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Short Note

Performance of Computer-Assisted Photographic Matching of Guiana Dolphins (*Sotalia guianensis*)

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Photo-identification is a well-established method in aquatic mammal research (e.g., Hammond et al., 1990; Hastings et al., 2008; Ansmann et al., 2013). Recognition of individuals through natural markings is the standard approach for addressing questions on population dynamics (e.g., Ansmann et al., 2013), social structure (e.g., Lusseau, 2003), movements and site fidelity (e.g., Rossi-Santos et al., 2007), general behavior (e.g., Ottesmayer & Whitehead, 2003), human threats, and general health condition (Van Bressem et al., 2007). Individual identifications are possible by long lasting and temporary marks in flukes and dorsal fins, acquired during interactions with conspecifics or other species (e.g., Würsig & Jefferson, 1990). In addition, pigmentation patterns, skin diseases, and scars from human activities may serve as complementary marks for identification (Würsig & Jefferson, 1990; Van Bressem et al., 2007). Advantages of the non-invasive photo-identification methods are, among others, low disturbance to the animals, low cost, and relatively high precision to researchers (Würsig & Jefferson, 1990). Nonetheless, one of the main drawbacks of this method is the amount of data collected compounded by the introduction of digital photography in the early 2000s. Hence, long-term studies can lead to very large digital photographic catalogues and, thus, a laborious and time-consuming photographic matching procedure (Adams et al., 2006).

The large amount of data associated with photo-identification helped to ignite efforts to automate the process with semi-automated photographic matching software (Markowitz et al., 2003; Speed et al., 2007). Computer-assisted photo-identification tools are feasible solutions for the comparison of large amounts of digital images, reducing processing time and increasing matching rates (e.g., Auger-Methé et al., 2011). Moreover, photo-identification software can store and link other textual information from the sightings to the identified individuals (Wilkin et al., 1999), for instance, allowing researchers to sort identifications by date, location, type, and intensity of marks, among other identifiers. Most of the available photographic matching software has been designed for specific species such as humpback whales (*Megaptera novaeangliae*; Kniest et al., 2010), sperm whales (*Physeter macrocephalus*; Beekmans et al., 2005), narwhals (*Monodon monoceros*; Auger-Methé et al., 2011), sea otters (*Enhydra lutris*; Finerty et al., 2007), bowhead whales (*Balaena mysticetus*; Hillman et al., 2008), and bottlenose dolphins (*Tursiops truncatus*; e.g., Markowitz et al., 2003; Adams et al., 2006).

To our knowledge, cetacean dorsal fin-matching software was designed for identifying individual bottlenose dolphins (*Tursiops* spp.), which are relatively large-bodied, travel in groups that are usually easy to approach, and have a high proportion of well-marked individuals (Würsig & Würsig, 1977). Therefore, it is unknown how computer-assisted photo-identification performs for other dolphin species (but see Towner et al., 2013, for an example with white sharks [*Carcharodon carcharias*]), especially those with smaller dorsal fins that are harder to approach, inhabit murky waters (Azevedo et al., 2007), and that are sometimes less marked than bottlenose dolphins (about 60% of individuals with unmarked fins; e.g., Cantor et al., 2012) such as the Guiana dolphin (*Sotalia guianensis*).

The Guiana dolphin is a small coastal dolphin that occurs on the western South Atlantic Ocean from the coast of Nicaragua (Carr & Bonde, 2000) to southern Brazil (Simões-Lopes, 1988).

Most studies on Guiana dolphins largely depend on photo-identification and are normally based on the standard protocol for comparing pictures manually (e.g., Flores & Bazzalo, 2004; Azevedo et al., 2007; Rossi-Santos et al., 2007; Santos & Rosso, 2008). Here we performed a straightforward test of the performance of *DARWIN* (http://darwin.eckerd.edu), a commonly used matching software program, using a large photo-identification catalogue of Guiana dolphins.

The *DARWIN* software creates an approximate contour line from a digital photo of a dorsal fin through a semi-automated process called *chain code representation*. The algorithm identifies nicks and notches in the fin edge by calculating the angular direction to subsequent points at regular length intervals along the fin outline. The outline is used to formulate a sketch-based query of the dolphin database. Dorsal fin outlines of unknown individuals are then compared with previously catalogued ones. The output is a list of catalogued fin images ranked according to the resemblance with the unknown fin image (Stanley, 1995).

We performed boat-based surveys between August 2005 and December 2011 in Sepetiba Bay, southeastern Brazil, where one of the largest populations of Guiana dolphins, estimated to be thousands of individuals (Flach et al., 2008a; Nery & Simão, 2012), is found. Sighted groups of dolphins were slowly approached and followed, while an attempt was made to take pictures of all group members, with no preference, using a digital SLR camera Canon 40D equipped with a 100 to 400 mm lens (Flach, 2006). First, we performed the standard photo-identification protocol, cataloguing and matching each dorsal fin manually. We used only high-quality pictures, those with good contrast and the dorsal fin in focus, close, and perpendicular to the photographer (Würsig & Jefferson, 1990). To evaluate the performance of computer-assisted photo-identification, we created a *DARWIN* database of Guiana dolphins using 2,180 fin pictures of 645 individuals and replicated the test performed by the developers of *DARWIN* (Wilkin et al., 1999). We selected a random sample of 200 high-quality pictures of different known individuals with moderate and high distinctiveness (Würsig & Jefferson, 1990) which were not part of our database on *DARWIN* and ran the software to match them with the catalogue and evaluate the proportion of correct identifications. We replicated the developers' test because there is no standard test for computer-assisted matching nor a consensus on the optimum sample (number of pictures, and if they should be from different individuals; see Beekmans et al., 2005).

Out of these individuals, 126 (63%) were correctly identified and ranked as the first option

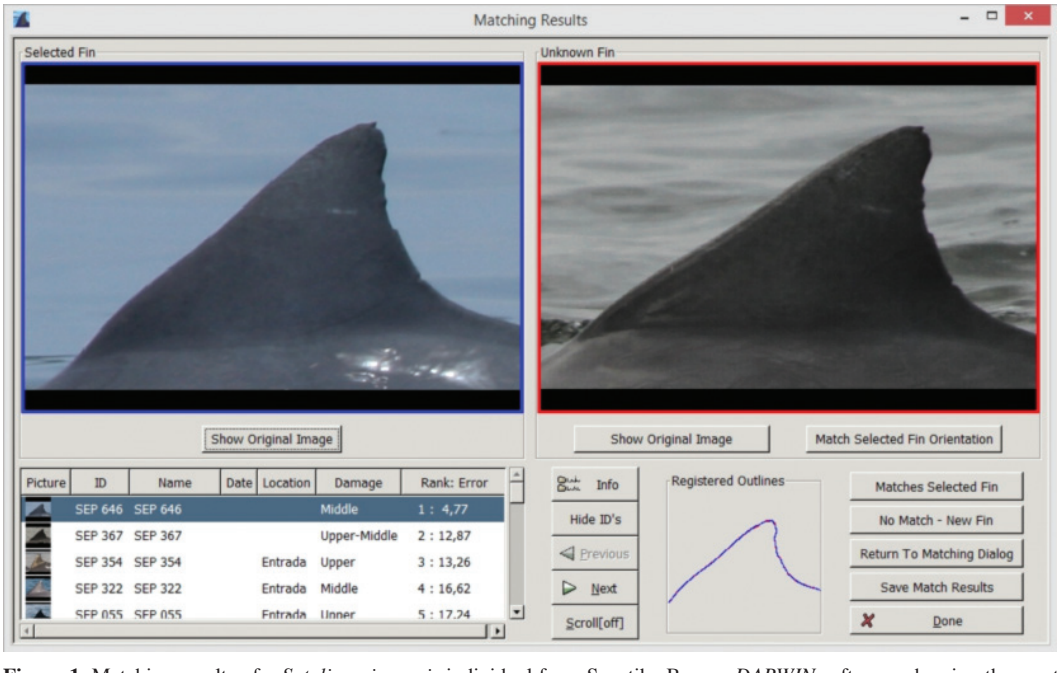

Figure 1. Matching results of a *Sotalia guianensis* individual from Sepetiba Bay on *DARWIN* software, showing the most likely pictures in ranks

by *DARWIN* (Figure 1). Moreover, 85% (170) of the pictures appeared on the 10 first ranks. These findings are comparable to those found by *DARWIN*'s developers for bottlenose dolphins. Eighty-five percent of their random sample appeared on the first 10 positions on *DARWIN*'s rank (Wilkin et al., 1999). In addition, our results are comparable to those obtained for other cetacean species by different photo-identification software (e.g., Auger-Methé et al., 2008; Gamble et al., 2008; Kniest et al., 2010). Therefore, we suggest that the computer-assisted photo-identification by *DARWIN* software can be successfully applied with Guiana dolphins.

Guiana dolphin population and group size vary along its range distribution, probably due to prey availability and predation pressure (Santos & Rosso, 2007). While the standard, manual photo-identification procedure may be feasible for small populations (e.g., Flores & Bazzalo, 2004; Cantor et al., 2012), computer-assisted photo-identification can be especially helpful for areas where the population and the groups encountered are very large (Flach et al., 2008b; Dias et al., 2009). Analysis of high-quality images as performed by the software program *DARWIN* can improve the efficiency of matching and identifying individual Guiana dolphins by reducing the number of photos manually handled and yielding a high percentage of correct identifications.

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