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Two cases of malformations in bottlenose dolphins *Tursiops truncatus* (Montagu, 1821) in Aragua, Venezuela

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Body and bone malformations have been widely studied in cetaceans, both in live and deceased individuals (Alexander *et al.*, 1989). This has led researchers to investigate the subject further, with vertebral asymmetry, scoliosis (lateral curvature of the spine), kyphosis (increased convexity in the curvature of the spine), lordosis (anterior concavity in the curvature of the vertebrae), and kyphoscoliosis or lordo-scoliosis combinations (Miller and Keane, 1983; Wise *et al.*, 1997; DeLynn *et al.*, 2011). This has been widely reported in mysticetes, such as the blue whale *Balaenoptera musculus* (Crovetto, 1991) and humpback whale *Megaptera novaeangliae* (Osmond and Kaufman, 1998) as well as odontocetes, such as the sperm whale *Physeter macrocephalus* (Berzin, 1971), beluga *Delphinapterus leucas* (Johnston and McCrea, 1992), Guiana dolphin *Sotalia guianensis* (Fragoso, 1998), Risso's dolphin *Grampus griseus* (Nutman and Kirk, 1988) and bottlenose dolphin *Tursiops truncatus* (Alexander *et al.*, 1989).

Malformations like these can be classified as idiopathic or congenital (DeLynn *et al.*, 2011). In the first case, malformations are typically the result of collisions with boats (Robinson, 2014) or aggression by conspecifics (Watson *et al.*, 2004; DeLynn *et al.*, 2011); however, disease and illness such as rhabdomyeliosis (muscle fibres death by stress), bacterial infection, spondylodiscitis, and spondylo-osteomyelitis may also cause these malformations (Watson *et al.*, 2004). Congenital abnormalities occur due to anomalous vertebral development in the embryo (DeLynn *et al.*, 2011). This has been observed in terrestrial mammals as a result of chromosomal abnormalities and allelic mutations in genes associated with developmental pathways (Farley, 2010; Giampietro, 2012). Environmental factors such as exposure to teratogens are also known to affect the embryonic development in mammals and cause scoliosis (Sagiv *et al.*, 2008; Giampietro, 2012). With more than 150 syndromes and diseases causing spinal deformities reported in humans (Robin, 1990), it is clear that there may be many other possible causes of spinal malformations in cetaceans.

A comprehensive review of small cetacean skeletal diseases in Latin America waters reported a high prevalence of cervical vertebrae malformations in Guiana dolphin in the state of Rio de Janeiro (Brazil), likely as result of a population bottleneck (Van Bressem *et al.*, 2007). Recently, also in Brazil, Costa *et al.* (2016) described in detail a wide variety of bone malformations in both coastal and offshore ecotypes of bottlenose dolphins, including spinal deviations, extra-numerary joints, abnormal cervical fusion and neural arch clefting. Specific cases of scoliosis in dolphin species have been recorded in New Zealand and Iceland (Berghan and Visser, 2000), Scotland (Wilson *et al.*, 1997) and USA (Ambert *et al.*, 2017). The current study aims to describe for the first time in the Aragua state, Venezuela, two cases of bottlenose dolphins presenting conspicuous body deformities which, based on literature, are suggested to be cases of scoliosis.

The two reports came from the western coast of Aragua (Venezuela, South Caribbean) in a coastal strip ~30 km long and ~3 km wide, from Turiamo Bay (10°28'N, 67°50'W) to Port Colombia (10°30'N, 67°36'W). This coastline has rocky cliffs with some sandy beaches and is characterized by three main habitat types: internal (bays and sounds) and external (coastline) coastal habitats, and neritic habitat (north end of study area) (Novoa *et al.*, 1998; Gowans *et al.*, 2007) (Fig. 1).

Along this coastline, two separate photo-identification studies were performed. The first one, conducted between 2004 and 2008, focused on bottlenose dolphin ecology (occurrence, abundance, home range, residence patterns, behaviour, habitat use, social structure and social networks). During this study, 86 individuals were photo-identified by their permanent marks (for more information see Cobarrubia-Russo, 2011; Cobarrubia-Russo *et al.*, 2019; 2020; 2021). Among these 86 dolphins, we identified Quasimodo (AD4), an adult female sighted 20 times between July 2005 and November 2008 (gender was verified on multiple occasions by the visual inspection of the genital area). Due to her frequent resighting, Quasimodo was considered a resident individual with a home range extending from Turiamo Bay to Port

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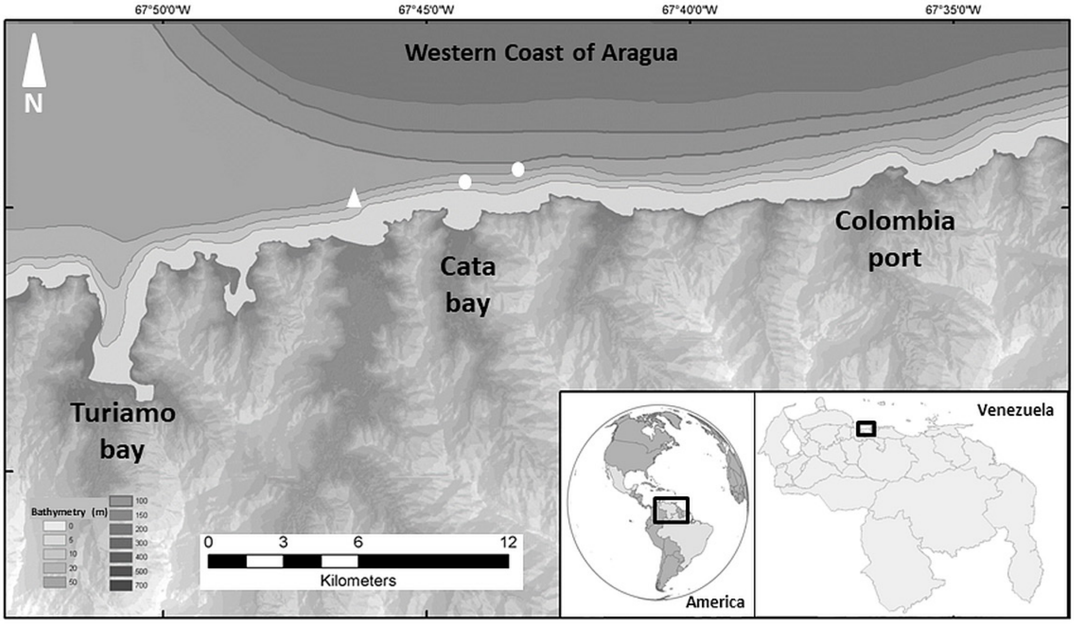

Figure 1. Map indicating the study area, western coast of Aragua, Venezuela. The circles indicate the locations where photographs of Quasimodo were taken, the triangle indicates the location where Juno was photographed.

Colombia in Venezuela (see Cobarrubia-Russo *et al*., 2019; 2020 for more detail). This female showed a prominent protrusion on the right lateral surface towards the rear of the dorsal fin (Fig. 2A), and the left side showed a depression or concave area without a scar (Fig. 2B) with the peduncle deviating horizontally and ventrally

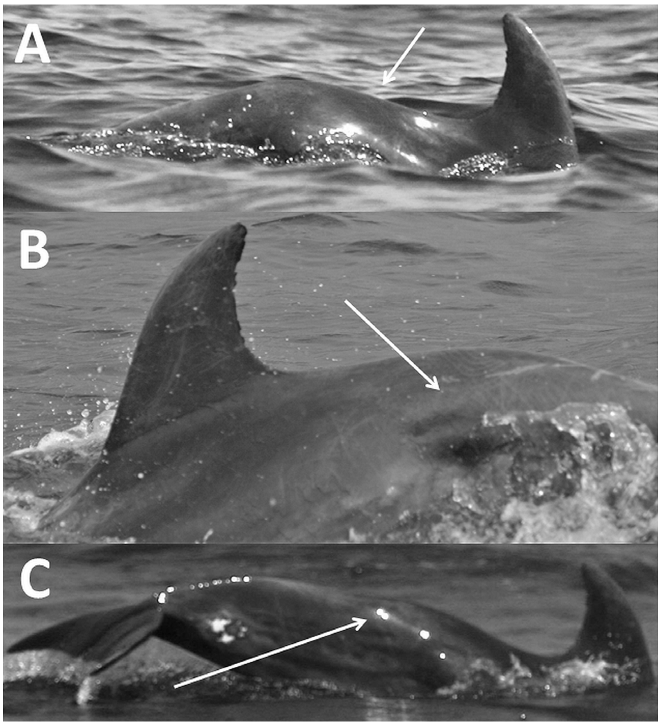

Figure 2. Lateral views of female bottlenose dolphin Quasimodo (AD4), showing (A) protrusion on the right flank of the caudal peduncle, (B) depression on the left flank of the peduncle and (C) deviation of the upper edge of the peduncle in the left ventral direction; 24 November 2007, in Aragua, Venezuela (photo credit: Cobarrubia-Russo).

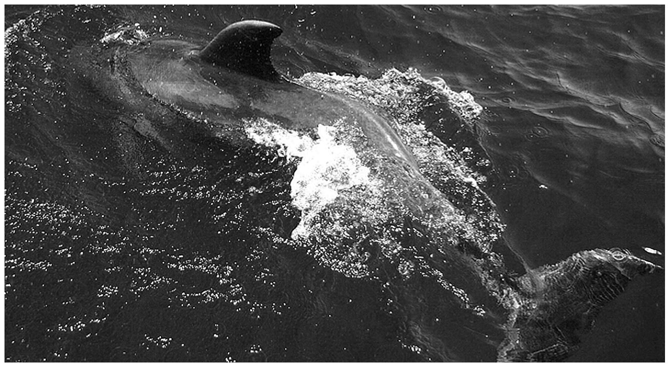

Figure 3. Image showing female bottlenose dolphin Quasimodo's spinal axis deviation (last record, November 2007), in Aragua, Venezuela (photo credit: Cobarrubia-Russo).

from the protrusion to the left (Fig. 2C). During the last sighting, two images of the deviated spinal axis were obtained (Fig. 3).

Monitoring of this adult female over an extended period allowed for the observation of abnormality development as follows: the deviation progressed to the point that a concave fold (on the left flank; Fig. 2B) was formed on the opposite side to the protrusion (right flank), and it was possible to see the peduncle, which (had) deviated vertically downwards, became much more curved, losing its natural straightness in the dorsal line (Figs 2A and 2C).

Afterwards, another study commenced in the same area in June 2019, in order to study the social sympatry between bottlenose dolphins and Atlantic spotted dolphins *Stenella frontalis*. To date, this study includes 21 boat-based surveys during which 60 individual bottlenose dolphins were photo-identified. During this study, a second dolphin with a malformation was observed and identified: Juno (T004), an individual of similar size to adults (of unknown gender) sighted only once in June 2019. During the observation, Juno was traveling west under conditions that prevented to identify its gender and obtain better quality

Figure 4. Lateral view of bottlenose dolphin Juno (T004), showing the right flank protrusion of the peduncle and deviation of the peduncle in the ventral direction, June 2019, in Aragua, Venezuela (photo credit: Cobarrubia-Russo).

photographs (4 Douglas scale). This adult showed a large protrusion on the right flank, located approximately between the dorsal and caudal fins, with no signs of trauma. Juno did not present a concave fold towards the left flank or at least it was not evident from the observation and photographs. However, Juno did have a horizontal deviation of the body axis to the left and the dorsal edge of the peduncle deviated downward. This deviation was located more posteriorly than in Quasimodo's case (Fig. 4).

A typical cetacean spine has a straight profile when viewed from behind. Scoliosis occurs when this profile is deformed by a curvature that may appear in one or more segments (Wise *et al*., 1997). In humans, the most common spinal deformity is caused by idiopathic scoliosis, usually presenting as a visible rib hump on forward flexion and asymmetrical girdle (Erol *et al*., 2002). Whilst the etiology remains unknown, Grauers *et al*. (2016) suggest that genetic factors may be critical and the condition is unpredictable in its progressivity over time. Robin (1990) proposed that there are over 150 syndromes and diseases in which scoliosis may play a part in mankind, which makes this issue complex.

From the characteristics described in these two individuals, we suggest that both malformations could originate from scoliosis, as neither individual presented obvious trauma. While it was not possible to confirm if deformities were congenital or idiopathic, it is worth noting that the anthropic impact in the study area (~92 km^2) is minimal when compared to highly urbanized coasts. A mean of 26.5 (SD = 13.45) artisanal vessels, nine metres in length and of similar design to the survey vessel, were present within the study area at any one time (Cobarrubia-Russo, pers. obs.) with no deep-draft vessels observed. Human population density along the bordering coastline is also low, with pollution levels believed to be correspondingly low and likely further reduced by the openness of the coastline to the Caribbean Sea. In light of this, we hypothesise that even though the observed malformations may be congenital, they are unlikely related to exposure to teratogens (Sagiv *et al*., 2008).

At first sight, the spinal malformations do not appear to affect the dolphins' survival, at least as adults. Studies of bottlenose dolphins in New Zealand and Mississippi (USA) (Bergham and Visser, 2000; Amber *et al*., 2017) reported individuals that survived the difficulty of moving with full motor efficiency. Here, we reported Quasimodo on 20 different occasions over a three-year period (see Cobarrubia-Russo *et al*., 2020), and it was reported as the unique member with a visible malformation of the resident population in Aragua (see Cobarrubia-Russo *et al*., 2019) with sightings continuing throughout the first six months of 2009 (see Bolaños-Jiménez, 2017).

Berghan and Visser (2000) documented cases of scoliosis, lordosis, and lateral malformations in delphinids that had reached adulthood and showed independence and good general health. DeLynn *et al*. (2011) reported a case in which an 18-year-old female with congenital scoliosis gave birth to two calves. Despite not having seen Quasimodo breeding, it was recorded in several sightings providing care for calves of other resident females for minutes. She used a home range similar to other adult individuals in her pod, and was able to travel in pairs with another individual from a neighbouring pod (Cobarrubia-Russo *et al*., 2020). In addition, preliminary analyses of social structure and social networks identified Quasimodo as the tenth in degree (a measure of the "power" of the network individuals) and had with a low betweeness value (a measure of the volume of information exchanged between clusters, a sort of information bottleneck) (Cobarrubia-Russo, pers. obs.). On the other hand, Juno was observed on a single survey within a pod, and so might be a transient, who travels far greater distances than a resident.

Although an individual with scoliosis would have more limitations than one without, the degree of limitation may be more reduced in an aquatic environment where the spine is less tasked with body support. Although it is highly likely that the hydrodynamic flow is reduced by the pronounced asymmetry, we do not know how much this would prevent the individual from being effective in hunting and predator avoidance activities.

In general, it is believed that more attention should be given to animals with visible deformities, in order to photographically record progression and aid in the understanding of how individuals may adapt their activities. Many questions remain to be answered: To what degree is fitness reduced? How deleterious are these deformities in small populations such as the one studied? What is the rate of inheritance of these malformations when congenital? Is the presence of concavity or not due to a further development of the deformation or because the deformation is S-shaped (which could apply to Quasimodo) or C-shaped (Juno)?

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References

Alexander, J.W., Solangi, M.A. and Riegel, L.S. (1989) Vertebral osteomyelitis and suspected diskospondylitis in an Atlantic bottlenose dolphin (*Tursiops truncatus*). *Journal of Wildlife Diseases* 25(1): 118-121. https://doi.org/10.7589/0090-3558-25.1.118

Ambert, A.M., Samuelson, M.M., Pitchford, J.L. and Solangi, M. (2017) Visually detectable vertebral malformations of a bottlenose dolphin (*Tursiops truncatus*) in the Mississippi Sound. *Aquatic Mammals* 43(4): 447-462. https://doi.org/10.1578/AM.43.4.2017.447

Berghan, J. and Visser, I.N. (2000) Vertebral column malformations in New Zealand delphinids with a review of cases worldwide. *Aquatic Mammals* 26(1): 17-25.

Berzin, A.A. (1971) *The Sperm Whale*. Edited by A.U. Yaelokov. Pacific Scientific Research Institute of Fisheries and Oceanography. Izdatel'stvo "Pishchevaya Promyshlennost", Moskva, 1971. Translated from Russian. Israel Program for Scientific Translations, Jerusalem 1972. John Wiley & Sons Ltd, Chichester, Sussex. 394 pp.

Bolaños-Jiménez, J. (2017) *Population ecology of bottlenose dolphins* (Tursiops truncatus) *in waters off the west coast of Aragua State, Venezuela.* M.Sc. Thesis. Universidad Veracruzana. Xalapa, Mexico. 41 pp.

Cobarrubia-Russo, S. (2011) *Ecology and behavior of bottlenose dolphin. Characterization of the ecology and behavior of* Tursiops truncatus *on the coast of Aragua, Venezuela.* Editorial Académica Española. 63 pp. ISBN-13 978-3-8465-6340-3.

Cobarrubia-Russo, S., Barreto, G., Molero-Lizarraga, A., Quintero-Torres, E. and Wang, X. (2019) Occurrence, abundance, range, and residence patterns of *Tursiops truncatus* on the coast of Aragua, Venezuela. *Mammal Research* 64: 289-297. https://doi.org/10.1007/s13364-018-0401-1

Cobarrubia-Russo, S.E., Barreto-Esnal, G.R., Molero-Lizarraga, A.E. and Mariani-Di Lena, M.A. (2020) Individual home ranges of *Tursiops truncatus* and their overlap with ranges of *Stenella frontalis* and fishermen in Aragua, Venezuela, South Caribbean. *Journal of Marine Biology Association of UK* 100(5): 857-866. https://doi.org/10.107/S0024315420000557

Cobarrubia-Russo, S.E., Barber-Meyer, S., Barreto-Esnal, G.R. and Molero-Lizarraga, A.E. (2021) Historic population estimates for bottlenose dolphins (*Tursiops truncatus*) in Aragua, Venezuela, indicate monitoring need. *Aquatic Mammals* 47(1): 10-20. https://doi.org/10.1578/AM.47.1.2021.10

Costa, A.P.B., Loch, C. and Simões-Lopes, P.C. (2016) Variations and anomalies in the vertebral column of the bottlenose dolphin (*Tursiops truncatus*) from southern Brazil. *Latin American Journal of Aquatic Mammals* 11(1-2): 212-219. https://doi.org/10.5597/lajam00230

Crovetto, A. (1982) Étude osteometrique et anatomofuncionelle de la colonne vertébrale chez lês grands cétacés. *Investigations on Cetacea* 23: 7-189.

DeLynn, R., Lovewell, G., Wells, R.S. and Early, G. (2011) Congenital scoliosis of a bottlenose dolphin. *Journal of Wildlife Diseases* 47(4): 979-983.

Erol, B., Kusumi, K. and Dormans, J.P. (2002) Etiology of congenital scoliosis. *The University of Pennsylvania Orthopaedic Journal* 15: 37-42.

Farley, F.A. (2010) Etiology of congenital scoliosis. *Seminars in Spine Surgery* 22(3): 110. https://doi.org/10.1053/j.semss.2010.03.001

Fragoso, A.B.L. (1998) Bone anomalies of marine tucuxi dolphin *Sotalia fluviatilis* of Rio de Janeiro Coast, Brazil. Page 35 *in* Abstracts, *The World Marine Mammal Science Conference*, 20-24 January, Monaco.

Giampietro, P.F. (2012) Genetic aspects of congenital and idiopathic scoliosis. *Scientifica* 152365. https://doi.org/10.6064/2012/152365.

Gowans, S., Würsig, B. and Karczmarski, L. (2007) The social structure and strategies of delphinids: predictions based on an ecological framework. *Advances in Marine Biology* 53: 195-294. https://doi.org/10.1016/S0065-2881(07)53003-8

Grauers, A., Einarsdottir, E. and Gerdhem, P. (2016) Genetics and pathogenesis of idiopatic-scoliosis. *Scoliosis Spinal Disorder* 11(45). https://doi.org/10.1186/s13013-016-0105-8.

Johnston, P. and McCrea, I. (1992) *Death in small doses - the effects of organochlorines on aquatic ecosystems*. Greenpeace International, Amsterdam, Netherlands. 19 pp.

Miller, B.F. and Keane, C. B. (1983) *Encyclopaedia and Dictionary of Medicine, Nursing, and Allied Health*. W. B. Saunders (Eds). Elsevier Health Sciences, USA. 370 pp.

Novoa, D., Mendoza, J., Marcano, L. and Cárdenas, J. (1998) *Atlas Pesquero Marítimo de Venezuela* [Maritime fishing atlas of Venezuela]. MAC-SARPACONGEPESCA.VENCEP. 70 pp.

Nutman, A.W. and Kirk, E.J. (1988) Abnormalities in the axial skeleton of a Risso's dolphin, *Grampus griseus. New Zealand Veterinary Journal* 36: 91-92.

Osmond, M.G. and Kaufman, G.D. (1998) A heavily parasitized humpback whale (*Megaptera novaeangliae*). *Marine Mammal Science* 14(1): 146-149. https://doi.org/10.1111/j.1748-7692.1998.tb00698.x

Robin, G.C. (1990) *The Aetiology of Idiopathic Scoliosis-a review of a century of research*. CRC Press, Boca Raton, Florida. 259 pp.

Robinson, K.P. (2014) Agonistic intraspecific behaviour in free-ranging bottlenose dolphins: Calf-directed aggression and infanticidal tendencies by adult males. *Marine Mammal Science* 30(1): 381-388. https://doi.org/10.1111/mms.12023

Sagiv, S.K., Nugent, J.K., Brazelton, B., Choi, A.L. Tolbert, P.E., Altshul, L.M. and Korrick, S.A. (2008) Prenatal organochlorine exposure and measures of behavior in infancy using the Neonatal Behavioral Assessment Scale (NBAS). *Environmental Health Perspectives* 116(5): 666-673. https://doi.org/10.1289/ehp.10553

Van Bressem, M.F., Van Waerebeek, K., Reyes, J.C., Fernando, F., Echegaray-Skontorp, M., Siciliano, S., Di Beneditto, A., Flach, L., Viddi, F., Avila, I.C., Herrera-Carmona, J.C., Tobón, I.C., Bolaños-Jiménez, J., Moreno, I.B., Ott, P.H., Sanino, G.P., Castineira, E., Montes, D., Crespo, E.A. and Fragoso, A.B. (2007) A preliminary overview of skin and skeletal diseases and traumata in small cetaceans from South American waters. *Latin American Journal of Aquatic Mammals* 6(1): 7-42. https://doi.org/10.5597/lajam00108.

Watson, A., Bahr, R.J. and Alexander, J.W. (2004) Thoracolumbar kyphoscoliosis and compression fracture of a thoracic vertebra in a captive bottlenose dolphin (*Tursiops truncatus*). *Aquatic Mammals* 30(2): 275-278.

Wilson, B., Thompson, P.M. and Hammond, P.S. (1997) Skin lesions and physical deformities in bottlenose dolphins in the Moray Firth: Population prevalence and age-sex differences. *Ambio* 26(4): 243-247.

Wise, L.D., Beck, S.L., Beltrame, D., Beyer, B.K., Chahoud, I., Clark, R.L., Clark, R., Druga, A.M., Feuston, M.H., Guittin, P., Henwood, S.M., Kimmel, C.A., Lindstrom, P., Palmer, A.K., Petrere, J.A., Solomon, H.M., Yasud, M. and York, R.G. (1997) Terminology of developmental abnormalities in common laboratory mammals (version 1). *Birth Defects Research* 55: 249-292.