A comparative study of the habitats, growth and reproduction of eight species of tropical anchovy from Cleveland and Bowling Green Bays, North Queensland.

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in September 1994

for the degree of Doctor of Philosophy in
the Department of Marine Biology
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ABSTRACT

In this thesis the habitat preferences, growth and reproductive biology were examined for eight species of tropical anchovies from Townsville, North Queensland. The species examined were: *Encrasicholina devisi*; *Stolephorus insularis*; *Stolephorus carpentariae*; *Stolephorus nelsoni*; *Stolephorus commersonii*; *Thryssa aestuaria*; *Thryssa setirostris* and *Thryssa hamiltoni*. The study species grew to a wide range of maximum sizes (encompassing most of the size-range found amongst tropical clupeoid species), and therefore provided an opportunity to undertake a detailed comparative study of biological parameters and life-histories.

Samples were collected at three nearshore tropical habitats; mangroves, beaches and subtidal waters at 3-12m depth. Beach seines and gill nets were used to sample the first two habitats and an otter trawl at the subtidal habitat. The age-specific habitat preferences of each species were qualitatively investigated by comparing the catches of juveniles and adults in each habitat. In the subtidal waters of Cleveland Bay, anchovy were most common at depths of less than 7m. Juveniles of all species were common in shallow waters along beaches and the juveniles of some species were also common in mangrove estuaries. Age-related habitat differences were found to occur in *Stolephorus commersonii*, *Thryssa aestuaria*, *Thryssa setirostris* and *Thryssa hamiltoni*. In these species juveniles predominantly occurred in shallow nearshore habitats (beaches and mangroves) and adults occurred in the subtidal habitat at depths to 12m. *S. nelsoni*, *E. devisi* and *S. insularis* occurred in shallow water off beaches and in shallow subtidal waters throughout their life-cycle. *S. carpentariae* was almost exclusively caught along beaches and in mangroves (depths less than 3m) at all life stages.

Seasonal changes in habitat were exhibited by species in the present study. Adult *E. devisi* and *S. insularis* occurred in shallow waters off beaches in the autumn and winter months but were rare in summer. This suggests that these species move to deeper water in summer. Catches of all species in subtidal trawl samples in summer

were also lower, suggesting that a change in distribution occurs at this time, possibly movement to deeper water.

Growth was estimated in the study species using three methods: counting primary increments in the sagittal otolith; analysing length-frequency data; and in *Thryssa spp.* from counts of seasonal growth rings in the sagittal otolith. Prior to using primary otolith increments to age the study species, experiments were conducted to determine the periodicity of growth increment formation. The study species proved extremely sensitive to handling. However, evidence of daily periodicity of growth increment formation was obtained for four species:: *E. devisi*; *S. carpentariae*; *S. nelsoni* and *T. aestuaria*. Evidence was also given that the seasonal growth rings in sagitta from *Thryssa spp.* were deposited annually.

Growth curves (length versus. age) were constructed for each species from primary otolith increment counts. Length versus age plots were linear in *E. devisi* and *S. insularis* while von Bertalanffy growth curves were fitted to this data for the remaining species. These findings suggest that growth in very small stolephorid anchovies may not conform to the conventional von Bertalanffy growth curve. Consequently, some standard techniques for analysing length-frequency data which are based on von Bertalanffy growth parameters should be employed with caution on small tropical anchovies. This study of primary otolith increments indicated that the longevities of the stolephorid anchovies ranged from several months to just over one year. These structures also indicate a 1-2 year lifespan for *Thryssa aestuaria*. The larger species of *Thryssa* could not be aged beyond a certain size with confidence using these structures.

Length versus age plots from primary otolith increment counts were linear for juvenile-sized fish in all of the study species. A comparison of the linear growth rates in the study species showed that growth rate was directly related to the maximum size attained by a species. This indicates that larger species of tropical anchovy have faster

growth rates than small species. Primary otolith increment age data was also used to compare the patterns of growth in weight (plots of weight versus age) between the study species. These were found to exhibit one of two patterns of exponential growth in weight. The larger species, *S. commersonii*, *T. setirostris* and *T. hamiltoni* had a common faster rate of weight-growth than *S. insularis*, *S. carpentariae S. nelsoni* and *T. aestuaria*. The weight-age data in these smaller species followed a similar exponential pattern with a slower rate of increase. The similarity in weight-growth for groups of species show that growth can be conservative at an inter-species level in tropical anchovies. Furthermore, the difference in weight-growth between small and large species suggests that weight-growth may be another distinguishing feature of the life-history strategies of small and large tropical clupeoids (Lewis 1990).

An important outcome of the analyses of primary otolith increments and seasonal growth rings in this study was that the von Bertalanffy growth curve suitably described the length-age relationship for the three species of *Thryssa*. Growth in length in larger tropical anchovies therefore follows a pattern which is common to most other marine fishes. In the stolephorid anchovies, length-age plots did not exhibit a marked asymptote and consequently, a modified form of the equation had to be used. This finding indicates that length-frequency analysis methods that are based on the von Bertalanffy growth function may be more suited to large rather than small species of tropical anchovy. Growth parameters obtained from otoliths compared favourably with those from length-frequency analyses in the genus *Thryssa*, further confirming this view.

Counts of seasonal growth rings in otoliths gave estimates of longevity for the genus *Thryssa*. The oldest *T. hamiltoni* individual was 4 years of age, and the oldest individuals of *T. setirostris* and *T. aestuaria* were 2 and 1 years respectively. For *T. hamiltoni*, von Bertalanffy growth curves fitted to plots of length against age from seasonal growth rings indicated growth differences between male and female fish; females grew faster and larger than males.

Length-frequency data were analysed for all of the study species. Two methods of analysis were employed these being the estimation of growth rates in juveniles from modal progressions, and the estimation of growth parameters using the ELEFAN computer software. Length-frequency histograms indicated that growth differed between males and females in all *Thryssa spp.*, supporting the findings of otolith-ageing. Growth rates estimated visually for juvenile fish from modal progressions were consistent with those calculated from primary otolith increments for several species. This indicates that modal progressions can provide meaningful growth estimates in tropical anchovies. However, this analysis indicated that the residency-time for cohorts (or modes in length-frequency histograms) in populations of small species is short highlighting the importance of obtaining frequent and representative samples to allow analysis of modal progressions.

Von Bertalanffy growth parameters calculated from otoliths and ELEFAN analyses compared favourably in *S. nelsoni* and the three species of *Thryssa* indicating that these techniques give meaningful age estimates for larger clupeoids. Values of K computed from otolith-derived length-age data were generally higher than those computed by ELEFAN for the remaining stolephorid anchovies and this supports recent literature in the view that ELEFAN may yield biased growth estimates for small tropical clupeoids.

The following reproductive parameters were estimated for the study species: spawning season; length and age-at-maturity; fecundity and spawning frequency. Two types of spawning seasonality were observed. *E. devisi* and *S. insularis* spawned over most of the year while the remaining species spawned during the warmer part of the year between September and January. Length-at-maturity occurred at around 70% of maximum length in all species suggesting that this ratio may be conservative in tropical anchovies. Ages-at-maturity varied from several months in small species to around one year in larger species. Fecundity for all species combined was related to

both length (exponential curve) and weight (linear regression), indicating that the relationship between these parameters is conservative at an inter-species level in this group. Spawning frequency was estimated as three days for *S. nelsoni* and between 2 and 5 days in *T. hamiltoni*. The pattern of oocyte-diameter frequencies differed between stolephorid anchovies and *Thryssa spp.* indicating possible differences in spawning biology.

In the present study it was shown that fecundity and growth rate were related to maximum species-size at an inter-species level. Furthermore, longevity was shown to be directly related to maximum species-size for a wide range of tropical clupeoids. These findings indicate that it may be possible to estimate certain biological parameters based on maximum species size for tropical clupeoid species. Another finding of this study was that growth and reproductive parameters in large tropical clupeoids were comparable to those in some short-lived temperate species. Beverton's (1963) ratio of $1/KT_{max}$ was also similar in some large tropical clupeoids to that in temperate anchovies. Following Beverton's (1963) reasoning, the similarity in this ratio in these two groups suggests that these may exhibit similar population and fishery dynamics.

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DECLARATION

I declare that this thesis is my own work and has not been submitted in any form for another degree or diploma at any university or other institution of tertiary education. Information derived from published or unpublished work of others has been acknowledged in the text and a list of references is given.

F. Hoedt

ACKNOWLEDGMENTS

My thanks go to the supervisors of this project Prof. J.H. Choat and Dr. D.M^{c}B. Williams (Australian Institute of Marine Science). Thanks for creating the opportunities that you have in tropical fisheries research. I have enjoyed working in that environment. Thanks also for your support and help during the writing of this thesis.

I am indebted to some of my fellow PhD students in the Marine Biology Department. It takes two people to haul a seine net and Brett Molony was always available for that task. Thanks also Brett for fruitful scientific discussions inter-mixed with light-hearted banter over coffee. I owe many thanks to both George Jackson and Annadel Cabanban for allowing me collect fish during their trawling days on board the 'James Kirby' and also for assistance during some seine-netting trips. Thanks also to the other frontline PhD soldiers with whom I shared rooms, equipment and conversation: Pat; Lou; Len, Beatrice; Mark; Bridgett; Cambell and Glen. The PhD environment was a pleasure to work in. I am also extremely grateful to the hard-working and enthusiastic Mike Cappo (A.I.M.S.) for helping collect samples and for many discussions concerning our shared interest in clupeoid and other fishes (which still continue today).

In the Marine Biology department I extend my gratitude to Anne Sharp for her generosity with time when problems arose, especially during the printing of this thesis. Thanks also to Leigh Windsor who provided both cheerful company and professional advice with regard to histology.

I would like to thank the crew of the research vessel 'James Kirby' with whom I have worked for a good seven years on various projects. The long hours at sea were well worth the many glimpses of the fascinating marine life of our northern seas.

I am also grateful to the research staff of the Phillip Island Penguin Reserve for employing me and allowing me to use their facilities to produce this thesis.

Thanks go to my family, Mum, Dad and brothers for encouragement and support during some pretty torrid times. Special thanks to my wife for providing support and encouragement during this busy time. This thesis is dedicated to my son with whom I fell in love during the two years he was with us.