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Patterns of cranial skeleton ontogeny in Syngnathidae: a comparison between Syngnathus rostellatus and Hippocampus capensis

The special reproductive strategies of Syngnathidae, their elongated snout without teeth, the fastest food intake among teleosts and the vertical position in the water column with the accompanying tilted head of seahorses, makes pipefishes and seahorses very remarkable. Despite their exceptional appearance little is known about their morphology and ontogeny. The aim of this research is to compare the ontogeny of the head skeleton in *Syngnathus rostellatus* and *Hippocampus capensis*. A detailed morphological study was performed using cleared and stained specimens, as well as serial histological sections for graphical 3D-reconstructions. The obtained results were compared with those of *Gasterosteus aculeatus*, which has a basal position within the same order. Based on the results of this study and data from literature it could be concluded that the elongation of the snout appears very early in the development. Already at the moment of being expelled from the brooding pouch, the juveniles are provided with a specialized feeding-apparatus, comparable to the adult situation. It could also be shown that there is a close resemblance between *S. rostellatus* and *H. capensis*, with the most important dissimilarities being related to the different levels of snout elongation. However, a distinct neurocranial dissimilarity was observed during early ontogeny, with the seahorse braincase being tilted with respect to the ethmoid region. The differences with *G. aculeatus* involve a series of structural specializations in *S. rostellatus* and *H. capensis* that can be related to powerful and fast suction feeding, such as the reduced maxillary bones without protrusion, the elongation of the ethmoid region to form the tubular snout and the well developed hyoid arch.

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In vivo activity of zebrafish inhibitory spinal interneurons across behaviours

Inhibitory commissural spinal interneurons play a key role in shaping the rhythmicity underlying undulatory locomotion. Here we present data on the morphology, activity, and possible interconnectivity of these cell types in 2-5 day post-fertilization zebrafish larvae obtained by targeted patch clamping in a stable transgenic line of zebrafish expressing green fluorescent protein in glycinergic cells. Commissural bifurcating longitudinal interneurons (CoBLs) are active during swimming frequencies of 30-60 hz and have motor neurons and other CoBLs as likely postsynaptic targets (as indicated by confocal imaging). Some CoBLs have a relatively long descending axon (> 4 myotomes) compared to the ascending axon while others have short ascending and descending axons (< 2 myotomes). Long-axon CoBLs are active at swimming frequencies of 30-60 Hz, as well as during struggling, when the body wave passes caudal to rostral. Short-axon CoBLs are active at 30-40 Hz and not during struggling. Commissural longitudinal ascending interneurons (CoLAs) are not active during swimming at any frequency, but rather are only recruited during struggling. Their likely post-synaptic targets include motor neurons. Commissural local interneurons (CoLOs) have a high threshold for firing and possess a short, robust descending axon that is excited by the descending reticulospinal Mauthner axon. These cells are not active during swimming or struggling, but are active during the escape response, as has been found in goldfish. Commissural secondary ascending interneurons (CoSAs) are active during swimming at 30-40 Hz as well as during struggling. Our data suggest that some cell types are dedicated to particular behaviors, whereas others are shared among behaviors. The challenge now is to understand better their ability to serve either more generalized or specific behavioral roles.

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Passive Muscle Facilitates Rapid Perturbation Recovery in an Insect Leg

Isolated and intact legs of cockroaches begin to recover from vertically directed impulse perturbations within 5 ms and return to within 99% of their original position within the swing phase duration. This response is due to the leg's passive exoskeletal properties because of their vertically oriented joint axes. To examine recovery from horizontal plane leg perturbations involving passive muscle, we used a small servomotor and material testing techniques including sinusoidal oscillations and impulses to classify the passive dynamic system of the metathoracic leg of *Blaberus discoidalis*. We focused on motion of the coxa-femur joint that is responsible for fore-aft motion of the foot. Passive viscoelastic forces from muscle and exoskeleton were nonlinear and history dependent. For low speed ramp perturbations, recovery was slow and highly overdamped. For rapid perturbations, legs returned quickly and recovery was slightly underdamped. Applying sinusoidal forces to legs elicited periodic displacement as in running. Adding ramps and impulses confirmed that the passive system alone rejected perturbations to a periodic trajectory in less than 40 ms. Using this system as a model for the swing phase of running, we conclude that passive forces from the exoskeleton and inactive muscle allow the leg to completely recover from large impulse perturbations before footfall at stride frequencies over 8 Hz. Further, the swing phase can act as a stabilizer for leg position, rejecting perturbations to leg displacement that occur during stance phase. Stance phase perturbations that create an error in leg position at the onset of swing do not affect footfall position.

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Humans use a unique mechanism to stabilize the head during running

Mammals must stabilize the head during running to keep angular accelerations of head within the operating range of the vestibulo-ocular (VOR) reflexes. However, several unique aspects of the human body plan and locomotor kinematics make head stabilization more challenging than in other cursors. Most bipedal and quadrupedal cursors have cantilevered heads and necks that act to attenuate forces and counter sagittal head pitching through controlled flexion and extension movements. In contrast, humans have short vertical necks that emerge from near center of head, combined with relatively extended, stiff legs at heel strike (HS), resulting in a strong tendency for the head to pitch forward at the beginning of stance. Using EMG, kinematic, and kinetic measurements of human arm and head movements during running and walking we show that humans stabilize the head following HS using a unique tuned-mass damper system. This mechanism, which links the head with inertial forces in the stance side (ipsilateral) arm, is facilitated by a number of derived aspects of human anatomy and running kinematics. Notably, humans have lost all muscular connections between shoulder girdle and head except for the cleidocranial portion of the trapezius (CCT), which reaches the occiput via a tendon-like nuchal ligament. Additionally, coordinated movements of the arm and thorax position the ipsilateral arm behind the head-neck joint prior to HS, when the ipsilateral CCT fires. Out of phase accelerations of the arm and head then link the counterbalancing mass of the arm and the flexed forearm via a compliant connection to the head, controlling the head's rate of pitch. Because the nuchal ligament, a key component of the system, leaves a trace on the skull, it is possible to show that this novel mechanism for head stabilization originated within the genus *Homo* approximately 2 million years ago.