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Age and Growth of Four Everglades Fishes Using Otolith Techniques

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Age and Growth of Four Everglades Fishes
Using Otolith Techniques

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INTRODUCTION

The Everglades region of southern Florida is a large, subtropical, freshwater marsh prone to periodic droughts. Usually about 70% of the annual rainfall occurs between June and October (Leach *et al.*, 1979), and water levels increase during this period. The marsh gradually dries until the next rainy season begins again the following spring.

Small fishes of the families Cyprinodontidae and Poeciliidae are an important link in the Everglades food web (Kushlan, 1976), but information about their biology in southern Florida is limited. The effect of seasonally fluctuating water levels on growth, the length of time that individuals remain in the population, the age at which they become available to predators, and the age at maturation must be determined to accurately assess the role of these fishes in the Everglades ecosystem. The first step to answer these questions is age determination.

Most cyprinodontids and poeciliids reproduce during much of the year in the Everglades (Loftus and Kushlan, pers. comm.), and the results of age and growth determination by length-frequency analysis have been generally unsatisfactory. The best way to determine the age of these small fishes appears to be by the counting of daily growth increments in the otoliths.

Otoliths are calcium deposits found in the inner ear of teleost fishes, and are useful in age determination. There are three pairs of otoliths: the sagittae, asterisci and lapilli. Panella (1971) reported finding daily growth layers in the sagittae of some fishes, and other workers (Brothers *et al.*, 1976; Taubert and Coble, 1977; Barkman, 1978; Tanaka *et al.*, 1981; and Radtke and Dean, 1982) have raised fishes in the laboratory to a known age, conclusively showing that the formation of growth increments is a daily event in many species. The environmental cues that control growth increment information are presently undetermined. Periodic feeding has been discounted as a cue (Taubert and Coble, 1977; Tanaka *et al.*, 1981; Brothers, pers. comm.) but the roles of temperature cycles and photoperiod have not been fully investigated. There is evidence that, in some species, the controlling signal is photoperiod (Taubert and Coble, 1977; Tanaka *et al.*, 1981), but in other species it is a cyclic change of temperature (Brothers, pers. comm.; Haake and Dean, unpublished data). Apparently one cue is more important than another only if they have different periodicities. We have not investigated this topic and assume that wild fish respond in a manner similar to lab-reared fish exposed to a normal photoperiod.

In this study we used daily growth increments for age determination and analyzed the age-size distributions of two species in the family Cyprinodontidae (*Fundulus chrysotus* and *Lucania goodei*) and two species in the family Poeciliidae (*Gambusia affinis* and *Heterandria formosa*) in the Everglades. The hypothesis that the growth rate of each species is affected by the season of the year was tested.

METHODS AND MATERIALS

Samples were collected using rotenone in the Shark River Slough of Everglades National Park, approximately 3 km west of Canal L-67 Extended. The study site was a typical Everglades mixed marsh prairie, dominated by *Eleocharis cellulosa*, *Panicum hemitomon*, *Rhynchospora tracyi*, *Sagittaria lancifolia*, and *Utricularia purpurea*. Collections were made near the end of the wet season (October 30, 1980), during the transition from wet to dry conditions (March 3, 1981), and at the end of a dry season (June 25, 1981). The average water depths for each month from April 1980 to August 1981 are presented in Figure 1 (Loftus and Kushlan, pers. comm.). The water levels were recorded at gauging station P-33 located in Shark River Slough approximately 3 km. south of the study site. Water depth was calculated by subtracting the elevation of the substrate from the water level (MSL).

The specimens were preserved in 95% ethanol. To estimate the amount of shrinkage that occurred due to alcohol fixation, we measured the standard length (SL) of subsamples of each species (15 *G. affinis*, 14 *H. formosa*, 15 *F. chrysotus*, 15 *L. goodei* from the October 1980 sample and 27 *G. affinis*, 30 *H. formosa*, and 6 *F. chrysotus* grown in the laboratory) both before and after fixation. The mean shrinkage (as proportion of original length after three weeks of fixation) was determined, and fresh lengths were back calculated from preserved lengths. The effects of fixation in 10% formalin were also determined for each species so that the results of this study could be used to estimate ages from the lengths of fishes fixed in formalin. All *F. chrysotus* had to be used for age estimates because of their scarcity in our samples, so the shrinkage of *F. chrysotus* was estimated by substituting *F. heteroclitus* of the same size range as the *F. chrysotus* in our samples. *F. chrysotus* is in the *F. heteroclitus* species group (Foster, 1967), so *F. heteroclitus* should provide a good estimate of shrinkage in *F. chrysotus*.

To avoid gaps in the length vs. age distribution, specimens used for otolith analysis were chosen nonrandomly to include the broadest size range possible. In some samples, all fishes captured were analyzed. In others, only a proportion of the total sample was used. If the entire sample was not used, the specimens were chosen so that relatively rare size classes would be included.

The terms used to describe otoliths in the recent literature are somewhat confusing, so we have followed the terminology used by Radtke and Dean (1982) and Tanaka *et al*. (1981). One growth increment consists of an incremental zone and a discontinuous zone. The thick incremental zones are separated from each other by relatively thin discontinuous zones. Incremental zones contain some organic material, but they are composed primarily of calcium carbonate; discontinuous zones are mostly organic matrix. When an otolith is etched, the discontinuous zones become visible as grooves in the surface (Watabe *et al*., 1982). Because each growth increment has one incremental and one discontinuous zone, the number of increments can be determined by counting the discontinuous zones. The region inside the first discontinuous zone is called the core. The core can have subunits, and dark spots called primordia can frequently be seen within the core when observing sections with the light microscope (Fig. 2).

The otoliths used for age determination, the sagittae, were removed, cleaned, and dried. After embedding them in the hard mixture of the low viscosity electron microscopy embedding medium reported by Spurr (1969), the sagittae were sanded with 600 grit wet-or-dry sandpaper to the plane used for counting (see Fig. 3). The surface was polished against 0.3 micron alumina polishing compound or Microcloth (r) adhesive-backed cloth. After polishing, the sagittae were decalcified for 4 min. in an aqueous solution of 2% glutaraldehyde (buffered to pH 7.6 with 0.1m Nacacodylate), 3.4% sucrose and 2.5% disodium ethylenediaminetetraacetate (the mixture is referred to as EDTA/GA). The specimens were gold-coated and observed in either a JEOL JSM U3 or a JEOL JSM 35 scanning electron microscope (SEM), operated at 25 kV. This technique is described in detail by Haake *et al*. (1982).

To validate the formation of daily growth increments, adults of each species were induced to reproduce in the laboratory. The offspring were maintained on a light-dark cycle of 14L:10D at constant temperature and were fed *Artemia* nauplii or frozen adults *ad libitum*. Fishes were sampled at several ages (see Table 1 for ages for each species), preserved lengths were measured, and the otoliths were removed and prepared as described above.

When observing known-age poeciliids, a distinctive pattern of growth increments was found in the otolith which was also present in wild fishes (Fig. 4-6). This growth pattern was correlated to the day of birth in known-age poeciliids and was therefore termed a birth mark. The prebirth discontinuous zones of *G. affinis* were relatively short, but those formed just after birth extended almost completely around the otolith (Fig. 4). The pre-birth discontinuous zones of *H. formosa* were usually complete and the first post-birth increments were much shorter. There also was a wider space between pre- and post-birth discontinuous zones in *H. formosa* otoliths (Figs. 5 and 6). A fish's age was estimated by the number of increments after the birthmark for the poeciliids.

No such mark was found in the cyprinodontid otoliths. Since no birth mark was found in either *F. chrysotus* or *L. goodei*, all growth increments were counted. Individual age estimates were calculated by subtracting the average number of increments present at hatching for the species from the total increment count. The number of increments present at hatching for each cyprinodontid was estimated by the y-intercept (rounded to the nearest integer) of a regression line relating age to increment number of lab reared fish.

Increment counts were made on the SEM. By marking sections with a number which could be read while observing the otolith, the counter did not know the specimen's age or size before the count was made. This procedure avoided biasing counts. After the count had been made, the identification number and the count were recorded. A random subsample of 75 wild H. formosa were counted by an inexperienced reader to determine if any bias was present in the counting technique. Only the experienced reader's (PWH's) counts were used in the analysis of the field samples.

Growth was modeled by three types of equations to determine which best fit the data. Regression lines were fitted using the GLM (general linear model) procedure of the Statistical Analysis System (SAS) (Helwig and Council, 1979) and SAS' NLIN (nonlinear regression) procedure was used to fit growth curves of the von Bertalanffy and Gompertz types; see Kaufmann (1981) for a discussion of the different types of growth curves. The model which resulted in the lowest sum of squares due to error in the greatest number of species-sampling date combinations was chosen as the best growth model overall (Dunham, 1978) and was used for comparison of growth among sampling dates.

Data for male poeciliids were separated from those of the females and juveniles so we could analyze growth rates. The hypothesis that maturity causes a cessation of somatic growth in male poeciliids was tested by comparing the slopes of least squares regression lines to 0. If the slope was significantly greater than 0 (t-test $p<0.05$), then the growth rate was considered to be greater than 0 also.

Because von Bertalanffy curves fit the data best (see Results), growth rates were compared by using the von Bertalanffy models. Von Bertalanffy curves are of the form:

$$L = Li(1 - EXP\ (K * (T - T_o))) \qquad (1)$$

where,

T = time in days after birth or hatch
L = length at age T
Li = L-infinity, asymptotic maximum size
EXP ( ) = e raised to the ( ) power
K = the von Bertalanffy growth constant
and T_o = the theoretical age at which $L = 0$.

The estimates used for L-infinity were 71mm, 41mm, 21mm, and 34mm for F. chrysotus, G. affinis, H. formosa, and L. goodei, respectively. These values represent the maximum standard lengths recorded for those species in Everglades National Park (Loftus and Kushlan, pers. comm.). The growth rate is the derivative of (1) with respect to time:

$$dL/dT = K * (Li - L). \qquad (2)$$

Notice that the growth rate at a given length is proportional to K. Because L-infinity was assumed to be the same for the three periods of growth, the growth rates could be compared by comparing growth constants (K). The von Bertalanffy growth curve (1) can be linearized by rearranging the terms and taking the natural logarithm of both sides:

$$\ln(1 - L/Li) = K*T - K*T_o. \qquad (3)$$

Comparisons of growth rate, measured as K in the von Bertalanffy equation, were made by comparing the slopes of regression lines fit to the transformed data. The hypothesis that the growth rates were equal among the three sample dates was tested by comparing the sum of squares due to error (SSE, also called the sum of squared residuals) between a complete and a reduced model for each species (Ott, 1977, pp. 469-472). The complete model fits three lines to the three data sets, allowing the slopes to be different. The reduced model fits three lines to the data, but forces the slope to be the same for the three data sets. The test statistic used is:

$$F = ((SSEr - SSEc)/(dfr-dfc))/(SSEc/dfc)$$

where,

SSEr = the sum of squares error for the reduced model
SSEc = the sum of squared error for the complete model
dfr = the degrees of freedom of the SSEr
and dfc = the degrees of freedom of the SSEc.

The null hypothesis that the slopes are equal is rejected if the difference in the sum of squares due to error between the two models is large relative to the mean square error of the complete model ($p<0.05$). If an overall difference was found for a species then Scheffe's method for multiple comparisons (Ott, 1977) was used to identify the growth rates that differed between sample dates. Intermediate statistical calculations and the data are provided in Appendices A-G.

RESULTS

Poeciliidae

The sagittae of *Heterandria formosa* and *Gambusia affinis* exhibit minor morphological differences from those of other fishes we have examined. They are laterally compressed like most sagittae, but are elongated dorso-ventrally (Fig. 3). Because the sagittae of most other fishes are longest in the anterior-posterior axis, other workers have found sagittal or frontal sections to give the best increment definition. We found it easier, however, to count increments in transverse sections. The increments did not appear over the entire surface of the sectioned sagittae (Figs. 4-6). Most discontinuous zones appeared on the medial half of the decalcified surface but failed to completely encircle the core. The discontinuous zones were present in all parts of the otoliths (seen by light microscopy; Fig. 2), but did not decalcify uniformly with EDTA/GA (Fig. 6). Nevertheless accurate counts could be obtained.

Increment counts before and after the birthmark in otoliths of known-age poeciliids are presented in Table 1. The number of increments before the mark corresponded very closely with the number of days after birth. Figures 4 and 5 show the otoliths from an 11-day-old G. affinis and a 6-day-old H. formosa respectively, note that the number of increments after the birth mark is equal to the age.

The between-reader counting differences were distributed around the mode difference 0, indicating the absence of reader bias. The mean difference was 0.2 increments (s = 3.83 increments) pointing out that some variability in counting does exist.

All individuals that were measured before and after alcohol fixation decreased in length (Table 2). Because gross differences between the shrinkage of field samples and lab-reared fish were not observed, we assumed the same amount of shrinkage occurred in all samples. Fresh lengths were back calculated for all wild poeciliids by dividing the preserved length after 3 weeks of fixation in 10% formalin (Table 2).

The von Bertalanffy model resulted in the lowest sum of squares due to error in 5 of the 6 species - month combinations, so it was used to compare the growth rates among seasons. The values of the sum of squared residuals (SSE) and coefficients of determination (R-squared) are presented in Table 3. The relationships between age and fresh length for G. affinis are presented in Figure 7, and those for H. formosa are shown in Figure 8.

The growth constant estimates (K) and "T_o's" for each month and species are presented in Table 4. The test statistics for comparing the growth constants among sample dates are presented in Table 5. No significant differences were found among growth constants for the three sample dates for either of the poeciliids ($p>0.05$).

The growth rates of male G. affinis and H. formosa were quite variable. The correlation coefficients for linear regressions are reported in Table 6. The growth rates of G. affinis males in June and H. formosa males in October and June were significantly greater than 0 ($p<0.05$).

Lifespan is an important parameter to determine the reproductive characteristics of a population. The ages of the five oldest males and females of each species (Table 7) suggest that females have longer lifespans. We maintained individuals of each species in the laboratory for over one year, but the oldest specimens in field samples were considerably less than one year old.

Cyprinodontidae

The sagittae of Fundulus chrysotus and Lucania goodei are similar in shape to the sagittae of G. affinis and H. formosa but are less elongated dorso-ventrally (Fig. 3). Mid-transverse sections resulted in the best increment resolution for F. chrysotus, but for L. goodei a section normal to the sagittal plane but between the frontal and transverse sections was best (Fig. 3). As found in G. affinis and H.

formosa, increments did not appear over the entire surface of the sectioned sagittae but appeared on the medial half of the decalcified surface (Figs. 9 and 10).

No recognizable mark was formed at hatch for either F. chrysotus or L. goodei. The intercepts of least squares regressions of age and total increment number for known-age F. chrysotus and L. goodei were 4.1 and 1.6 increments respectively. We assumed that these represented a good estimate of the number of increments present at hatch and we subtracted these estimates (rounded to nearest integer) from the total counts of wild fish otoliths.

Increment counts in otoliths of known-age cyprinodontids are presented in Table 1. Figures 9 and 10 show the otoliths from a 28-day F. chrysotus and 30-day L. goodei respectively.

All individuals that were measured before and after alcohol fixation decreased in length (Table 2). Because gross differences between the shrinkage of field samples and lab-reared fish were not observed, we assumed the same amount of shrinkage occurred in all samples. Fresh lengths were back-calculated for wild F. chrysotus and L. goodei by dividing the preserved length by 0.9621 and 0.9825 respectively. Neither species changed appreciably in length after 3 weeks of fixation in 10% formalin (Table 2; F. chrysotus estimated from shrinkage of F. heteroclitus).

The von Bertalanffy model resulted in the lowest sum of squares due to error in 4 of the 6 species - month combinations, so it was used to compare the growth rates among seasons. The values of the sum of squared residuals (SSE) and coefficients of determination (R-squared) are presented in Table 4. The relationships between age and fresh length are shown in Figure 11 for F. chrysotus and in Figure 12 for L. goodei.

The growth constant estimates (K) and "To's" for each month and species are presented in Table 5. The test statistics for comparing the growth constants among sample dates are presented in Table 6. No significant differences were found among growth constants for the three sample dates for L. goodei ($p < 0.05$), but at least one growth constant was different from the others for F. chrysotus. Multiple comparisons showed the growth rates of the March and June F. chrysotus samples were not significantly different from each other but both were significantly greater than the October growth rate ($p < 0.0001$; Table 8).

Cyprinodontids, like the poeciliids, did not live as long in the field as when kept in the laboratory. The oldest males and females of each species (Table 7) showed no apparent sex-related difference in longevity.

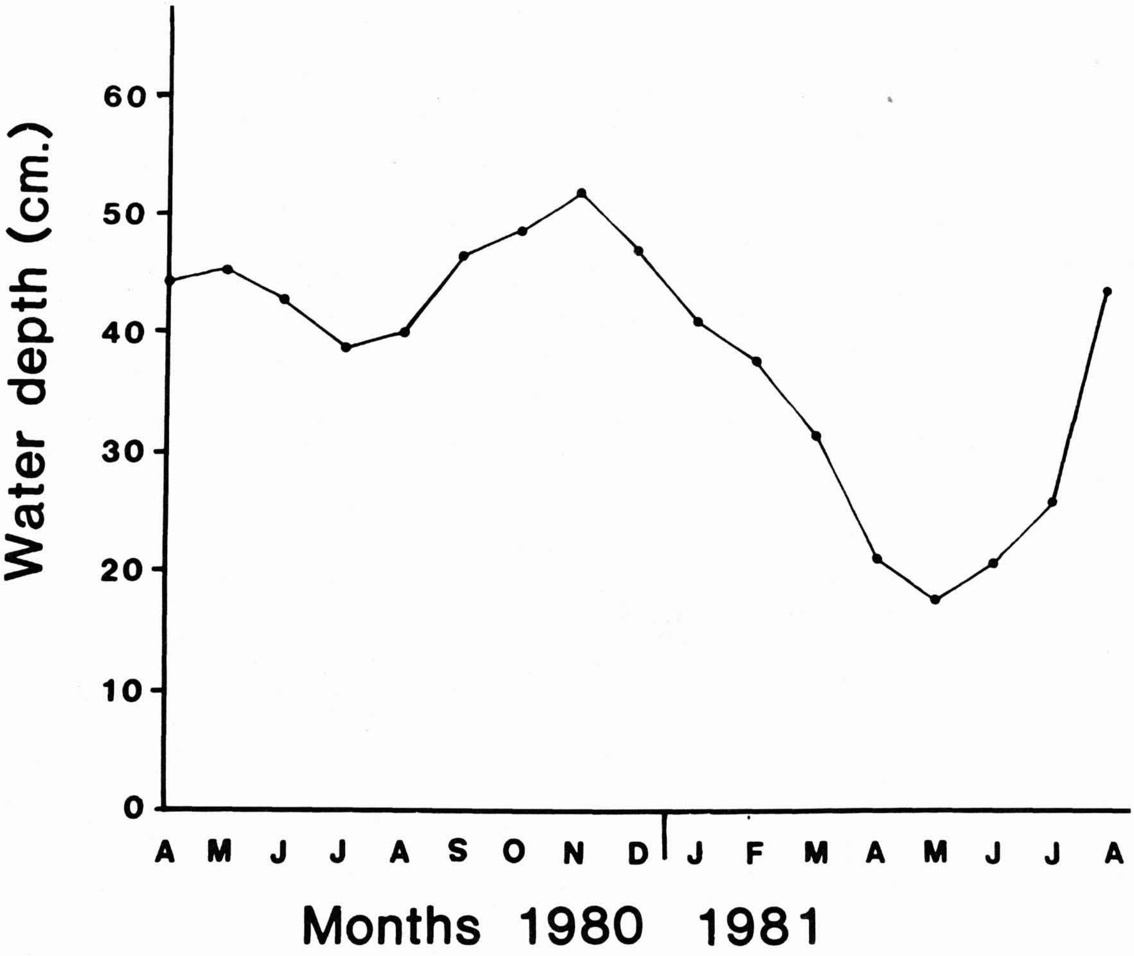

Figure 1: Mean monthly water depth at gauging station P-33, about 3 km. south of the study site.

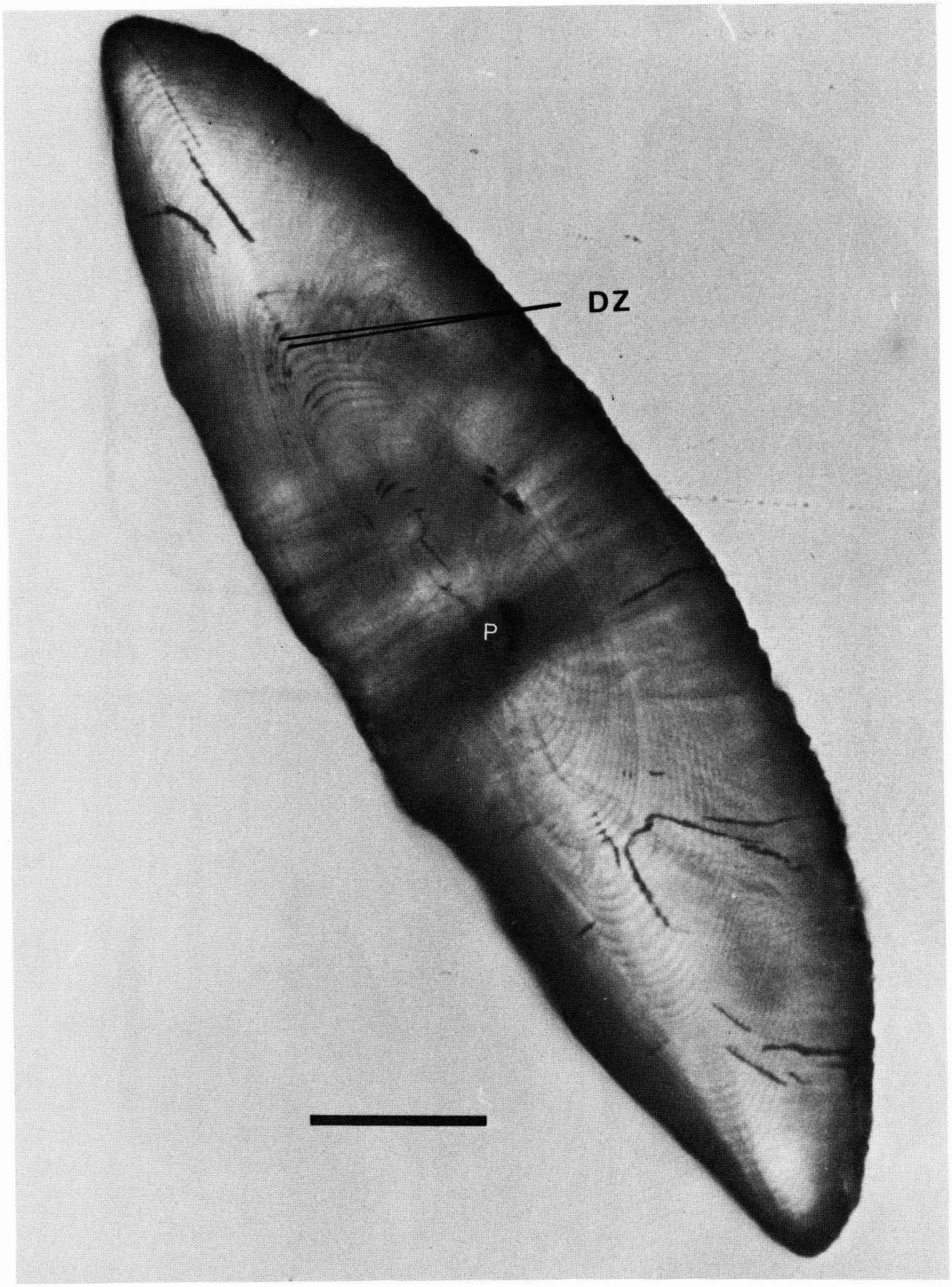

Figure 2: Photomicrograph of a Heterandria formosa sagitta transverse section, undecalcified. The primordia (P) appear as dark spots in the center. The discontinuous zones (two are indicated by DZ) appear as narrow dark lines extending completely around the otolith. Same specimen as Figure 6, bar represents 100 microns.

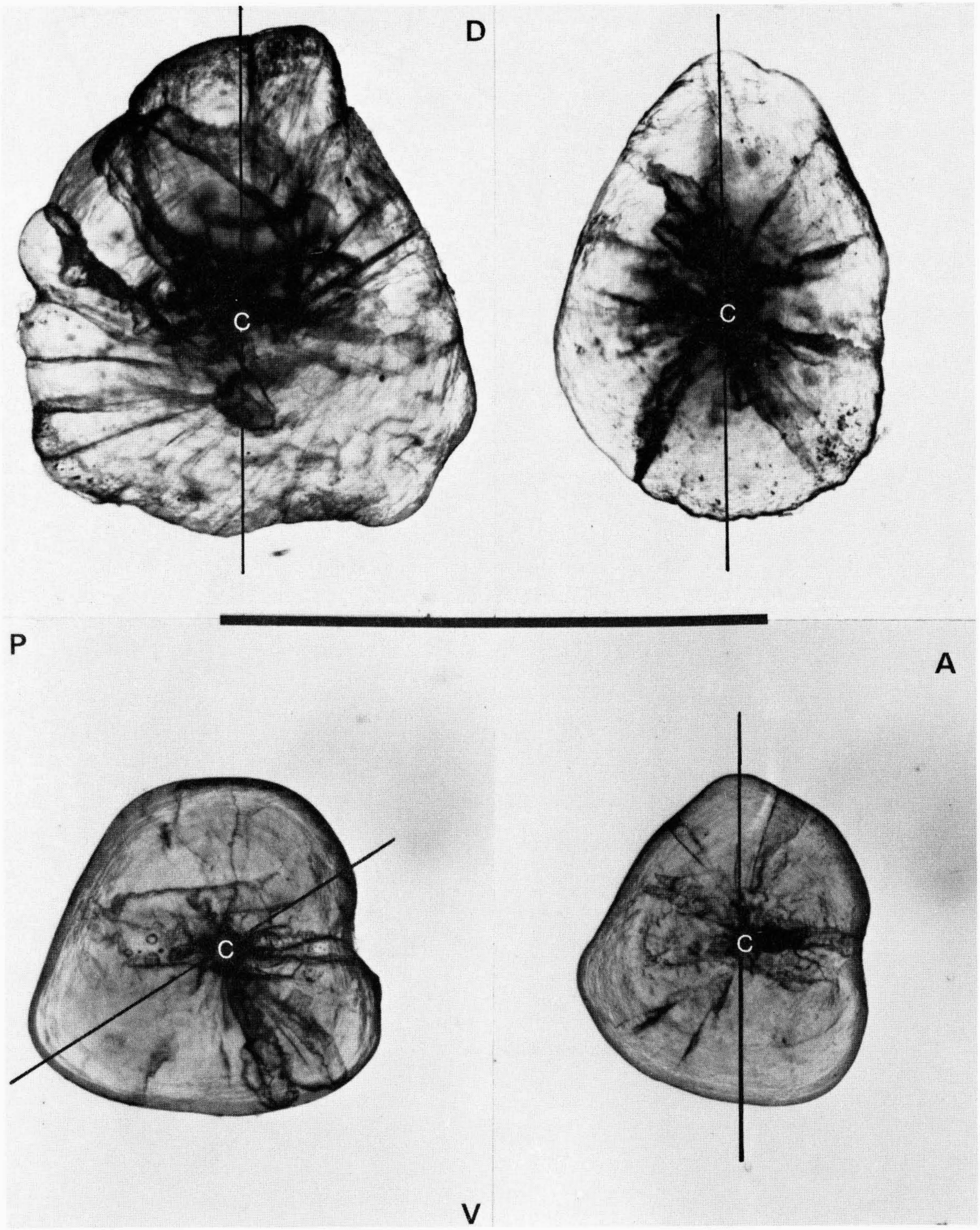

Figure 3: Photomicrographs of the sagittae from Fundulus chrysotus (upper left), Gambusia affinis (upper right), Lucania goodei (lower left), Heterandria formosa (lower right), showing their shapes and planes of sectioning (narrow lines). C = core, D = dorsal, V = ventral, A = anterior, P = posterior, thick horizontal bar represents 500 microns.

Figure 4: Scanning electron micrograph of a sagitta from an 11-day-old G. affinis. Note that the number of discontinuous zones after the birthmark (B) is equal to the age. Bar represents 100 microns.

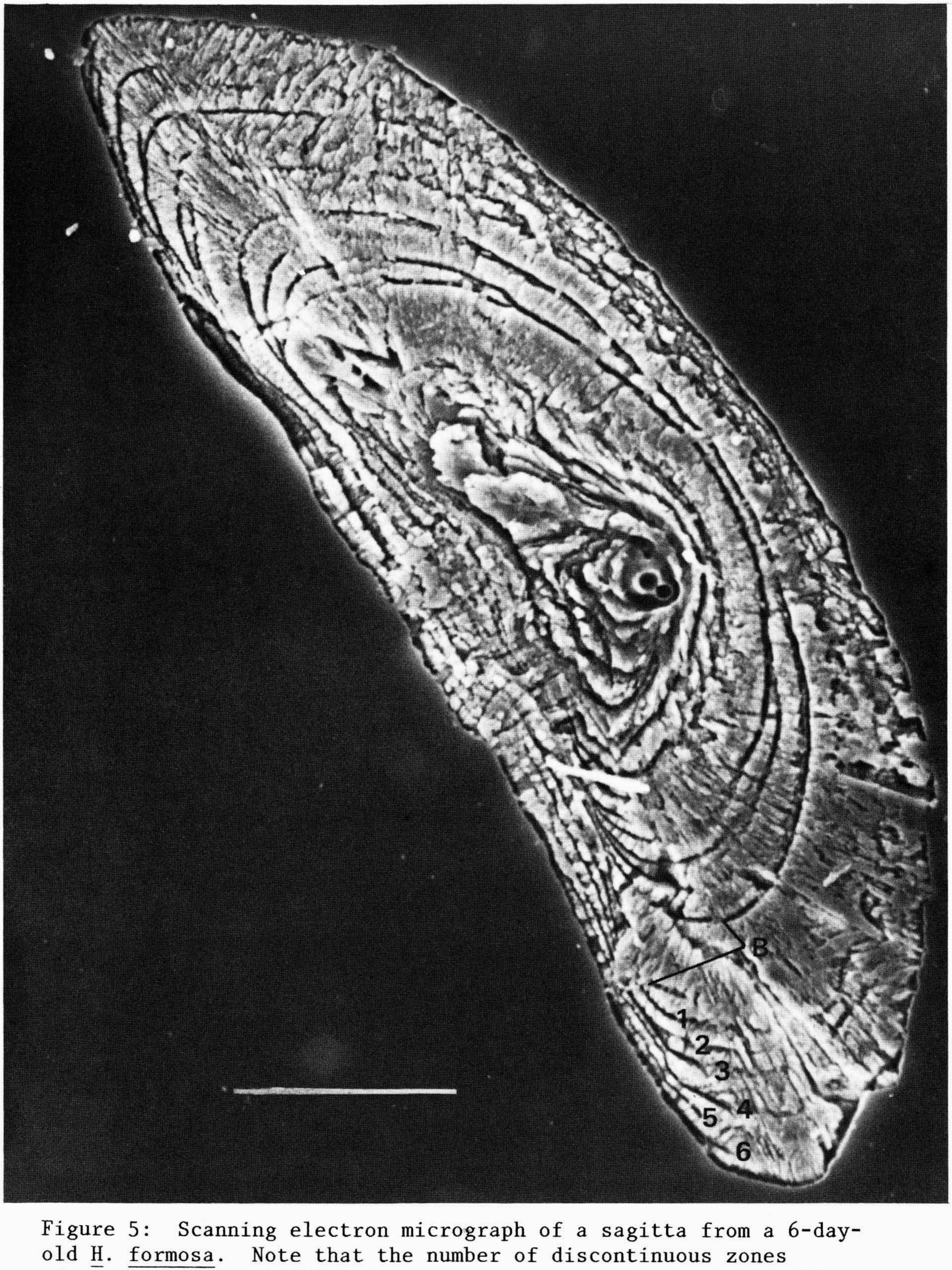

Figure 5: Scanning electron micrograph of a sagitta from a 6-day-old H. formosa. Note that the number of discontinuous zones after the birthmark (B) is equal to the age. Bar represents 50 microns.

Figure 6: Scanning electron micrograph of a sagitta from a wild H. formosa. Same specimen as Figure 2. Note that the discontinuous zones (DZ) extend only partially over the surface. Birthmark = B, bar represents 50 microns.

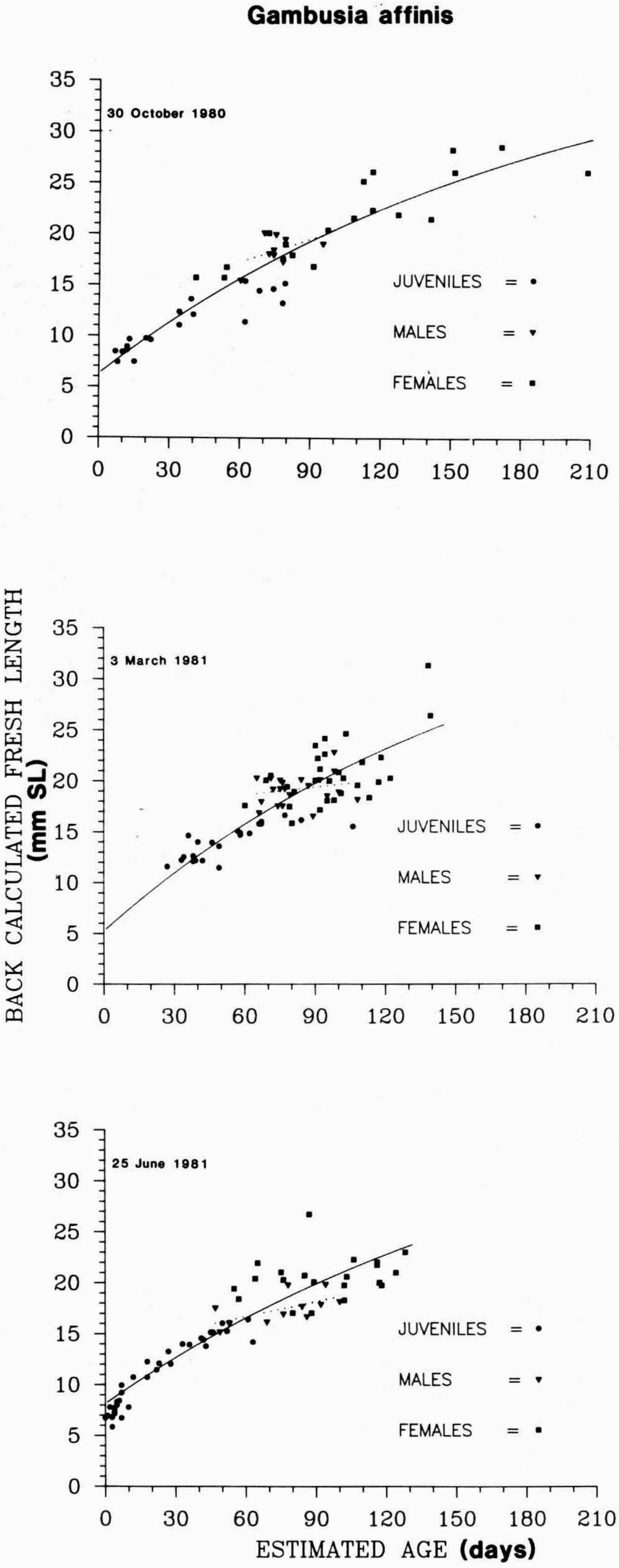

Figure 7: The relationship between length and age for G. affinis. Solid curves are the von Bertalanffy growth models for the females and juveniles. Dotted lines are linear models of male growth.

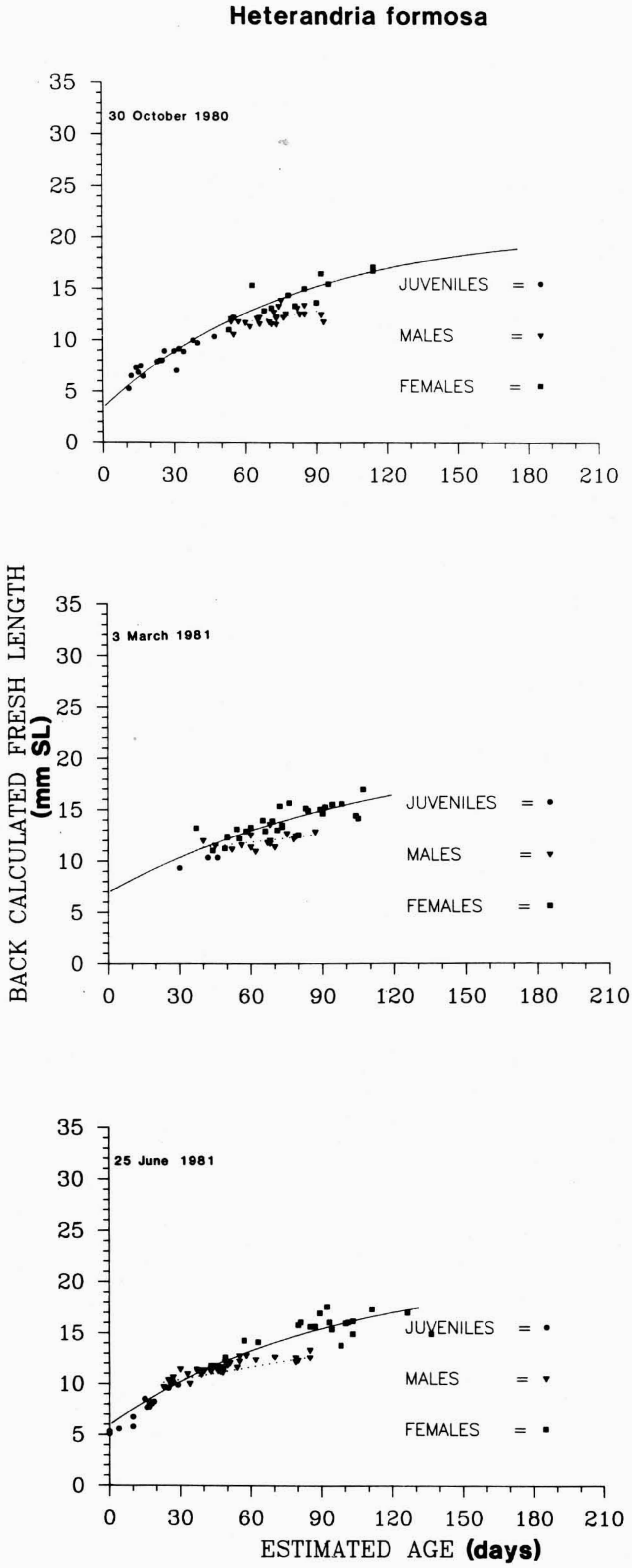

Figure 8: The relationship between length and age for H. formosa. Solid curves are the von Bertalanffy growth models for the females and juveniles. Dotted lines are linear models of male growth.

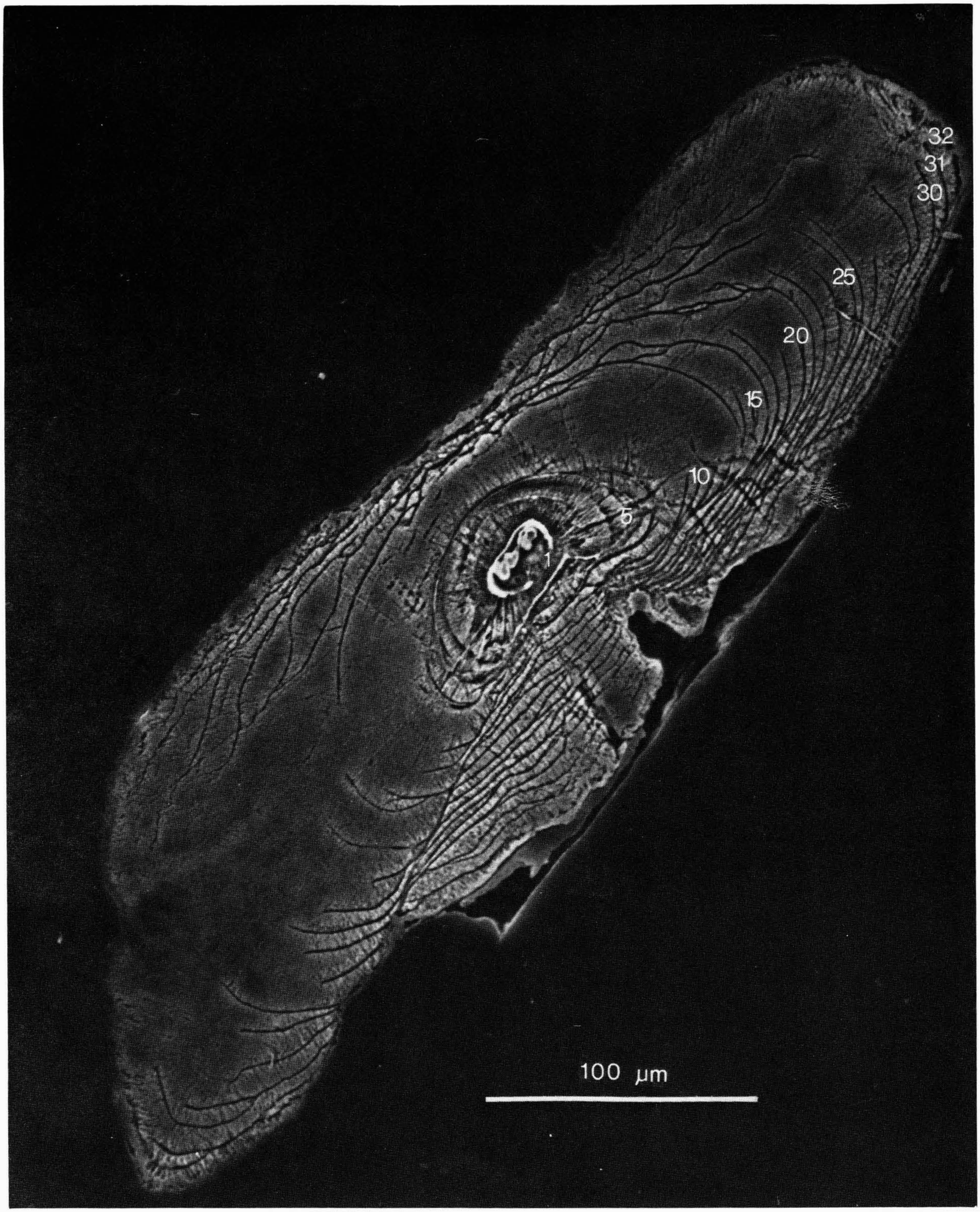

Figure 9: Scanning electron micrograph of a 28-day-old F. chrysotus otolith showing daily growth increments.

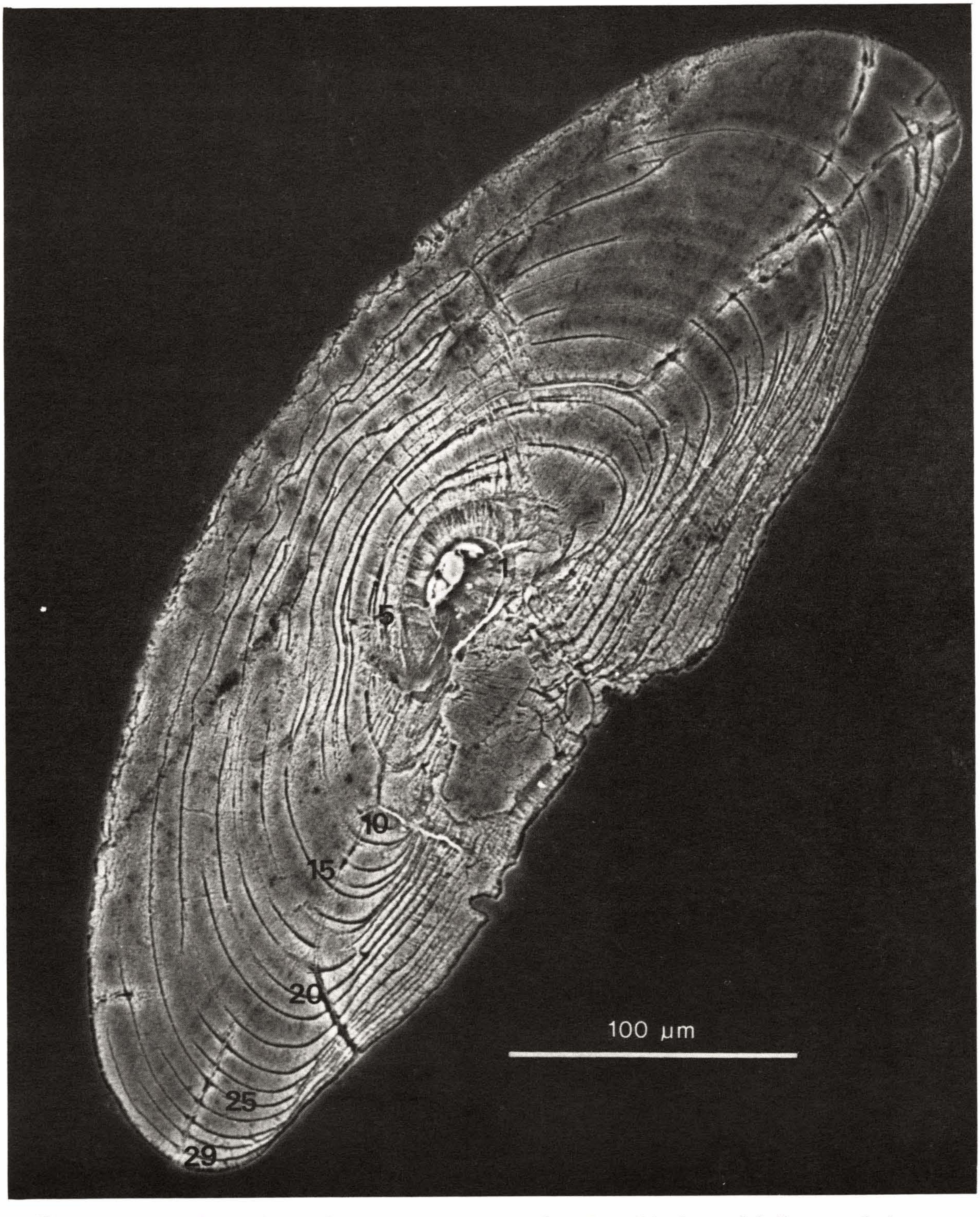

Figure 10: Scanning electron micrograph of a 30-day-old *L. goodei* otolith showing growth increments.

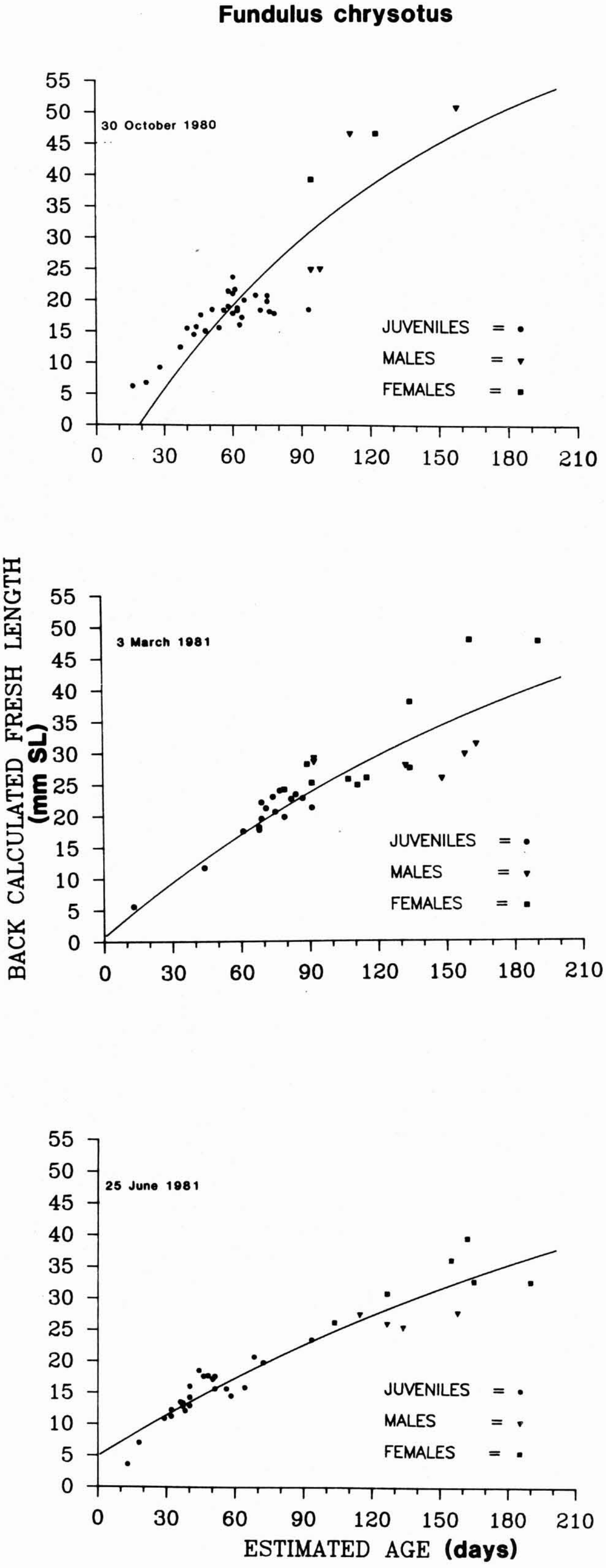

Figure 11: The relationship between length and age for *F. chrysotus*. Curves are the von Bertalanffy growth models.

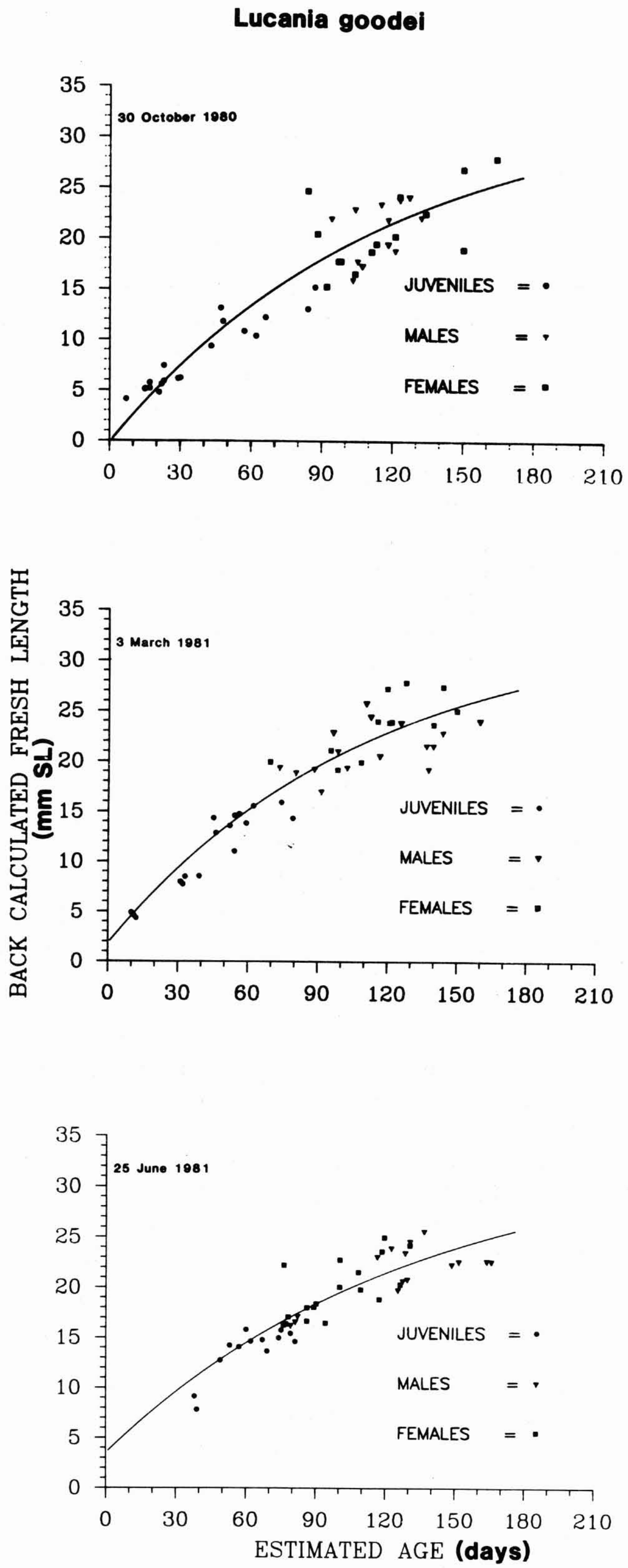

Figure 12: The relationship between length and age for L. goodei. Curves are the von Bertalanffy growth models.

DISCUSSION

Poeciliidae

Our laboratory results indicate that daily increment formation occurs for at least 33 days after birth in Gambusia affinis and 39 days after birth in Heterandria formosa. All lab-reared individuals in the 18-, 22- and 33-day Gambusia, and 29- and 39-day Heterandria groups were sexually mature. The presence of daily increments in these fishes showed that the onset of maturity does not interrupt the process. Furthermore, Taubert and Coble (1977) have shown that as long as growth continues, daily increment formation continues. Panella (1980) reported that several types of growth interruptions can be seen in otoliths, depending on the type of stress that produces the cessation of growth. No growth interruptions were observed in the otoliths of wild fishes; so although no known-age individuals were kept in the lab for as long as the age of the oldest field-collected specimens, it is reasonable to assume that daily increment formation continued in the older fishes.

The works of Colson (1969) and Krumholz (1948) are the most complete studies of the growth of Heterandria formosa and Gambusia affinis, respectively. Colson (1969) reported the growth of female H. formosa in Florida from April to August and found individuals as large as 29mm SL. This is much larger than the maximum size measured in the Everglades population. We fitted Colson's data to a von Bertalanffy growth curve (using 29mm as L-infinity) and obtained a very good fit (R-squared = 0.9874) indicating that the von Bertalanffy equation can model H. formosa growth very well in some cases. It is impossible, however, to compare the results of Colson's study to our results because of the difference in L-infinity estimates.

Krumholz (1948) found that Gambusia affinis in Illinois grew from about 7mm to 18mm standard length in 9 days. Everglades G. affinis take about 80 days to reach the same size (based on the June growth rate). Because the Illinois populations had been stocked into previously uninhabitated ponds 3 years earlier, their growth rates might be higher than normal, but even when Everglades G. affinis were raised in the laboratory under near optimum conditions of temperature and food availability they reached only 16.3mm in 22 days. Either Krumholz worked with particularly fast-growing populations of G. affinis, or his length-frequency estimates of age were incorrect.

In three of our cases, the slopes of the best fitting straight line models of male growth were significantly greater than 0 (G. affinis-June; H. formosa-October and June). The correlation coefficients for the G. affinis-June and H. formosa-October samples were low, indicating that a straight line does not describe the relationship between length and age well, therefore only the H. formosa-June sample results are discussed. The sizes at maturity of two other male poeciliids, Gambusia manni and Xiphophorus variatus, are controlled by social interactions with other males (Borowsky, 1973; Sohn, 1977). In aquariums, the presence of mature males inhibits the maturation process until the immature individuals are larger than the mature fish. If this mechanism applied to wild H. formosa populations one would expect to find some juvenules as large as the mature males. No juveniles over 10.4mm standard length were found, although we did find mature males up to 13.9mm long. Mature H. formosa can be sexed by the presence of a gonopodium (males) or a dark spot on the anal fin (female), so immature males would not be misidentified as mature females. We conclude that male H. formosa mature at about 10mm in length and continue to grow after reaching maturity although at an apparently slower rate than females. These data show H. formosa to be an exception to the widely accepted belief that male poeciliids cease somatic growth at sexual maturity, in agreement with Snelson's (1982) recent findings for Poecilia latipinna. Although the male poeciliids may exhibit apparently determinate growth patterns, future studies may show that body growth in many species merely slows rather than ceasing altogether.

Cyprinodontidae

Our results indicate that daily growth increments formation occurs for at least 28 days after hatching in F. chrysotus and for at least 28 days for L. goodei. We found no growth interruptions in any wild cyprinodontid sagittae and assume that daily growth increment formation continues in adults.

To our knowledge there have been no studies of the growth of either F. chrysotus or L. goodei. Of the four species that we analyzed for growth rates, only F. chrysotus showed any differences among sampling dates. It had the fastest growth rate, in terms of mm/day and did not have a dramatically different lifespan than the other species. The reduced rate of growth of F. chrysotus occurred in the October 1980 sample when water depth was greatest (Fig. 1). The underlying factors causing the reduced growth rate (lack of food, increased reproductive effort, higher maintenance costs, and physiological stress are some obvious possibilities) were not examined in this study, but with valid age estimates it is now possible to test the effects of these factors on growth rates.

Conclusions

Our results pose some interesting questions about the ecology of these small fishes. None of the four species examined lives as long in nature as in the laboratory. The samples were non-randomly selected, however, to include low frequency size classes so a statistical analysis of sex-related differences in lifespan could not be performed. Future research should be directed at determining if such differences exist, and their causes and effects on the population dynamics of these important fishes.

This study was designed to provide equations modeling change in length as a function of age at different times of the year. Although no differences in growth rate were found among seasons for G. affinis, H. formosa, or L. goodei, we have not grouped the sample dates. The statistical tests we used control the error rate in rejecting the null hypothesis (H_o) that growth rates are equal but cannot control the error rate in accepting H_o (i.e. grouping the data). We believe that the most accurate age estimates can be obtained by using the model derived from that time of year closest to that of the sample being analyzed.

There are two important non-biological sources of variation in this method of determining the growth curves. The mean shrinkage was used to back-calculate the fresh length of the preserved specimens, but not all fishes lost the same amount of length. The effect of this error was to increase the variance of lengths of fish of the same age. Also, while the mean reader error was insignificant, the standard deviation was not. This source of error caused an increase in the variance of age estimates of fish of the same length. Together, these errors combined to make the data more scattered. We are assuming that the errors are normally and independently distributed with a mean of 0, in agreement with the assumptions of linear regression by the method of least squares.

This study demonstrates that daily growth increments in the otoliths of Fundulus chrysotus, Gambusia affinis, Heterandria formosa, and Lucania goodei can be used to determine the ages and growth rates of these species for nonrandomly collected samples. The technique is particularly useful for populations which cannot be aged by classical methods such as analysis of annual marks or length-frequencies because of short lifespan, collection methods or a prolonged reproductive season.

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Table 1: Increment counts of laboratory-reared fishes.

G. affinis

	# after birth mark			# before birth mark	
Age	Mean	Stan. Dev.	n	Mean	Stan. Dev.
0	-	-	8	8.9	1.55
7	7.0	0.0	8	8.0	2.07
11	11.0	0.0	3	7.3	0.58
18	18.3	0.58	3	7.3	1.53
22	21.6	0.84	10	8.5	1.90
33	32.7	0.58	3	Not determined	

H. formosa

	# after birth mark			# before birth mark	
Age	Mean	Stam. Dev.	n	Mean	Stan. Dev.
0	-	-	6	13.3	3.98
6	6.0	0.0	3	13.0	1.73
12	12.2	0.45	5	10.6	2.79
29	29.4	0.53	7	11.7	2.29
39	39.2	0.89	7	10.7	2.22

F. chrysotus

	total # of increments		
Age	Mean	Stan. Dev.	N
0	5	1	3
4	7	-	1
12	15	0.816	4
28	30.5	2.121	2

L. goodei

	total # of increments		
Age	Mean	Stan. Dev.	N
0	1	1.732	3
3	5	0	2
9	10.5	0.957	4
30	30	1.414	2

Table 2: Proportion of original length after three weeks fixation in 95% ethanol or 10% formalin.

G. affinis

	Mean	Stan. Dev.	N
Ethanol	0.9492	0.0386	42
Formalin	0.9960	0.0208	20

H. formosa

	Mean	Stan. Dev.	N
Ethanol	0.9492	0.0293	44
Formalin	1.0059	0.0298	20

F. chrysotus

	Mean	Stan. Dev.	N
Ethanol	0.9621	0.0325	21
Formalin	1.0004	0.0209	20 *

L. goodei

	Mean	Stan. Dev.	N
Ethanol	0.9825	0.0161	15
Formalin	0.9921	0.0392	20

* Estimated by shrinkage of *Fundulus heteroclitus*; see text.

Table 3: The sums of squared residuals (SSE) and coefficients of determination (R-squared) for each growth model.

G. affinis

	linear		von Bertalanffy		Gompertz	
	SSE	R-squared	SSE	R-squared	SSE	R-squared
Oct	186.9	0.8740	162.2	0.8907	164.95	0.8881
Mar	254.9	0.7175	261.8	0.7098	257.8	0.7143
Jun	254.7	0.8457	198.3	0.8799	250.0	0.8486

H. formosa

	linear		von Bertalanffy		Gompertz	
	SSE	R-squared	SSE	R-squared	SSE	R-squared
Oct	23.29	0.9372	20.64	0.9443	19.45	0.9476
Mar	28.64	0.6958	26.68	0.7167	27.11	0.7121
Jun	71.12	0.8840	30.66	0.9500	39.44	0.9357

F. chrysotus

	linear		von Bertalanffy		Gompertz	
	SSE	R-squared	SSE	R-squared	SSE	R-squared
Oct	684.9	0.8016	835.2	0.7580	675.9	0.8041
Mar	523.5	0.7579	520.5	0.7592	542.8	0.7489
Jun	248.1	0.8973	212.9	0.9118	266.0	0.8898

L. goodei

	linear		von Bertalanffy		Gompertz	
	SSE	R-squared	SSE	R-squared	SSE	R-squared
Oct	272.8	0.8770	268.9	0.8787	263.2	0.8809
Mar	296.7	0.8399	211.7	0.8857	241.7	0.8695
Jun	196.7	0.7551	159.1	0.8019	171.9	0.7860

Table 4: Estimates of parameters in the von Bertalanffy equations for the three sample dates as obtained from least squares fit of the linearized equations. K = von Bertalanffy growth constant, T_o = theoretical age when length is 0, N = sample size.

	G. affinis			*H. formosa*		
	K	T_o	N	K	T_o	N
Oct	-0.005263	-31.53	38	-0.01249	-13.99	30
Mar	-0.005802	-23.55	51	-0.009212	-43.49	31
Jun	-0.004951	-44.63	54	-0.01112	-29.91	38

	F. chrysotus			*L. goodei*		
	K	T_o	N	K	T_o	N
Oct	-0.007635	-18.90	36	-0.008402	- 0.5595	45
Mar	-0.004388	- 2.347	32	-0.008965	- 5.983	45
Jun	-0.003502	-20.36	34	-0.007469	-14.44	46

Table 5: F-test statistics for the comparison of growth constants using procedure of Ott, (1977, p.469) (abbreviations are explained in the text, p. 5).

	SSE	df	Test statistic(F)	p-value
G. affinis				
Complete model	1.622	137	0.887	0.4142
Reduced model	1.643	139		
H. formosa				
Complete model	1.970	93	2.431	0.0935
Reduced model	2.073	95		
F. chrysotus				
Complete model	0.973	96	18.65	<0.0001
Reduced model	1.351	98		
L. goodei				
Complete model	4.133	130	1.007	0.3681
Reduced model	4.197	132		

Table 6: Growth rate (slope) estimates, standard errors, correlation coefficients and sample sizes calculated from least squares regression line for male *G. affinis* and *H. formosa*. P-values are for t-test of the null hypothesis: slope = 0.

	Slope	Stan. Err.	p-value	r-squared	n
G. affinis					
Oct	0.07497	0.05287	0.1991	0.2232	9
Mar	0.02572	0.02627	0.3400	0.04800	21
Jun	0.05015	0.01874	0.0233	0.4172	12
H. formosa					
Oct	0.03425	0.01141	0.0064	0.2812	25
Mar	0.02547	0.01286	0.0677	0.2188	16
Jun	0.04100	0.004710	0.0001	0.7096	33

Table 7: The ages (days) of the oldest field-collected specimens and their time of collection. O = October 30, 1980, M = March 3, 1981, J = June 25, 1981.

	Females	Males
G. affinis	208 O	108 M
	171 O	108 M
	151 C	100 J
	150 O	100 M
	141 M	98 M
H. formosa	136 J	93 O
	126 J	92 O
	114 O	87 M
	113 O	85 J
	111 J	85 J
F. chrysotus	190 M	163 M
	189 J	158 M
	164 J	157 O
	161 J	157 J
	160 M	148 M
L. goodei	164 O	165 J
	150 O	163 J
	150 O	159 M
	149 M	151 J
	111 M	148 J

Table 8: Scheffe's multiple comparisons test for differences among von Bertalanffy growth constants (K) sampling dates for *Fundulus chrysotus*. P-value is probability that difference is > 0 (i.e. growth rates are different).

Comparison	Estimate of difference	Standard error	P-value
Mar. - Oct.	0.003247	0.0007886	0.0001
Jun. - Oct.	0.004132	0.0007180	0.0001
Jun. - Mar.	0.0008859	0.0005978	0.1416
Oct.-½(Mar. + Jun.)	0.003690	0.0006924	0.0001

APPENDICES

Appendices A-F are tables of intermediate statistical calculations necessary to construct confidence intervals around age estimates from length data and analysis of variance tables for the regression lines. The variables for which the statistics are reported are: back calculated fresh length (frle), transformed fresh length (trans = 1-(frle/Linf)), estimated age (age), age times fresh length (transage). The statistics reported are: the number of observations (N), the average of the observations (mean, the standard deviation (N-1 weight), the minimum value, the maximum value, the sum of all the observations (Sum = $\sum_{i=1}^{n} X_i$), and the sum of the squared observations (SS = $\sum_{i=1}^{n} (X_i)^2$). Appendix G is a list of the data.

APPENDIX A - Statistics for *Fundulus chrysotus*.

October 30, 1980

Variable	N	Mean	Standard deviation	Minimum value	Maximum value
Frle	36	20.767	9.930	6.18	50.46
Trans	36	-0.359	0.243	-1.175	-0.088
Age	36	65.917	27.842	16.0	157.0
Frleage	36	1609.547	1602.143	98.880	7922.220
Transage	36	-29.418	37.189	-184.501	-1.415

Variable	Sum	SS
Frle	747.610	18977.079
Trans	-12.924	6.711
Age	2373.000	183551.0
Frleage	57943.680	183103224.939
Transage	-1059.035	79560.572

March 3, 1981

Variable	N	Mean	Standard deviation	Minimum value	Maximum value
Frle	32	24.987	8.351	5.61	47.81
Trans	32	-0.437	0.201	-1.064	-0.080
Age	32	97.156	38.369	13.0	190.0
Frleage	32	2697.921	1922.355	72.930	9044.000
Transage	32	-48.677	42.677	-200.585	-1.040

Variable	Sum	SS
Frle	799.600	22141.956
Trans	-13.972	7.356
Age	3109.000	347697.000
Frleage	86333.470	347479831.680
Transage	-1557.679	131975.303

APPENDIX A (continued)

Statistics for *F. chrysotus* (continued).

June 25, 1981

Variable	N	Mean	Standard deviation	Minimum value	Maximum value
Frle	35	20.071	9.097	3.64	39.86
Trans	35	-0.338	0.187	-0.790	-0.051
Age	35	76.029	49.790	13.0	189.0
Frleage	35	1939.639	1976.959	47.320	6417.460
Transage	35	-34.098	37.726	-127.145	-0.665

Variable	Sum	SS
Frle	702.500	16913.790
Trans	-11.815	5.180
Age	2661.000	286601.000
Frleage	67887.350	264561447.613
Transage	-1193.420	89083.208

APPENDIX A (continued)

Analysis of variance tables for *F. chrysotus*: dependent variable = age, independent variable = transformed length.

October 30, 1980

Source	Degrees of freedom	Sum of squares	Mean square	R-squared
Model	1	20710.827	29710.827	0.763
Error	34	6419.923	188.821	
Corrected total	35	27130.750		

Parameter	Estimate	Standard error of estimate
Intercept	30.022	4.122
Slope	-99.987	9.547

March 3, 1981

Source	Degrees of freedom	Sum of squares	Mean square	R-squared
Model	1	31921.371	31921.371	0.699
Error	30	13716.848	457.228	
Corrected total	31	45638.219		

Parameter	Estimate	Standard error of estimate
Intercept	27.559	9.147
Slope	-159.404	19.078

June 25, 1981

Source	Degrees of freedom	Sum of squares	Mean square	R-squared
Model	1	73071.948	73071.948	0.867
Error	33	11217.024	339.910	
Corrected total	34	84288.971		

Parameter	Estimate	Standard error of estimate
Intercept	-7.535	6.496
Slope	-247.554	16.884

APPENDIX A (continued)

Analysis of variance tables for _F. chrysotus_: dependent variable = transformed length, independent variable = age.

October 30, 1980

Source	Degrees of freedom	Sum of squares	Mean square	R-squared
Model	1	1.581	1.581	.763
Error	34	0.490	0.0144Z	
Corrected total	35	2.072		

Parameter	Estimate	Standard error of estimate
Intercept	0.1443	0.05205
Slope	-0.007635	0.000729

March 3, 1981

Source	Degrees of freedom	Sum of squares	Mean square	R-squared
Model	1	0.8787	0.8787	0.699
Error	30	0.3776	0.01259	
Corrected total	31	1.2563		

Parameter	Estimate	Standard error of estimate
Intercept	-0.01030	0.05474
Slope	-0.004388	0.0005252

June 25, 1981

Source	Degrees of freedom	Sum of squares	Mean square	R-squared
Model	1	1.034	1.034	0.867
Error	33	0.1587	0.004808	
Corrected total	34	1.192		

Parameter	Estimate	Standard error of estimate
Intercept	-0.07131	0.02161
Slope	-0.003502	0.0002388

APPENDIX B - Statistics for female and juvenile Gambusia affinis.

October 30, 1980

Variable	N	Mean	Standard deviation	Minimum value	Maximum value
Frle	38	16.329	6.332	7.400	28.700
Trans	38	-0.545	0.286	-1.204	-0.199
Age	38	72.000	50.564	7.000	208.000
Frleage	38	1467.995	1433.902	59.150	5460.000
Transage	38	-52.332	57.757	-212.644	-1.592

Variable	Sum	SS
Frle	620.490	11615.104
Trans	-20.705	14.316
Age	2736.000	291590.000
Frleage	55749.550	157864548.945
Transage	-1988.620	227496.032

March 3, 1981

Variable	N	Mean	Standard deviation	Minimum value	Maximum value
Frle	51	17.852	4.248	11.480	31.340
Trans	51	-0.591	0.208	-1.446	-0.329
Age	51	78.314	28.905	27.000	139.000
Frleage	51	1499.995	847.350	312.930	4324.920
Transage	51	-51.032	35.221	-199.490	-8.970

Variable	Sum	SS
Frle	910.430	17154.922
Trans	-30.138	19.979
Age	3994.000	354560.000
Frleage	76499.760	150649341.313
Transage	-2602.621	194842.705

APPENDIX B (continued)

Statistics for *G. affinis* continued.

June 25, 1981

Variable	N	Mean	Standard deviation	Minimum value	Maximum value
Frle	54	14.688	5.582	5.850	26.760
Trans	54	-0.467	0.221	-1.058	-0.154
Age	54	49.648	40.544	0.000	128.000
Frleage	54	933.506	900.358	0.000	2952.960
Transage	54	-31.162	31.627	-105.868	0.000

Variable	Sum	SS
Frle	793.160	13301.301
Trans	-25.205	14.346
Age	2681.000	220229.000
Frleage	50409.300	90021541.581
Transage	-1682.747	105452.654

APPENDIX B (continued)

Analysis of variance tables for *G. affinis* females and juveniles: dependent variable = age, independent variable = transformed length.

October 30, 1980

Source	Degrees of freedom	Sum of squares	Mean square	R-squared
Model	1	81684.246	81684.246	0.863
Error	36	12913.754	358.715	
Corrected total	37	94598.000		

Parameter	Estimate	Standard error of estimate
Intercept	-17.397	6.674
Slope	-164.071	10.873

March 3, 1981

Source	Degrees of freedom	Sum of squares	Mean square	R-squared
Model	1	27090.611	27090.611	0.648
Error	49	14684.370	299.681	
Corrected total	50	41774.980		

Parameter	Estimate	Standard error of estimate
Intercept	-12.261	7.358
Slope	-111.773	11.756

June 25, 1981

Source	Degrees of freedom	Sum of squares	Mean square	R-squared
Model	1	72077.631	72077.631	0.827
Error	52	15044.683	289.320	
Corrected total	54	87122.315		

Parameter	Estimate	Standard error of estimate
Intercept	-28.349	5.457
Slope	-167.101	10.587

APPENDIX B (continued)

Analysis of variance tables for *G. affinis* females and juveniles: dependent variable = transformed length, independent variable = age.

October 30, 1980

Source	Degrees of freedom	Sum of squares	Mean square	R-squared
Model	1	2.620	2.620	0.863
Error	36	0.4142	0.01151	
Corrected total	37	3.034		

Parameter	Estimate	Standard error of estimate
Intercept	-0.1659	0.03055
Slope	-0.005263	0.0003488

March 3, 1981

Source	Degrees of freedom	Sum of squares	Mean square	R-squared
Model	1	1.406	1.406	0.648
Error	49	0.7622	0.01556	
Corrected total	50	2.168		

Parameter	Estimate	Standard error of estimate
Intercept	-0.1366	0.05088
Slope	-0.005802	0.0006102

June 25, 1981

Source	Degrees of freedom	Sum of squares	Mean square	R-squared
Model	1	2.136	2.136	0.827
Error	52	0.4458	0.008572	
Corrected total	53	2.582		

Parameter	Estimate	Standard error of estimate
Intercept	-0.2210	0.02003
Slope	-0.004951	0.0003137

APPENDIX C - Statistics for *Gambusia affinis* males only

October 30, 1980

Variable	N	Mean	Standard deviation	Minimum value	Maximum value
Frle	9	18.482	1.469	15.500	20.170
Age	9	75.222	9.257	60.000	95.000
Frleage	9	1395.983	235.026	930.000	1816.400

Variable	Sum	SS
Frle	166.340	3091.599
Age	677.000	51611.000
Frleage	12563.860	17980851.925

March 3, 1981

Variable	N	Mean	Standard deviation	Minimum value	Maximum value
Frle	21	19.212	1.465	16.590	22.860
Age	21	82.095	12.486	65.000	108.000
Frleage	21	1581.024	293.971	1116.060	2240.280

Variable	Sum	SS
Frle	403.450	7793.996
Age	1724.000	144650.000
Frleage	33201.500	54220737.641

June 25, 1981

Variable	N	Mean	Standard deviation	Minimum value	Maximum value
Frle	12	17.391	1.466	15.220	19.910
Age	12	73.417	18.880	47.000	100.000
Frleage	12	1293.163	405.134	754.780	1871.540

Variable	Sum	SS
Frle	208.690	3652.931
Age	881.000	68601.000
Frleage	15517.960	21872725.975

APPENDIX C (continued)

Analysis of variance tables for G. affinis males only: dependent variable = age, independent variable = transformed length.

October 30, 1980

Source	Degrees of freedom	Sum of squares	Mean square	R-squared
Model	1	152.989	152.989	0.223
Error	7	532.566	76.081	
Corrected total	8	685.556		

Parameter	Estimate	Standard error of estimate
Intercept	20.206	38.906
Slope	-2.977	2.099

March 3, 1981

Source	Degrees of freedom	Sum of squares	Mean square	R-squared
Model	1	149.655	149.655	0.048
Error	19	2968.154	156.219	
Corrected	20	3117.810		

Parameter	Estimate	Standard error of estimate
Intercept	46.235	36.740
Slope	1.867	1.907

June 25, 1981

Source	Degrees of freedom	Sum of squares	Mean square	R-squared
Model	1	1635.707	1635.707	0.417
Error	10	2285.209	228.521	
Corrected total	11	3920.917		

Parameter	Estimate	Standard error of estimate
Intercept	-71.248	52.248
Slope	8.318	3.109

APPENDIX C (continued)

Analysis of variance tables for *G. affinis* males only: dependent variable = transformed length, independent variable = age.

October 30, 1980

Source	Degrees of freedom	Sum of squares	Mean square	R-squared
Model	1	3.853	3.853	0.223
Error	7	13.413	1.916	
Corrected total	8	17.266		

Parameter	Estimate	Standard error of estimate
Intercept	12.843	4.004
Slope	0.0750	0.0529

March 3, 1981

Source	Degrees of freedom	Sum of squares	Mean square	R-squared
Model	1	2.062	2.062	0.048
Error	19	40.892	2.152	
Corrected	20	42.954		

Parameter	Estimate	Standard error of estimate
Intercept	17.101	2.181
Slope	0.0257	0.0263

June 25, 1981

Source	Degrees of freedom	Sum of squares	Mean square	R-squared
Model	1	9.861	9.861	0.417
Error	10	13.777	1.378	
Corrected total	11	23.638		

Parameter	Estimate	Standard error of estimate
Intercept	13.709	1.417
Slope	0.0501	0.0187

APPENDIX D - Statistics for female and juvenile *Heterandria formosa*.

October 30, 1980

Variable	N	Mean	Standard deviation	Minimum value	Maximum value
Frle	30	10.814	3.576	5.270	17.170
Trans	30	-0.797	0.413	-1.702	-0.289
Age	30	49.800	31.867	11.000	114.000
Frleage	30	645.158	573.642	57.970	1957.380
Transage	30	-51.958	54.647	-193.989	-3.178

Variable	Sum	SS
Frle	324.410	3878.884
Trans	-23.911	24.005
Age	1494.000	103850.000
Frleage	19354.750	22029763.080
Transage	-1558.735	167590.080

March 3, 1981

Variable	N	Mean	Standard deviation	Minimum value	Maximum value
Frle	31	13.407	1.772	9.320	16.860
Trans	31	-1.044	0.236	-1.624	-0.587
Age	31	69.839	21.267	30.000	107.000
Frleage	31	966.771	389.786	279.600	1804.020
Transage	31	-76.940	37.350	-173.749	-17.599

Variable	Sum	SS
Frle	415.630	5666.6842
Trans	-32.363	35.459
Age	2165.000	164769.000
Frleage	29969.890	33531996.161
Transage	-2385.136	225362.073

APPENDIX D (continued)

Statistics for H. formosa continued.

June 25, 1981

Variable	N	Mean	Standard deviation	Minimum value	Maximum value
Frle	38	12.112	4.070	5.110	17.590
Trans	38	-0.970	0.484	-1.818	-0.279
Age	38	57.263	40.623	0.000	136.000
Frleage	38	844.956	701.538	0.000	2143.260
Transage	38	-73.390	66.480	-209.252	0.000

Variable	Sum	SS
Frle	460.270	6187.906
Trans	-36.842	44.371
Age	2176.000	185664.000
Frleage	32108.330	45339893.477
Transage	-2788.815	368197.370

APPENDIX D

Analysis of variance tables for *H. formosa* females and juveniles: dependent variable = age, independent variable = transformed length.

October 30, 1980

Source	Degrees of freedom	Sum of squares	Mean square	R-squared
Model	1	27366.865	27366.865	0.929
Error	28	2801.935	74.355	
Corrected total	29	29448.800		

Parameter	Estimate	Standard error of estimate
Intercept	-9.479	3.468
Slope	-74.374	3.877

March 3, 1981

Source	Degrees of freedom	Sum of squares	Mean square	R-squared
Model	1	9332.641	9332.641	0.688
Error	29	4235.553	146.054	
Corrected total	30	13568.194		

Parameter	Estimate	Standard error of estimate
Intercept	-8.113	9.990
Slope	-74.670	9.341

June 25, 1981

Source	Degrees of freedom	Sum of squares	Mean square	R-squared
Model	1	53310.771	53310.771	0.873
Error	36	7748.597	215.239	
Corrected total	37	61059.368		

Parameter	Estimate	Standard error of estimate
Intercept	-18.844	5.390
Slope	-78.499	4.988

APPENDIX D (continued)

Analysis of variance tables for *H. formosa* females and juveniles: dependent variable = transformed length, independent variable = age.

October 30, 1980

Source	Degrees of freedom	Sum of squares	Mean square	R-squared
Model	1	4.598	4.598	0.929
Error	28	0.3498	0.01249	
Corrected total	29	4.947		

Parameter	Estimate	Standard error of estimate
Intercept	-0.1748	0.03832
Slope	-0.01250	0.0006513

March 3, 1981

Source	Degrees of freedom	Sum of squares	Mean square	R-squared
Model	1	1.151	1.151	0.688
Error	29	0.5225	0.01802	
Corrected total	30	1.674		

Parameter	Estimate	Standard error of estimate
Intercept	-0.4006	0.0840
Slope	-0.009212	0.001152

June 25, 1981

Source	Degrees of freedom	Sum of squares	Mean square	R-squared
Model	1	7.553	7.553	0.873
Error	36	1.098	0.03050	
Corrected total	37	8.651		

Parameter	Estimate	Standard error of estimate
Intercept	-0.3326	0.04940
Slope	-0.01112	0.0007067

APPENDIX E - Statistics for <u>Heterandria</u> <u>formosa</u> males only.

October 30, 1980

Variable	N	Mean	Standard deviation	Minimum value	Maximum value
Frle	25	12.300	0.721	10.640	13.960
Age	25	71.720	11.156	54.000	93.000
Frleage	25	886.220	168.648	585.200	1158.280

Variable	Sum	SS
Frle	307.490	3794.466
Age	1793.000	131581.000
Frleage	22155.490	20317243.101

March 3, 1981

Variable	N	Mean	Standard deviation	Minimum value	Maximum value
Frle	16	11.981	0.680	10.960	13.540
Age	16	64.688	12.483	40.000	87.000
Frleage	16	778.758	176.202	585.200	1158.280

Variable	Sum	SS
Frle	191.700	2303.738
Age	1035.000	69289.000
Frleage	12460.130	10169132.237

June 25, 1981

Variable	N	Mean	Standard deviation	Minimum value	Maximum value
Frle	33	11.698	0.830	9.740	13.380
Age	33	50.030	17.054	23.000	85.000
Frleage	33	596.812	238.874	224.020	1137.300

Variable	Sum	SS
Frle	386.030	4537.779
Age	1651.000	91907.000
Frleage	19694.780	13580015.514

APPENDIX E (continued)

Analysis of variance tables for *H. formosa* males only: dependent variable = age, independent variable = transformed length.

October 30, 1980

Source	Degrees of freedom	Sum of squares	Mean square	R-squared
Model	1	839.901	839.901	0.281
Error	23	2147.139	93.354	
Corrected total	24	2987.040		

Parameter	Estimate	Standard error of estimate
Intercept	-29.255	33.719
Slope	8.210	2.737

March 3, 1981

Source	Degrees of freedom	Sum of squares	Mean square	R-squared
Model	1	511.336	511.336	0.219
Error	14	1826.102	130.436	
Corrected total	15	2337.438		

Parameter	Estimate	Standard error of estimate
Intercept	-38.215	52.051
Slope	8.589	4.338

June 25, 1981

Source	Degrees of freedom	Sum of squares	Mean square	R-squared
Model	1	6604.430	6604.430	0.710
Error	31	2702.539	87.179	
Corrected total	32	9306.970		

Parameter	Estimate	Standard error of estimate
Intercept	-152.437	23.318
Slope	17.308	1.989

APPENDIX E (continued)

Analysis of variance tables for <u>H. formosa</u> males only: dependent variable = transformed length, independent variable = age.

October 30, 1980

Source	Degrees of freedom	Sum of squares	Mean square	R-squared
Model	1	3.504	3.504	0.281
Error	23	8.958	0.389	
Corrected total	24	12.462		

Parameter	Estimate	Standard error of estimate
Intercept	9.843	0.828
Slope	0.0343	0.0114

March 3, 1981

Source	Degrees of freedom	Sum of squares	Mean square	R-squared
Model	1	1.516	1.516	0.218
Error	14	5.416	0.387	
Corrected total	15	6.932		

Parameter	Estimate	Standard error of estimate
Intercept	10.334	0.847
Slope	0.0255	0.0129

June 25, 1981

Source	Degrees of freedom	Sum of squares	Mean square	R-squared
Model	1	15.645	15.645	0.710
Error	31	6.402	0.207	
Corrected total	32	22.047		

Parameter	Estimate	Standard error of estimate
Intercept	9.647	0.249
Slope	0.0401	0.00471

APPENDIX F - Statistics for *Lucania goodei*.

October 30, 1980

Variable	N	Mean	Standard deviation	Minimum value	Maximum value
Frle	45	15.500	7.098	4.120	27.890
Trans	45	-0.688	0.416	-1.716	-0.129
Age	45	82.422	44.331	7.000	164.000
Frleage	45	1565.679	1187.053	28.840	4573.960
Transage	45	-72.836	64.661	-281.495	-0.904

Variable	Sum	SS
Frle	697.500	13028.323
Trans	-30.952	28.887
Age	3709.000	392173.000
Frleage	70455.570	172311017.463
Transage	-3277.632	422697.317

March 3, 1981

Variable	N	Mean	Standard deviation	Minimum value	Maximum value
Frle	45	18.085	6.489	4.330	27.890
Trans	45	-0.842	0.417	-1.716	-0.136
Age	45	87.911	41.147	10.000	159.000
Frleage	45	1829.120	1184.718	48.900	3929.640
Transage	45	-88.842	66.825	-236.163	-1.553

Variable	Sum	SS
Frle	813.830	16570.706
Trans	-37.880	39.534
Age	3956.000	422270.000
Frleage	82310.390	212312030.666
Transage	-3997.901	551670.063

APPENDIX F (continued)

Statistics for *L. goodei* continued.

June 25, 1981

Variable	N	Mean	Standard deviation	Minimum value	Maximum value
Frle	46	18.643	4.225	7.840	25.700
Trans	46	-0.833	0.282	-1.410	-0.262
Age	46	97.065	32.221	38.000	165.000
Frleage	46	1925.306	963.369	305.760	3745.500
Transage	46	-88.430	52.540	-191.774	-10.223

Variable	Sum	SS
Frle	857.580	16791.098
Trans	-38.313	35.496
Age	4465.000	480115.000
Frleage	88564.080	212276536.203
Transage	-4067.758	483931.291

APPENDIX F (continued)

Analysis of variance tables for *L. goodei*: dependent variable = age, independent variable = transformed length.

October 30, 1980

Source	Degrees of freedom	Sum of squares	Mean square	R-squared
Model	1	69474.522	69474.522	0.803
Error	43	16994.456	395.220	
Corrected total	44	86468.978		

Parameter	Estimate	Standard error of estimate
Intercept	16.649	5.779
Slope	-95.627	7.212

March 3, 1981

Source	Degrees of freedom	Sum of squares	Mean square	R-squared
Model	1	58320.392	58320.392	0.783
Error	43	16173.252	376.122	
Corrected total	44	74493.644		

Parameter	Estimate	Standard error of estimate
Intercept	14.402	6.573
Slope	-87.326	7.013

June 25, 1981

Source	Degrees of freedom	Sum of squares	Mean square	R-squared
Model	1	33955.719	33955.719	0.727
Error	44	12763.085	290.070	
Corrected total	45	46718.804		

Parameter	Estimate	Standard error of estimate
Intercept	16.018	7.901
Slope	-97.310	8.994

APPENDIX F (continued)

Analysis of variance tables for L. goodei: dependent variable = transformed length, independent variable = age.

October 30, 1980

Source	Degrees of freedom	Sum of squares	Mean square	R-squared
Model	1	6.104	6.104	0.803
Error	43	1.493	0.03473	
Corrected total	44	7.597		

Parameter	Estimate	Standard error of estimate
Intercept	0.004701	0.05916
Slope	-0.008402	0.0006337

March 3, 1981

Source	Degrees of freedom	Sum of squares	Mean square	R-squared
Model	1	5.987	5.987	0.783
Error	43	1.660	0.03861	
Corrected total	44	7.648		

Parameter	Estimate	Standard error of estimate
Intercept	-0.05364	0.06974
Slope	-0.008965	0.0007200

June 25, 1981

Source	Degrees of freedom	Sum of squares	Mean square	R-squared
Model	1	2.606	2.606	0.727
Error	44	0.9796	0.02226	
Corrected total	45	3.586		

Parameter	Estimate	Standard error of estimate
Intercept	-0.1079	0.07053
Slope	-0.007469	0.0006903

Appendix G- A list of all the data: one line of data represents one fish. The variables are: id# (col. 1-4), sex (col. 5), preserved length (col. 8-12), # increments counted (col. 14-16), fresh length (col. 18-22), and sample date (col. 24-28). Codes for the variables id# and sex are as follows:

Sex 0 = juvenile
1 = male
2 = female

ID# 1000-1999 = *Fundulus chrysotus*
2000-2999 = *Gambusia affinis*
3000-3999 = *Heterandria formosa*
4000-4999 = *Lucania goodei*

The number of increments counted for *G. affinis* and *H. formosa* is equal to the estimated age because only those after the birthmark were counted. Since the cyprinodontids did not have a birthmark, all increments were counted. To get the proper age estimate for the cyprinodontids, number of increments present at hatching must be subtracted from the increment count: for *F. chrysotus* age = inc - 4 and for *L. goodei* age = inc - 2.

```
INPUT  ID  1-4  SEX  6  PRLE  8-12 INC 14-16 FRLE 18-22 DATE $ 24-28;
1101  0   5.95   20   6.18  OCT80
1103  0   6.50   26   6.76  OCT80
1105  0   8.85   32   9.20  OCT80
1107  0  13.95   47  14.50  OCT80
1109  0  15.45   67  16.06  OCT80
1111  0  17.20   82  17.88  OCT80
1113  0  20.25   64  21.05  OCT80
1115  0  22.80   64  23.70  OCT80
1117  1  24.00   98  24.95  OCT80
1119  1  24.10  102  25.05  OCT80
1123  2  37.70   98  39.19  OCT80
1125  2  44.65  126  46.41  OCT80
1127  1  44.70  115  46.46  OCT80
1129  1  48.55  161  50.46  OCT80
1131  0  20.00   74  20.79  OCT80
1133  0  19.25   69  20.01  OCT80
1135  0  20.65   62  21.46  OCT80
1137  0  20.90   65  21.72  OCT80
1139  0  19.95   79  20.74  OCT80
1141  0  19.05   79  19.80  OCT80
1143  0  18.30   62  19.02  OCT80
1145  0  17.80   55  18.50  OCT80
1147  0  18.05   66  18.76  OCT80
1149  0  17.20   64  17.88  OCT80
1151  0  17.70   76  18.40  OCT80
1153  0  17.70   60  18.40  OCT80
1155  0  16.60   68  17.25  OCT80
1157  0  17.65   66  18.35  OCT80
1159  0  17.50   80  18.19  OCT80
```

APPENDIX G (continued)

1161	0	17.80	97	18.50	OCT80
1165	0	15.15	48	15.75	OCT80
1167	0	16.95	50	17.62	OCT80
1175	0	14.90	44	15.49	OCT80
1177	0	15.00	58	15.59	OCT80
1179	0	14.50	52	15.07	OCT80
1181	0	12.00	41	12.47	OCT80
1201	0	5.40	17	5.61	MAR81
1203	0	11.30	48	11.75	MAR81
1205	0	17.50	72	18.19	MAR81
1207	0	18.80	73	19.54	MAR81
1209	0	19.05	85	19.80	MAR81
1211	0	16.90	65	17.57	MAR81
1213	0	17.10	72	17.77	MAR81
1215	0	20.40	75	21.20	MAR81
1217	0	20.45	95	21.26	MAR81
1221	0	21.80	86	22.66	MAR81
1223	0	22.50	88	23.39	MAR81
1225	0	21.30	73	22.14	MAR81
1227	0	19.85	79	20.63	MAR81
1229	0	21.90	91	22.76	MAR81
1231	0	22.15	78	23.02	MAR81
1234	2	23.90	115	24.84	MAR81
1235	0	23.10	81	24.10	MAR81
1237	2	23.25	83	24.17	MAR81
1239	2	24.80	111	25.78	MAR81
1241	2	24.25	95	25.21	MAR81
1243	2	27.10	93	28.17	MAR81
1245	2	25.00	119	25.98	MAR81
1247	1	25.00	152	25.98	MAR81
1249	1	27.00	136	28.06	MAR81
1251	2	26.50	138	27.54	MAR81
1253	1	28.10	96	29.21	MAR81
1255	1	27.55	96	28.64	MAR81
1257	1	28.70	162	29.83	MAR81
1259	1	30.25	167	31.44	MAR81
1261	2	36.60	138	38.04	MAR81
1263	2	45.80	194	47.60	MAR81
1265	2	46.00	164	47.81	MAR81
1301	0	3.50	17	3.64	JUN81
1303	0	6.80	22	7.07	JUN81
1305	0	10.85	36	11.28	JUN81
1307	0	10.50	33	10.91	JUN81
1309	0	11.85	36	12.32	JUN81
1311	0	11.70	42	12.16	JUN81
1313	0	12.50	44	12.99	JUN81
1315	0	12.40	41	12.89	JUN81
1317	0	13.80	44	14.34	JUN81
1319	0	13.05	40	13.56	JUN81
1323	0	12.90	41	13.41	JUN81
1325	0	15.10	55	15.69	JUN81

APPENDIX G (continued)

1327	0	14.00	62	14.55	JUN81
1329	0	15.10	60	15.69	JUN81
1331	0	16.55	54	17.20	JUN81
1333	0	15.30	68	15.90	JUN81
1335	0	15.45	44	16.06	JUN81
1337	0	17.90	48	18.61	JUN81
1339	0	17.00	50	17.67	JUN81
1341	0	17.10	52	17.77	JUN81
1343	0	17.00	55	17.67	JUN81
1345	0	20.00	72	20.79	JUN81
1347	0	19.15	72	20.79	JUN81
1351	1	24.70	137	25.67	JUN81
1353	2	25.30	107	26.30	JUN81
1355	0	22.65	97	23.54	JUN81
1357	1	25.25	130	26.24	JUN81
1359	1	26.65	118	27.70	JUN81
1361	1	27.00	161	28.06	JUN81
1363	2	29.80	130	30.97	JUN81
1365	2	31.75	168	33.00	JUN81
1367	2	31.70	193	32.95	JUN81
1369	2	35.00	158	36.38	JUN81
1371	2	38.35	165	39.86	JUN81
1373	2	38.25	145	39.76	JUN81
2101	0	8.02	7	8.45	OCT80
2105	0	8.16	12	8.60	OCT80
2107	0	9.11	22	9.60	OCT80
2109	0	10.82	62	11.40	OCT80
2111	0	11.49	40	12.10	OCT80
2113	0	13.91	74	14.65	OCT80
2115	1	14.71	60	15.50	OCT80
2117	1	17.56	74	18.50	OCT80
2119	1	18.56	79	19.55	OCT80
2121	2	19.41	97	20.45	OCT80
2123	2	20.88	127	22.00	OCT80
2125	2	23.97	112	25.25	OCT80
2127	2	27.24	171	28.70	OCT80
2133	2	24.86	116	26.19	OCT80
2135	2	20.54	108	21.64	OCT80
2139	2	19.10	72	20.12	OCT80
2141	0	14.42	79	15.19	OCT80
2143	0	14.62	62	15.40	OCT80
2145	2	20.48	141	21.58	OCT80
2147	2	26.95	150	28.39	OCT80
2149	2	24.92	208	26.25	OCT80
2151	2	21.28	116	22.42	OCT80
2153	2	24.86	151	26.19	OCT80
2155	2	18.05	79	19.02	OCT80
2157	2	17.06	82	17.97	OCT80
2159	2	16.71	78	17.60	OCT80
2162	0	13.73	68	14.46	OCT80
2163	0	12.93	39	13.62	OCT80

APPENDIX G (continued)

2165	0	12.58	78	13.25	OCT80
2167	0	11.73	34	12.36	OCT80
2169	0	10.49	34	11.05	OCT80
2171	0	9.25	20	9.74	OCT80
2173	0	9.15	13	9.64	OCT80
2179	0	7.96	10	8.39	OCT80
2181	0	8.46	12	8.91	OCT80
2183	0	7.02	8	7.40	OCT80
2187	0	7.06	15	7.44	OCT80
2189	1	19.15	70	20.17	OCT80
2191	1	18.99	75	20.01	OCT80
2193	1	18.15	95	19.12	OCT80
2195	1	17.10	74	18.02	OCT80
2197	1	16.46	78	17.34	OCT80
2199	1	17.21	72	18.13	OCT80
2701	2	15.91	54	16.76	OCT80
2703	2	16.01	91	16.87	OCT80
2705	2	14.92	53	15.72	OCT80
2707	2	14.92	41	15.72	OCT80
2201	0	11.00	27	11.59	MAR81
2203	0	10.90	49	11.48	MAR81
2205	0	11.90	34	12.54	MAR81
2207	0	12.00	38	12.64	MAR81
2209	0	11.60	33	12.22	MAR81
2211	0	11.50	38	12.11	MAR81
2213	0	11.55	42	12.17	MAR81
2215	0	11.55	39	12.17	MAR81
2217	0	13.25	46	13.96	MAR81
2219	0	12.90	49	13.59	MAR81
2221	0	14.10	62	14.85	MAR81
2223	0	15.00	67	15.80	MAR81
2225	0	15.20	67	16.01	MAR81
2227	2	16.70	60	17.59	MAR81
2229	0	14.15	58	14.91	MAR81
2231	0	13.95	58	14.70	MAR81
2233	0	13.30	40	14.01	MAR81
2235	0	13.90	36	14.64	MAR81
2237	0	14.75	106	15.54	MAR81
2239	2	16.30	92	17.17	MAR81
2241	2	16.60	79	17.49	MAR81
2243	2	15.05	80	15.85	MAR81
2245	0	15.00	66	15.80	MAR81
2247	0	15.35	84	16.17	MAR81
2249	0	14.30	57	15.06	MAR81
2251	2	17.45	113	18.38	MAR81
2253	2	17.20	98	18.12	MAR81
2255	2	18.90	117	19.91	MAR81
2257	2	19.00	96	20.02	MAR81
2260	0	15.80	77	16.64	MAR81
2261	2	17.85	101	18.80	MAR81
2263	2	18.45	78	19.44	MAR81

APPENDIX G (continued)

2265	2	18.00	81	18.96	MAR81
2267	2	19.05	69	20.07	MAR81
2269	2	19.25	122	20.28	MAR81
2271	2	18.60	108	19.59	MAR81
2273	2	19.05	90	20.07	MAR81
2275	2	19.80	100	20.86	MAR81
2277	2	19.50	71	20.54	MAR81
2279	2	19.25	102	20.28	MAR81
2281	2	17.15	95	18.07	MAR81
2283	2	20.10	92	21.17	MAR81
2285	2	21.10	91	22.23	MAR81
2287	2	20.75	110	21.86	MAR81
2289	2	21.20	118	22.33	MAR81
2291	2	21.50	94	22.65	MAR81
2293	2	22.95	94	24.18	MAR81
2295	2	22.30	90	23.49	MAR81
2297	2	23.40	103	24.65	MAR81
2299	2	25.10	139	26.44	MAR81
2802	2	29.75	138	31.34	MAR81
2803	1	17.75	79	18.70	MAR81
2805	1	18.25	72	19.23	MAR81
2808	1	19.95	98	21.02	MAR81
2809	1	17.65	95	18.59	MAR81
2811	1	19.15	84	20.17	MAR81
2814	1	19.30	71	20.33	MAR81
2815	1	18.00	100	18.96	MAR81
2817	1	18.60	87	19.59	MAR81
2819	1	16.70	76	17.59	MAR81
2821	1	21.70	98	22.86	MAR81
2824	1	17.10	67	18.01	MAR81
2825	1	19.30	65	20.33	MAR81
2827	1	18.30	77	19.28	MAR81
2829	1	18.90	76	19.91	MAR81
2831	1	19.15	92	20.17	MAR81
2833	1	19.10	75	20.12	MAR81
2835	1	15.75	89	16.59	MAR81
2837	1	18.30	75	19.28	MAR81
2839	1	16.70	74	17.59	MAR81
2841	1	16.05	66	16.91	MAR81
2843	1	17.30	108	18.22	MAR81
2301	0	5.55	3	5.85	JUN81
2305	0	6.40	7	6.74	JUN81
2307	0	6.40	0	6.74	JUN81
2309	0	6.45	3	6.80	JUN81
2311	0	7.00	4	7.37	JUN81
2313	0	6.60	1	6.95	JUN81
2315	0	7.90	5	8.32	JUN81
2317	0	7.40	2	7.80	JUN81
2319	0	6.80	4	7.16	JUN81
2322	0	7.30	4	7.69	JUN81
2324	0	7.60	5	8.01	JUN81

APPENDIX G (continued)

2325	0	7.40	10	7.80	JUN81
2327	0	8.00	6	8.43	JUN81
2330	0	8.75	7	9.22	JUN81
2333	0	10.20	12	10.75	JUN81
2335	0	9.45	7	9.96	JUN81
2337	0	10.20	18	10.75	JUN81
2339	0	10.90	22	11.48	JUN81
2341	0	11.50	23	12.12	JUN81
2343	0	11.65	18	12.27	JUN81
2345	0	11.45	28	12.06	JUN81
2347	0	12.60	27	13.27	JUN81
2349	0	13.30	33	14.01	JUN81
2351	0	13.10	43	13.80	JUN81
2353	0	13.85	41	14.59	JUN81
2355	0	14.40	45	15.17	JUN81
2357	0	13.50	63	14.22	JUN81
2359	0	13.70	42	14.43	JUN81
2361	0	15.25	50	16.07	JUN81
2363	0	13.25	36	13.96	JUN81
2365	0	14.40	46	15.17	JUN81
2367	0	14.50	52	15.28	JUN81
2369	0	15.60	61	16.44	JUN81
2371	2	16.20	80	17.07	JUN81
2373	2	18.45	55	19.44	JUN81
2375	2	18.80	118	19.81	JUN81
2377	2	19.30	76	20.33	JUN81
2379	2	19.70	85	20.75	JUN81
2381	2	19.40	64	20.44	JUN81
2383	2	16.20	88	17.07	JUN81
2385	2	18.80	102	19.81	JUN81
2387	2	19.05	117	20.07	JUN81
2389	2	17.50	57	18.44	JUN81
2391	2	20.00	124	21.07	JUN81
2394	2	19.10	89	20.12	JUN81
2395	2	17.40	102	18.33	JUN81
2399	2	20.00	75	21.07	JUN81
2901	2	20.95	116	22.07	JUN81
2903	2	19.60	103	20.65	JUN81
2905	2	20.70	116	21.81	JUN81
2907	2	20.85	65	21.97	JUN81
2909	2	21.20	106	22.33	JUN81
2911	2	21.90	128	23.07	JUN81
2915	2	25.40	87	26.76	JUN81
2917	1	15.25	53	16.07	JUN81
2919	1	15.40	69	16.22	JUN81
2921	1	17.30	100	18.23	JUN81
2923	1	17.05	92	17.96	JUN81
2925	1	15.90	86	16.75	JUN81
2928	1	15.30	53	16.12	JUN81
2929	1	16.15	76	17.01	JUN81
2931	1	18.90	94	19.91	JUN81

APPENDIX G (continued)

2933	1	16.70	47	17.59	JUN81
2935	1	16.85	84	17.75	JUN81
2937	1	18.85	78	19.86	JUN81
2943	1	14.45	49	15.22	JUN81
3101	0	5.00	11	5.27	OCT80
3105	0	6.95	14	7.32	OCT80
3107	0	7.60	25	8.01	OCT80
3109	0	8.45	34	8.90	OCT80
3111	0	9.25	40	9.74	OCT80
3113	0	9.85	47	10.38	OCT80
3115	1	11.30	57	11.90	OCT80
3119	2	13.70	78	14.43	OCT80
3121	2	14.30	85	15.06	OCT80
3123	2	15.70	92	16.54	OCT80
3127	2	15.95	114	16.80	OCT80
3133	0	6.15	17	6.48	OCT80
3135	0	6.70	31	7.06	OCT80
3137	0	6.20	12	6.53	OCT80
3139	0	7.50	23	7.90	OCT80
3141	0	6.50	15	6.85	OCT80
3143	0	7.10	16	7.48	OCT80
3145	0	7.60	24	8.01	OCT80
3147	0	8.50	30	8.95	OCT80
3149	0	8.50	26	8.95	OCT80
3151	0	8.70	32	9.17	OCT80
3153	0	9.50	38	10.01	OCT80
3155	2	11.65	55	12.27	OCT80
3157	2	10.50	53	11.06	OCT80
3165	2	12.70	81	13.38	OCT80
3167	2	13.00	90	13.70	OCT80
3169	2	12.50	71	13.17	OCT80
3171	2	12.25	68	12.90	OCT80
3173	2	14.60	63	15.38	OCT80
3175	2	14.75	95	15.54	OCT80
3177	2	16.30	114	17.17	OCT80
3181	1	13.25	75	13.96	OCT80
3183	1	11.10	71	11.69	OCT80
3185	1	12.00	85	12.64	OCT80
3187	1	12.55	82	13.22	OCT80
3189	1	11.60	65	12.22	OCT80
3191	1	12.80	85	13.48	OCT80
3193	1	12.00	83	12.64	OCT80
3197	1	12.00	77	12.64	OCT80
3199	1	11.30	93	11.90	OCT80
3701	1	11.70	66	12.33	OCT80
3703	1	11.75	73	12.38	OCT80
3705	1	11.05	73	11.64	OCT80
3711	1	10.10	55	10.64	OCT80
3715	1	10.85	62	11.43	OCT80
3717	1	11.30	70	11.90	OCT80
3721	1	11.20	60	11.80	OCT80

APPENDIX G (continued)

3723	1	11.95	92	12.59	OCT80
3725	1	11.55	54	12.17	OCT80
3727	1	11.60	73	12.22	OCT80
3729	1	11.30	54	11.90	OCT80
3731	1	11.70	76	12.33	OCT80
3737	1	12.15	72	12.80	OCT80
3739	1	11.10	66	11.69	OCT80
3741	1	12.70	74	13.38	OCT80
3201	1	11.80	79	12.43	MAR81
3203	1	11.40	68	12.01	MAR81
3205	1	10.80	70	11.38	MAR81
3207	1	11.40	40	12.01	MAR81
3209	1	12.15	87	12.80	MAR81
3211	1	12.00	75	12.64	MAR81
3213	1	11.00	56	11.59	MAR81
3215	1	10.95	45	11.54	MAR81
3219	1	10.60	52	11.17	MAR81
3221	1	10.80	60	11.38	MAR81
3223	1	10.40	62	10.96	MAR81
3225	1	11.20	67	11.80	MAR81
3227	1	11.80	60	12.53	MAR81
3229	1	11.55	78	12.17	MAR81
3233	1	12.85	68	13.54	MAR81
3237	2	14.65	94	15.43	MAR81
3239	2	14.70	98	15.49	MAR81
3245	2	12.75	73	13.43	MAR81
3247	2	13.60	104	14.33	MAR81
3249	0	8.85	30	9.32	MAR81
3255	2	14.80	76	15.59	MAR81
3259	2	12.60	73	13.27	MAR81
3261	2	10.65	49	11.22	MAR81
3263	2	11.65	50	12.27	MAR81
3265	2	10.45	44	11.01	MAR81
3267	2	16.00	107	16.86	MAR81
3269	2	14.30	83	15.06	MAR81
3271	2	12.50	37	13.17	MAR81
3275	2	11.85	80	12.48	MAR81
3279	0	9.80	46	10.32	MAR81
3281	0	9.80	42	10.32	MAR81
3283	2	12.30	71	12.96	MAR81
3285	2	11.55	55	12.17	MAR81
3287	1	11.15	68	11.75	MAR81
3289	2	11.70	50	12.33	MAR81
3291	2	12.15	69	13.85	MAR81
3293	2	12.55	60	13.22	MAR81
3295	2	13.35	105	14.06	MAR81
3297	2	12.20	58	12.85	MAR81
3299	2	13.20	65	13.91	MAR81
3801	2	14.40	91	15.17	MAR81
3803	2	14.50	72	15.28	MAR81
3805	2	14.20	89	14.96	MAR81

APPENDIX G (continued)

3807	2	12.20	66	12.85	MAR81
3809	2	14.10	84	14.85	MAR81
3811	2	13.80	90	14.54	MAR81
3813	2	12.40	54	13.06	MAR81
3301	1	12.05	70	12.69	JUN81
3303	1	11.06	54	11.65	JUN81
3305	1	10.70	47	11.27	JUN81
3307	1	11.55	49	12.17	JUN81
3309	1	11.60	79	12.22	JUN81
3311	1	10.75	46	11.32	JUN81
3315	1	12.70	85	13.38	JUN81
3327	1	9.25	23	9.74	JUN81
3329	1	10.85	37	11.43	JUN81
3333	1	11.75	80	12.38	JUN81
3335	1	11.30	50	11.90	JUN81
3343	1	11.60	50	12.22	JUN81
3345	1	10.90	30	11.48	JUN81
3347	1	9.55	34	10.06	JUN81
3349	1	12.00	79	12.64	JUN81
3353	1	10.80	40	11.38	JUN81
3355	1	11.10	47	11.69	JUN81
3357	1	11.50	51	12.11	JUN81
3363	1	10.80	48	11.38	JUN81
3365	1	11.65	55	12.27	JUN81
3369	1	12.20	58	12.85	JUN81
3373	1	10.60	48	11.17	JUN81
3375	1	10.70	43	11.27	JUN81
3377	1	12.15	55	12.80	JUN81
3379	1	11.20	45	11.80	JUN81
3381	1	10.45	33	11.01	JUN81
3385	1	12.00	85	12.64	JUN81
3387	1	10.80	38	11.38	JUN81
3389	1	9.90	25	10.43	JUN81
3391	1	10.40	39	10.96	JUN81
3393	1	10.15	27	10.69	JUN81
3395	1	11.80	62	12.43	JUN81
3397	1	10.65	39	11.22	JUN81
3399	2	13.55	57	14.27	JUN81
3901	2	14.05	103	14.92	JUN81
3905	0	9.60	26	10.11	JUN81
3907	2	15.05	100	15.98	JUN81
3909	2	14.75	87	15.66	JUN81
3911	2	15.25	103	16.19	JUN81
3913	2	15.25	93	16.07	JUN81
3915	2	15.00	80	15.80	JUN81
3921	2	12.00	49	12.64	JUN81
3923	0	9.10	25	9.59	JUN81
3925	2	16.15	126	17.01	JUN81
3927	2	16.45	111	17.33	JUN81
3929	2	14.60	94	15.38	JUN81
3931	2	15.25	101	16.07	JUN81

APPENDIX G (continued)

4383	1	22.30	167	22.70	JUN81
4385	1	22.35	165	22.75	JUN81
4387	1	23.15	130	23.56	JUN81
4389	1	22.30	153	22.70	JUN81
4391	1	24.25	132	24.68	JUN81
4393	1	23.60	125	24.02	JUN81
4395	1	25.25	138	25.70	JUN81

APPENDIX G (continued)

4163	2	17.40	100	17.71	OCT80
4165	2	16.20	106	16.49	OCT80
4167	2	18.35	113	18.68	OCT80
4169	2	20.05	90	20.41	OCT80
4171	2	18.60	152	18.93	OCT80
4173	2	19.10	115	19.44	OCT80
4175	2	22.05	136	22.44	OCT80
4179	2	23.70	125	24.12	OCT80
4181	2	24.20	86	24.63	OCT80
4183	2	26.35	152	26.82	OCT80
4185	1	22.50	106	22.90	OCT80
4187	1	15.65	105	15.93	OCT80
4189	1	18.50	123	18.83	OCT80
4191	1	17.45	107	17.76	OCT80
4193	1	21.60	96	21.98	OCT80
4197	1	21.70	134	22.09	OCT80
4199	1	21.50	120	21.88	OCT80
4701	1	23.00	117	23.41	OCT80
4201	0	4.25	14	4.33	MAR81
4203	0	4.55	13	4.63	MAR81
4205	0	4.80	12	4.89	MAR81
4207	0	7.85	33	7.99	MAR81
4209	0	8.35	35	8.50	MAR81
4211	0	7.60	34	7.74	MAR81
4215	0	10.85	56	11.04	MAR81
4217	0	8.40	41	8.55	MAR81
4219	0	14.10	81	14.35	MAR81
4222	0	12.65	48	12.88	MAR81
4223	0	13.60	61	13.84	MAR81
4225	0	14.10	47	14.35	MAR81
4227	0	15.30	64	15.57	MAR81
4229	0	13.35	54	13.59	MAR81
4231	0	14.35	56	14.61	MAR81
4233	0	14.50	58	14.76	MAR81
4235	0	15.65	76	15.93	MAR81
4241	2	19.60	110	19.95	MAR81
4243	2	19.60	71	19.95	MAR81
4245	2	18.85	100	19.19	MAR81
4247	2	20.75	97	21.12	MAR81
4249	2	23.50	122	23.92	MAR81
4251	2	23.30	141	23.72	MAR81
4253	2	23.55	123	23.97	MAR81
4255	2	23.60	117	24.02	MAR81
4257	2	24.65	151	25.09	MAR81
4259	2	27.00	145	27.48	MAR81
4262	2	26.80	121	27.28	MAR81
4264	2	27.40	129	27.89	MAR81
4265	1	16.75	93	17.05	MAR81
4267	1	19.10	74	19.44	MAR81
4269	1	18.95	90	19.29	MAR81
4271	1	18.95	139	19.29	MAR81

APPENDIX G (continued)

4274	1	18.60	82	18.93	MAR81
4276	1	19.10	104	19.44	MAR81
4278	1	20.70	100	21.07	MAR81
4279	1	21.25	138	21.63	MAR81
4281	1	21.25	141	21.63	MAR81
4283	1	22.55	145	22.95	MAR81
4285	1	20.25	118	20.61	MAR81
4287	1	22.55	98	22.95	MAR81
4289	1	23.50	127	23.92	MAR81
4291	1	23.70	161	24.12	MAR81
4293	1	25.40	112	25.85	MAR81
4295	1	24.10	114	24.53	MAR81
4301	0	7.70	41	7.84	JUN81
4303	0	9.00	40	9.16	JUN81
4305	0	12.55	51	12.77	JUN81
4307	0	13.45	71	13.69	JUN81
4309	0	14.00	55	14.25	JUN81
4312	0	14.40	83	14.66	JUN81
4313	0	14.40	64	14.66	JUN81
4315	0	14.55	69	14.81	JUN81
4317	0	13.85	59	14.10	JUN81
4319	0	14.75	76	15.01	JUN81
4321	0	15.20	81	15.47	JUN81
4323	0	15.50	77	15.78	JUN81
4325	0	15.55	62	15.83	JUN81
4328	2	16.40	88	16.69	JUN81
4329	2	16.10	79	16.39	JUN81
4331	2	16.00	78	16.28	JUN81
4333	2	16.20	96	16.49	JUN81
4335	2	16.80	80	17.10	JUN81
4337	2	17.75	91	18.07	JUN81
4339	2	18.10	92	18.42	JUN81
4341	2	17.70	88	18.02	JUN81
4343	2	18.55	119	18.88	JUN81
4345	2	19.75	102	20.10	JUN81
4347	2	19.50	111	19.85	JUN81
4349	2	20.00	128	20.36	JUN81
4351	2	21.20	110	21.58	JUN81
4353	2	21.85	78	22.24	JUN81
4355	2	22.40	102	22.80	JUN81
4357	2	23.25	120	23.66	JUN81
4361	2	23.85	132	24.27	JUN81
4363	2	24.60	121	25.04	JUN81
4365	1	16.35	83	16.64	JUN81
4367	1	16.00	81	16.28	JUN81
4369	1	16.90	84	17.20	JUN81
4373	1	19.50	127	19.85	JUN81
4375	1	20.40	129	20.76	JUN81
4377	1	20.55	131	20.92	JUN81
4379	1	22.00	150	22.39	JUN81
4381	1	22.75	118	23.16	JUN81

APPENDIX G (continued)

4383	1	22.30	167	22.70	JUN81
4385	1	22.35	165	22.75	JUN81
4387	1	23.15	130	23.56	JUN81
4389	1	22.30	153	22.70	JUN81
4391	1	24.25	132	24.68	JUN81
4393	1	23.60	125	24.02	JUN81
4395	1	25.25	138	25.70	JUN81