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# Pearlspot, *Etroplus suratensis* (Bloch 1790): A Commercially Important Candidate Species for Aquaculture and Livelihoods: A Review

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## ABSTRACT

*Etroplus suratensis*, or pearlspot, is the largest Indian cichlid used in brackish and freshwater aquaculture in India and Sri Lanka. Despite advances in breeding, larval rearing and fingerling production, mass-scale seed production remains elusive. The Aquaculture Authority of Kerala (ADAK), in collaboration with ICAR-NBFGR, leads the pearlspot Brood Bank Project under the PMMSY program to boost seed production by assessing genetic variability and identifying superior brooders. This initiative is crucial for developing pearlspot aquaculture. This review covers taxonomy, biology, aquaculture, reproduction, nutrition, diseases, genetics and breeding of this commercially important species.

**Key words:** Aquaculture, *Etroplus suratensis,* Genetics, Germplasm conservation.

*Etroplus suratensis*, the state fish of Kerala, is a priced species with strong market demand. It is found in brackish and freshwater habitats across India, Sri Lanka, Bangladesh and Pakistan, it is especially abundant in Kerala's Vembanad Lake. Historically, landings in the lake reached 1252 tonnes in 1960's (Samuel, 1969) but dropped to 200 tonnes by 2002 (Padmakumar *et al.*2002) due to overexploitation, habitat destruction and pollution. Inland production decreased from 4644 tonnes in 2006-07 to 4194 tonnes in 2018-19 (Kerala Inland Fisheries Statistics, 2010; Fisheries Handbook, 2020). Despite these challenges, the species is listed as 'Least Concern' on the IUCN Red List (2019). Key threats include overfishing, habitat loss, pollution and competition from introduced species like Tilapia. Conservation efforts are now focused on protecting wild stocks and improving seed availability for aquaculture. This review highlights critical aspects of pearlspot's taxonomy, biology, ecology, aquaculture, reproduction, nutrition and genetics, essential for sustainable management and commercial development.

## Taxonomy

The taxonomic studies of pearlspot began in 1785 where Bloch described it as *Chaetodon suratensis* from Surat, Gujarat, in his book "Nature History of Foreign Fish, The Surattic Cliff Fish," based on its meristic characteristics. The genus *Etroplus* is endemic to India, with Day (1889) identifying three species: *E. canarensis*, *E. maculatus* and *E. suratensis*. Earlier, Hamilton (1822) had described *Chaetodon caris*, which resembled *Chaetodon suratensis* but differed in coloration. *Etroplus meleagris*, described by Cuvier and Valenciennes (1830), was later synonymized as *Etroplus suratensis* by Günther (1868) and Day (1878, 1889). Initially placed under the family Chromidae and order Acanthopterygii (Day, 1878), subsequent works by Berg (1940), Günther (1868) and Jayaram (1981) classified *Etroplus* under the family Cichlidae and order Perciformes. The current taxonomy lists *E. suratensis* in the order Perciformes and family Cichlidae (Berg, 1940; Mishra *et al.,* 1999). Its taxonomic classification includes Phylum: Vertebrata, Class: Teleostei, Subclass: Actinopterygii, Order: Perciformes and Family: Cichlidae.

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## Biological and ecological aspects

Pearlspot is a dioecious species found in rivers, ponds, farm fields, canals and estuaries (Shyam *et al.,* 2013). It exhibits a greyish-green coloration with 6 to 8 distinct black vertical bars and a dark spot at the base of the pectoral fin. Pearly spots are prominent on most scales along its flanks, contributing to its unique appearance (Costa, 1983). The species grows to a maximum reported size of 37 cm and a weight of 1200 g which is reported from Vembanad lake (Padmakumar *et al.,* 2004b), with table-sized fish being harvestable within 9-12 months of culture (Shyam *et al.,* 2013). Age and growth studies reveal a lifespan of approximately 7 years and a maximum length of 32.4 cm (Weatherley and Gill, 1987; Kannan *et al.,* 2014).

Pearlspot displays subtle sexual dimorphism, visible only during the breeding season. Females are generally smaller, with a muddy yellowish coloration, while males exhibit a greenish-blue iridescence, pearly white spots, darker color bands and slightly reddish fin rays. The genital papilla in females is larger and broader, serving as an ovipositor close to spawning, whereas in males, it is thin and pointed (Padmakumar *et al.,* 2004b). Females mature at a size of 16.9 cm, while males mature slightly earlier at 14.5 cm (Padmakumar *et al.,* 2004b). Other studies report varying sizes at first maturity, with females maturing at lengths of 110-120 mm and males at 125-140 mm (Thampy, 1980; Jayaprakas and Nair, 1981; Vijayaraghavan *et al.,* 1981; Raju *et al.,* 1986; Vikas and Subramaniyan, 2020).

Pearlspot is a substrate-spawning species within the cichlid group, differing from mouth-brooding species like tilapia. During spawning, the species demonstrates monogamy and remarkable parental care, guarding its eggs against potential threats (Ward and Wyman, 1977; Ward and Samarakoon, 1981). Habitat and environmental conditions greatly influence its distribution and reproductive success. Pearlspot thrives in both brackish and freshwater environments and can tolerate a wide salinity range from 0 to 30 ppt, though it prefers salinities around 15 ppt (De Silva *et al.,* 1984; Shyam *et al.,* 2013; Kailasam *et al.,* 2020). Additionally, like other cichlids, it exhibits surface respiration under low dissolved oxygen conditions, a crucial adaptation for surviving in challenging environments (Lowe-McConnell, 1991). The ecological and physiological versatility of *E. suratensis* makes it a valuable species for aquaculture. The differences in the average length and weight of adults between brackish and freshwater environments (Prathiba, 2022) highlight its adaptability, while its ability to tolerate a range of salinity and oxygen conditions further enhances its aquaculture potential. Such adaptive traits, coupled with its nutritive value as a food fish, underline the importance of pearlspot in sustainable aquaculture systems.

## Pearlspot aquaculture

As global demand for fish rises, pearlspot has gained popularity in aquaculture due to its resilience, tolerance to varying salinity levels and strong local consumer preference. The species reaches a commercial size of 200-300 g within 6-9 months, depending on salinity (Shyam *et al.,* 2013; Kailasam *et al.,* 2020). In Kerala, pearlspot commands a market price of Rs. 350-500 per kilogram (Shyam *et al.,* 2013), reflecting its significant economic and tourism value in the state. The consistent demand and lucrative price have encouraged farmers to adopt pearlspot culture, initially relying on wild-caught seeds to stock backyard ponds, tanks, artisanal cages and other systems. However, the current annual production of 2,000 MT falls short of the estimated 10,000 MT needed to meet domestic demand for pearlspot (Vikas and Subramaniyam, 2020).

The optimal water quality requirements for pearlspot culture include a temperature range of 25-32$^{o}$C, salinity of 0-30 ppt, pH between 7 and 8.5, water transparency of 25-40 cm, dissolved oxygen (DO) levels above 4.5 ppm and alkalinity ranging from 200-300 ppm (Ignatiou *et al.,* 2021).

The species thrives in diverse culture systems, including ponds, cages and pens in both brackish and freshwater environments (Patil *et al.,* 2020). Monoculture in brackish ponds can yield 1,000 kg/ha annually at stocking densities of 10,000-12,000/ha, but polyculture with mullets (*Mugil cephalus*) and milkfish (*Chanos chanos*) is more cost-effective and profitable (Mathews, 2012). In Kerala's traditional Pokkali fields, pearlspot is cultured alongside prawns and mullets, producing 3-5 tonnes annually. Experiments show that lower stocking densities (20,000/ha) yield better production in mixed cultures compared to higher densities (25,000/ha) (Shyam *et al.,* 2013). Cage farming has also gained popularity in Kerala's backwaters, with stocking densities of 100/m$^3$ yielding 20 kg/m$^3$, while lower densities promote faster growth rates (Kailasam *et al.,* 2020; Imelda and Gopalakrishnan, 2017). Additionally, low-volume cage culture has proven to be a viable livelihood option for small-scale fish farmers (Pramod Kiran *et al.,* 2014).

The eggs of pearlspot are oblong in shape, measuring approximately 1-2 mm in diameter. The incubation period ranges from 82 to 100 hours, after which the yolk is absorbed by the sixth day. At this stage, the larvae, known as "wrigglers," begin to move freely. Under tank breeding conditions, freshly hatched Artemia nauplii serve as the most effective live feed substitute for hatchlings, facilitating their development into free-swimming individuals (Padmakumar *et al.,* 2012; Shyam *et al.,* 2013).

Small-sized ponds, ranging from a few cents to an acre (preferably below 60 cents), are ideal for community breeding of pearlspot. Suitable ponds should have well-constructed bunds and a reliable water exchange system. Tidal inflow ponds use sluice gates for water regulation, while pump-fed ponds require an installed pumping system before stocking (Vikas and Subramaniyam, 2020). Nursery rearing of pearlspot is commonly carried out in happas or encircled nets made of velon screen material, with square-shaped happas (1.2 m × 1.2 m × 1.2 m) being preferred for shallow ponds due to easier handling. The stocking density in happas varies based on fry size, water quality and pond depth (Vikas and Subramaniyam, 2020). Studies have shown that growth parameters significantly decline with increasing stocking density, whereas a lower stocking density (100/m$^3$) notably enhances the growth performance of *Etroplus suratensis* in the biofloc rearing system (Ruby *et al.,* 2022b). A significant challenge in pearlspot farming is the limited availability of high-quality seeds, as aqua culturists often depend on wild populations (Kailasam *et al.,* 2020). Experimental seed production in ponds and raceways has shown promise, but large-scale farming is hindered by persistent seed shortages (Padmakumar *et al.,* 2009). Despite these limitations, pearlspot farming remains a profitable venture, especially in polyculture systems and integrated farming practices (Shyam *et al.,* 2013).

## Reproductive biology and captive propagation

Pearlspot is a dioecious species, capable of breeding naturally in both brackish and freshwater environments (Pethiyagoda, 1991). Sexual maturity is typically reached by the end of its first year, with females maturing at around 14.4 cm and males at 14 cm; however, in brackish waters, maturity can occur at smaller sizes of 8-9 cm (Selvaraj *et al.,* 2017; Costa, 1983; Padmakumar *et al.,* 2004a, b). The species displays noticeable sexual dimorphism during the breeding season. Habitat and environmental factors, such as water temperatures ranging from 25-30.5$^{o}$C, significantly influence maturation (Felix *et al.,* 2016; Bindu and Padmakumar, 2014). Pearlspot exhibits monogamous breeding behavior, characterized by reproductive activities like nest-building and parental care (Costa, 1983). Recently a study has proven that pearlspot exhibits serial monogamy and not classical monogamy *i.e*., lifelong relationship with its partner (Christo *et al*., 2024). It is a multiple-spawning species with asynchronous ovarian development and has two major breeding peaks: June-July and December-February (Jayaprakas and Nair, 1981; Krishnan and Diwan, 1990). Fecundity is generally low, with larger individuals producing up to 3,900 eggs (Jayaprakas *et al.,* 1990; Samarakoon, 1985). Environmental conditions, including increased food availability and high primary productivity, are key factors influencing gonad recrudescence and reproductive success (Bindu and Padmakumar, 2014).

In aquaculture, controlled environments such as raceway tanks have shown to enhance fecundity due to better nutritional care (Padmakumar *et al.,* 2009). Hormonal treatments, especially using human chorionic gonadotropin (HCG), have proven effective in inducing spawning (Dhas *et al.,* 2010; Felix *et al.,* 2016). Despite these advances, the species' complex reproductive behavior and challenges associated with inducing natural spawning in captivity continue to limit large-scale seed production (Biswas *et al.,* 2014).Seasonal and abiotic factors, including temperature and salinity, also play critical roles in regulating reproduction, growth rates, egg fertilization, larval development and survival (Van Der Kraak and Pankhurst, 1997; Boeuf and Payan, 2001). Understanding reproductive performance across seasons remains essential for optimizing seed production techniques. Innovative rearing methods, such as pit culture, have been identified as cost-effective alternatives, producing higher numbers of fingerlings than conventional pond culture (Pradeep *et al.,* 2021). However, further research is needed to refine breeding strategies and enhance seed production to meet the growing demand for pearlspot aquaculture.

## Nutritional aspects

Feeding and nutrition are critical components of sustainable aquaculture, particularly in developing countries like India. pearlspot, a benthic and visual feeder, exhibits specific feeding behaviors, primarily consuming food during the early morning and late afternoon (De Silva *et al.,* 1984). Its diet in natural habitats is highly diverse, including aquatic plants, algae, zooplankton, phytoplankton, crustaceans, detritus, small worms, prawns and insects (Costa, 1983; Shyam *et al.,* 2013). Juveniles predominantly feed on detritus and filamentous algae, transitioning to zooplankton and later returning to filamentous algae as they grow (Bhaskaran, 1946; Alikunhi, 1957; Shyam *et al.,* 2013). Seasonal dietary variations are evident, with filamentous algae being a major component in several habitats, as indicated by gut content analyses (Bindu and Padmakumar, 2008). The species is classified as a non-absolute herbivore, with molariform pharyngeal teeth enabling it to shred macrophytes and crush molluscan shells (De Silva *et al.,* 1984). In natural conditions, the diet is composed mainly of macrovegetation, detritus, filamentous algae and occasionally insects and mollusks (Padmakumar *et al.,* 2004a; De Silva *et al.,* 1984), with Spirogyra identified as a preferred food source (Shyam *et al.,* 2013) studies have proven that it has an effect on growth performance as well (Salkapuram *et al.,* 2025). Moreover, substrates play an essential role in promoting periphyton growth, which significantly enhances pearlspot growth (Garg *et al.,* 2007).

In aquaculture, supplementary feeding is essential for growth, maturation and breeding. Feeding is typically carried out twice daily, preferably at dawn and dusk (Vikas and Subramaniyam, 2020). Artificial feed formulations for pearlspot include groundnut oil cake (40%), rice bran (45%) and fish meal (15%), along with vitamin and mineral mixtures at 2.5 kg per 100 kg of feed (Shyam *et al.,* 2013). Studies have shown that incorporating crude protein (Lekshmi and Prasad, 2014), carbohydrates (Ramachandra Moorthy *et al.* 2022) and probiotics (Sankar *et al.,* 2017) into the feed improves growth performance. Despite these advancements, significant gaps remain in developing an ideal artificial feed to fully meet the nutritional requirements of pearlspot in aquaculture systems (Ramachandra Moorthy *et al.,* 2022). The dietary needs of pearlspot vary across life stages. Young fry primarily feed on zooplankton, while advanced fry consumes aquatic insect larvae, filamentous algae and vegetable matter. Adults rely on aquatic microvegetation, planktonic organisms, worms, shrimp and insect larvae (Shyam *et al.,* 2013). Additionally, microbial biofilms have been identified as a valuable resource for enhancing *E. suratensis* production. These biofilms, formed on readily available and cost-effective submerged substrates, promote heterotrophic microbial growth, supporting pearlspot's herbivorous tendencies and boosting production efficiency (Keshava *et al.,* 1988; Sugiura and Hardy, 2000).

**Table 1:** Summarized view of diseases reported during pearlspot farming.

| Disease | Clinical signs | Causative agent | Reference |
|---|---|---|---|
| **Parasitic diseases** | | | |
| Gill lice infection | Affects gills and destruction of gill epithelium | *Ergasilus ceylonensis* | (Wijeyaratne and Gunawarde, 1988) |
| Whirling disease | Occurrence of cyst on the bulbous arteriosus of the fish. | *Myxobolus etropli* | (Rajendran *et al.*, 1998) |
| Trichodiniasis | The parasite infects the gill filaments. The occurrence of 5-10 No. per gill arch. | *Trichodina* sp. | (Rattan and Parulekar, 1998) |
| Gill fluke or gill worm disease | Cause infection to the gill filaments 30-90 No. per gill arch.The fish appears to be inactive, respiratory stress, open operculum, gill colour and body colour of the fish changes. | *Ancyrocephalus* sp. | (Rattan and Parulekar, 1998) |
| Sea lice or caligidosis | Infects the branchial chamber of the fish. | *Caligus* sp. | (Rattan and Parulekar, 1998) |
| Tongue-eating louse | Isopod parasite that affects buccopharyngeal cavity. | *Cymothoa krishnai* | (Rattan and Parulekar, 1998) |
| Tongue-eating louse | Thickening of gill arch and gill filaments, irritations, lesions on the body, difficulty in swimming. | *Cymathoa indica* | (Rajkumar *et al.*, 2007) |
| Gill maggot | Damage of tissue and gills, increased mucous production, osmoregulatory failure, mortality. | *Ergasilus parvitergum, E. sieboldi, E. parvitergum* | (Vinobaba, 2007) |
| | Infection on the gill cavities | *Caligus rotundigenitalis* | (Solanki *et al.*, 2016) |
| | Infection on the gill | *Ergasilus parvitergam, Er-gasilus sieboldi, Ergasilus sp, Caligus epidemicus, caligus sp., Dermoergasilus hoi, Dermoergasilus sp. Nothobo-molochus sp., Lernea sp. and Lepiophtherius sp.* | (Dhanya and Amina, 2019) |
| | Opercular lesions and excess mucous secretion during south-west monsoon. | *Caligus rotundigenitalis* | (Job *et al.*, 2022) |
| Gill fluke | Infects the gill of fish. | *Dactylogyrus* sp. | (Swaminathan *et al.*, 2022) |

**Table 1: Continue...**

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| **Bacterial diseases** | | | |
| Motile Aeromonas Septicemia" (MAS) or "Hemorrhagic Septicemia | Haemorrhagic lesions, ulcerations and fin erosions. | *Aeromonas hydrophila* | (Pathirantne *et al.*, 1994) |
| *Vibriosis Pseudomoniasis* | Fin rot, the peripheral surface of the caudal peduncle gets eroded, The fish fold its fins and becomes inactive, exhibiting hiding behaviour. | *Vibrio*, *Pseudomonas* and *Aeromonas* spp. | (Rattan and Parulekar, 1998) |
| | Reddening and white patches on the body, wide opened mouth. | *Vibrio* | (Dhivya and Lipton, 2015) |
| *Klebsiella septicemia* | Gill rot Anorexia, restlessness, gill tissue decay. | *Klebsiella pneumoniae* | (Makesh *et al.,* 2015) |
| | Haemorrhagic septicaemiaSwollen belly, inflammated anus, spleen, swimbladder. | *Pseudomonas aeruginosa* | (Makesh *et al.,* 2015) |
| | Haemorrhagic septicaemia | *Aeromonas*, *Pseudomonas*, *Klebsiella*, *Chromobacterium*, *Burkholderia*, *Enterobacter* and *Pantoea* | (Ravi *et al.,* 2019) |
| Bacterial meningitis | Inflammation, meningitis and mortality. | *Streptococcus agalactiae* | (Girijan *et al.*, 2023) |
| | Infects the gill | *Klebsiella pneumoniae*, *Pseudomonas sp.*, *Burkholderia* sp. | (Ravi *et al.,* 2019) |
| | Infects the intestine | *Aeromonas jandaei, Klebsiella pneumoniae, Aeromonas jandaei* | (Ravi *et al.,* 2019) |
| | Infects the body surface, ulcerations | *Chromobacterium violaceum, Aeromonas jandaei, Pantoea pleuroti, eromonas hydrophila, Aeromonas veronii, Klebsiella pneumoniae, Aeromonas jandaei* | (Ravi *et al.,* 2019) |
| **Viral diseases** | | | |
| | Emaciation, dark body colouration, swim bladder inflation, vacuolation of the brain and retina, Mortality. | Viral Nervous Necrosis (VNN) Betanodavirus | (Marappan *et al.,* 2018) |

**Table 1: Continue...**

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|---|---|---|---|
| | Mortality and the dead fish exhibited symptoms such as external lesions like hemorrhagic patches, erosions on the skin, lossof scales swelling of gills and body. | Infectious spleen and kidney necrosis virus (ISKNV) *Megalocytivirus* | (Swaminathan *et al.*, 2022) |
| **Fungal diseases** | | | |
| Epizootic Ulcerative Syndrome (EUS) | Occurrence during south west monsoon (June-September).Red patches and lesions on the head region and lateral parts of the body. Heavy ulcerations on the visceral part. | Pathogenic fungi *Aphanomyces invadans* | (Rattan and Parulekar, 1998) |
| | Haemorrhages and ulcers. | *Aphanomyces invadans.* | (Das *et al.*, 2021) |

By integrating natural feeding behaviors with optimized supplementary feeding strategies and innovative techniques like biofilm utilization, pearlspot production can be enhanced, contributing to sustainable aquaculture practices.

## Disease diagnosis and management

The overall fish production can be increased through sustainable aquaculture practices and responsible fisheries management (FAO, 2020). However, the major threats experienced by the aquaculture sector are the serious impacts of the rapid spreading of infectious diseases among fish, which reduces aquaculture production. Any stress factor in a culture environment leads to the loss of balance in the system. The outbreak of several diseases resulted in the drastic decline of the pearlspot population in Sri Lanka and India (Maya *et al.,* 1995; Padmakumar *et al.,* 2012). The bacterial population can infect the pearlspot population from southern Kerala during the pre-monsoon period. The dominant species were micrococcus on these fish's alimentary canal, gills and reproductive organs (Maya *et al.,* 1995). Studies have shown that pearlspot is more vulnerable to Aeromonas hydrophila infection than other brackish water cultivable species (Vijayakumar *et al.,* 2017). Additionally, *Vibrio anguillarum* has been identified as an opportunistic fish pathogen that predominantly affects pearlspot in brackishwater environments (Ruby *et al.,* 2022a). During transportation, the fin rots disease and the subsequent higher mortality rate was described in pearlspot seeds. In nature, parasites generally don't cause issues. However, a few reported cases of parasites such as *Trichodina, Ancyrocephalus, Caligus and Cymothoa* cause harm to the operculum, skin and gills of important fish species. These incidents have reduced consumer preference and declining market demand (Vinoth *et al.,* 2010; Nike *et al.,* 2013). pearlspot demonstrates greater resistance to copepod infections than other brackish water fishes (Vinoth *et al.,* 2010). A summarised view of diseases and clinical signs reported during pearlspot farming is given in Table 1.

## Genetics and breeding program

The pearlspot population in its natural habitat has declined (Bindu and Padmakumar, 2016). Understanding its genetic makeup is vital for setting conservation goals, as genetic information helps estimate effective population size, essential for managing endangered species (Osborne *et al.,* 2010). Molecular markers, like mitochondrial genes, aid in assessing genetic variation, minimizing inbreeding and maintaining genetic diversity (Sebastian *et al.,* 2019). Genetic studies using markers such as mitochondrial displacement loops (Chandrasekar *et al.,* 2019), ATPase6/8 genes (Balasubramanian *et al.,* 2022) and COI markers (Surekha and Nagarajan, 2018) reveal distinct genetic divisions among pearlspot populations in India.

Research indicates that populations on the west coast show more genetic diversity than those on the east coast, likely due to environmental fluctuations (Balasubramanian *et al.,* 2022). However, studies on genetic diversity, such as Dhanya *et al*. (2013), are limited due to inadequate data. Recent efforts by Christo *et al*. (2024) developed microsatellite primers for identifying pearlspot stocks for breeding programs. Despite its importance in aquaculture, wild pearlspot populations lack sufficient conservation attention. Stock improvement and promoting genetic diversity are critical for addressing the species' decline, especially in Kerala (Bindu and Padmakumar, 2016).

## CONCLUSION

In India, the large-scale production of pearlspot seeds has still not been achieved. Thus, captive breeding programs are undertaken to conserve the natural gene pool of the population for commercial pearlspot production. Scientific as well as technological support to develop disease-resistant and high-yielding varieties of fish through selective breeding programs, artificial diets that promote good growth of the fishes, *etc.* can be accomplished through a solid network of farmers, Government agencies and aquaculture experts. At this juncture, ADAK and ICAR-NBFGR are executing a pearlspot Brood Bank Project to overcome the challenges the pearlspot farming system faces.

### Disclaimers

The authors affirm that the views and conclusions presented in this article reflect their own perspectives and do not necessarily align with those of their affiliated institutions. While every effort has been made to ensure the accuracy and completeness of the information, the authors accept no responsibility for any direct or indirect consequences arising from the use of this content.

### Informed consent

All animal-related procedures conducted during the experiments were reviewed and approved by the University's Committee on Animal Care, adhering to established guidelines for the ethical treatment and handling of experimental animals.

### Conflict of interest

The authors declare no conflicts of interest related to the publication of this article. Furthermore, no funding or sponsorship influenced the study design, data collection, analysis, decision to publish or manuscript preparation

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