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[Management Brief]

Comparison of Channel Catfish Age Estimates and Resulting Population Demographics Using Two Common Structures

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Abstract.—Sagittal otoliths and the articulating process of the pectoral spine have both been validated as accurate techniques for estimating the age of channel catfish *Ictalurus punctatus* (≤age 4). However, there is limited information on the relative precision of estimates from these two structures. Thus, we analyzed the precision of age estimates derived from otoliths and the articulating process of the pectoral spine and compared the dynamic processes (recruitment, growth, and mortality) resulting from those estimates. Aging structures were removed from 110 channel catfish captured from the Wabash River (river kilometers 550–9.6) via day–time electrofishing. The age estimation methodologies were similar to those described in previous studies. Agreement between the ages derived from the two structures was high; the average percent error was 8.4%, the coefficient of variation was 11.4, and the slope of the age bias plots did not differ from 1, indicating similar age assignments between structures. The corresponding recruitment patterns, von Bertalanffy growth models, and mortality rates did not differ between the aging structures. We conclude that the articulating process of the pectoral spine provides age assignments similar to those of otoliths and that the dynamic processes do not differ between structures. Further, based on the results of this study, the articulating process of the pectoral spine provides a suitable alternative to otoliths and has the advantage that channel catfish do not have to be sacrificed.

Characterizing the dynamics of a fish population requires estimation of the ages of individuals. Further, acquiring accurate fish ages is imperative for obtaining accurate population demographics. Previous studies have used many structures to determine fish ages; however, the age estimates derived from some of these structures are incorrect, which can lead to false assessments of the dynamic processes (recruitment, growth, and mortality) of a population. Despite their apparent relevance, these issues have received little attention. In our case, much research has focused on the management and ecology of catfish (Hubert 1999); however, accurate determination of the population demographics of channel catfish *Ictalurus punctatus* is complicated by the conflicting methods of age estimation.

Channel catfish can be aged via several hard structures (Siegwarth 1994; Daugherty and Sutton 2005; Kwak et al. 2006; Shephard and Jackson 2006; Holley et al. 2009). Previously, the basal recess of the pectoral spine was used (Sneed 1951), although age estimates derived from this structure may be biased downwards in the case of old fish (Nash and Irwin 1999). Crumpton et al. (1987) found that otolith annuli were not distinguishable and recommended the use of pectoral spines for aging channel catfish; however, both the sagittal otolith and articulating process of the pectoral spine have been used as aging structures (Nash and Irwin 1999; Buckmeier et al. 2002). Both of the latter have been validated for pond-reared catfish up to age 4 (Buckmeier et al. 2002). Furthermore, using otoliths involves sacrificing the fish (which may not be practical under certain circumstances), while using the articulating process requires minimal handling time and permits the fish to be released alive afterwards (Stevenson and Day 1987).

Given the lack of agreement on the preferred aging structure in prior studies, we initiated a study involving sagittal otoliths and the articulating process of the pectoral spine as the bases for estimating channel

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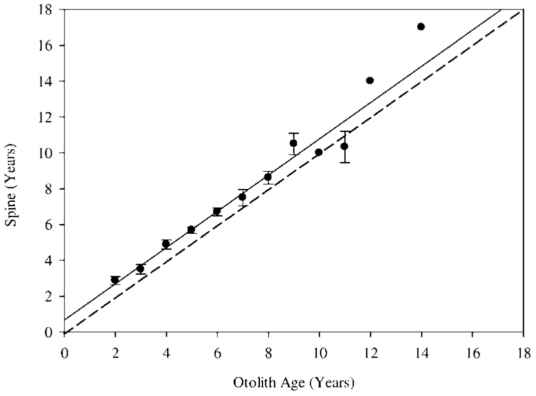

FIGURE 1.—Age bias plot comparing channel catfish ages derived from otoliths with those derived from the articulating process of the pectoral spine. The solid line represents the estimated relationship between the two sets of age estimates, while the dashed line has a slope of one and runs through the origin; the error bars represent SEs. The slopes of the two lines were not significantly different ($P > 0.05$).

catfish ages. Unfortunately, no channel catfish of known ages were available, so age validation was impossible. Therefore, the objectives of our study were to compare the precision of the age estimates from otoliths (a lethal technique) with that of those from the articulating process of the pectoral spine (a nonlethal technique). Secondly, we compared the dynamic processes (recruitment, growth, and mortality) generated by these structures.

Methods

In fall 2001, we collected 110 channel catfish from river kilometers 550 to 9.6 of the Wabash River, as measured from the confluence of the Wabash and Ohio rivers, using three-phase AC electrofishing. The left pectoral spines and sagittal otoliths were removed from all fish sampled for age determination. The pectoral spines were disarticulated from the fish, brought back to the Southern Illinois University fisheries laboratory, and dried for 24 h at 60°C. We then removed three 700-μm sections of the articulating process of the spine using a Beuhler low-speed Isomet saw. The articulating process was placed in immersion oil and viewed with a stereo microscope under low magnification (7–40×) using reflected light from a fiber optic light source. Sagittal otoliths (hereafter, otoliths) were removed by cranial dissection at the most rostral extent of the pectoral spine (Buckmeier et al. 2002), allowed to air dry, and heated on a hotplate. After the otoliths had browned, they were mounted on their posterior edge on glass microscope slides with thermoplastic cement. The otoliths were sanded to the nucleus with a Dremel high-speed rotary tool with a medium-grit sand attachment mounted to a drill press to provide an edge for aging. These structures were also aged with a stereo microscope under low magnification (7–40×), with side illumination from a fiber optic light source.

For both structures, two independent readers estimated channel catfish ages by counting the number of annuli (one translucent band + one opaque band = one annulus). Disagreements about individual structures were resolved by consensus between the two readers; if a consensus could not be reached, the specimen was excluded from the analysis.

The age estimates derived from the two structures were compared in terms of their average percent error and coefficient of variation ($CV = 100 \times SD/mean$) (Beamish and Fournier 1981; Chang 1982). Differences in age were analyzed by comparing the slope of the age bias plot with 1, the slope of a line denoting complete equality (Campana et al. 1995). Mortality was estimated using catch curves (Ricker 1975). We compared the catch curves obtained from the two structures using a homogeneity of slopes test (a test of interaction using analysis of covariance [ANCOVA]; Sokal and Rohlf 1995). Recruitment patterns were assessed descriptively from age-frequency distributions, and comparisons between structures were made quantitatively with a Kolmogorov–Smirnov test. Growth was assessed using von Bertalanffy growth models generated by FAST software (Slipke and Maceina 2000). The growth curves derived from the two structures were compared by analyzing the residual sums of squares of the coinciding curves (Chen et al. 1992).

Results and Discussion

The two readers were able to reach a consensus on all age estimates; therefore, all 110 channel catfish were used in our analysis. The average percent error between the estimates based on sagittal otoliths and those based on the articulating process of the pectoral spines was 8.4%, and the coefficient of variation was 11.4. Based on these values, there was relatively high agreement between the two structures used to estimate channel catfish ages. Furthermore, the slope of the age bias plot did not differ from 1 ($P > 0.05$; Figure 1), indicating similar age assignments between structures. However, multiple catfish studies suggest that otoliths are the superior aging structure (Nash and Irwin 1999; Buckmeier et al. 2002). By contrast, Phelps et al. (2007) found that the pectoral fin sections of common carp *Cyprinus carpio* provided age assignments similar to those provided by otoliths through age 13.

Recruitment patterns appear to be similar between structures (Figure 2). Both structures led to the

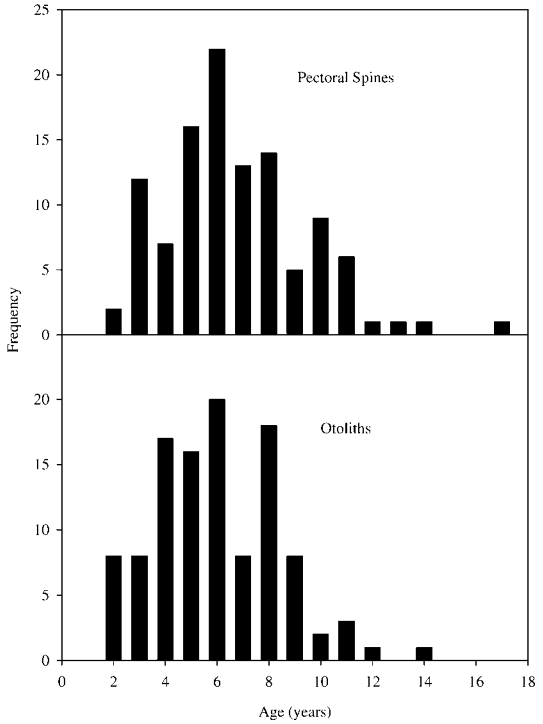

FIGURE 2.—Age-frequency histograms for channel catfish derived from sagittal otoliths and the articulating process of the pectoral spine.

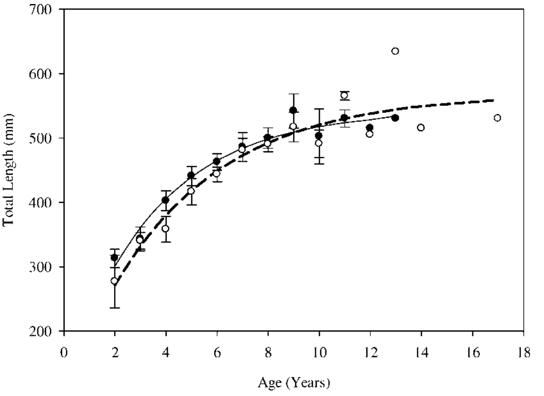

FIGURE 3.—Mean length at age and von Bertalanffy models for channel catfish aged with otoliths (filled circles and solid line) and the articulating process of the pectoral spine (open circles and dashed line) The error bars represent SEs; the two lines are statistically equivalent ($P > 0.05$).

detection of the strong age-6 year-class (Figure 2). However, the articulating process of the pectoral spine led to the detection of older individuals than did otoliths, though the age-frequency distributions based on these two structures were not different (Kolmogorov–Smirnov statistic = 0.867, $P = 0.455$). We were unable to locate any studies comparing catfish recruitment patterns between aging structures. However, a study of bluegills *Lepomis macrochirus* in Lake Louise, South Dakota, found different recruitment patterns when two different structures were employed (Edwards et al. 2005), the patterns based on otoliths being more erratic than those based on scales.

Corresponding to the lack of differences in age structure, mortality was not different between the two aging structures (ANCOVA; $P = 0.540$). Annual mortality was 36% based on otoliths ($r^2 = 0.81$, $P < 0.01$) and 33% based on pectoral spines ($r^2 = 0.74$, $P = 0.014$). Based on our results, channel catfish mortality could be estimated from either structure. Nash and Irwin (1999) found that otoliths were superior to articulating processes for aging flathead catfish *Pylodictis olivaris* but suggested that pectoral articulating sections provide adequate ages when catfish are not sacrificed. Nash and Irwin (1999) also noted that the articulating process may underestimate age by as much as 7 years, which would influence mortality rates.

Channel catfish growth as estimated by von Bertalanffy models did not differ between aging structures ($F = 1.95$; df = 2, 23; $P = 0.136$). Up to age 9, channel catfish aged by means of the articulating processes of the pectoral spines grew slightly more slowly than those aged by means of otoliths, but beyond age 9 the growth rates derived from the two structures were similar (Figure 3). A larger sample of age-9 and older fish would be needed to confirm the use of pectoral spines as an accurate aging structure for older individuals.

Management Implications

No apparent bias was associated with aging channel catfish using the articulating processes of pectoral spines as opposed to otoliths, and there is a growing consensus among Midwestern biologists that spines are comparable to otoliths as aging structures (Kevin Sullivan and Paul Michaletz, Missouri Department of Conservation, personal communication). Further, the recruitment patterns and growth and mortality rates derived from the two structures did not differ. Thus, the articulating process of the pectoral spine provides a nonlethal method for aging channel catfish that produces population demographics similar to those obtained from otolith aging.

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