INSPIRATIONAL TAILS FROM THE LITERATURE: IMPLICATIONS FOR PROSTHETICS

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INTRODUCTION

Prostheses are generally defined as replacement for body parts that have been lost to injury, disease, or congenital defect. However, the replacement of body parts lost to evolution is not typically attempted. It is known that adaption to changing environments over many generations has resulted in an overall reduction of, for instance, body hair and the number of teeth in modern humans compared to our remote ancestors. Natural selection has also led to the disappearance of a tail, of which only the coccyx remains today. It may be assumed that bipedal gait and improved balancing skills made human tails expendable in evolutionary selection. Then, it becomes arguable that providing a prosthetic tail may be effective in countering balance deficits resultant of neuromuscular impairments.

We investigated the most common functions of tails in the animal kingdom and whether any of those may be helpful for people with balance impairments. Such functions may be realized in novel prosthetic devices.

METHOD

A literature search was conducted using the string "tail functions in animals" in Google Scholar. The first 100 search hits were reduced by excluding non-pertinent papers in three stages: after reading the title, the abstract, and eventually the full paper. Two authors (NM, GF) independently performed reviews and any disagree-ments were resolved by soliciting the opinion of a third author as the tie breaker. Articles were summarized, and common findings compiled into table form.

RESULTS

Of the initial 100 search hits, 80 were excluded after reviewing the title, a further eight were excluded after reading the abstract, and one was removed after reading the full text, leaving 11 articles for analysis (Table 1).

Table 1: Summary of analyzed articles

Authors	Year	Animal	Tail functions
Hersek & Owings	1993	Squirrels	Communication
Hickman	1979	Various	Various
Walker et al	1998	Cats	Balance
Telemeco et al	2011	Lizards	Defense
Hoff & Wassersug	2000	Tadpoles	Locomotion
Garber &Rehg	1999	Capuchins	Prehension
O'Connor et al	2014	Kangaroos	Propulsion
Finkler & Clausen	1997	Turtles	Locomotion
Hasson et al	1989	Lizards	Deterrence
Rand et al	1965	Rats	Thermoregulation
Greene	1973	Snakes	Defense

According to these articles, the most common functions of tails are: Inertia and balance, transport and construction, defense, communication, courtship, and thermoregulation (Hickman, 1979).

DISCUSSION

Animal tails serve a large variety of functions, most of which would be unattainable and/or worthless for modern humans. For instance, human courtship rituals are unlikely to be enhanced by the ability to display a large and colorful tail (as, e.g., in peacocks). The most pertinent tail function for humans, especially those with physical disabilities, may indeed be that of improving balance. In animals, this may be achieved by either using the tail to increase the base of support (e.g., in kangaroos), to counter un uneven weight distribution (e.g., in birds), or to generate corrective moments of inertia when falling (e.g., in cats).

An integration of balance correcting principles, in theory, could be adopted to some extent in a prosthetic tail. One example of such influence on prosthetic design is the "Arque" tail (Nabeshima, et al, 2019), consisting of multiple articulated elements that make up a 71 cm robotic tail controlled by four pneumatic muscles. This prosthesis was inspired by the seahorse tails and further solidifies our base assertion that animal kingdom influenced design may be of value to prosthetic development in this context. A similar design was proposed by others as well (Xie et al, 2019). While somewhat successful in mimicking effective tails, the appearance of these contraptions is likely incompatible with the priorities of typical rehabilitation patients and they are likely too complex for marketability as an independent mobility product.

CLINICAL APPLICATIONS

Prosthetic tails, pending some needed improvements with respect to appearance and effectiveness, may have promise as assistive devices for people with balance impairments. We assert that these improved prostheses would further benefit such persons if inspired in design and function by existing and evolutionarily selected animal tails. This would benefit many in the typical Prosthetic and Orthotic patient population and could expand the professional profile of prosthetists in the future to limb replacement and limb addition.

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REFERENCES

Hickman. Mammal review 9.4 (1979): 143-157.
Nabeshima, et al. ACM SIGGRAPH 2019.
Xie, et al. Proc 10th Augmented Human Int Conf 2019.