

Short Communication

Evaluating hot water immersion as a quarantine method: impact on *Obama nungara* egg capsule viability

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Globalization has intensified the spread of invasive species through human-mediated transport, particularly via horticultural trade through soil contamination of potted plants. The South American land planarian *Obama nungara* has become a widespread invasive soil-dwelling predator in Europe, preying mainly on earthworms and potentially disrupting soil processes. It reproduces rapidly and has likely relatively broad habitat requirements. In Sweden, the Environmental Protection Agency (EPA) recommends heat treatment as a preventive measure against this species. This study tested the hypothesis that a 15 minutes 40 °C water bath, as recommended by the Swedish EPA, is lethal to *O. nungara* egg capsules. Thirteen egg capsules were collected from six adult individuals. Every second capsule was subjected to heat treatment, while the remaining served as controls. None of the six heat-treated capsules hatched, whereas five of the seven untreated egg capsules hatched, each producing between five and seven hatchlings after approximately 24 days. These results demonstrate that the recommended heated water bath is effective not only against adults but also against *O. nungara* egg capsules. In addition, the study provides basic ecological information regarding the species' reproductive biology. Given the species' invasive potential and its capacity to spread via potted plants, these findings support the implementation of thermal quarantine treatments in nurseries and plant trade to prevent establishment and spread of this invasive flatworm in northern Europe.

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INTRODUCTION

Globalization has facilitated the spread of alien species worldwide, driven by human activities such as travel and trade, which have introduced numerous organisms to new regions (Early *et al.* 2016; Hulme 2021). Introduced species often negatively impact native ecosystems. Soil animals such as earthworms, snails, predatory flatworms and ants have increasingly been recognized as major invasive threats. These organisms can alter nutrient cycling, outcompete or prey upon native fauna and disrupt vegetation. Many invasions occur through human-mediated transport, particularly via soil contamination of potted plants, highlighting the need for effective quarantine measures.

The land planarian *Obama nungara* (Carbayo *et al.*, 2016) is native to South America, primarily the Atlantic Forest of Brazil and

Argentina (Boll & Leal-Zanchet 2016; Lago-Barcia *et al.* 2018). It has invaded several European countries, with introductions largely linked to human activity (Lago-Barcia *et al.* 2018; Justine *et al.* 2020; Negrete *et al.* 2020). Invasive populations have mainly been found in gardens, nurseries, greenhouses and occasionally in natural areas adjacent to human-modified habitats (Justine *et al.* 2020; Negrete *et al.* 2020). Genetic analyses indicate multiple independent introductions, often associated with the horticultural trade (Lago-Barcia *et al.*, 2018), especially through transportation of potted plants (Lago-Barcia *et al.* 2018; Negrete *et al.* 2020). The effect of local dispersal is likely minor, but may occur by slow crawling under moist conditions (Justine *et al.* 2020). This distributional pattern highlights that managing horticultural trade is likely key to prevent further spread of *O. nungara*.

O. nungara is carnivorous, preying mainly on earthworms but also consuming other soil macrofauna such as gastropods (Boll & Leal-Zanchet 2016; Roy *et al.* 2022). Gut-content metabarcoding confirms earthworms as the dominant prey in invaded ranges (Roy *et al.* 2022), but the species is likely a generalist predator, opportunistically using available food resources (Noël *et al.* 2025b), including different types of soft-bodied soil invertebrates, such as gastropods, annelids, and other land planarians (Boll & Leal-Zanchet 2016; Roy *et al.* 2022). The species is hermaphroditic and reproduces sexually, laying egg capsules (Lago-Barcia *et al.* 2018; Justine *et al.* 2020). Egg capsule production supports rapid local population buildup in favourable habitats (Noël *et al.* 2025a). Although detailed fecundity rates, generation times and survival under variable climates remain incompletely quantified, populations have been shown to reach high densities in gardens and nurseries (Noël *et al.* 2025a). Potential ecosystem-level impacts, as a result of earthworm predation, include reduced soil aeration and altered nutrient cycling, although long-term consequences in natural habitats are still uncertain.

The exact upper and lower thermal and desiccation tolerances are not fully quantified. Populations persist in temperate European climates, which indicates some thermal adaptability (Negrete *et al.* 2020). Hot water treatment has emerged as a promising method to mitigate invasions. Immersion of plants in hot water can kill different soil pests with minor effects on plant health. For example, another invasive flatworm, *Platydemus manokwari* (De Beauchamp, 1963), submerged for 5 minutes in 43 °C water showed a 100 % mortality rate (Sugiura 2008). Given the significant ecological impacts of invasive soil animals, such quarantine approaches may be crucial for protecting ecosystems and preventing further biological invasions.

The first Nordic observation of *O. nungara* was in Malmö, Sweden, in 2024 (Bouguerche *et al.* 2025; de Waart *et al.* 2025), and the Swedish Environmental Protection Agency since recommends heat treatment as a method to prevent its spread. Based on pilot testing on *O. nungara* adults in plant nurseries, the recommendation is to submerge the plant pot in a 40 °C water bath until the entire root ball reaches this temperature and keep it at this temperature for 15 min. This treatment is assumed to kill adult and juveniles (Sugiura 2008). The effect of heat treatment on flatworm egg capsules has not been evaluated, but I hypothesize that heat treatment indeed is effective against *O. nungara* egg capsules. Here, I report results from a laboratory experiment investigating a potential lethal effect of a 15 minutes 40 °C water bath.

METHODS

The experiment was carried out at Karlstad University, in a laboratory authorized by the Swedish Environmental Protection Agency to conduct research on *O. nungara* (Permit No: SE-IAS 25014). The

temperature in the climate-controlled room was held constant at 15 °C. Adult *O. nungara* (Figure 1) were provided by the plant nursery Hallbergs Plantskola (Nossebro, Sweden) and kept individually in 0.6 L plastic containers equipped with pieces of moist paper towels. The *O. nungara* were fed earthworms (*Dendrobaena veneta* Rosa, 1886) *ad libitum*. Terrestrial planarians are known to be able to store sperm and produce egg capsules also in isolation (Ducey *et al.* 2005; Noël *et al.* 2025b). Egg capsules used in this study ($n = 13$; Figure 1) were produced by six adult individuals between 15 August and 19 September 2025 (min = 1, max = 3 egg capsules per individual); containers were checked on weekdays and found egg capsules were collected and removed directly on sight and their diameters measured to the nearest mm.

Every second egg capsule found was submerged for 15 minutes in a 40 °C water bath directly on discovery, using a small aquarium fish net and a 500 mL glass beaker placed in a heating cabinet (i.e., the water temperature was maintained by thermostatic control). Either after heat treatment or directly on discovery (controls), egg capsules were placed in separate 50 mL Falcon tubes. The tubes were provided with a piece of moist paper towel and punctured lids to allow air into the tube. The tubes were kept in a 14 L holding box with a non-tight-fitting black plastic bag around the box to minimize light input. The egg capsules were checked every 1 – 3 days (on weekdays), and when hatchlings appeared (Figure 1) their number and the day were recorded. Since the plastic containers were checked for new egg capsules and Falcon tubes for hatchlings on weekdays only, the estimated incubation times may have been up to maximum ± 2 days from the true incubation times. An egg capsule laid on a Saturday (found on Monday) and hatched on a weekday would have an estimated incubation time 2 days shorter than the true time. Likewise, an egg capsule laid on a weekday and hatched on a Saturday would have an estimated incubation time 2 days longer than the true time. These potential errors, however, should not affect the mean value. The experiment was terminated on 14 October, observing intact, non-hatched egg capsules for at least 36 days. Non-hatched egg capsules at this time were assumed not to be viable. For egg capsules that hatched, we calculated incubation time (time from the observation of a new egg capsule to its hatching) and evaluated the effect of heat treatment on viability using a 2×2 Fisher's exact test.

RESULTS

The egg capsule maximum diameter ranged from 3 to 5 mm (mean $\pm$ SD = 4.2 ± 0.7 mm). Out of the seven untreated egg capsules, five capsules hatched, each producing between five and seven hatchlings (mean $\pm$ SD = 5.8 ± 0.8 ; Table 1). It took between 21 and 25 days from the discovery of a new egg capsule and its observed hatching (mean $\pm$ SD = 23.6 ± 1.7 days; Table 1). None of the six heat-treated egg capsules hatched (one-tailed Fisher's exact test, $n = 13$, $p = 0.01$;

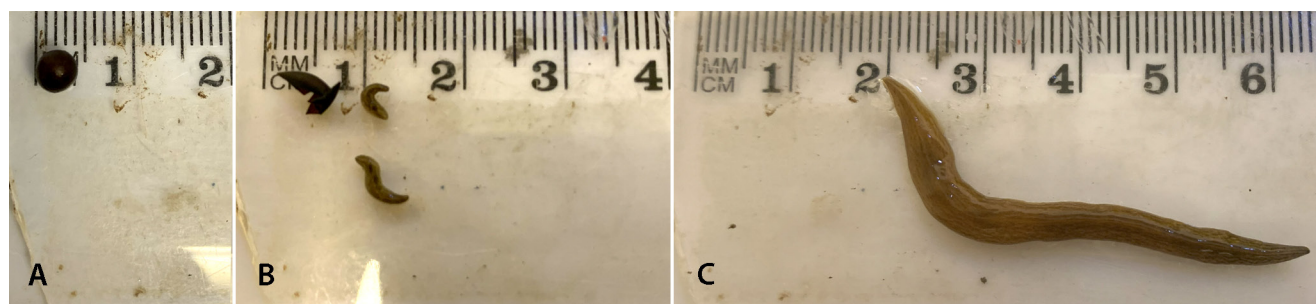


Figure 1. The invasive planarian *Obama nungara* at different life stages: egg capsule (A), newly hatched juveniles (B) and adult (C). Photo: Johan Watz.

Table 1), effectively demonstrating that the heat treatment was lethal. Most heat-treated egg capsules looked the same as the untreated ones during incubation, except one heat-treated egg capsule that burst after 13 days, releasing a whitish sludge.

Table 1. Results from a hot water immersion treatment (40 °C for 15 minutes) on *Obama nungara* egg capsule viability.

Capsule diameter (mm)	Treatment	Hatching outcome	Incubation time (days)	No. of hatchlings
4	Control	No	-	-
5	40 °C; 15 min	No	-	-
4	Control	Yes	25	5
4	40 °C; 15 min	No	-	-
5	Control	Yes	25	6
4	40 °C; 15 min	No	-	-
5	Control	No	-	-
3	40 °C; 15 min	No	-	-
3	Control	Yes	23	6
4	40 °C; 15 min	No	-	-
4	Control	Yes	21	5
5	40 °C; 15 min	No	-	-
4	Control	Yes	24	7

DISCUSSION

The results from the test of the heat-treatment protocol support the hypothesis that heat treatment is effective also against *O. nungara* egg capsules. In addition, the study provides basic ecological data regarding the species' life history, such as egg capsule incubation time (~ 24 days at 15 °C), number of hatchlings per egg capsule (5 – 7) and a rough estimate of interval between egg capsule laying (4 – 13 days). In a recent study on *O. nungara* by Noël *et al.* (2025b), the most fecund individual laid 10 egg capsules in one month (~ 1 every 4 days), a similar frequency as reported here. Moreover, Noël *et al.* (2025b) observed more hatchlings per egg capsule (mean = 9, min – max = 7 – 12) and the incubation time in their study was shorter (2 – 3 weeks) than the mean values reported in this study. Nevertheless, the maximum numbers of hatchlings per egg capsule (7) and minimum incubation time (21 days) overlaps with the values presented by Noël *et al.* (2025b). They used a temperature regime with 18 °C during the day and 14 °C at night; therefore the average temperature was 1 °C higher in their study, which may partly explain the discrepancies, because the developmental rate in Geoplanidae is likely temperature dependent (McDonald & Jones 2014). Differences in prey food source may also play a role, and different haplotypes connected to different invasion occasions (Justine *et al.* 2020; Bouguerche *et al.* 2025) also potentially result in variation in some life history parameters.

O. nungara is spreading rapidly over Europe and has potentially not yet reached its northern distribution limit (Fourcade 2021), and a scenario with rapid and extensive spread in the Nordic countries is possible (*sensu* the case of the Spanish slug *Arion vulgaris* Moquin-Tandon, 1855, a severe pest species using similar vectors for dispersal; Hatteland *et al.* 2013), with detrimental effects on the native fauna and soil-related ecosystem services. *O. nungara* was found in a park in Malmö, Sweden, in November 2024 (Bouguerche *et al.*, 2025), and

was subjected to emergency measures by the Swedish government (under Section 11, Ordinance 2018:1939 on Invasive Alien Species). This meant that the operators in the plant trade was required to carry out measures targeting the species, such as inspections, cleaning, and heat treatment. To prevent further spread, effective quarantine measures targeting its vectors need to be developed and evaluated. Acknowledging potential limitations of plant tolerance, soil volume, and upscaling, the present study provides evidence that a 15 minutes 40 °C water bath, recommended by the Swedish Environmental Protection Agency, effectively kills off potential egg capsules hidden in root balls of potted plants.

Declaration of Generative AI and AI-assisted technologies

Elicit was used to search for scientific publications on *O. nungara*, and chatGPT was used to check grammar and improve readability.

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