A Preliminary Report on a New System for Recording Jaw-muscle Electromyograms From Free-ranging Primates

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In vivo lab-based studies of primate mastication describing jaw-muscle activity and mandibular bone strain provide the empirical basis for most evolutionary hypotheses linking primate masticatory form to diet. However, testing these hypotheses is problematic because data recorded in the lab often lack the appropriate ecological context for fully understanding masticatory function and performance. For example, rhythmic chewing in these studies is elicited using foods that may not represent the diets of wild primates. Because the textural and mechanical properties of foods influence jaw-muscle activity and the resulting strain patterns, chewing behaviors observed in the lab may not adequately reflect chewing behaviors of primates feeding in their natural habitats. Here, we present recent efforts to address this limitation of lab-based studies of primate mastication. Specifically, we developed a system for recording jaw-muscle electromyograms (EMGs) from free-ranging primates so that in vivo studies of primate jaw-muscle function can be conducted in the field. We used the system to successfully record jaw-muscle EMGs from mantled howling monkeys (*Alouatta palliata*) at La Pacific, Costa Rica. These represent the first EMGs recorded from a non-captive primate in the field. Further refinements of the system will allow long-term EMG data collection so that jaw-muscle function can be correlated with food mechanical properties in primates feeding freely in their natural habitats. In addition to furthering our understanding of primate feeding biology, this work will foster improved adaptive explanations for topics like the evolution of primate jaw form. Supported by NSF.

Skeletal Development of the Embryonic Leopard Gecko (*Eublepharis macularius*): A Real–Time Study of the Genesis of Gross Pattern and Its Correlation with Developmental Stages

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The Gekkota is a major early squamate radiation, with over 1050 described species. Major clades within the Gekkota are the Eublepharidae, Pygopodidae and Gekkonidae, the former generally regarded as a basal assemblage. Phylogenetic studies of the Gekkota based on morphological characters rely heavily on features of the dermatocranium, which has not been well studied from a developmental context, leaving open many questions regarding the homology of individual elements. It has been suggested that pre-hatching development may be a valuable source of phylogenetic information, but for the Gekkota little such information is available. We herein document the pattern and sequence of ossification of the dermatocranial elements of the eublepharid *Eublepharis macularius* (the leopard gecko), and correlate these to an embryonic staging sequence assembled in real time from embryos incubated under standardized and controlled conditions. We correlate this information with that available for other clades of lizards, and compare changes in shape and form to posit predictions about potential onset of skeletogenic pattern, and proportional changes that may be associated with rate changes and growth trajectories. This initial documentation is the first step in the compilation of a comparative data base of gekkotan head skeleton development, the assembly of which is directed towards investigation of variation in skeletogenic pattern that may be clade specific.

Evolving an On-board Flight Computer: Brains, Ears, and Exaptation in the Evolution of Birds and Other Theropod Dinosaurs

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Evolutionary studies of flying groups typically focus more on the aerodynamic components (flight surface, skeleton) than the sensorineural components (brain, senses). We examine the evolution of the brain and inner ear in Theropoda, using CT scanning and 3D-visualization. Specimens of about 100 species of fossil archosaurs and 50 species of extant sauropsids were CT scanned and analyzed, yielding the largest dataset of virtual cranial endocasts and osseous labyrinths. Sampling includes over 30 species of non-neornithine coelurosaurian theropods, spanning the transition to birds. Despite dense sampling, reconstructing this transition in detail is hampered by the lack of critical information on neural wiring in fossils. Nevertheless, many aspects of avian brain and ear structure are present in numerous nonavian coelurosaurs, and many "modern" traits are not encountered until well within the avian radiation. Mechanistically linking particular brain and ear attributes to flight has been problematic, and the reason now seems clear: many of these attributes did not evolve in a flight context, but rather were exapted in birds for the sensorineural control of flight. Controversy about whether some "nonavian" theropods may actually be secondarily flightless birds is relevant in that they display some strikingly avian attributes of the brain and ear. Likewise, the discovery of aerodynamic feathers in some nonavian clades raises questions about the inferred adaptive context. The evolutionary pattern appears complex: early aerodynamic experimentation may have contributed to the evolution of birdlike sensorineural attributes, and these attributes were subsequently exapted and honed during the course of the avian radiation.

Early and Late Vertebral Fusion in Atlantic Salmon (*Salmo salar*): Vertebral Bodies and Arches as Developmental Modules and the Lifelong Role of the Notochord

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Classically, the somitic mesoderm is viewed as the source of segmental patterning of the vertebral bodies. Ablation experiments in amphibians and birds and developmental studies on teleosts challenge this view and show that the notochord directs the segmental patterning of vertebral bodies. Spinal ganglia on the other hand determine the segmentation of neural arches. In fact, the independent segmentation of vertebral bodies and vertebral arches is required to construct the teleost caudal fin. In evolution and in development, fusion of vertebral body anlagen leads to multiple neural and haemal arches which become elements of the caudal fin endoskeleton. Fusion of vertebral bodies in teleosts is not restricted to early caudal fin development. We have followed vertebral fusion in other parts of the salmon spine and conclude that vertebral fusion can be initiated at any time in life. Although later vertebral fusion must be considered as pathological, the process shows remarkable resemblance to early vertebral fusion. Like early normal fusion, late fusion can be fully completed and result in the reconstruction of one regular vertebral body, yet with multiple haemal and neural arches remaining separated. Our results support the idea that vertebral bodies and neural arches are independent developmental modules and suggest a lifelong role of the notochord for keeping vertebral bodies separate in teleosts.

The Influence of Food Material Properties on Jaw Kinematics and EMG Activity in Humans

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Electromyographic and kinematic recordings and analyses of the granulometry of the food bolus are the main methods used to study mastication in man. They allowed to reach the following conclusions: 1) Physiological recordings have shown that the number of cycles, the muscle contraction and the vertical amplitude of the jaw movements are the variables that are the most concerned by adaptation to an increase in either the size, the hardness or a change in other rheological properties of the food mouthful. There is, however, a large variability between subjects in the mastication parameters. With aging, the number of cycles and the total muscle contraction in one masticatory sequence are enhanced but the ability to adapt to an increased hardness is not impaired. 2) The distribution of particle sizes in food boli collected before swallowing are very similar from one subject to another even if physiological parameters recorded during the corresponding mastication are very different. This suggests that subjects with healthy dentition have different strat-