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**EXTENDED ABSTRACTS**



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# **GROWTH CHARACTERISTICS OF CRETACEOUS AND CENOZOIC NORTH AMERICAN ESOCIFORMES: IMPLICATIONS FOR SYSTEMATICS**

Michael G. NEWBREY

*Department of Biological Sciences, North Dakota State University,  
Fargo, ND 58105, USA;  
michael.newbrey@ndsu.edu*

Mark V.H. WILSON

*Department of Biological Sciences, University of Alberta,  
Edmonton, Alberta T6G 2E9, Canada*

& Allan. C. ASHWORTH

*Department of Geosciences, North Dakota State University, Fargo, ND 58105*

## **INTRODUCTION**

Fossil esocoids, mostly consisting of isolated bones, centra, and scales, have a fossil record extending from the Cretaceous through the Quaternary (e.g., WILSON *et al.* 1992). The lack of complete fish hampers systematic and phylogenetic studies but incomplete specimens provide growth data.

We examined the growth patterns and the response of the various components of the von Bertalanffy growth equation to **Mean Annual Temperature (MAT)** from extant esocids and umbrids to document the variation between the species. The variation and variable responses to temperature provide a context to classify growth patterns in the Cretaceous and Cenozoic fossil record. Specifically, we quantified and contrasted the growth characteristics of fossil and extant esociforms with regard to relationships between MAT and the: 1) total length (TL) at age four, 2) percentage of maximum observed TL attained by age four (PMTL), 3) K (Brody growth coefficient), 4) longevity, and 5) maximum observed total length (MTL).

## **RESULTS**

Our analysis is primarily based on North American von Bertalanffy growth data, parameters, and regressions from the extant esocids and

umbrids, which include: *Esox masquinongy* (n = 23), *E. lucius* (n = 21), *E. reicherti* (n = 3), *E. niger* (n = 9), and *E. americanus* (n = 6); *Umbra limi* (n = 4), *Umbra krameri* (n = 1), and *Dallia pectoralis* (n = 1). Total length at age four was positively correlated with MAT for *E. masquinongy*, *E. lucius*, *E. niger*, and *U. limi*. The PMTL at age four is influenced by the effects of K and MTL and was positively correlated with MAT for *E. masquinongy*, and *E. lucius*, but was negatively correlated for *E. niger*. The responses of K, longevity, and MTL for *E. niger* are opposite to those for *E. masquinongy* and *E. lucius*. For *E. niger*, K is negatively correlated with MAT; however, longevity and MTL are positively correlated with MAT. *Esox americanus* has growth characteristics not significantly related to temperature, except with regard to MTL, which responds in a similar manner to MAT as that for *E. lucius*.

We found that esocid centra from the Cretaceous Dinosaur Park Formation (DPFm) of Alberta and Saskatchewan (BRINKMAN & NEUMAN 2002) were from fish up to 10 years old with a bimodal age distribution of ages one and five. Centrum diameters did not exceed 4.4mm (range 1.1 - 4.4mm) indicating that they remained small throughout their life. Growth was linear and moderately slow ( $\bar{x} = 0.19$ , range 0.1 - 0.36 K). We would have expected growth to be faster given the high Cretaceous MAT (i.e., ~19°C). Centra reached their maximum diameters as early as four years in age. No differences existed in the growth patterns of the centra to suggest different species even though the deposits contain dentaries of *Estesesox* and *Oldmanesox* (WILSON *et al.* 1992).

The centra of incomplete *Esox* specimens from the Paleocene Bullion Creek Formation in North Dakota attained much larger sizes (i.e., 5.8 - 13.2mm diameter) and ages up to 12 years old. *Esox* of the Paleocene Sentinel Butte Formation in North Dakota lived at least as old as nine years, attaining an estimated total length of about 115cm. The largest centrum recorded was 13.5mm diameter for a specimen that was six years old. Examination of *Esox tiemani* WILSON 1980 of the Paleocene Paskapoo Formation indicated that the holotype and another specimen attained a TL of 26 to 32cm by age one, which is similar to one year old *E. masquinongy* in the southern end of their range today.

Scales of Paleocene *Esox* were similar in size and age to those from the Eocene Coalmont and Clarno Formations from Colorado and Oregon, respectively. Two *Esox* scales were aged from the Coalmont Formation at six and 10 years old. One scale was aged from the Clarno Formation at eight years old. *Esox kronneri* GRANDE, 1999 of the Eocene Green River Formation, age zero, has a TL of 11.8cm with centrum diameters similar in size to those of Paleocene esocids at age one and much larger than those of the Cretaceous specimens at age one.



