

Potting soil selection by the invasive planarian *Obama nungara*

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The invasive South American land planarian *Obama nungara* has spread rapidly throughout Europe through horticultural trade, raising concerns regarding its impacts on soil biodiversity and ecosystem functioning. Despite its expanding distribution, knowledge of the species' habitat preferences remains limited. We experimentally investigated soil preference in *O. nungara* using laboratory habitat-choice trials with four commercially available potting soils. Individuals were allowed to move freely between substrates, and their substrate use was recorded. The *O. nungara* individuals did not select soil type randomly. Most individuals selected the rhododendron soil characterized by low pH, followed by the rose and perennial soil. Planting soil, both with and without extra added lime, was selected less than would be expected by a random choice. These findings suggest that *O. nungara* prefers acidic substrates, which may facilitate establishment in horticultural environments associated with acidophilic plants and low-pH growing media.

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INTRODUCTION

Soil ecosystems consist of complex networks of microorganisms, fungi and invertebrates that regulate decomposition and nutrient cycling, and are essential for maintaining soil structure and ecosystem functioning (Delgado-Baquerizo *et al.* 2020). Predatory soil organisms influence the abundance and composition of species involved in these processes and therefore indirectly affect soil function. During the last two decades, non-native, terrestrial planarian belonging to the family Geoplanidae have spread rapidly throughout Europe (Bouguerche *et al.* 2025). These planarian are generalist predators (Sluys 1998; 2016) that feed on several ecologically important soil organisms (Cseh *et al.* 2017; Noël *et al.* 2026; Ventura *et al.* 2026), raising concerns regarding their potential impacts on soil biodiversity and ecosystem functioning. One example of an invasive terrestrial planarian is the South American planarian *Obama nungara* Carbayo, Álvarez-Presas, Jones & Riutort, 2016. Although scientifically described as recent as 2016, the species was likely introduced to Europe prior to that and has since spread rapidly across multiple European countries vectored by the trade of ornamental plants (Justine *et al.* 2018; 2020). By 2024,

the species had been recorded in 19 European countries (de Waart *et al.* 2025).

O. nungara possesses a broad dietary niche and preys upon earthworms, slugs, snails, and other planarians (Boll & Leal-Zanchet 2016; Noël *et al.* 2026). Predation on earthworms is of particular concern because of their central role in decomposition and nutrient turnover in soils (Álvarez-Presas *et al.* 2014). Combined with the species' relatively long lifespan and ability to survive prolonged starvation, its generalist feeding behavior may contribute to its invasive potential and facilitate establishment following long-distance transport (Noël *et al.* 2026). The species is dispersed through horticultural trade, where individuals are transported within the soil of potted plants (Lago-Barcia *et al.* 2019).

Knowledge regarding the ecological requirements and habitat preferences of *O. nungara* remains limited. Soil properties such as pH, nutrient contents and water retention capacity influence the occurrence of soil-dwelling organisms (Wu *et al.* 2023), and may therefore also affect soil preference in *O. nungara*. The aim of this study is to investigate this preferences of *O. nungara* in a laboratory

experiment to shed light on the species' habitat selection as well as potential dispersal pathways associated with the plant trade. Soils with low pH are common within the species' native distribution range (Fageria & Nascente 2014, Soors *et al.* 2019), and we therefore predicted that *O. nungara* would exhibit selective preference for soil with low pH.

METHODS

We carried out two separate experiments in a laboratory room dedicated to *O. nungara* work. During fall 2025, we tested soil preference of eleven larger (30 – 80 mm) individuals in separate habitat choice trials, and in winter 2026, we tested ten smaller (12 – 34 mm) individuals. In each trial, we placed an individual in the center of a plastic container with four compartments. Each compartment contained a commonly used and commercially available potting soils (Table 1; Table A1 Appendix). The partitions separating the soils did not extend all the way to the top of the arena, allowing the individual to move freely between compartments throughout the experiment. We kept the soil moist by spraying water on the surface at the start of each trial. Between trials, the experimental arena was cleaned with hot water and the soil substrates were replaced in order to minimize the influence of residual chemical cues. The relative positions of the soil substrates were randomized between trials to avoid learning effects.

The individual's position after 24 hours was recorded as its soil preference. This time interval was selected as a standardized period that allowed individuals sufficient time to move between the different substrates. For individuals that had burrowed into the soil, we measured the depths of their positions. Each individual was tested multiple times: three times for individuals of the large size category and five times for individuals of the small size category. For the larger size category, we used quadratic plastic containers (height × width × depth = 16 × 13 × 13 cm) that allowed individuals to burrow down in to the soil (270 mL of each soil type). For the smaller size category, we used a smaller, circular experimental arena (height = 2 cm, diameter = 7 cm; 13 mL of each soil type). Soil chemistry was assessed by mixing 100 g soil with 200 mL distilled water, filtrating the water and measuring the pH and conductivity of the water. The temperature throughout the experiment was maintained at 16° C, and a dim light was on between 07:00 and 20:00.

Data analysis

We did not include observations of individuals that resided on a plastic wall or the ceiling (8 out of 83 observations) in the analysis. Each individual's observed habitat choices were converted into proportions summing to 1. An increase in the proportion of one soil type necessarily resulted in a decrease in another, and thus the proportions constituted compositional data. The components therefore contain only relative information and cannot be analyzed as independent

variables (Quinn *et al.* 2019). To account for this dependency, we transformed the data by using centered log-ratio (CLR) values, a common method for compositional data analysis (Greenacre 2021). This allows the data to be analyzed using statistical methods without violating assumptions of independence between variables. To perform the CLR transformation, values of zero were replaced with a small constant (0.0001), after which the proportions were adjusted so that each individual's habitat composition once again summed to 1. The data were transformed according to:

$$\text{CLR}(x_i) = \ln(x_i/g(x)),$$

where x_i is the proportion of substrate type i , and $g(x)$ is the geometric mean of the individual's proportional habitat use.

We used separate one-sample Hotelling's T^2 tests to determine whether the CLR-transformed mean values differed from a random distribution for the large and small size categories, respectively. In addition, we carried out the same one-sample Hotelling's T^2 test on the pooled data from the two size categories. All statistical analyses were performed in R version 4.5.2.

RESULTS

With three exceptions, no *O. nungara* was observed burrowing into the soil: one individual was located approximately 15 mm below the surface in planting soil, whereas another individual was partially submerged approximately 8 mm below the surface in rose and perennial soil. One additional individual was covered by a thin layer of soil over parts of its body. The *O. nungara* individuals did not select soil type randomly (Figure 1). Most individuals selected the rhododendron soil, followed by the rose and perennial soil. Planting soil, both with and without extra added lime, was selected less than would be expected by a random choice. One sample Hotelling's T^2 tests demonstrated that these differences were represented by large effect sizes, although the deviation from a random selection was only statistically significant for the small size category and the pooled data, and not the large size category (large size category: $T^2 = 2.78$, $df_1 = 3$, $df_2 = 8$, $p = 0.110$, $\eta^2 = 0.217$; small size category: $T^2 = 5.12$, $df_1 = 3$, $df_2 = 7$, $p = 0.035$, $\eta^2 = 0.363$; all individuals: $T^2 = 6.00$, $df_1 = 3$, $df_2 = 18$, $p = 0.005$, $\eta^2 = 0.231$).

DISCUSSION

The results of this study demonstrate that individuals of *O. nungara* did not distribute randomly among the presented soil substrates. The rhododendron soil was preferred by most individuals, while the planting soil with lime addition was selected less frequently than expected under random habitat choice. These findings support the

Table 1. Properties of the four soil types that individual *Obama nungara* could select in a habitat use experiment.

Soil type	pH	Conductivity (µS/cm)	Use
Rhododendron soil	4.9	350	Peat-based with good moisture retention. Used for acidophilic plants
Rose and perennial soil	5.4	1630	Peat-based with added nutrients and clay. Used for plants such as clematis, roses and perennials
Planting soil	5.6	1580	Peat-based with moderate nutrient availability. General use for various plant types
Planting soil with 10 g L ⁻¹ added lime	5.7	1800	Same as the above

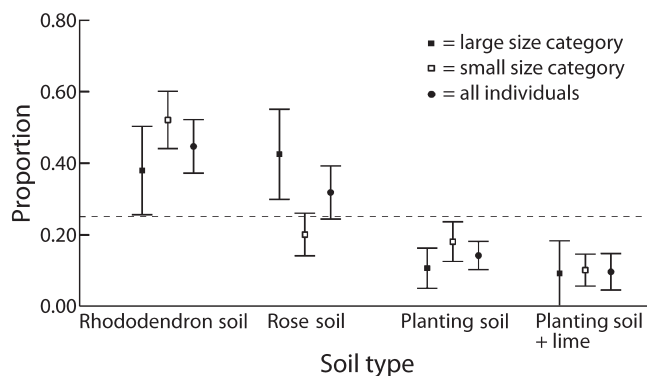


Figure 1. Mean proportion of habitat use by *Obama nungara*. Individual *O. nungara* could select one of four different soil types in an experimental setting. The figure shows habitat use by large (length: min – max = 30 – 80 mm, n = 11), small (length: min – max = 12 – 34 mm, n = 10), and all individuals. Error bars indicate ± 1 standard error. The dashed line indicate the expected proportion of habitat use (0.25) if the selection of soil was random.

hypothesis that individuals exhibit a preference for substrates with low pH, which is consistent with the predominance of acidic soils within the species' native range in southern Brazil and Argentina (Fageria & Nascente, 2014; Soors *et al.* 2019).

Three individuals displayed limited burrowing behavior, whereas most individuals remained on the soil surface, suggesting that the species primarily occupies surface-level microhabitats. Such behavior may facilitate management efforts because individuals are easier to detect visually, and control measures can focus on the outer soil layers. However, little is known about egg capsule-laying behavior of *O. nungara* (Noël *et al.* 2026, Watz 2025). In related Geoplanidae species inhabiting surface environments, egg capsules have been found buried up to 7 cm beneath moss layers (McDonald & Jones 2007). No egg capsules were found during this study, but observations of limited burrowing behavior combined with findings from related planarian species suggest that subterranean egg deposition in *O. nungara* cannot be excluded.

Alien invasive terrestrial planarian primarily spread through horticultural trade (Álvarez-Presas *et al.* 2014, Lago-Barcia *et al.* 2019). Current recommendations in, for example, Sweden include inspecting potted plants and, if *O. nungara* is detected, heat-treating, freezing or discarding the plant while euthanizing the discovered individuals (Watz, 2025). Substrate characteristics may influence the occurrence of *O. nungara* in horticultural settings and could therefore be relevant to the risk of inadvertent transport with potted plants. The observed preference for rhododendron soil in the present study is consistent with a preference for acidic potting substrates, while the underlying mechanism remains unresolved. Future experiments with larger sample sizes should therefore manipulate individual substrate properties independently to determine which properties influence substrate selection by *O. nungara*.

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Appendix: Table A1. Suppliers information for products used in habitat selection experiments with *Obama nungara*.

Product	Producer	Item No	Description	Contents	Conductivity (mS/cm)	pH
Rhododendron soil	Rölunda gård	69552	Unlimed and naturally fertilized; suitable for planting acid-loving plants such as blueberries, rhododendrons, astilbes and others	53% light peat; 21% dark peat; 21% bark; 5% composted chicken manure	~1.0	4 – 5
Rose and perrennial soil	Rölunda gård	69162	Heavily enriched with natural fertilizer and amended with sand and clay	26 % light peat; 26% dark peat; 21% bark; 21% composted chicken manure; 5% sand; lime; clay	2 – 3	5.5 – 6.5
Planting soil	Blomsterlandet	325690	Mineral-fertilized soil with a balanced nutrient content and added rock dust	Light peat; dark peat; bark; composted chicken manure; rockdust; lime	3 – 5	5.5 – 6.5
Garden lime	Rölunda gård	69961	Finely crushed Swedish garden lime containing dolomite	Lime	-	-