

Energetics of median and paired fin swimming, body and caudal fin swimming, and gait transition in parrotfish (*Scarus schlegeli*) and triggerfish (*Rhinecanthus aculeatus*)

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To determine the energetic costs of rigid-body, median or paired-fin (MPF) swimming versus undulatory, body-caudal fin (BCF) swimming, we measured oxygen consumption as a function of swimming speed in two MPF swimming specialists, Schlegel's parrotfish and Picasso triggerfish. The parrotfish swam exclusively with the pectoral fins at prolonged swimming speeds up to 3.2 total lengths per second ($L s^{-1}$; 30 min critical swimming speed, U_{crit}). At higher speeds, gait transferred to a burst-and-coast BCF swimming mode that resulted in rapid fatigue. The triggerfish swam using undulations of the soft dorsal and anal fins up to $1.5 L s^{-1}$, beyond which BCF undulations were recruited intermittently. BCF swimming was used continuously above $3.5 L s^{-1}$, and was accompanied by synchronous undulations of the dorsal and anal fins. The triggerfish were capable of high, prolonged swimming speeds of up to $4.1 L s^{-1}$ (30 min U_{crit}). In both species, the rates of increase in oxygen consumption with swimming speed were higher during BCF swimming than during rigid-body MPF swimming. Our results indicate that, for these species, undulatory swimming is energetically more costly than rigid-body swimming, and therefore support the hypothesis that MPF swimming is more efficient. In addition, use of the BCF gait at higher swimming speed increased the cost of transport in both species beyond that predicted for MPF swimming at the same speeds. This suggests that, unlike for terrestrial locomotion, gait transition in fishes does not occur to reduce energetic costs, but to increase recruitable muscle mass and propulsive surfaces. The appropriate use of the power and exponential functions to model swimming energetics is also discussed.

Key words: Scaridae, Balistidae, labriform, balistiform, aquatic locomotion, rigid-body swimming, undulatory swimming, respirometry, cost of transport

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