

NOTES ON THE ECOLOGY OF *PATELLA CONCOLOR* AND *CELLANA CAPENSIS*, AND THE EFFECTS OF HUMAN CONSUMPTION ON LIMPET POPULATIONS

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ABSTRACT

Patella concolor occurs on the east coast of South Africa and predominates in the balanoid zone. It is a generalized browser, feeding on any available material. *Cellana capensis* has similar distribution, zonation and feeding habits and is a probable competitor with *P. concolor*. Large specimens of *P. concolor* occur in the upper regions of the shore and possess home scars, but homing is erratic. Smaller specimens occur in the lower balanoid and lack scars. This pattern suggests an upward migration. Recent excessive human consumption of *P. concolor* has reduced the maximum size considerably. The implications of this in terms of biomass and gonad output are considerable.

INTRODUCTION

The intertidal rocky shores of South Africa are divisible into three faunistic regions. In general the cold west coast fauna is distinct from the warmer south coast element and the subtropical east coast species (Stephenson 1939). Most of the *Patella* spp. occur on either the west or the south coast regions and have been described in a previous paper (Branch 1971). Only *P. concolor* is restricted to the East coast.

Krauss (1848) recognized several subspecific colour variations of *P. variabilis* including *P. variabilis concolor*. Justification for these subspecies is tenuous, as the colour variations are numerous and show no constancy with respect to distribution or zonation. The following colour variations are common: yellow with brown rays, black, russet, yellow with brown spots, and white with black rays.

Krauss' subspecific name *concolor* has now been proposed as a specific name to replace the preoccupied *P. variabilis* (Kilburn 1972).

The present paper deals with the zonation, feeding and movements of *P. concolor*. Mention is also made of the biology of *Cellana capensis* as a possible competitor with *P. concolor*. Details of the interaction between these two limpets will be considered in a subsequent paper.

MATERIALS AND METHODS

Collections of both *P. concolor* and *C. capensis* were made at various sites including East London, Port St. Johns, Cintza, Bulugha, Lwandile, Bashee River Mouth, St. Lucia and Xai Xai. Quantitative transects were made at Lwandile (31° 53'S, 29° 15'E) and at Cintza (32° 53'S, 28° 6'E), and 0,25 m² quadrats used to assess densities. Gut contents were examined from 50 specimens

of each species, covering a wide range of sizes. Daily photographs were taken for two weeks at fixed sites to determine the amount of movement taking place.

I am most grateful to Mrs. Giles of Cape Town for access to her collection of *P. concolor*, which has been made systematically over the past five years in the Transkei. This has enabled assessment of the effects of human consumption on the populations of *P. concolor*.

Gonads were dissected out whole and weighed wet. Smears of each gonad were microscopically examined and the ovaries graded according to whether they were mature (containing only mature oocytes), immature (with a mixture of mature and immature oocytes), or spent (filled with interstitial tissue and obviously deflated).

ECOLOGY

Patella concolor

P. concolor has been recorded from Richmond (near Port Elizabeth) to Cape Vidal (Day 1969), but a single specimen recorded from Xai Xai in Moçambique now extends its northern limits. Typically it occurs in the balanoid zone. Intertidal pools may extend the upper limits (Figure 1). In areas of relatively strong wave action, such as Lwandile, the zonation is extended considerably up the shore (Figure 1) in comparison with more sheltered areas such as Cintza (Figure 2).

Examination of gut contents reveals a great variety of food substances. About 60% contained large quantities of sand, comprising roughly 80% of the gut contents, and small amounts of diatoms, sponge spicules and algal fragments. 32% of the specimens contained a mixture of algae, lichens and detritus, while a few animals had eaten only a single species of alga. Most of the algal fragments were unidentifiable, but the following could be recognized: ? *Polysiphonia* sp., *Ralfsia expansa*, *Chaetomorpha* sp., *Enteromorpha* sp., "lithothamnion" and jointed coralines. In general the diet is that of a generalized grazer, and *P. concolor* appears to rasp almost randomly over the substrate, devouring all particles in its path. Organic detritus blown ashore in spume is also eaten. Even the unusually large amounts of sand in the gut of many specimens must yield a certain amount of nutriment as they are often coated with dried spume and probably bear bacterial populations.

The radula teeth terminate in sharply pointed cusps (Koch 1949), in common with all other limpets living fairly high up the shore: presumably an adaptation to rasping desiccated and hard food.

There is a marked tendency for small specimens to be found low on the shore, in crevices, or even covered completely by sand. Specimens left exposed on dry rock by the receding tide were observed migrating a few centimetres down a rock and forcing their shells under damp sand. Juveniles clearly prefer moist situations and are intolerant of dry hot conditions. Larger specimens are found higher up the shore: the majority still occur on moist rocks or in pools, but very large individuals may occur on bare rock (Figure 3).

A similar relationship between zonation and size has been found in *P. vulgata* in Britain (Jones 1948; Das & Sesheppa 1948; Lewis 1954), and also in *Acmaea digitalis* in California. In

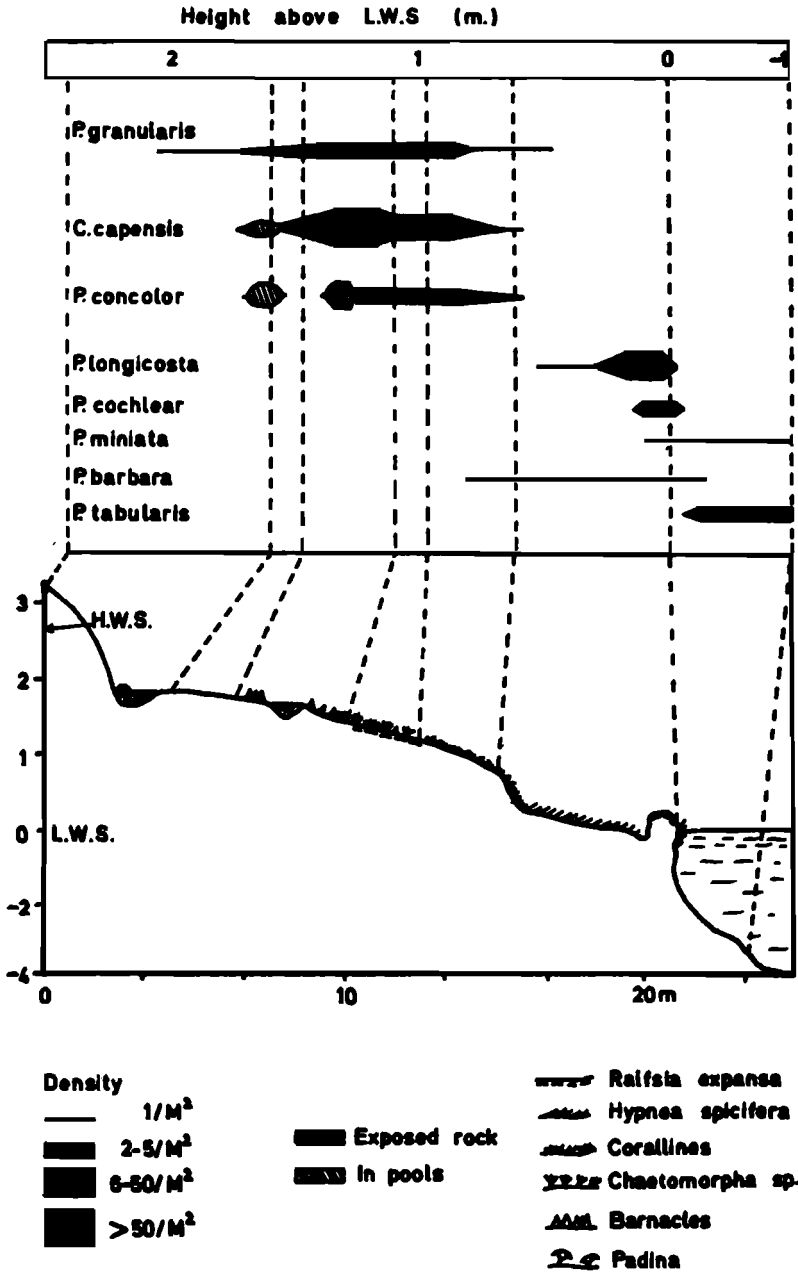


FIGURE 1
Transect at Lwandile.

the latter case, an upward winter migration and a lesser downward spring migration have been shown by Frank (1965) and by Breen (1973).

There is thus probably a general tendency for many limpets to migrate up the shore, so that older and larger individuals are found in the upper regions. This is certainly true of *P. concolor* at both Lwandile and Cintza. Such a zonation according to size is logical in terms of physical stresses, as smaller individuals lose water faster (Davies 1969) and are presumably less tolerant to desiccation.

Most large *P. concolor* (over 35 mm) possess a home scar to which they return after feeding.

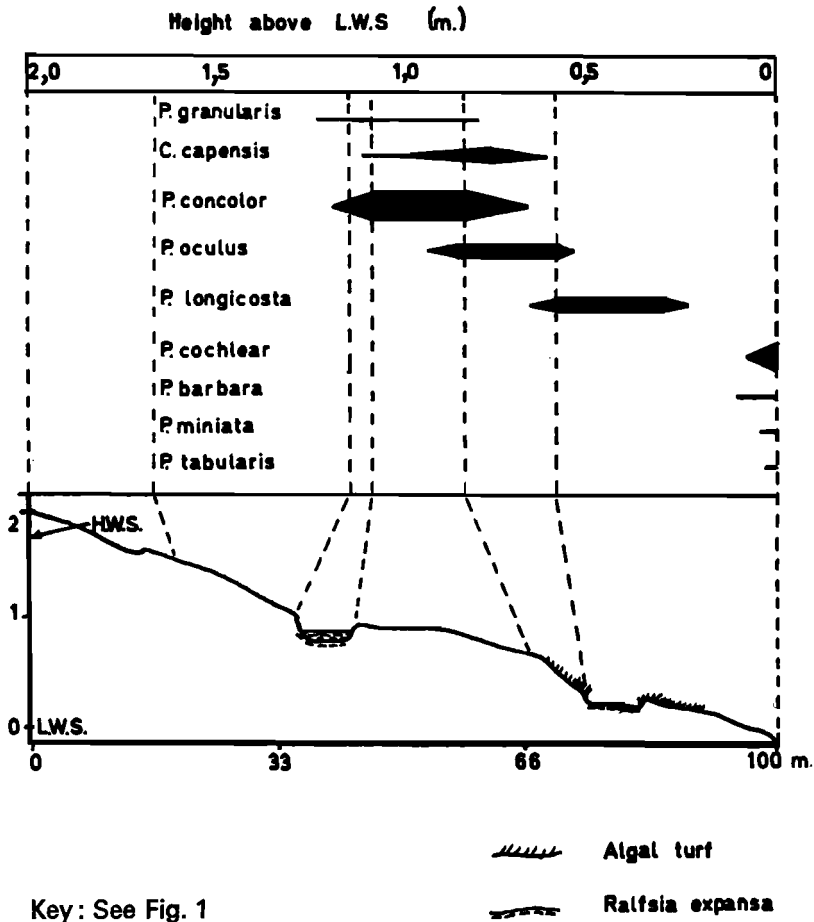


FIGURE 2
Transect at Cintza.

Photographic records at daily intervals show that this behaviour is variable. Of 50 specimens, 36 remained on (or returned to) their scars for the complete 10 days of observation at Lwandile. Seven remained for part of the time, and seven moved every few days.

Small individuals (under 20 mm) do not possess fixed scars, but have a tendency to return to the same general area after feeding. Frequently they may retreat into crevices in small groups, or force their way under moist sand.

Some species of upper-shore limpets form aggregates or clusters. Lewis (1954) has described this in high level *P. vulgata*, and Breen (1973) in *A. digitalis*. Willoughby (1973) has shown that a high proportion of *A. digitalis* are in contact with one another, and suggests that this contact is necessary before an animal will settle. Juveniles of *P. concolor* may form small groups in crevices, but this is probably simply a reaction to moisture and not due to contact. Adult *P. concolor* space themselves and are seldom in contact.

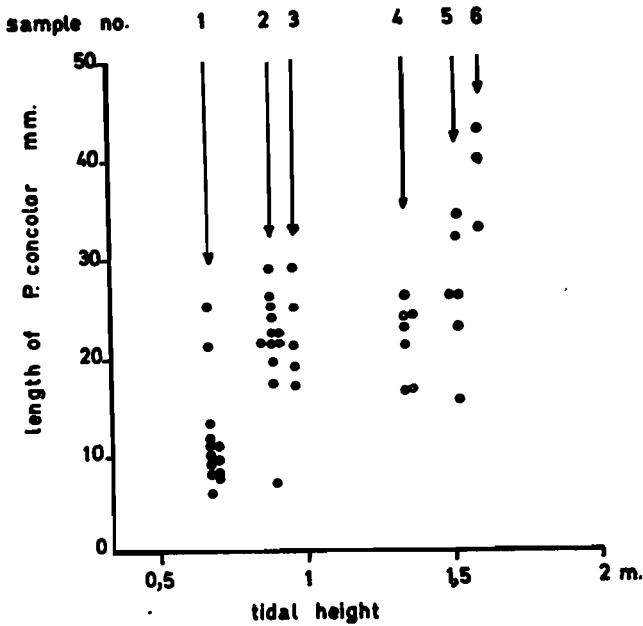


FIGURE 3

The relationship between limpet size and tidal height for six samples. Closed and open circles respectively indicate samples from bare rock or pools.

Cellana capensis

Extending from Port Alfred to northern Moçambique (Kalk 1959), the distribution of *C. capensis* overlaps with that of *P. concolor*. In addition, it also predominates in the balanoid zone, thus increasing the overlap in habitats. At Lwandile *C. capensis* extends higher up the shore than *P. concolor* (Figure 1) while at Cintza the reverse is true (Figure 2).

Examination of gut contents indicated a diet essentially similar to that of *P. concolor*. A small number contain quantities of sand in their intestine, but most had a mixture of algal fragments, diatoms, sponge spicules, unidentifiable organic debris, and even occasional copepod exoskeletons. Algae which could be identified were *Ralfsia expansa*, lithothamnion, and *Padina* sp. As in *P. concolor* the diet is typical of a generalized browser, feeding on any available material, and rasping up quantities of indigestible substances in the process.

Although the homing behaviour of *Cellana* was not examined in detail, they appear to return to a fixed scar more frequently than *P. concolor*, and even relatively small individuals may possess scars. Unlike *P. concolor* there was no obvious correlation between zonation and size at either Lwandile or Cintza.

P. concolor changes its position frequently and appears to migrate up the shore, while *C. capensis* has a more rigid homing behaviour and does not migrate. Adults of *C. capensis* are always solitary. This is similar to the situation described by Haven (1971) in which *Acmaea digitalis* moves up the shore and forms loose clusters, while *A. scabra* is solitary, has a fixed homing behaviour, and does not migrate seasonally.

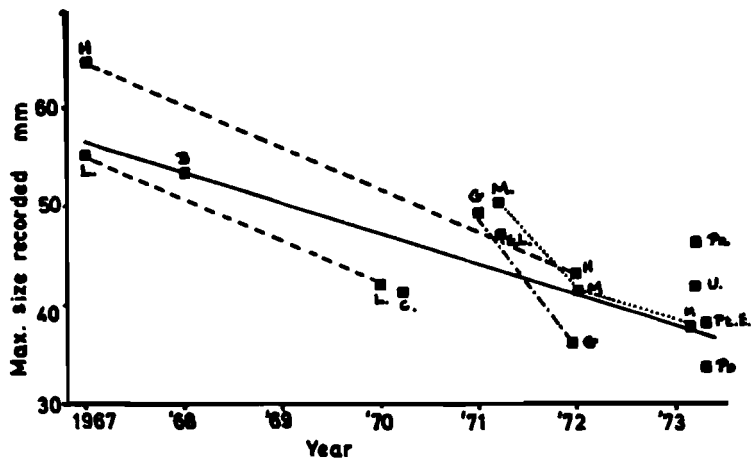


FIGURE 4

Maximum sizes of *P. concolor* at various localities. Isolated records have been included to show the overall reduction in size. The regression gives an approximation of average reduction. B: Bulughha Mouth; C: Coffee Bay; E.L.: East London; G: Gonubie; H: Haga Haga; L: Lwandile; M: Mboyti; N: Nthloniyane; P.R.: Park Rynie; Pa: Palm Beach; Po: Portobello; Pt.E.: Port Edward; U: Umbo-gintwini.

Human consumption of P. concolor

For many years the indigenous people of the Transkei have supplemented their diet by collecting intertidal molluscs. Over the past five years, with crop failure and droughts coinciding, the collecting of molluscs has been intensified. This has led to a dramatic reduction in densities and average sizes of some molluscs. *P. concolor* and *C. capensis* are particularly susceptible, as they predominate in the balanoid zone and are thus accessible at all low tides: in addition they are favoured because they yield a reasonable quantity of meat, and the flesh is easily removed. The entire animal is eaten, after removal of the radula from larger specimens.

An obvious change in the populations of *P. concolor* has been noted at the following sites: Haga Haga, Lusikisiki, Lwandile, Mboyti (near Lusikisiki), Qolora and Gonubie. No monitoring of this effect has been attempted, but Giles (pers. comm.) has systematically collected specimens of *P. concolor* from various sites on the East coast over the past five years. Measurements of the largest specimens from this collection indicate the progressive reduction in maximum size (Figure 4). In most areas a reduction of about 15 to 20 mm has occurred in the maximum size, over the last three to five years.

DISCUSSION

P. concolor and *C. capensis* are both generalized browsers, feeding on any available food material. This is similar to the diet of *P. granularis*, *P. oculus*, and *P. granatina* in the Cape Peninsula (Branch 1971), *P. vulgata* in Britain (Moore 1938; Southward 1964), and *Acmaea digitalis* and *A. scabra* in California (Test 1945). Thus it appears a general principle that high level species of limpet are generalized in their feeding habits, while low level and subtidal species may be very specialized. Examples of the latter group are *P. longicosta*, *P. miniata*, *P. cochlear*, *P. tabularis* and *P. compressa* (Branch 1971); *Patina pellucida* on *Laminaria* (Graham & Fretter 1947); and *Acmaea paleacea* on the blades of *Phyllospadix torreyi* (Yonge 1962).

This differentiation is logical, as the upper shore supports little macroscopic algal life, and limpets in this region must feed on any available material, including washed-up debris and spume. Lower on the shore, and subtidally, algae are abundant and specialized feeding is not only possible, but preferable in order to reduce competition.

Clearly *P. concolor* and *C. capensis* are possible competitors for food: their interspecific relationship will be described in greater detail in a later paper.

P. oculus normally occupies the upper balanoid. It is distributed principally on the south coast, extending as far north as The Haven on the east coast. The potential overlap between *P. oculus* and *P. concolor* is avoided, because towards the extremes of its distribution on the east coast, *P. oculus* is restricted to a much narrower band lower on the shore, and is limited to the lower balanoid (Figure 2). This is a general principle applicable to most intertidal organisms: that zonation and choice of habitat become restricted at the extremities of distribution. An instance of this had already been described for *P. granatina* (Branch 1971).

The consumption of shellfish on the Transkei coast has clearly had an effect on the populations of *P. concolor*, reducing the maximum size of specimens considerably. This reduction is

more dramatic when consideration is given to the wet body weight and to gonad output. Figure 5 shows the exponential relationship between shell length and wet flesh weight. This is expressed by the function:

$$w = bL^c$$

where L = length
 b = intercept of y axis
 w = wet flesh weight
 c = exponent

Logarithmic transformation yields a linear relationship from which c and b can be calculated to yield the relationship:

$$w = 0,000\ 0229\ L^{3,05}$$

Clearly a decrease in maximum length will have a dramatic effect on the biomass. A regression line through all the points in Figure 4 gives an estimate of the "average" decrease in length throughout the region (*i.e.* from Gonubie to Lusikisiki) in five years. This yields a reduction of 20 mm in the maximum length, which on transformation is equivalent to diminishing the maximum body weight from 5,4 g to 1,5 g.

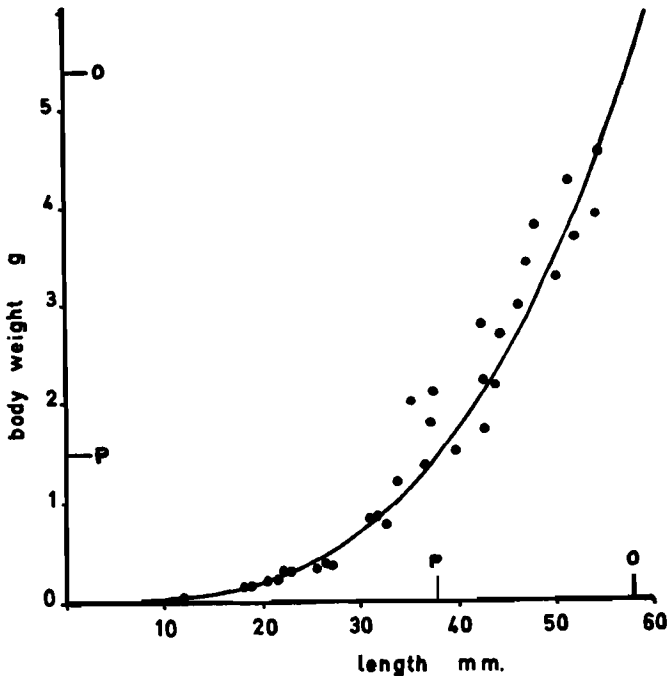


FIGURE 5

Length-weight relationship in *P. concolor*. O and P indicate the original and present maximum lengths and weights, as deduced from the regression in Figure 4.

The available biomass must have been sharply reduced, thus increasing the need to collect far larger numbers of animals for a comparable amount of meat.

The effect on gamete output is more difficult to predict, as the gonad cycle and quantitative output are not known. An approximation can be gained from a single sample of 40 animals collected from Lwandile and Cintza in January 1969, in which mature, immature and a single spent animal were present. No collecting of molluscs for consumption had occurred at Cintza by that date so that an assessment of an unaltered population was possible.

Figure 6 shows the relationship between body weight and mature gonad weight, and also

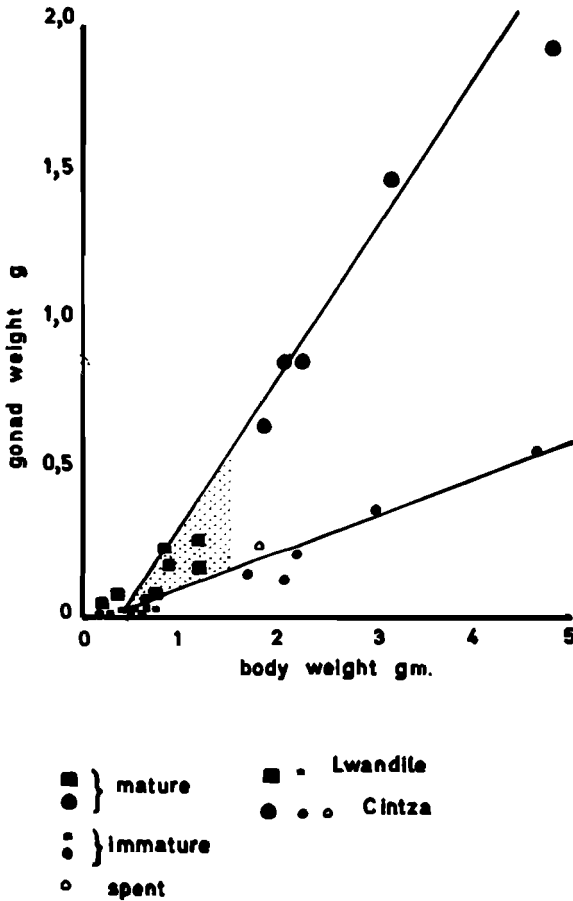


FIGURE 6

Gonad weight in *P. concolor*. The shaded area indicates the estimated output in depleted areas, and the total area between the two regression lines is an estimate of the original output.

between body weight and immature or spent gonad weight. (Immature and spent gonads have been lumped, as I have previously shown their weights to be similar.) The difference between these two relationships gives an estimate of gamete output. Statistical analysis of the slopes and intercepts (Table 1) indicate that the slopes of mature and immature gonads are significantly different (analysis of covariance, $p < 0,001$). Samples from Lwandile and Cintza were not significantly different and were grouped together.

TABLE 1

Statistical analysis of the relationship between body weight and gonad weight.

<i>Samples</i>	<i>Regression</i>	<i>Significance of difference</i>	
		<i>Slopes</i>	<i>Intercepts</i>
Cintza (mature)	$y = -0,176 + 0,468x$	} $p > 0,1$	$p > 0,1$
Lwandile (mature)	$y = -0,013 + 0,216x$		
Cintza (immature)	$y = -0,242 + 0,075x$	} $p > 0,1$	$p > 0,1$
Lwandile (immature)	$y = -0,021 + 0,125x$		
Total Mature	$y = -0,191 + 0,472x$	} $p < 0,001$	$p > 0,1$
Total Immature	$y = -0,011 + 0,158x$		

If the maximum body weight is being reduced from approximately 5,4 g to 1,5 g (Figure 5), the equivalent gonad output will be reduced by roughly 90% or more (Figure 6).

Even if these estimates are only accurate to within 20%, the reductions in maximum size, biomass and gamete output are dramatic, and the populations are being reduced considerably.

ACKNOWLEDGEMENTS

My wife Margo assisted with the field work. Professor J. H. Day kindly criticized the first draft of this paper. Both are acknowledged with appreciation.

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