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**Topic Summary**

Annotated Articles: 9

The attachment of remoras to artificial and natural marine substrates is a recurring behaviour that presents itself as a symbiotic relationship. Researchers interested in deciphering some of the perks of the hitch-hiking found that the behaviour increases the remoras' locomotive efficiency allowing for energy to be allocated towards other things (Flammang et al., 2020; Lee et al., 2019). Furthermore, there is an increased likelihood of finding conspecifics, reduced cost for foraging, and low predation (Flammang et al., 2020). The primary benefit offered to the host is that the remoras consume parasites that may be attached to their skin (Cohen, 2020).

The behaviour is studied through an analysis of the morphology of the remora. Phylogenomic analyses may also be conducted by comparing morphology to close relatives such as *Rachycentron canadum* (Gamel et al., 2019). Furthermore, it is an aquatic behaviour so most of the evidence is present in photographs; however, the development of biotags equipped with video cameras recently have allowed for more detailed observations (Flammang et al., 2020).

Adhesion of remoras to marine animals is facilitated through a highly developed dorsal structure referred to as the adhesion disc. Gamel et al. (2019) analyzed the morphology of remoras by microtomographic scanning and found that there are a series of pectinated bony lamellae on the disc which rotate from a flat to erect position when adhering to host surfaces. Lamellae are thought to have a function in creating a suction tight seal (Gamel et al., 2019). Beckert et al. (2015) measured the contact surface topology using a material confocal microscope and found that small spinules are responsible for increased friction on rough host topologies. The significance of these structures is further exemplified by a study that analyzed the evolutionary assembly of this and found an increase in the number of lamellae and spinules through generations (Friedman et al., 2013). The findings of Friedman et al. (2013), Beckert et al. (2015), and Gamel et al. (2019) depict the three crucial elements of the disc that aid in the adhesion function: the lamellae, spinules and fleshy lip.

Host specificity varies based on the species of remoras; some remoras are able to attach to various hosts whereas some attach to a specific host (Kenaley et al., 2019). Researchers interested in evaluating host specificity through bio-inspired discs found that host diversification is determined by the skin surface roughness, host specialization, and hydrodynamic regime, and that the disc always performed the best on the surfaces that had between 180 and 350-grit (Kenaley et al., 2019; Gamel et al., 2019). This is similar to shark skin, indicating remoras may favour sharks as hosts as they can grasp onto them better (Gamel et al., 2019).

Remoras are able to minimize energy allocated towards foraging by relying on the food scraps left from the host (Flammang et al., 2020). Researchers interested in studying the eating habits of remoras found that remoras consume on food particles by either detaching from the host or by remaining attached (Sazima and Grossman, 2006). The further the substrate falls, the more likely the remora is to detach and scavenge for these particles.

The location which a remora chooses to bind on the host is specific to where locomotive efficiency is maximized (Flammang et al. 2020). Researchers interested in studying the adhesion patters of remoras found that remoras show preference to regions where drag is minimal, and the ventral side to avoid predation from sea birds (Sazima and Grossman, 2006; Flammang et al. 2020). Most interactions were with juvenile remoras, and adult remoras were attached as couples, indicating they may be mating pairs (Sazima and Grossman, 2006). Generally, this coincides with a higher remora/turtle ratio, which means there would be more hydrodynamic drag experienced by the host. As drag increases, the host would be slower which is as a disadvantage in times where there are predators (Sazima and Grossman, 2006).

Future research can be directed towards determining the role of cranial vasculature on adhesion. Researchers interested in determining the cranial vasculature of remoras hypothesized that it may have a role in the equalization of pressure in lamellar compartments; however, no function was attributed (Flammang and Kenaley, 2017).

**References:**

**Primary Articles:**

Beckert, M., Flammang, B. E., & Nadler, J. H. (2015). Remora attachment is enhanced by spinule friction. *Journal of Experimental Biology*, jeb.123893.

<https://doi.org/10.1242/jeb.123893>

Cohen, K. E., Flammang, B. E., Crawford, C. H., & Hernandez, L. P. (2020). Knowing when to stick: Touch receptors found in the remora adhesive disc. *Royal Society Open Science*, *7*(1), 190990. <https://doi.org/10.1098/rsos.190990>

Flammang, B. E., & Kenaley, C. P. (2017). Remora cranial vein morphology and its functional implications for attachment. *Scientific Reports*, *7*(1), 5914. <https://doi.org/10.1038/s41598-017-06429-z>

Flammang, B. E., Marras, S., Anderson, E. J., Lehmkuhl, O., Mukherjee, A., Cade, D. E., Beckert, M., Nadler, J. H., Houzeaux, G., Vázquez, M., Amplo, H. E., Calambokidis, J., Friedlaender, A. S., & Goldbogen, J. A. (2020). Remoras pick where they stick on blue whales. *Journal of Experimental Biology*, *223*(20). <https://doi.org/10.1242/jeb.226654>

Friedman, M., Johanson, Z., Harrington, R. C., Near, T. J., & Graham, M. R. (2013). An early fossil remora (Echeneoidea) reveals the evolutionary assembly of the adhesion disc. *Proceedings of the Royal Society B: Biological Sciences*, *280*(1766), 20131200. <https://doi.org/10.1098/rspb.2013.1200>

Gamel, K. M., Garner, A. M., & Flammang, B. E. (2019). Bioinspired remora adhesive disc offers insight into evolution. *Bioinspiration & Biomimetics*, *14*(5), 056014. <https://doi.org/10.1088/1748-3190/ab3895>

Kenaley, C. P., Stote, A., Ludt, W. B., & Chakrabarty, P. (2019). Comparative functional and phylogenomic analyses of host association in the remoras (Echeneidae), a family of hitchhiking fishes. *Integrative Organismal Biology*, *1*(1). <https://doi.org/10.1093/iob/obz007>

Lee, S. H., Song, H. W., Kang, B. S., & Kwak, M. K. (2019). Remora-inspired reversible adhesive for underwater applications. *ACS Applied Materials & Interfaces*, *11*(50), 47571–47576. <https://doi.org/10.1021/acsami.9b16350>

**Secondary Articles:**

Sazima, I., & Grossman, A. (2006). Turtle riders: Remoras on marine turtles in Southwest Atlantic. *Neotropical Ichthyology*, *4*(1), 123–126. <https://doi.org/10.1590/S1679-62252006000100014>