperm, the presence of gravid females throughout much of the year in many populations, and the knowledge that larval development is very rapid and that mature glochidia are released in direct proportion to the intensity that they are produced, provided clear evidence that spawning and breeding of V. angasi in the Magela Creek were repetitive and occurred year round. Spawning and breeding were asynchronous among individuals at any given time and locality. Superimposed upon a repetitive reproductive cycle, the relative activity of which was only marginally slowed to any degree by low water temperatures, major interruptions to gonadal activity and larval production were found. These were associated with seasonal lulls in dissolved oxygen concentrations, and with seasonally high turbidities in the billabongs.

The glochidia of V. angasi were found to be unspecific parasites of their fish hosts; from both field and laboratory observations, a total of 19 fish hosts in the Magela Creek were recorded. Bottom feeding and dwelling fishes, and fishes notably inactive in the water column,

served disproportionately as hosts to the glochidia. Infections of the toothed glochidia were higher on the gills than the fins of the fish hosts.

The duration of the parasitic period of glochidia of V. angasi was temperature dependent. Metamorphosed juveniles were recorded from a host fish, Glossogobius giurus, on an average of 5 days after infection, at 30° C(shortest period was 48 hours); and on an average of 10 days, at 22° C (shortest period was 96 hours). By monitoring the seasonal incidence of parasitism of glochidia upon the host fish species, G. giurus, it was shown that V. angasi released glochidia throughout the year in direct proportion to their seasonal production. The seasonal pattern of recruitment of mussels in the Magela Creek did not correlate with the seasonal intensity of larval production; breeding was aseasonal and year round, while recruitment was seasonal (see above).

V. angasi in the Magela Creek was observed to be a phytophagous and detritivorous filter feeder, the food comprising unicellular algae and plant detritus. The algal fraction of the ingested material was generally low in the stomachs of mussels. However, algae were assumed to be underrepresented amongst the stomach contents as evidenced by the dominance of digestion-resistant forms. Digestion was assumed to be very rapid in the warm waters of the Magela Creek. Ingestion rates as measured by intestinal fullness were correlated with phytoplanktonic biomass of the environment when the influence of periods of sustained oxygen depletion was excluded from analysis. (Mussels ceased to feed in waters of very low dissolved oxygen

concentration, and reduced their feeding in waters with high concentrations of suspended solids.) This correlation provided some evidence that algae were the chief food source of the mussel. Evidence, however, that unicellular algae were the main utilisable food item and energy source of V. angasi (as opposed to the organic detrital fraction) was found in the correlation between shell and somatic growth and mean abundance of phytoplankton in suspension among the Magela Creek populations; growth was not correlated with the measure of organic detritus. Seasonal shifts in the abundance of major taxa of phytoplankton were noted in the stomachs of mussels. These changes have not previously been detected in the phytoplankton of the Magela Creek waters. Relative to green algae, diatoms were underrepresented in the stomach contents of mussels. However, no other indication of selective feeding was found. Given that a large inorganic fraction was included in the diet moreover, V. angasi appeared to be unselective in its feeding.

Generally, very few significant differences were found in the length/weight relationships averaged over the seasons, between the sexes of mussels from the Magela Creek waterbodies. A diphasic annual cycle was evident in populations where condition was followed at monthly intervals. A major peak in the mid-Dry season and a minor peak in the early-Wet were observed, while lulls in condition were noted at the end of the Dry and again at the end of the Wet. The fluctuations in condition were most clearly related to the seasonal availabiity of food; in 5 out of 8 billabongs, monthly chlorophyll concentrations and condition were significantly correlated. Further, condition and chlorophyll concentration averaged over the seasons were

significantly correlated among the billabongs. Thus, the two peaks in condition were generally associated with (1) increasing Dry season eutrophy and (2) major early-Wet, nutrient inputs from a dry catchment. Declines in condition coincided with (1) periods of either increasing turbidity with resultant suppression of algal production, aestivation or with spawning intensity during the latter period of the Dry and (2) progressive oligotrophy of the Wet season waters.

There was evidence that independent of food concentration, condition was depressed during periods of very low concentrations of dissolved oxygen and especially at times of high turbidity in the billabongs. High water temperatures during the late Dry were responsible for peaks in reproductive activity of mussels in the non-turbid Magela Creek billabongs; in oligo-mesotrophic waters, condition declined in response to reproductive activity, while in eutrophic waters, no decline was evident.

Annual production in V. angasi was measured in four of the Magela Creek populations. Production values were high in relation to other published data on freshwater mussels, ranging between 0.39-1.75 g/m^2/year shell free, dry weight. Moreover, gametic and larval production in the mussel, a repetitive breeder, were not included in the estimates. (Larval production would contribute a very significant fraction of total annual production of mussels in many billabongs of the Magela Creek.) Production/Biomass or turnover ratios of V. angasi were exceedingly low, however, varying between 0.07-0.13. These trivial values could be explained by the long-lived nature of the populations, in which adult mortality was low. While the contribution

of mussels as food for other trophic levels was probably minimal, the high densities and estimated turnover rates in the soft, acidic waters of some billabongs, suggested that the mussels probably contributed significantly to the nutrient and calcium cycles.

From study of the biology and ecology of mussel populations in the Magela Creek, important roles of V. angasi as an ecological indicator organism of present day and paleoenvironments are advocated. Description and quantification of shell form, densities, growth rates, recruitment, mortality, age structures, and relative condition in relation to environmental factors, may provide valuable baseline data upon which to monitor the effects of environmental disturbance such as potential pollutants, both organic and inorganic. Distributional information about V. angasi could provide useful indications of the local dissolved oxygen environment in waterbodies and, more broadly, of the flow regime in waterways perhaps throughout much of tropical northern Australia. Analysis of the size distribution and growth (shell and visceral) of mussel populations, could additionally indicate the trophic status of the environment seasonally, or integrated over time. Shell form and size might similarly indicate a variety of paleoenvironments with the knowledge of environmental determinants, and interpretations of functional morphologies of shell form.

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