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Pigmentation abnormality in the blotched round ray *Urotrygon asterias* (Myliobatiformes: Urotrygonidae): first case of partial xanthism within the family

Sebastián Argüello-Rojas[1,2,3]; https://orcid.org/0009-0009-0787-2956
Arturo Angulo[2,3,4]; http://orcid.org/0000-0002-4587-1446
Verónica Valverde-Cantillo[5]; https://orcid.org/0000-0002-1853-1294
Diego Fallas-Madrigal[1,3,5,6*]; https://orcid.org/0000-0001-9327-0752

1. Oceanic Alliance, Aserrí, San José, Costa Rica; diegofallasmadrigal@gmail.com (*Correspondence); sebasarguellorojas0504@gmail.com
2. Escuela de Biología, Universidad de Costa Rica. 11501–2060, San Pedro de Montes de Oca, San José, Costa Rica; arturo.angulosibaja@ucr.ac.cr
3. Museo de Zoología/Centro de Investigación en Biodiversidad y Ecología Tropical, Universidad de Costa Rica, 11501–2060, San Pedro de Montes de Oca, San José, Costa Rica.
4. Centro de Investigación en Ciencias del Mar y Limnología (CIMAR). 11501–2060, San Pedro de Montes de Oca, San José, Costa Rica.
5. Asociación para la Conservación Integral de Recursos Naturales Equipo Tora Carey (ETC), El Jobo, Guanacaste, Costa Rica; verovalcan@gmail.com
6. Posgrado en Biología, Universidad de Costa Rica, 11501–2060, San Pedro de Montes de Oca, San José, Costa Rica.

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ABSTRACT

Introduction: Malpigmentation or pigment disorders can result from either a deficiency or an excess of pigments and have been reported in a wide variety of fish taxa. Color abnormalities are rare among elasmobranchs. Among nearly 1 250 known species, only 22 cases of malpigmentations as albinism and leucism, have been reported, most involving sharks and rarely batoids. Xanthochromism is a rare pigmentation disorder characterized by a yellow-orange coloration caused by multiple factors. This condition has been scarcely reported in elasmobranchs, with only seven known cases, five of them in batoids.

Objectives: Here, we present the first record of xanthochromism in the blotched round ray *Urotrygon asterias,* and the first within the family Urotrygonidae.

Methods: One juvenile specimen was captured two times during a monitoring program at Playa Manzanillo, El Jobo, Guanacaste, Costa Rica, and photographic identification confirmed it was the same individual. Additionally, morphometric measurements of the individual were taken to assess whether it had grown.

Results: The recapture of this specimen indicates that xanthochromism does not necessarily compromise short-term survival. Potential causes of the condition include genetic mutations, diet, gestation disorders, or environmental factors, such as contamination. Playa Manzanillo exhibits evidence of anthropogenic impacts, including fishing waste and pollutants, which may influence local ichthyofauna health.

Conclusions: This finding expands the understanding of pigmentation anomalies in batoids and highlights the need for further research to assess the environmental drivers of morphological abnormalities, including

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pigmentation, in elasmobranchs. Such studies are crucial for evaluating the ecological and conservation implications of these disorders in the Ester Tropical Pacific.

Key words: malpigmentation; chromatic aberration; stingray; Central America; xanthochromic anomaly.

RESUMEN

Pigmentación anormal en la raya redonda manchada *Urotrygon asterias* (Myliobatiformes: Urotrygonidae): primer caso de xantismo dentro de la familia

Introducción: Los trastornos de pigmentación pueden deberse tanto a una deficiencia como a un exceso de pigmentos y se han reportado en una amplia variedad de especies. Dichos trastornos suelen ser raros en peces y aún más en elasmobranquios. De las casi 1 250 especies conocidas de elasmobranquios, sólo se han documentado 22 casos de pigmentación anormal para albinismo/leucismo, la mayoría en tiburones y raramente en batoideos. El xantocromismo, desorden caracterizado por una coloración amarilla-anaranjada es causado por múltiples factores. Este ha sido escasamente reportado en elasmobranquios, con siete casos conocidos, cinco de los cuales son rayas.
Objetivos: En este trabajo se presenta el primer registro de xantocromismo en *Urotrygon asterias*, así como para la familia Urotrygonidae.
Métodos: Un espécimen juvenil fue capturado en dos ocasiones durante un programa de monitoreo en Playa Manzanillo, El Jobo, Guanacaste, Costa Rica. Mediante foto-identificación se confirmó que se trata del mismo individuo. Además, se le tomaron medidas morfométricas para evaluar si tuvo crecimiento.
Resultados: La recaptura de este ejemplar indica que el xantocromismo no necesariamente compromete la supervivencia a corto plazo. Posibles causas de esta condición incluyen mutaciones genéticas, dieta, problemas de gestación o factores ambientales, como la contaminación. Playa Manzanillo presenta evidencia de impactos antropogénicos, incluyendo desechos de pesca y contaminantes, que podrían influir en la salud de la ictiofauna local.
Conclusiones: Este hallazgo amplía el conocimiento sobre las anomalías de pigmentación en batoideos y resalta la necesidad de realizar más investigaciones para evaluar los factores ambientales que impulsan las anormalidades morfológicas, incluyendo aberraciones cromáticas, en elasmobranquios. Estos son cruciales para evaluar las implicaciones ecológicas y de conservación de estos trastornos en el Pacífico Tropical Oriental.

Palabras clave: malpigmentación; aberración cromática; raya redonda; Centroamérica; anomalía xantocrómica.

INTRODUCTION

Abnormal skin coloration disorders can be produced either by a lack of pigmentation (hypomelanosis), e.g., albinism or leucism, or by over-pigmentation (hypermelanosis), e.g., melanosis (Arronte et al., 2022; Bañón et al., 2020; Rodrigues et al., 2023; Soldo, 2023). Such disorders have been reported in several species of wild and farmed teleost fishes, but are less represented among elasmobranchs (Bañón et al., 2023; Jawad et al., 2017). Xanthochromism or xanthism, on the other hand, is a form of hypomelanosis caused by the lack of melanin chromatophores in any part of the body and the presence of unmasked xanthophores, giving the fish an orange-yellowish coloration (Akat et al., 2022; San Gil-León & Angulo, 2021). The exact causes of these color changes are certainly unclear and can be attributed to many factors. Among these, there are non-pathological mutations, skin pathologies, a diet rich in or with excess of carotenoids, hormonal imbalances and interspecific hybridization (Burton, 2010; Kijewska et al., 2012; Miyazawa et al., 2010; Quigley et al., 2017). Moreover, xanthochromic or yellowish colorations have been correlated with the melanogenesis and tyrosine metabolic pathways (Jiang et al., 2014), as well as the regulation of multiple related genes (Kanika et al., 2023; Xue et al., 2024).

Cases of malpigmentation in elasmobranchs are relatively rare in nature, but there are several reports in the literature. Of the barely 1 250 elasmobranch species currently known, only about 60 have been documented with albinism/leucism and only seven for xanthochromism (Bañón et al., 2023; Soldo, 2023). Most of these reports of albinism, leucism and/or xanthochromism/xanthism have been done in sharks and, to a lesser extent in batoids (Ball et al., 2013; Bañón et al., 2023; Bigman et al., 2015). Among the nearly 633 valid batoid species, cases of albinism and leucism have been reported in only 22 (Quigley et al., 2018a). Xanthochromism is even rarer, with only five reported cases in batoid species (four in Rajidae and one in Dasyatidae), as well as in at least two sharks (Bañón et al., 2023; Macías-Cuyare et al., 2025). There is also a rare case of albino-xanthohcromic individual of *Raja montagui* Flowel, 1910 (Quigley et al., 2018b).

In general, the lack of encounters with abnormal color rays can be explained by the fact that a more noticeable coloration can increase the chance of depredation or reduce the reproduction chance (Soldo, 2023), giving rise to a kind of negative selection, thus reducing the frequency of such phenotypes in natural populations. Xanthism has been documented only once in Myliobatiformes, in a specimen of *Dasyatis pastinaca* Linnaeus 1758 from the Atlantic Ocean, none of these xanthic elasmobranchs have been reported from the Eastern Tropical Pacific (ETP) (Bañón et al., 2023). In Costa Rica, a single case of a xanthochromic elasmobranch, *Ginglymostoma cirratum* Bonnaterre 1778, from the Atlantic coast, has been reported (Macías-Cuyare et al., 2025).

The blotched round ray *Urotrygon asterias* Jordan & Gilbert, 1883 is a medium-sized round ray species native to the ETP. It inhabits from the west coast of Mexico (including the Gulf of California) to Costa Rica (Ehemann et al., 2024). This species has a distinctive dark spot pattern over a nearly smooth disc which distinguishes it from other congeneric species (Ehemann et al., 2024; Last et al., 2016). *Urotrygon asterias* has recently been revalidated as a different species and separated from *U. chilensis* Günther 1872 which was considered as a unique lineage with a wide distribution from the Gulf of California to Northern Chile (today restricted to South America; Ehemann et al., 2021). Several morphological abnormalities such as tail, liver and disc deformations have been described for *U. asterias* (Ehemann et al., 2022), as well as other members of the family Urotrygonidae. At the family level there is only one report of albinism in *Urotrygon nana* Miyake & McEachran, 1988 by Anislado-Tolentino et al. (2016). Nevertheless, a wide intraspecific variation in coloration is known to occur in *U. asterias*, as well as in the related species *Urotrygon munda* Gill, 1863 (Ehemann et al., 2024). However, to our best knowledge, there are no previous records of color disparities (such as xanthism or albinism) in the species, since the previously reported chromatic variation in the species has not been considered as such. In this contribution, we undertake the task of formalizing the first record of xanthochromism in *U. asterias*, presenting the corresponding evidence and discussing it under a regional and ecological framework.

MATERIALS AND METHODS

El Jobo is located in the province of Guanacaste, at the northernmost peninsula in the Northern Pacific coast of Costa Rica (Fig. 1). In El Jobo, a great diversity of batoids can be found, which have been documented through ray monitoring efforts from the NGO Equipo Tora Carey since 2018. One female juvenile specimen of *U. asterias* with an abnormal coloration pattern was first captured and photographed during a ray monitoring program on February 16th of 2025 at Playa Manzanillo, El Jobo (11°00'28.08" N, 85°43'57.76" W). A second encounter of a female juvenile with a xanthocromic coloration occurred on April 18th of 2025, also in Playa Manzanillo. For both encounters each specimen was identified as *U. asterias* following the dichotomous key of Ehemann et al. (2024). The individuals were not fitted with external o internal tags, but to evaluate if both observations corresponded to the same individual, a Photo-ID assessment was conducted similarly to González-Ramos et al. (2017) and McIvor et al. (2024), a technique that has been find to be reliable to be used in

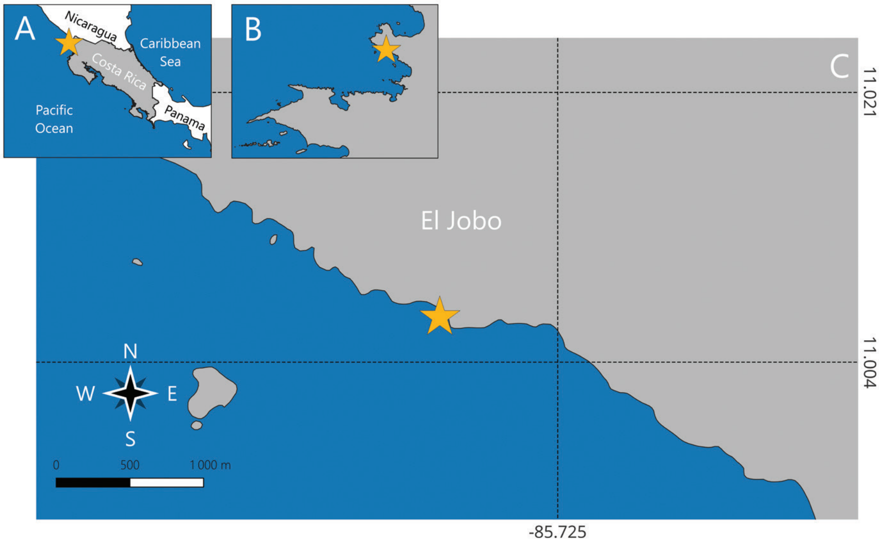

Fig. 1. Study site: Playa Manzanillo, El Jobo, Costa Rica showing: A general view of Costa Rica (A), a general view of the Santa Elena Gulf region (B) and detailed view of the study zone (C). The star in each figure indicates the study site location.

U. asterias (Soto-Lopez et al., 2026). The Photo-ID assessment was done by manually matching the dorsal spot pattern of both encounters. The following morphometric data were recorded for both encounters: 1) total length (TL), 2) disc width (DW), 3) tail length (TaL), and 4) internostril distance (IN). In addition, we counted the dorsal thorns in the nuchal, dorsal, and caudal regions. Finally, a tissue sample was collected during the second capture for genetic sequencing as part of the BioMar-ACG project (Cortés & Joyce, 2020).

RESULTS AND DISCUSSION

The identification of the specimens as *U. asterias* is based on the following combination of characters, described by Ehemann et al. (2024) as diagnostics for the species: 1) tail length relatively large, about 84 % of the disc length; 2) internostril distance about 72 % of the interorbital distance; and 3) thorns present along the dorsal midline, with six thorns in the nuchal zone, ten in the visceral zone, and 12 in the tail (Fig. 2). Although no internal or external tag was fitted, the distinct spot pattern enabled the identification of both captures as the same individual (Fig. 3). During the first capture, conducted in February, the individual's measured dimensions were: 22.0 cm total length, 13.0 cm disc width, and a weight of 25.0 g. Two months later the individual has grown to 23.9 cm total length, 13.9 cm disc width.

Encounters with abnormally pigmented chondrichthyans in nature are relatively rare (Bañón et al., 2023; Quigley et al., 2018a), and among the causes or factors associated with this, two of them have been traditionally considered: 1) the low intrinsic expression rates of such abnormalities; and 2) the reduced survival rates of the abnormal organisms (Arronte et al., 2022). Cases of albinism or xanthism appear to be less frequent in immature specimens than in larger individuals, suggesting, however, that such pigmentation anomalies do not necessarily decrease survival probability (Soldo, 2023). Furthermore, reports of abnormally pigmented specimens are predominantly associated with pelagic species, indicating that conspicuous coloration may have a limited impact within the water column but could be more pronounced against the substrate (Ball et al., 2013; Soldo,

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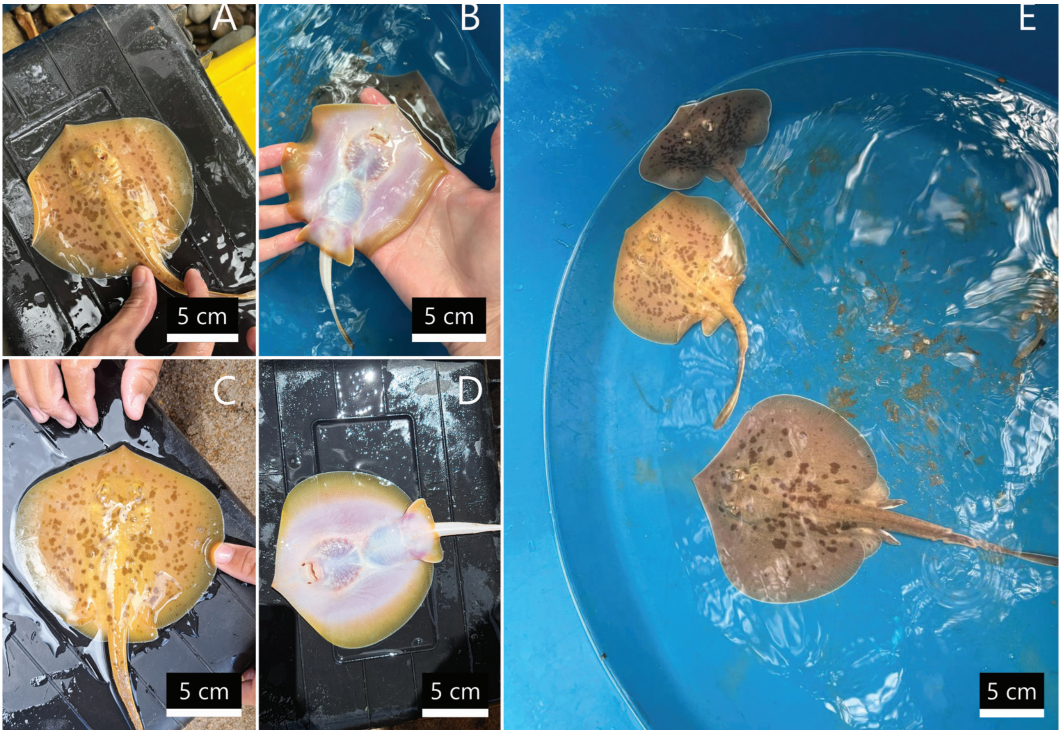

Fig. 2. Xanthochromic *Urotrygon asterias* individual: (A, B) dorsal and ventral view of the first capture, (C, D) dorsal and ventral view of the second capture, and (E) comparison of xanthochromic specimen (first capture) with normal-coloration pattern of *U. asterias.*

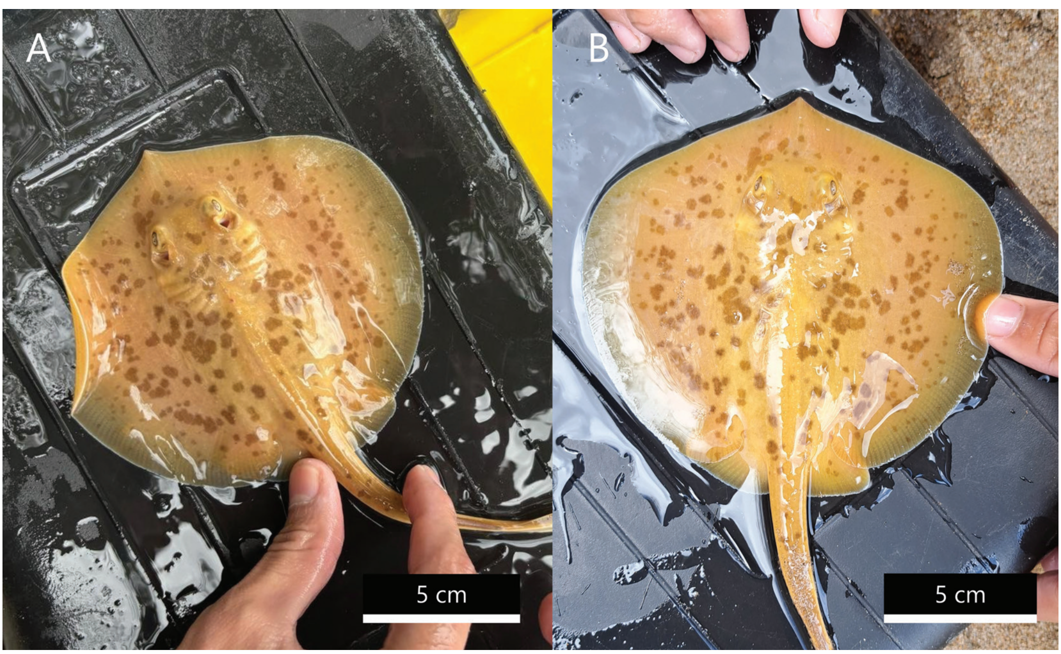

Fig. 3. Comparison of the spot pattern of the xanthochromic individual *of Urotrygon asterias*: A, captured in February and B, captured in April.

2023). Nonetheless, benthic rays have the ability to burrow into the substrate, potentially mitigating the disadvantages of a conspicuous pigmentation (Anislado-Tolentino et al., 2016, Meese & Lowe, 2019). The present study documented the recapture of the same individual after two months, with an increase in body size, indicating that xanthochromic coloration does not necessarily impose immediate costs on survival or fitness. However, further studies involving continuous monitoring and the assessment of additional health-related metrics are required to confirm this pattern.

Despite their intrinsic rarity, morphological abnormalities in round rays, in general, and, specifically, those related with the body color, have been relatively well documented in the last 20 years (Ehemann et al., 2022). This is probably due to i) an increase in the number of investigations, and greater "scientific" insight, awareness and activism at the citizen level (Macías-Cuyare et al., 2025), as well as to ii) the relatively high incidence, permanence, survival and heritability of such abnormalities in the group in comparison to other fish taxa (Torres-Huerta et al., 2015, Ehemann et al., 2022). Part of this incidence is attributed to their high capture rate in shrimp fisheries across the ETP, which increases the probability of capturing abnormal individuals. On the other hand, round rays in general tend to have high reproductive rates, with some species exhibiting biannual or even triannual reproductive periods and litters of up to six pups (Ehemann et al., 2022). These reproductive qualities elevate the probability of generating abnormal specimens. In blue sharks (*Prionace glauca* Linnaeus 1758), for example, it has been proposed that their numerous litters have an impact in the development of some embryos, resulting in a high rate of anomalous fetus (Kanagusuku et al., 2020).

Since the present report refers to a juvenile individual, it is important to consider that ontogeny could influence in coloration variation. It is known that some morphological features can be shaped while the specimen reach the maturity, including coloration variations in many cases (Booth, 1990). In fishes, several lineages exhibit ontogenetic variation in color patterns, with well-studied examples in Labridae and Cichlidae (Hodge et al., 2020; Prazdnikov & Shkil, 2023). Although color variation has been reported in elasmobranchs, the physiological mechanisms involved and their biological relevance remain relatively poorly explored compared to teleosts. Ontogenetic changes in color patterns have been documented in several elasmobranch species, such as *Narcine bancroftii* Griffith & Smith, 1834, *Bathyraja richardsoni* Garrick, 1961, and *Stegostoma fasciatum* Hermann, 1783, involving changes in the shape and size of colored sections within the coloration pattern (Dahl et al., 2019; Orlov et al., 2022; Zambrano, 2021). On the other hand, in manta rays (*Mobula* spp.), short-term color changes related to feeding and social interactions have been documented (Ari, 2014), highlighting the complexity that batoid skin can exhibit with respect to coloration. From this perspective, xanthochromism should not necessarily be regarded as an atypical condition that always diverges from the typical coloration of a species. In *Epinephelus drummondhayi* Goode & Bean, 1878, for example, a "normal" xanthochromic morph is present exclusively during the juvenile stage and subsequently transitions into a non-xanthic brown coloration (Ross, 1988). This suggests that, although the specimen reported in this study maintained a xanthochromic coloration over nearly two months, this trait may change as the individual reaches maturity.

Given the increase in abnormalities observed in elasmobranchs, some authors have suggested that these may be related to contamination, resulting in a higher incidence of mutations and deformities (Anislado-Tolentino et al., 2016; Ehemann et al., 2022; Ribeiro- Prado et al., 2008). Severe environmental factors can influence the coloration in fishes (Colihueque, 2010) and there is a complex genetic basis for yellowish pigmentation (Angus & Blanchard, 1991; Xue et al., 2024). On the other hand, there has been a link between the presence of water pollutants such as heavy metals and pesticides, with mutation and developmental disorders (Hauser- Davis et al., 2020; Jezierska et al., 2009; Torres- Huerta et al., 2015). Benthic fishes are especially at risk of suffering from this due to their continuous contact with contaminated substrate (e.g., ingestion during feeding; Barhoumi et al., 2009; McKinley et al., 2011) and bioaccumulation through the consumption of other benthic organisms (Reynoldson, 1987; Zhang et al., 2017). Nutrient deficiency during gestation has been also correlated with embryo abnormalities (Wosnick, 2019), carotenoid excess or deficiency may cause color abnormalities including forms of xanthism (Colihueque, 2010; Sefc et al., 2014).

At Playa Manzanillo, trash and remains from fishing activities, such as discarded fish waste, are frequently observed along the beach. These biological residues may contribute to environmental degradation and the accumulation of harmful substances, potentially affecting the ichthyofauna of the area and leading to developmental disorders and morphological abnormalities (Elgendy et al., 2023; Jezierska et al., 2009; Wu, 1995). In Playa Manzanillo, as well as in other sites within El Jobo, a high incidence of malformations has been recorded, including body deformities but mainly ocular abnormalities, both in *U. asterias* and in other ray species beyond the Urotrygonidae family (Argüello-Rojas et al., 2026). Therefore, further environmental studies are needed to assess whether these abnormalities are correlated with water pollution and more research is required to clarify the implications of these morphological abnormalities for elasmobranch populations and their relevance to conservation efforts.

Ethics statement: The authors declare that they all agree with this publication and that they have made contributions that justify their authorship; that there is no conflict of interest of any kind; and that they have complied with all relevant ethical and legal requirements and procedures. All sources of funding are fully and clearly detailed in the acknowledgements section. The respective signed legal document is in the journal's archives.

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