

Morphoidentification of intestinal nematodes in guinea pigs (*Cavia porcellus*) from Cajamarca City, Peru

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ABSTRACT

The research objective was to identify helminths in guinea pigs from processing centers in the city of Cajamarca, determining the frequency, morphometric characteristics, parasite gender, and location. The diagnosis of intestinal parasites was made by examining and opening the postmortem gastrointestinal tract and the morphometric characteristics were determined using a millimetric ruler, micrometric eyepiece, microscope, and stereoscope. At the end of the investigation, a frequency of 76% of nematodes was found, which according to morphometry correspond to *Paraspidodera uncinata* (74%), *Capillaria* spp. (18%), and *Trichuris* spp. (14%); according to location 18% were found in the small intestine (*Capillaria* spp. 18%), 72% in the cecum (58% correspond only to *P. uncinata*, 3% to *Trichuris* spp. and 11% to a mixed infection between both) and 23% in the colon (*P. uncinata*); no parasites were found in liver or stomach. Nematodes in guinea pigs from Cajamarca is high, with a greater presence of *P. uncinata*, located in the cecum and colon.

1. Introduction

Factors such as stress, lack of hygiene, poor management, poor feeding, and others, predispose the presentation of parasitosis in guinea pigs; parasites are generally transmitted directly or indirectly by other animals, they are located at the level of the intestinal tract mainly where they feed on blood and other nutritional substances, generating a decrease in growth and weight loss of the animal (Suárez et al., 2014).

Thus, several parasites have been reported in guinea pigs around the world, among the most frequent *Paraspidodera uncinata*, *Trichostrongylus* sp., *Trichuris* sp. (García et al., 2013; Kouam et al., 2015; Meutchieye et al., 2017), in addition to the guinea pig's own parasites; other non-species-specific parasites are also reported, which have been adapting as this rodent has been introduced in different places and interact with other species has increased (Kouam et al., 2015; Payne et al., 2015; Meutchieye et al., 2017).

In most cases of parasitosis guinea pigs do not manifest marked clinical signs, they are mild and subclinical so they appear clinically healthy, thus they go unnoticed, and gradually produce unquantifiable economic losses, due to decreased production, productivity, and

susceptibility to contracting other diseases (García et al., 2013; Huamán et al., 2020). The clinical signs of parasitosis are only manifested in moderate and severe infections, causing diarrhea, anorexia, weight loss, and poor coat (Ward, 2009), in addition to predisposing to secondary infections (Shomer et al., 2015). It should also be taken into account that some species of parasites are more pathogenic than others, and despite being present at low levels of infection, they cause severe damage to the intestinal mucosa of the host (Audebert et al., (2003)).

Although Cajamarca is one of the regions dedicated to guinea pig breeding and exploitation, it does not have extensive updated and published information on health, including parasitosis caused by gastroenteric and hepatic helminths. In this sense, this research aimed to identify gastroenteric helminths, their morphometric characteristics, and their location in guinea pigs from the processing center in the province of Cajamarca.

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2. Methods

2.1. Location

The study was conducted in several guinea pig slaughtering centers in the city of Cajamarca, which is located at 2749.53 m above sea level, in the province and department of Cajamarca (Fig. 1).

2.2. Sample collection

The sample n was calculated based on a previous study on guinea pigs from the nearest hamlet to the district of Cajamarca (Merino, 1991), with an estimated proportion in favor of 85%, confidence level of 95%, and estimation error of 5%, thus giving 99.96 (100) samples. The slaughtered guinea pigs were randomly selected in equal proportions from three main markets (Mercado Central, Mercado San Antonio, and Mercado San Sebastian). To extract the 100 viscera, the guinea pigs were scalded, and subsequently, the thoracic and abdominal cavity was opened through an incision in the ventral longitudinal plane; from the sternum to the pelvic symphysis, proceeding to remove all the structures between the esophagus and the rectum, including the liver. Then, they were placed in polyethylene bags, labeled, and deposited in an expanded polystyrene box; then, they were transferred to the Laboratorio de Parasitología Veterinaria of the Facultad de Ciencias Veterinarias from Universidad Nacional de Cajamarca, Perú, for the corresponding study.

For the separation of the digestive tract sections, the stomach, small intestine, and large intestine (cecum and colon) were identified on a 49.5 cm long by 36.7 cm wide and 2.6 cm high polyvinyl chloride tray, the ends of which were consecutively tied with string and cut transversely with straight surgical scissors. Once separated, each segment was incised longitudinally and the content was transferred to transparent polypropylene cups of one-liter capacity, previously labeled.

Additionally, the volume generated by washing the mucosa and remains of digestive content was added to the same content.

2.3. Analysis of samples and identification of parasites

The contents were deposited separately from the segments of the gastrointestinal tract in the beakers, water was added until 1.5 cm from the edge and allowed to settle for 10 min, followed by decanting, leaving one-third of the sediment, this procedure was performed two additional times.

The final sediment obtained was sieved through a metal mesh of 0.5 and 1 mm in diameter into a black bottom tray, and water was added to the sieve to allow the nematodes to pass through by dragging. For each section (stomach, small intestine, cecum, and colon), the presence or absence of helminths was verified with the aid of a magnifying glass, where those present were collected with a stilet and stored in individual, labeled, wide-mouthed glass jars (8 cm in diameter) with 10% formol solution.

According to size, the length of each nematode was measured with the aid of a stereoscope (1.6X) and a millimetric ruler. With a microscope and micrometric eyepiece with magnifications of 10X (correction factor 6.6) and 40X (correction factor 1.64), anatomical parts of the parasites were measured, such as length and width, as well as esophagus and spicules, mainly of the smallest and largest nematodes. The identification of the parasite genera found was made by contrasting the characteristics and morphometric data in veterinary parasitology texts, in addition to other studies published in scientific journals (Lindquist and Hitchcock, 1950; Urquhart et al., 2001; Baker, 2007; Taylor et al., 2007).

In the search for *Fasciola hepatica*, the liver and gallbladder were placed in Petri dishes, making transverse cuts to the hepatic ducts with sharp-tipped surgical scissors, continuing with the macroscopic search

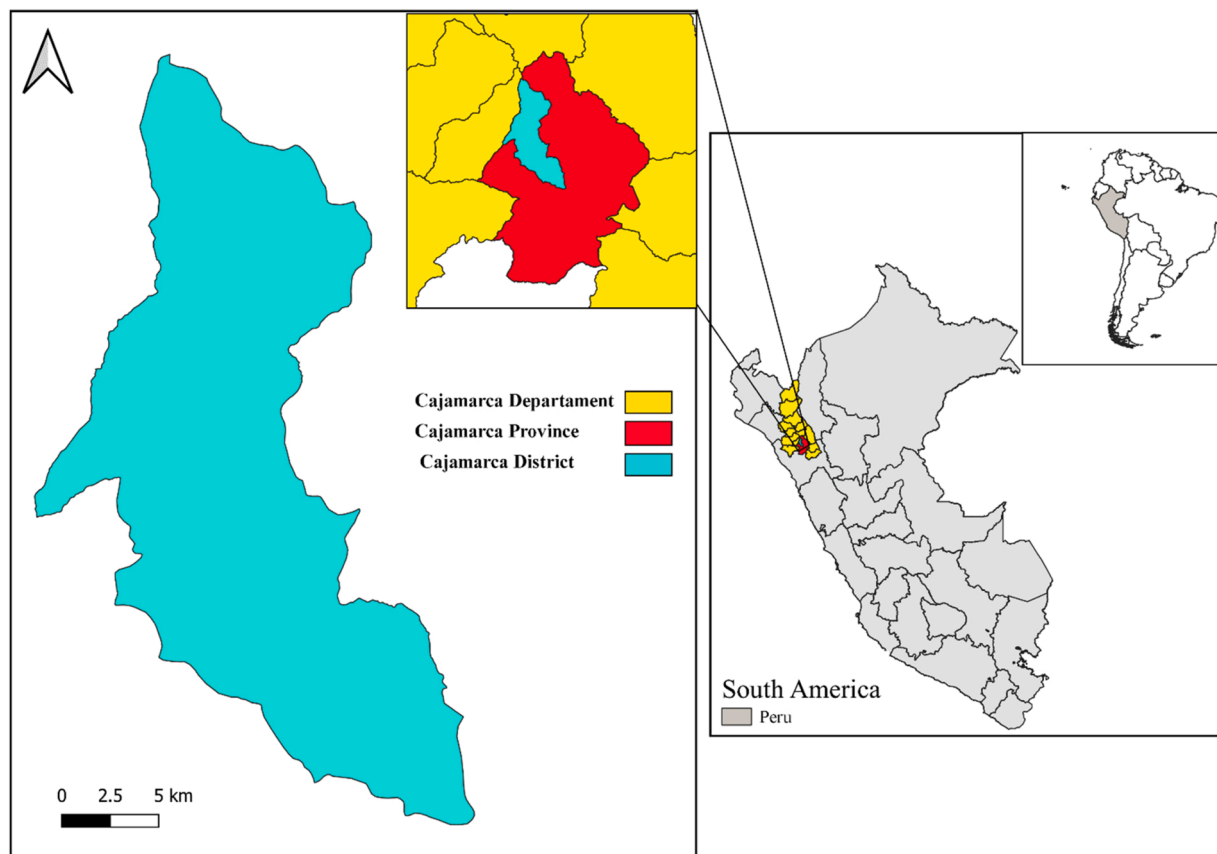


Fig. 1. Location of the study area.

for the parasite, by observation.

The data were recorded in Microsoft Office Excel sheets and the frequency found was calculated using descriptive statistics (Permin et al., 1999).

3. Results

A high frequency of *Paraspidodera uncinata* was found, followed by *Capillaria* spp. and *Trichuris* spp., which were found located in three sections of the intestine (Table 1).

3.1. *Paraspidodera uncinata*

These parasites were located in the guinea pigs' cecum and colon, where the total length of the female parasites ranged from 22 to 28 mm and the males from 18 to 21 mm (Fig. 2).

3.2. *Trichuris* spp.

The morphological characteristics of this parasite found in the present study are shown in Fig. 3.

3.3. *Capillaria* spp.

The parasites found measured from 22 to 27 mm. Characteristics of this parasite are shown in Fig. 4.

4. Discussion

4.1. *Paraspidodera uncinata*

The parasite *P. uncinata* is a nematode that presents 3 equal lips around the mouth at the anterior end with which they adhere to the mucosa of the cecum and colon; The adult male worms measure between 11 and 22 mm long and the females between 16 and 28 mm (Lindquist and Hitchcock, 1950), in the case of the males their posterior extremity is curved and thinned, containing two spicules of similar length (470–700 μm) and a gubernaculum (136–158 μm long); differing from the female that does not present thinning in the posterior region (Baker, 2007); the same that eliminates ellipsoidal eggs with a thick shell, measuring 53 μm long by 43 μm wide (d'Ovidio et al., 2015).

In the only regional research record found, through morphological identification at necropsy, an overall prevalence of 49% (40/81) was obtained only for *P. uncinata* in guinea pigs of non-technician home breeding, fed with green forage (*Medicago sativa*, *Trifolium repens* or *Lolium multiflorum*), food wastes such as potato peel, carrot, and vegetables in general. This study described 19 mm (17–21) long male parasites and 24 mm (23–27) long female parasites. Eggs were oval with thick shells, not segmented, and averaged 60 μm long by 47 μm wide (Merino, 1991). The values obtained are within the characteristics found in the present study, a length of 22–28 mm in female parasites, 18–21 mm in male parasites, and eggs 56–62 μm long by 44–49 μm wide

(Fig. 2).

This parasite is widely distributed in guinea pigs, it has been found as the most prevalent (8/60) in domestic guinea pigs raised as pets in Italy (d'Ovidio et al., 2015). It has also been reported in guinea pigs kept as research, breeding, and rearing laboratory animals; where in an investigation of a total of 105 animals 24.7% tested positive for the presence of *P. uncinata* eggs (Motamedi et al., 2014). It has also been reported in Cameroon, along with other parasites that have been acquired from other mammals, which are detrimental to host health, in addition to being zoonotic (Kouam et al., 2015).

4.2. *Trichuris* spp.

These nematodes are white to pinkish in color, with a length of 40–60 mm, they are called whipworms due to their appearance, their posterior end is thick and narrows sharply towards the anterior end, which is long, filamentous, and thin and is embedded in the cecal mucosa of the guinea pig. The female's tail is simply curved and the male is spirally coiled, with a single spicule surrounded by a sheath (Urquhart et al., 2001).

In a preliminary regional study in Cajamarca, the presence of *Trichuris* spp has been described in 5% (4/81). Only the female parasite was found, whitish in color, with an average length of 43 mm (30–51), with a longer and thinner anterior end of 25 mm (14–31) and a thicker posterior end of 18 mm (15–20). The eggs were elliptical, with a thick shell and plugs at the ends, measuring 66 μm long by 37 μm wide (Merino, 1991). The characteristics reported are similar to those found in the present study (Fig. 3).

4.3. *Capillaria* spp.

The species of this genus are filamentous worms, measuring from 10 to 50 mm in length with an extremely thin anterior end that is barely visible, they have a narrow esophagus that occupies half of the length. Males have a single long, thin spicule and a structure similar to a primitive pouch at the posterior end (Urquhart et al., 2001). The length ranges obtained in the present study of female *Capillaria* spp. (22–27 mm) were far from those established by Urquhart et al. (2001).

There are no regional records of the presence of *Capillaria* spp. in guinea pigs for comparison. The eggs of these parasites have a great potential for survival outside the body, the thickness of the shell prevents the larvae from drying out, thus the perpetuation of the direct biological cycle is not affected since they are viable when consumed with feed or water (Urquhart et al., 2001). In moderate or massive infections, parasitosis manifests with catarrhal and bloody mucous diarrhea, loss of appetite, decreased weight gain, thinning, bristly and dull coat, and anemia (Cordero del Campillo et al., 1999).

In the only regional study found, 81% (81/100) of animals were positive for gastrointestinal nematodes in guinea pigs, of which 49% corresponded to *P. uncinata* and 5% to *Trichuris* spp., both located in the cecum and colon, with an association of 46%, thus demonstrating the coexistence of both parasites in the same location (Merino, 1991).

Table 1

Frequency of parasites found and their intestinal location in guinea pigs.

Parasite	Frequency		Total (%)				
	By genus	By location			Cecum	Colon	
		Liver	Stomach	SI*			
<i>Capillaria</i> spp.	18	–	–	18	–	–	76
<i>P. uncinata</i>	74	–	–	–	58	23	
<i>Trichuris</i> spp.	14	–	–	–	3	–	
Association* *	–	–	–	–	11	–	
<i>Fasciola hepatica</i>	–	–	–	–	–	–	
Total (%)		0	0	18	72	23	

*Small intestine; **Association between *Paraspidodera uncinata* and *Trichuris* spp.

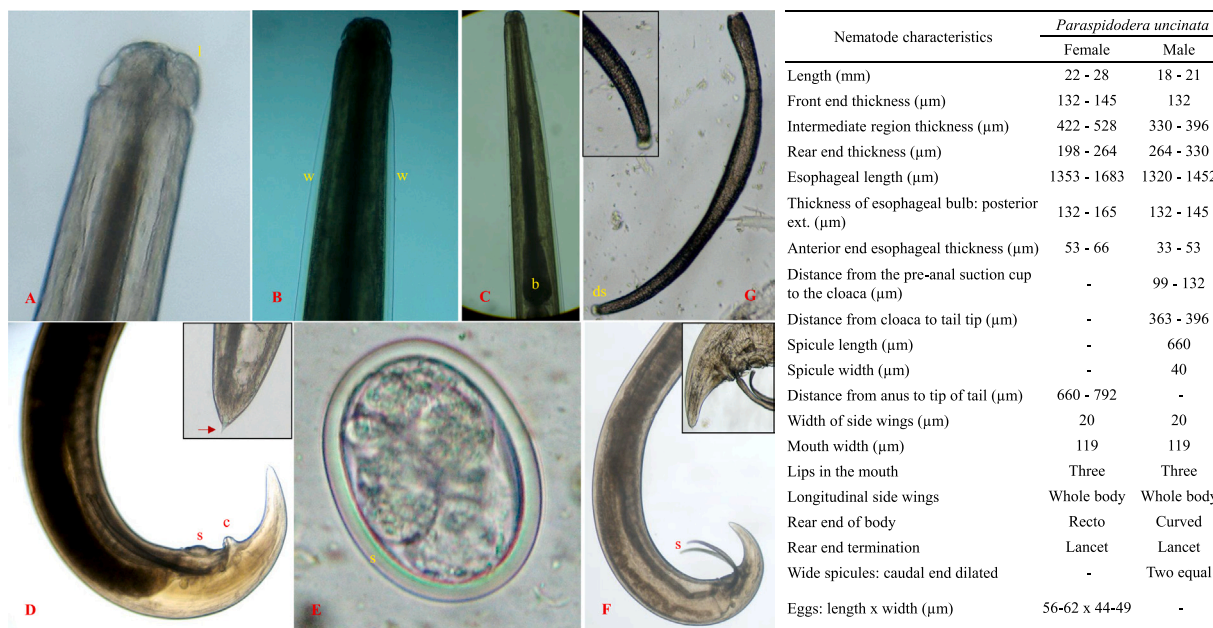


Fig. 2. Morphometric characteristics of *P. uncinata* found. A. mouth lips (l) (40X), B. Lateral wings on the body (w) (40X), C. Esophageal bulb (b) (10X), D. Female; sucker (s) and cloaca (c), lancet-shaped tip of tail (arrow) (10X), E. Egg with thick shell (s) (40X), F. Male; spicule (s) (10X), G. Dilatation at caudal end of spicule (ds) (40X).

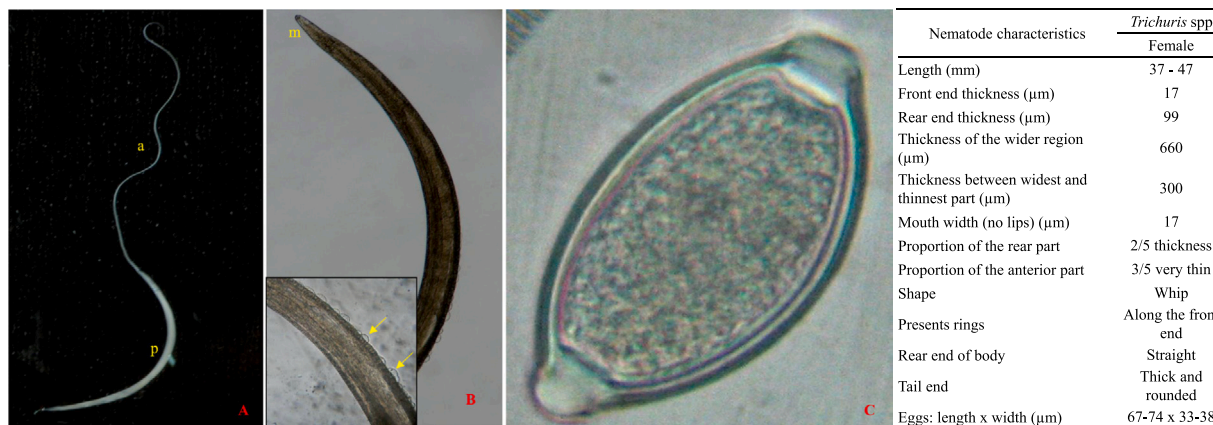


Fig. 3. Morphometric characteristics found for the parasite *Trichuris* spp. A. Thin anterior (a) and thick posterior end (p) (1.6X), B. Anterior end: mouth (m) (40X), box: rings around the cervical end (arrows) (40X), C. Lemon-shaped egg with thick shell, one operculum at each end (40X).

Similarly, in the present study, an association was found between *P. uncinata* and *Trichuris* spp. (11%), however, the location of the parasites was only limited to the cecum.

As in the present study, these parasites have also been reported in other investigations. In family-commercial guinea pigs in Caraz (Ancash, Peru), they evaluated 100 samples of guinea pigs and found 89% of gastrointestinal nematodes, the most prevalent being *Paraspidodera uncinata* (83%), followed by *Trichuris* spp. (31%), *Capillaria* spp. (18%) and *Trichostrongylus colubriformis* (2%); in addition, monoparasitism was present in 55.1%, biparasitism (most frequent association *P. uncinata* and *Trichuris* spp.) in 39.3% and triparasitism (*P. uncinata*, *Trichuris* spp., and *Capillaria* spp.) in 5.6% (García et al., 2013); these values are above those found in the present study, a prevalence of 76%, with a greater presence of *P. uncinata* in cecum and colon (74%), followed by *Capillaria* spp. in the small intestine (18%) and finally *Trichuris* spp. (14%), finding biparasitism between *P. uncinata* and *Trichuris* spp. only.

In another research conducted on guinea pigs under the same rearing system (family-commercial) in Oxapampa, Pasco (Peru), a prevalence of 90.0 ± 4.1% during the rainy season and 63.5 ± 6.7% during the dry

season was found by coproparasitology, identifying *P. uncinata* (one of the most frequent), *Trichuris* spp., *Capillaria* spp. and *Eimeria caviae* (Vargas et al., 2014). Also in intensive breeding, gastrointestinal parasites have been reported in guinea pigs; in Lima, out of 250 samples of the small intestine, large intestine, and cecum, analyzed by direct and microscopic observation, flotation, and sedimentation, 37.2 ± 6.0% were positive, finding *P. uncinata* (20.4%), *Capillaria* sp. (4.8%), *Trichuris* sp. (2.0%) and other parasites, where mixed parasitism was also found (Huamán et al., 2020).

Coprophagy in guinea pigs is one of the most important reasons that allows the perpetuation of parasites (Franz et al., 2011), they are easily reinfected and more in favorable environmental conditions, for example, a study found a 40% prevalence of *P. uncinata* in guinea pigs kept in free-range versus 10% in conventional breeding (Pinto et al., 2002). Low levels of infection should not be underestimated because certain parasites are highly pathogenic (Audebert et al., 2013), so their rapid identification is necessary since they can cause serious problems in guinea pig breeding, in addition to monitoring or ruling out cross-infection with other species of animals that share habitats or food



Fig. 4. Morphometric characteristics found for the parasite *Capillaria* spp. A. Thin front end (40X), B. Posterior end straight, thick and rounded with subterminal anus (arrow); box ($30 \times 1.64 = 49 \mu\text{m}$, 40X), C. presence of eggs in the interior of the parasite (40X), D. Barrel-shaped egg with thick shell and a plug at each end (40X).

type, as has happened with *P. uncinata*, which was a specific parasite of wild guinea pigs (*Cavia aperea aperea*) (Gressler et al., 2010) and is now widely distributed in domestic guinea pigs (García et al., 2014; Payne et al., 2015; Pinto et al., 2002; Coman et al., 2009). In wild guinea pigs from three Andean localities (Peru), out of 143 guinea pigs, *Capillaria hepatica* was found in the liver (6.9%), *Trichuris gracilis* in the large intestine (3.5%), and *P. uncinata* in large intestine and cecum (37%); in addition to *Fasciola hepatica* in the liver (4.2%) (Dittmar, 2002).

Although in many recent studies, as in the present one, no adult parasites of *Fasciola hepatica* were found in the liver, in a locality near Cajamarca (Chota) a copro-prevalence of $4.6 \pm 2.13\%$ of a total of 370 guinea pigs has been reported (Torrel et al., 2022), although in the same city of Cajamarca high prevalence rates of *F. hepatica* in guinea pigs have been found before (Gamarrá (1996)) and since that study, no more investigations have been reported.

Finally, it is concluded that the prevalence of intestinal helminthiasis in guinea pigs from processing centers in the city of Cajamarca is high, and according to their morphometric characteristics correspond to *Paraspidodera uncinata* (located in the cecum and colon), *Capillaria* spp. (present in the small intestine), and *Trichuris* spp. (located in the cecum).

Ethical considerations

We did not work directly with live animals. Samples were collected from specimens slaughtered by slaughterhouse personnel.

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Nematode characteristics	<i>Capillaria</i> spp.
	Female
Length (mm)	22 - 27
Front end thickness (μm)	8
Rear end thickness (μm)	41 - 49
Thickness mid-length (μm)	69 - 79
Thick rear	1/10
Thin anterior part	9/10
Rear end of body	Straight
Tail end	Thick and rounded
Eggs: length x width (μm)	54-61 x 25-33

CRediT authorship contribution statement

All authors contributed to the conception, design of the study, supervised, and conducted the research. EGS and STP contributed to the Software, validation, data curation, writing-preparation of original drafts. LVR and JRM collaborated in viewing, writing-reviewing and editing the manuscript. All authors read and approved the final manuscript.

Conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data Availability

All data pertinent to this study are included in this paper.

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