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On the "momentum enhancement" and hydrodynamic efficiency of gymnotiform and balistiform swimmers ANUP SHIRGAONKAR, Department of Mechanical Engg., MIT, NEELESH PATANKAR, MALCOLM MACIVER, Department of Mechanical Engg., Northwestern University — Gymnotiform and balistiform swimmers generate thrust by undulating ribbon fins while keeping the body nearly rigid. The question of whether there is a hydrodynamic basis for this evolutionary adaptation was considered by Lighthill and Blake. They used a two-dimensional inviscid approach and explained this adaptation based on their finding that the thrust produced by an undulatory ribbon fin is much higher when it is attached to a rigid body. This was termed momentum enhancement. We revisited this problem by performing high-resolution numerical simulations to calculate the thrust generated by undulatory ribbon fins in a plate-fin model of a gymnotiform swimmer. We did not find momentum enhancement. This disagreement could be explained by noting that an axial jet along the bottom edge of the ribbon fin is the primary thrust producing mechanism. This flow is not significantly affected by the presence of the body thus leading to no momentum enhancement. Lighthill's theory does not capture this dominant mechanism of thrust production. We find that the observed relative size of the body and the ribbon fins is such that it tends to optimize the cost of transport, as opposed to simply maximizing thrust. We present scaling analysis that supports this finding.

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