

A COMPARISON OF GROWTH PARAMETERS OF AUSTRALIAN MARINE FISHES NORTH AND SOUTH OF 28° SOUTH¹

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ABSTRACT

Estimated growth parameters in fish contribute to knowledge of fish biology, and assist in the appropriate management of commercial fisheries resources. Parameters can also be used to test theories of organic growth. Here, one such test is conducted, of the theory that the availability of oxygen to the internal tissues of fish limits their rate of growth, as proposed earlier by the second author. More precisely, what is being tested is a follow-up of that theory, i.e., that, other things being equal, fishes in the cold, high-latitude part of their overall distribution range will have von Bertalanffy growth parameters (L_{∞} , K) different (higher L_{∞} , lower K) from those in the warm, low-latitude part of that distribution range. To test this, growth parameters of Australian fishes were assembled from FishBase, and complemented with growth parameters from other sources, notably unpublished documents from Australian government agencies. All growth parameter sets, corresponding to fish populations north or south of 28°S, were assigned a mean water temperature, and analyzed using multiple log-linear regression of K *vs.* temperature and L_{∞} . The result was a multiple regression in which both L_{∞} and temperature had a significant effect on K. Thus, environmental temperature, which varies strongly along the east and west coast of Australia, had an effect on the growth parameters of Australian fishes, as predicted by the theory tested here.

INTRODUCTION

Growth parameters of fish are an important source of information on the biology of fish, and for management of fisheries. Few studies have looked simultaneously at the growth of a large number of species, in spite of the valuable insights this can provide (Cury and Pauly, 2000).

The purpose of this study was to compare the growth parameters of Australian fishes along a latitude (i.e., temperature) gradient as a way of indirectly testing the theory formulated by Pauly (1981, 1984, and see Pauly, 2006, this volume), which states that the growth of fish is linked with their oxygen supply. Other things being equal, fish at low temperature should use less of the oxygen available to them for maintenance, and hence can devote more of it to growth, with the result that they reach larger size (Figure 1). In the von Bertalanffy equation (see below), asymptotic length, L_{∞} , is positively and closely correlated with maximum size, and inversely correlated with the parameter K. Hence, at low temperatures, L_{∞} should be high, and K low, and the converse should apply at high temperatures (Longhurst and Pauly, 1987).

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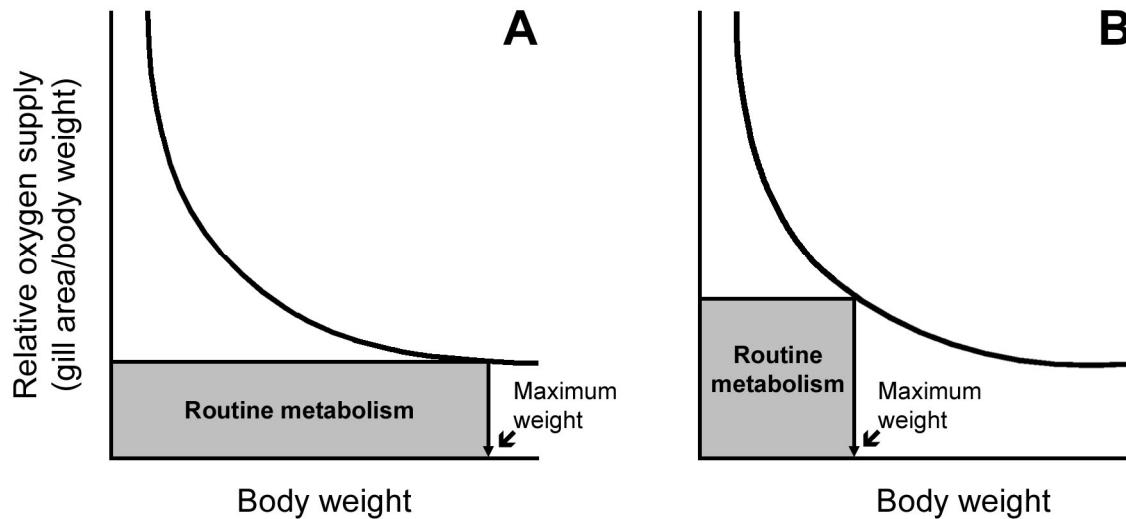


Figure 1 Schematic representation of the relationship between relative gill area (and hence relative oxygen supply) and body weight in fishes. Maintenance metabolism determines the maximum size that can be reached because relative gill area (and hence oxygen supply) *must* decline with body weight. **A:** A fish exposed to low environmental temperature will have a low maintenance metabolism and reaches a larger size. **B:** Exposure of a fish of the same species to high temperatures causes rapid denaturation of body protein, requiring more O₂ to be diverted to protein synthesis, and hence to maintenance of metabolism. Other things being equal, this fish will remain smaller than that in A (see also Pauly 2006, this volume).

MATERIALS AND METHODS

Growth parameters were obtained from the POPGROWTH Table of FishBase (www.fishbase.org). These were complemented with growth parameters from other sources, notably various published and unpublished documents from Australia (see References).

The von Bertalanffy growth function (VBGF) for length has the form:

$$L_t = L_\infty (1 - e^{-K(t-t_0)}) \quad \dots 1)$$

where L_t is the predicted mean length at time t , L_∞ is the asymptotic length, or the mean length the fish would reach if they were to grow a very long time (indefinitely, actually), K is a coefficient of dimension time^{-1} , expressing the rate at which L_∞ is approached, and t_0 is the (usually negative) age the fish would have had at length zero if they had always grown in the manner predicted by the equation (which they usually do not).

The length-at-age data from which these growth curves parameters were usually obtained from reading otoliths or vertebrae. Growth parameters were also inferred from length-frequency and tagging-recapture data. When this was not available from FishBase or the references below, a temperature was assigned to all growth parameter sets, corresponding to the mean water temperature at the sampling using the sampling location and depth (actual or inferred), based on data available from the Australian Oceanographic Data Centre (www.aodc.gov.au/).

RESULTS AND DISCUSSION

The following multiple regression was obtained from the 190 sets of growth parameters obtained:

$$\log K = 0.1652 + 0.0245 \cdot \text{Temp} - 0.681 \cdot \log L_\infty \quad \dots 2)$$

where K is in year^{-1} , Temp in $^{\circ}\text{C}$, L_{∞} in cm , and \log refers to base 10. The r^2 value was 0.544 and the effect of temperature was significant ($P < 0.01$), in addition to L_{∞} , in predicting K . This was solved for $\log K$ using different temperatures, as shown in Figure 2, i.e., a plot of $\log K$ vs. $\log L_{\infty}$, with isotherms at 30, 20, and 10°C superimposed.

As might be seen, the fish in the high K – low L_{∞} quadrant of Figure 2 stem overwhelmingly from Australian waters north of 28°S , while the fish with growth parameters in the opposite quadrant were sampled south of 28°S .

These findings are compatible with a number of biological mechanisms. The most likely mechanism, however, is that high temperature reduces the scope for growth of fishes, by increasing their metabolic rate, and hence the amount of water having to be passed across the gills in order for their respiratory requirements to be met. This task is made even more difficult by the fact that less oxygen is dissolved in warm than in cold water (Pauly 1981).

The different habitats of fishes, whether estuarine, coastal, neritic or oceanic, offer them food of different suitability and in different densities. However, there is no reason to assume that the suitability or density of food available to fish of different species should change, along the Australian coasts, in a close relationship to temperature or latitude (Longhurst and Pauly, 1987). Rather, food can be assumed to vary randomly, and to represent one of the causes for the variability around the values predicted by the multiple regression (Equation 1) and consequently, in Figure 2.

We thus feel that the evidence we presented support the existence of a strong linkage between fish growth and respiration.

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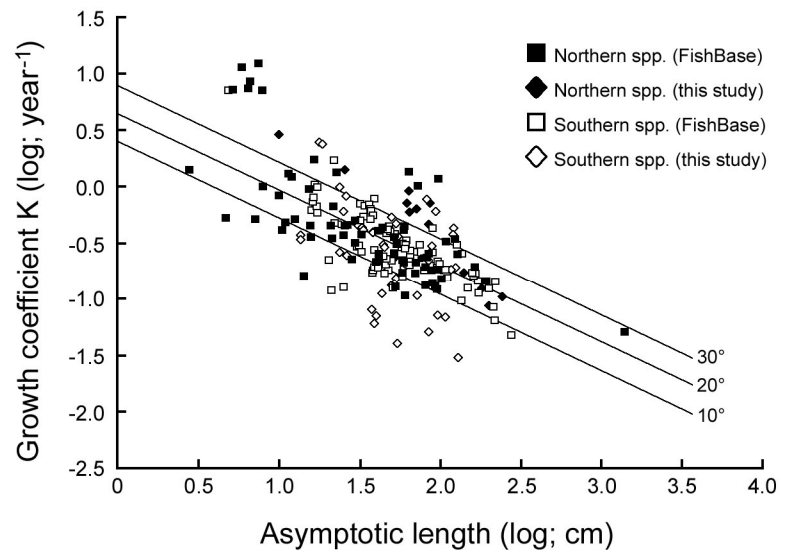


Figure 2 Plot of the von Bertalanffy parameter (\log) K vs. the parameter L_{∞} in 190 population of Australian marine fishes north and south of 28° South. The warm-water populations from the North tend to have lower L_{∞} and higher K than those in the South, and *vice versa* for those in the colder South. The isotherms for 10, 20 and 30°C were drawn using Equation 2 (see text).

³ Some of these references document sources of growth parameters (or growth data from which such parameters could be computed), and have not been cited in the text; the growth parameters were all subsequently entered in FishBase.

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