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Determining T-Bar Anchor Tag Placement in the Atlantic Stingray (*Dasyatis sabina*): Combining Fin Undulation Amplitude and Radial Calcification.

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ABSTRACT

Atlantic stingrays (*Dasyatis sabina)* are an enigmatic species, with little research done on their contributions to the environmental niche they occupy. Data collection and tagging of specimens is a vital step to understanding the role they play. Determining the proper placement of the T-bar anchor tag in pectoral fin of the Atlantic Stingray is important to ensure the longevity of the tag. Proper placement will also promote ray health and prevent motility interference. The physiology of the stingray family Dasyatidae includes thin radials that extend from the anterior and posterior basal cartilages outward through their dorsally compressed pectoral fins. Choosing a section of the pectoral disc that has calcified radials will support the tag, resisting pull through and reduce tag contact with sea floor substrates. Selecting a fin wave amplitude of less than 0.79 cm will decrease tag stress, and allow for full pectoral disc locomotion. The corresponding section of the pectoral disc that meets this criterion is the mid-line medial radials, plus one-quarter the disc length anterior and posterior to the mid-line. Restricting tags to this zone of the pectoral fin will promote ray health and tag longevity.

KEYWORDS: Atlantic Stingray, *Dasyatis sabina*, T-bar anchor tag, fin amplitude, medial radials.

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INTRODUCTION

There is little research concerning the distribution and migration routes of the Atlantic stingray (*Dasyatis sabina)* that inhabit the coastal systems of Alabama. As a mesopredator, their position in the trophic regime is an important role in maintaining the balance of predation. A better understanding of this role can be gained through tagging and tracking specimens. Tagging is accomplished by using polyolefin T-bar anchor tags that are inserted between the radials of the pectoral disc. Proper placement of the tags is important for the health and locomotion of the stingray, as well as the longevity of the T-bar tag. With enough tagged stingrays, we can gain a better understanding of *D. sabina's* habitat preferences, breeding locales and migrations patterns. The accumulation of research data can ultimately be used to assist in making regulatory policy, such as setting creel limits and designating population protections.

EXPERIMENTAL SECTION

Current Status

D. Sabina is of the order Myliobatiformes and the family Dasyatidae (whiptail stingrays)[1]. The International Union for Conservation of Nature and Natural Resources (ICUN) has designated the Atlantic Stingray a species of "Least Concern," but its population trends, life span and natural mortality rates are unknown[2]. The United States Fish and Wildlife Service (USFWS) does not have an estimated population and does not consider this species threatened, endangered or a candidate for protection. In Alabama, a state issued license to fish for stingray is required, but *D. sabina* is a non-regulated species with no creel limit. Research on this species does not require a permit in Alabama, but a research proposal for tagging *D. sabina* was submitted, and acknowledged by the Alabama Department of Natural Resources, Marine Resources Division in 2015.

Pectoral Locomotion

Myliobatiformes have a distinct mode of locomotion. Through complex modulation of their pectoral fins, a series of undulating waves produces acceleration for swimming and other behaviours[3].

Previous research by Blevins (2012) and Rosenberger (2001) into the undulation of stingrays provided data on pectoral fin wave amplitude variations. According to the 3D freshwater stingray (*Potamotrygon orbignyi)* research by Blevins, about 25% of the total pectoral fin undulates with significant amplitude (>0.50 cm) and is "centered on the distal medial and distal posterior quadrants of the disc" (2012). Rosenberger's research revealed that *D. sabina* has a mid-disc amplitude between 0.12 cm and 0.20 cm (2001). The average number of wave per disc length is 1.3[4].

Approximately one-third of the distal medial and distal posterior sections (the tertiary radials) of the pectoral disc can reach wave amplitude of ~1.58 cm^3. The distal fin margins are capable of extreme curvature, or cupping. The degree of fin modulation while swimming is a determining factor for tag placement.

Radial Calcification

Stingray internal anatomy is comprised of thin radials that extend distally from the anterior and posterior basal cartilages[5] (Fig 1). In *D.sabina*, calcification does not cover the entire radial. Instead, catenated (chain) calcifications form on the radial and vary with the position in the disc[6]. The proximal radials have nearly complete calcification but decreases distally until the first bifurcation at the medial radials. Calcification is then reduced to catenated, with one chain per each side of the radial. Due to the lack of substantial calcification of the distal radials, the distal fin can roll and cup in extreme measures[6]. Juvenile rays lack significant calcifications, often with just a single chain present on a radial or a scattering of tesserae (tile) on the surface[6].

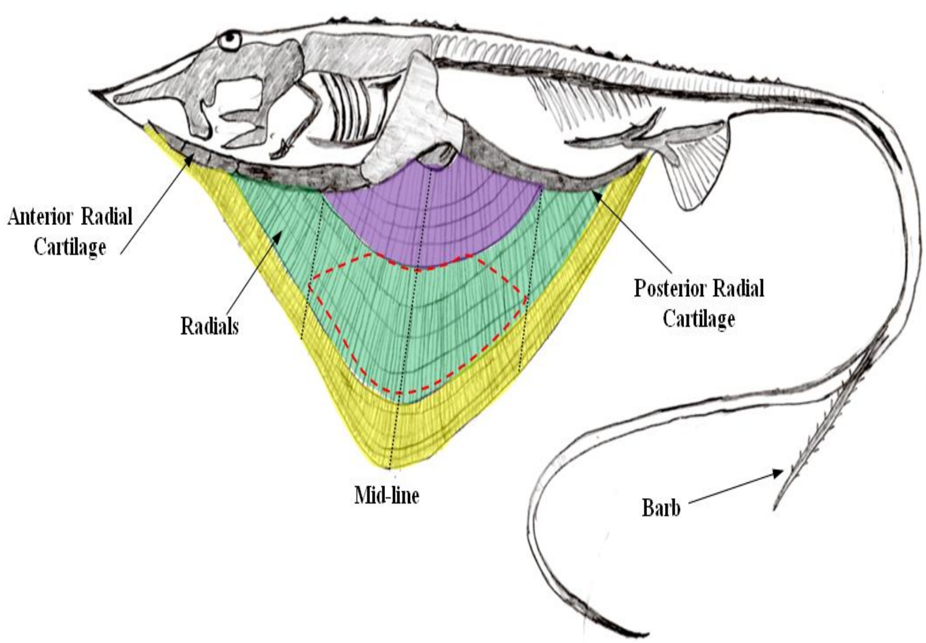

Fig 1. A figure displaying the internal skeletal anatomy of *D. sabina* in sagittal transverse view. Three radial structure sections are highlighted for identification. The primary (proximal) medial area is featured in purple, green represents the secondary (medial) radials and yellow denotes the tertiary radials. The red dashed box indicates the optimal mid-line tag insertion zone, including one-quarter of the disc length, anterior and posterior the mid-line. This representation is not to scale. The graphic is adapted from Government of Canada, Fisheries, and Oceans Statistical Services – Internal Anatomy with permission (original edits by William C. Hamlett). 2016. Edited by R.A. Lahn. Harvard University. 2017. This reproduction is a copy of the version available at http://www.dfo-mpo.gc.ca/species-especes/skates/anatomy/internal-eng.html.

RESULTS AND DISCUSSION

Using the Blevins 2012 research to make assumptions about maximum fin undulation heights, portions of the pectoral disc were determined to be too dynamic for tag insertion. Radials that have a lower degree of disc change would exert less stress on the tag anchor bar and corresponding filament. In effort to avoid tagging in a section of the pectoral fin that can reach wave amplitudes of 1.58 cm while swimming, tertiary radials are deselected as primary tagging zones. The junction of the secondary radials and tertiary radials in the posterior portion of the disc that reach over 0.80 cm in undulation height should be bypassed as well. Using an undulation amplitude range of 0.00 cm to 0.79 cm, the corresponding zone for preferred tag placement is the proximal and medial radials. This range was chosen based on the degree of fin movement of one-half the tertiary radial extreme of 1.58 cm.

Fig 2. A photo displaying the placement of a T-bar anchor tag in the tagging zone of the medial radials of *D. sabina* in dorsal view. Note that the tag is supine to the body and there is approximately 0.63 cm of space between the point of insertion and the pink polyolefin tubing. Photo by R. A. Lahn, 2015.

The radial acts as the anchoring base for the T-bar tag. According to Schaefer, “undulating batoids, stingrays and freshwater stingrays (Dasyatidae and Potamotrygonidae) both have reduced cartilage calcification in the distal fin relative to medial positions, reducing fin stiffness near the margin” (2005). Placing the tag into a section of the disc that contains more calcified radials would prevent tag pull out. The primary radials are the most calcified, but tagging in this area of the stingray may result in body cavity puncture and death of the ray. While the medial radials lack complete calcification, the catenated chain on either side of the radial offer enough support to keep an anchor tag in place. Placement in the thin membranes of the tertiary radials that lack significant calcification could result in pull through, tag loss and potential ray injury.

Considering the fin undulation heights range (0.00 cm to 0.79 cm), the degree of radial calcification and animal health safety, the mid-line section of the medial radials offers the best option for T-bar tag insertion. An expanded tagging zone that corresponds with the determined criteria is the mid-line medial radials, plus one-quarter the disc length anterior and posterior to the mid-line (Fig. 1). While the most anterior medial radials have a low wave amplitude (<0.79 cm), they are the second portion (behind the tertiary radials) of the pectoral disc to encounter the water body substrates. The anterior tertiary radials are avoided when tagging due to their extreme flexions. The anterior medial radials may receive excessive substrate exposure during predator avoidance and burying mechanisms. The posterior medial radials may reach wave amplitudes of over 0.80 cm. Amplitudes this high could cause tag stress, which would affect tag longevity, and the animals health.

CONCLUSION

Understanding the physiology of *D.sabina* and determining the proper tagging zone for placement of the T-bar anchor tags can decrease tag stress, reduce tag insertion health impacts and potentially increase tag longevity. By combining the fin undulation amplitude range of 0.00 cm to 0.79 cm and restricting the tag area to the catenated medial radials, a clear tagging zone in the mid-line section of the medial radials emerges. The radials in this pectoral disc section are catenated, the fin amplitudes are approximately 0.20 cm, and the tag would not have direct, first contact with the water body substrates.

As a potential linchpin between trophic regimes, acquiring scientific data on *D. sabina* in preparation for setting take limits is important to safeguard populations and their associated environmental niches. A properly placed tag will result in a healthy Atlantic Stingray that can be tracked and contribute analytical data for multiple years.

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