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ORIGINAL ARTICLE

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First record of the lobster cockroach *Nauphoeta cinerea* (Olivier, 1789) (Insecta: Blattodea) in Europe with remarks on synanthropic cockroaches of the Iberian Peninsula

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Abstract

Globalization has facilitated the introduction and establishment of organisms beyond their natural ranges, leading to significant ecological and economic consequences. While many non-native species are well documented, others remain understudied, either due to their unknown impact or morphological similarities with native species. This study addresses such a case, focusing on synanthropic cockroaches within the order Blattodea. Despite the order's diversity, less than 1% of known species are recorded in urban environments. While certain species like *Periplaneta americana*, *Blatta orientalis* and *Blattella germanica* are well distributed and studied, others remain largely unknown. This research unveils the first established population of *Nauphoeta cinerea* in Europe, specifically in Spain (Asturias, northern Iberian Peninsula), with specific genetic and morphological confirmation. This study also explores potential pathways of introduction for *N. cinerea*. Long-distance transport by ships or escape/release from captivity are proposed as potential pathways for the newly established populations in Asturias. The species' high fecundity and parthenogenetic reproduction raise concerns about its potential invasiveness. Additionally, this study includes unpublished data on various synanthropic cockroaches in Asturias (with the first records of *P. lateralis* and *Supella longipalpa* for this area), drawn from specimens deposited in biological collections and some extra collections. An identification key for all Spanish non-native synanthropic cockroach species is provided to assist in future detections. This research emphasizes the imperative need for robust monitoring systems, highlights the scarcity of scientific information regarding synanthropic cockroach distribution and underscores the pivotal role of biological collections in advancing our understanding of invasive species.

KEYWORDS
biological collections, non-native species, *Periplaneta lateralis*, *Supella longipalpa*, urban pests

1 | INTRODUCTION

Modern globalization is increasing the arrival and dispersal of alien species brought about by cross-border trade in goods, services, technology and flows of people (Hulme, 2009; Turbelin et al., 2022). Human-mediated invasions have been broadly reported worldwide, focusing the research on the most common introduction pathways of exotic species, such as horticulture and agriculture, pet trade, ships ballast water or stowaway transport (Faulkner et al., 2020; Pergl et al., 2017; Turbelin et al., 2022). Some alien species can become invasive and cause significant economic (Kourantidou et al., 2021; Pimentel et al., 2005) and ecological damage (Kumschick et al., 2015). However, despite of the increasingly common attention given to biological invasions, some exotic species can go unnoticed for years (Hiller & Haelewaters, 2019; Miglietta & Lessios, 2009). This may be explained by different reasons, including the lack of visibility of the alien species, the unrecognized impact in the new habitat and the difficulty of differentiating introduced species from similar native ones (Huey et al., 2000; Miglietta & Lessios, 2009). Moreover, certain alien species have gone unreported since their presence dates back several centuries or are difficult to detect, as in the case of some cockroaches (Rehn, 1945; Tang et al., 2019).

The order Blattodea (excluding termites) includes more than 4600 species distributed worldwide (Beccaloni, 2024). However, only less than 1% has been recorded in urban environments (Bell et al., 2007). Although there are some cases in which cockroaches can have medical importance (Kramer & Brenner, 2009), they are mostly considered nuisance and synanthropic pests (Bell et al., 2007). Of these, *Periplaneta americana* L., *Blattella germanica* L. and *Blatta orientalis* L. are the most widely distributed species and are common urban pests (Fakoorziba et al., 2010; Smith et al., 2024; Tang et al., 2019). However, other less common synanthropic cockroaches are also reported in different regions. For example, in the Iberian Peninsula, *Supella longipalpa* (Fabricius) (Pradera & Alexander González, 2023), *P. australasiae* (Fabricius) (Bueno Marí et al., 2018) and *P. lateralis* (Walker) (Pradera et al., 2023) have also established in urban environments. Furthermore, animal trade for live pet food and plants has made it possible to record the cockroach species *Pycnoscelus surinamensis* (L.) (Pradera & Carcereny, 2018), *Panchlora nivea* L., or *Blaptica dubia* Serville (Miralles-Núñez et al., 2020) without proving their establishment. However, many of the discoveries are recent, and it is expected that these same species could expand their ranges in the future.

The lobster cockroach, speckled cockroach, or (small) cinereous cockroach, *Nauphoeta cinerea* (Olivier, 1789), is the sole species in its genus, and its common name 'lobster cockroach' refers to its pronotal pattern, which vaguely resembles a lobster. This species is native to north-eastern tropical Africa. However, it has widely spread through commerce to other warm countries around the world, achieving a distribution that includes several regions of the North and South of America, other African regions (e.g., Madagascar) and mainly eastern insular Asia and Australia (Gurney & Fisk, 1991; Rehn, 1945). In their non-native areas, the lobster cockroach has been considered a pest affecting food warehouses and grain-milling plants (Gurney & Fisk, 1991).

Nauphoeta cinerea's historical distribution has not been reassessed in recent times, and therefore, its actual distribution and the potential new areas of invasion remain unknown. Here, we provide the first record of an established population of *N. cinerea* in Europe, with a genetic and morphological characterization of the specimens found. Also, we present brief notes on its reproductive biology and ecology at the new locations and discuss the most plausible introduction pathways and their potential impacts. Finally, we provide insights and a new identification key for the non-native cockroaches of the Iberian Peninsula in order to facilitate future identifications and early species detection.

2 | MATERIALS AND METHODS

2.1 | Specimen collection and morphological analysis

A total of 149 specimens *of Nauphoeta cinerea* were collected between 2022 and 2023 in different locations of Asturias (Spain), northern Iberian Peninsula (Figure 1a). Specimens were captured by sticky commercial traps (Figure 1b) in several urban areas (Figure 1c,d). All specimens were fixed and stored in 70% ethanol. Most specimens are deposited in the collection of the Department of Organisms and System (BOS) of the University of Oviedo (https://bos.uniovi.es/) except for some specimens used for the photographs that are deposited in the second and thirds authors' personal collection (AC). Specimens were examined under a dissecting stereomicroscope Optika SZM-2 (0.7–4.5X) to study their morphology. Photographs were taken with a Canon EOS 1200D Digital SLR Camera with EF-S 18–55 mm f/3.5–5.6 III lens.

2.2 | Genetic analysis

DNA was extracted from 20 to 50 mg of ethanol-preserved tissues from the leg pieces of two studied specimens, using E.Z.N.A Tissue DNA Kit (Omega Bio-tek) and following the manufacturer's protocol. DNA samples were stored at −20°C. The mitochondrial cytochrome c-oxidase subunit I (COI) gene was amplified by polymerase chain reaction (PCR) in a total volume of 40 μL using the universal primers LCO1490 and HCO2198 (Folmer et al., 1994). The reaction mixture contained 2.5 μL template DNA, 2.5 μL of 25 mM $MgCl_2$, 4 μL of 2.5 mM dNTPs, 1 μL of 10 μM primers, 0.15 μL Taq polymerase (GoTaq® G2 Flexi DNA Polymerase 5 U/μL) and 8 μL of 5× Buffer GoTaq® Promega (1× final concentration). The PCR conditions used were an initial denaturation step of 95°C for 4 min, then 35 cycles of 95°C for 45 s, 48°C for 45 s, 72°C for 30 s and finally an extension of 72°C for 7 min. The PCR product was checked in a horizontal electrophoresis (2% agarose gel). Finally, the samples were sent for forward and reverse sequencing to MACROGEN (Madrid, Spain) using

FIGURE 1 (a) Geographical situation of the Principality of Asturias (red) in Europe. (b) A commercial sticky trap used during sampling. Habitats where *Nauphoeta cinerea* was found were (c) the garbage containers located in the surroundings of the Milan University campus of Oviedo and (d) the garbage containers of Arbeyal beach Parking located near El Musel port in Gijón.

the standard Sanger sequencing method (Sanger & Coulson, 1975). The forward and reverse sequences obtained by Sanger sequencing were edited using Geneious Prime 2022.2.2 (https://www.geneious.com) for quality trimming and primer removal. Then they were manually aligned to correct any possible wrong base calling. After alignment and corrections, a consensus sequence was generated with the default parameters. The genetic species identification was attempted using nBlast implemented in Geneious Prime using the default values to search in GenBank databases.

2.3 | Other data of introduced cockroaches on the Iberian Peninsula

Introduced synanthropic cockroach material deposited in the BOS Collection was also examined. In the 'Material Examined' sections of the provided species checklist, all localities with collection data and additional information are fully listed. All specimens were identified to the species level, aiming to provide additional data on the potential expansion of this type of insect in the study area. Additional records from recent samplings were also included. The morphological study and the photographs were carried out with the same previously mentioned equipment, except for those photos kindly provided by collaborators. These and other additional materials were used for creating the identification key for the non-native synanthropic cockroaches of the Iberian Peninsula. For this purpose, several references were used as a baseline (Choate et al., 2008; Gurney & Fisk, 1991; Luna et al., 2021; Olivier, 1789; Pratt & Stojanovich, 1966). Maps were generated with ArcGis ArcMap 10.6. For those records from material from collections without coordinates, an approximation based on the 'locality' was used. For examined material, abbreviations are as follows: AC = Author's collection (Asturias/Cádiz, Spain), BOS = Department of Organisms and System (University of Oviedo, Asturias, Spain), *ex* = specimen, *deposit* = collection of deposit and *leg* = collector.

3 | RESULTS

Phylum **Arthropoda** von Siebold, 1848
Class **Insecta** Linnaeus, 1758
Order **Blattodea** Wattenwyl, 1882
Superfamily **Blaberoidea** Saussure, 1864
Family **Blaberidae** Saussure, 1864
Genus ***Nauphoeta*** Burmeister, 1838
Nauphoeta cinerea (Olivier, 1789)

Synonyms. *Blatta cinerea* Olivier, 1789; *Blatta elegans* Eschscholtz, 1822; *Blatta gallica* Fabricius, 1793; *Nauphoeta bivittata* Burmeister, 1838; *Nauphoeta grisea* Burmeister, 1838.

Material examined. SPAIN: **Asturias,** Gijón, Arbeyal beach near El Musel port (Figure 1d): 32 adults and 35 juveniles (A. Arias *leg*. and BOS and AC *deposit*.), 22-VII-2022 (30T 282234 4824768); 8 adults and 13 juveniles (A. Arias *leg*. and BOS *deposit*.), 14-VI-2022 (30T 282234 4824768); Gijón, Poniente beach parking: 3 adults (A. Arias *leg*. and BOS *deposit*.), 16-IX-2022, (30T 284323 4824465); Gijón, Cimadevilla: 7 adults (A. Arias *leg*. and BOS *deposit*.), 16-IX-2022, (30T 285017 4824900); Oviedo, surroundings of the Milán University Campus of Oviedo (Figure 1c): 5 adults and 23 juveniles (A. Arias *leg*. and BOS *deposit*.), 29-III-2023, (30T 269554 4805522).

Brief description. Body relatively broad, medium-sized cockroach with about 30 mm in length (or less). Mottled brown-greyish in

colour (Figure 2a,b). Pronotum pale with a complex central pattern of irregular brown blotches bordered on each side by a longitudinal black band (Figure 2c); posterior margin of pronotum not angulate, only somewhat broadly protruding. Alate at maturity, wings not exceeding the abdomen (Figure 2a,b).

Remarks. Studied adult specimens ($n = 53$) were 27.75 ± 2.05 mm height and 10.24 ± 0.82 mm width (mean ± SD; Figure 2a,b). Studied juvenile specimens at different growth stages ($n = 45$) were 6.95 ± 4.52 mm height and 3.30 ± 1.83 mm width (Figure 2d,e). All studied adult specimens were females, so it is assumed that it is a parthenogenetic population. Seven of them were found carrying brood sacs (oothecas) with 25 ± 5 eggs on each (Figure 2f). This species is quite unmistakable due to its mottled brown-greyish colouration with dark and brown patterns and both sexes have wings without exceeding the abdomen (Figure 2a–c).

Habitat. All specimens were found in urban environments, primarily near or inside garbage containers in areas with high human and goods traffic in Asturias (Figure 3). In the town of Gijón, *N. cinerea* was registered in containers at the beachfront, near the Musel Port, as well as in those of a car parking area (Figure 1d). In Oviedo, the specimens were located in underground garbage containers near the town centre (Figure 1c).

3.1 | Genetic results

The Blast identification engine identified the two identical sequences of the specimens (Genbank Accessions Numbers: PP236019 and PP236020) as *Nauphoeta cinerea* with 100% to 99.8% of pairwise identity with seven sequences (KF372547, NC_035052 and MT861035-MT861038; Table 1). The remaining hits were with the species *Henschoutedenia* sp., *Pseudophoraspis clavellata* and *Rhabdoblatta ecarinata* with a similarity of only 87.8% or below (Table 1). The Blast identification procedure revealed 100% similarity with one sequence (NC_035052) identified as *N. cinerea*, which was obtained from a Brazilian enterprise that sells *N. cinerea* specimens for reptile feeding, so no precise location on which the original specimens were collected is available. Furthermore, our two sequences analysed were found to be genetically identical, constituting the same haplotype.

3.2 | Annotated checklist of synanthropic cockroaches of the Iberian Peninsula

We have identified a total of nine non-native synanthropic species reported in the Iberian Peninsula, and with the inclusion of *N. cinerea*, the overall count rises to ten. However, only six species, including *N. cinerea*, are considered as established, while the remaining ones are referred to as sporadic records. Furthermore, we have alluded to an additional species not officially reported, emphasizing the need to meticulously examine the preserved material of the biological collections due to the potential for historical misidentifications.

3.2.1 | Established cockroaches

Family **Blattidae** Latreille, 1810
Genus ***Periplaneta*** Burmeister, 1838
Periplaneta americana L. 1758

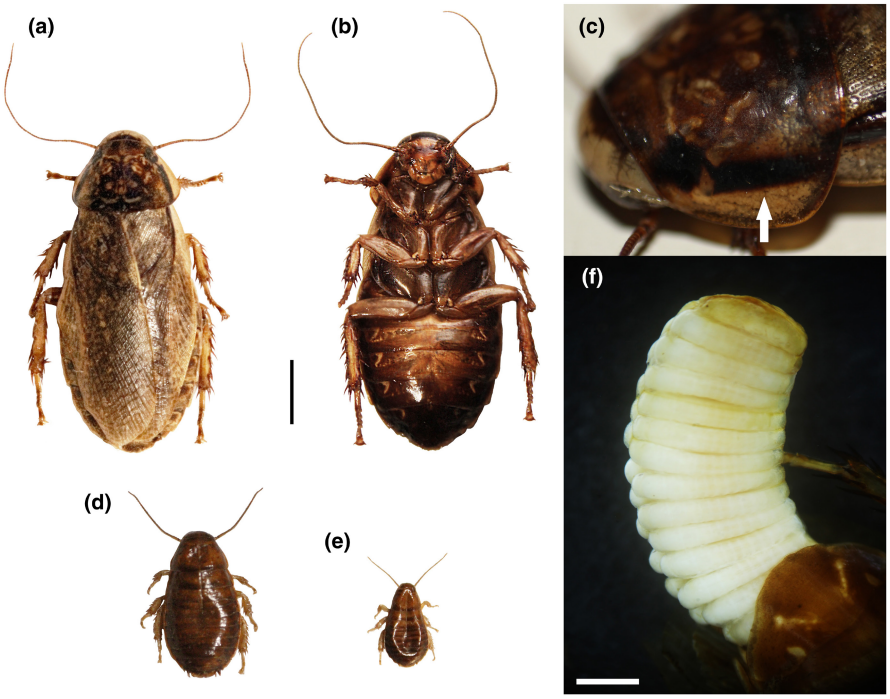

FIGURE 2 *Nauphoeta cinerea* specimens trapped in Asturias. (a) Dorsal and (b) ventral view of an adult with detail of pronotum (c). (d, e) Different immature stages. (f) Detail of an extruded brood sac with numerous eggs. Scale bars: (a, b) 5 mm, (d, e) 2 mm.

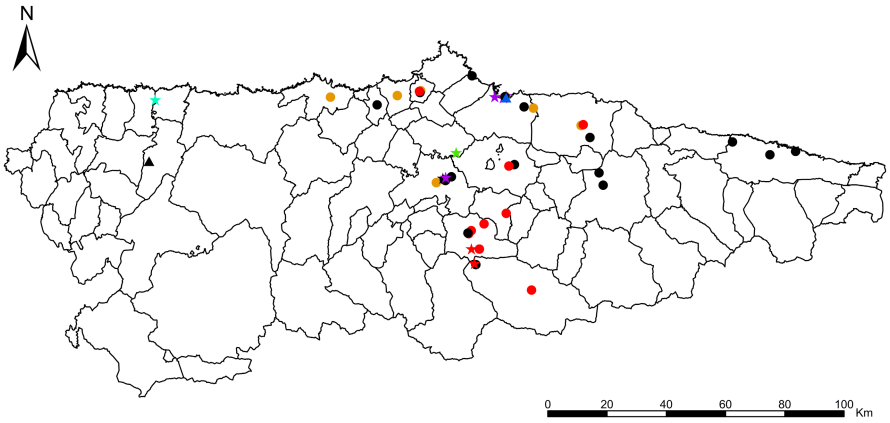

FIGURE 3 Records of non-native synanthropic cockroaches in Asturias (Spain, northern Iberian Peninsula). (●) records from biological collections, (▲) bibliographic records and (★) records from our new samplings. *Periplaneta americana* (red), *P. australasiae* (blue), *P. lateralis* (green), *Blattella germanica* (orange), *Blatta orientalis* (black), *Supella longipalpa* (turquoise) and *Nauphoeta cinerea* (purple).

TABLE 1 Better hits of BLAST for the identical assembly sequences by accession number.

Accession	% pairwise identity	Query coverage	Organism
NC_035052	100	100	*Nauphoeta cinerea*
LC793875	99.9	100	*N. cinerea*
MT861038	99.8	100	*N. cinerea*
MT861037	99.8	100	*N. cinerea*
MT861036	99.8	100	*N. cinerea*
MT861035	99.8	100	*N. cinerea*
MT861034	99.8	100	*N. cinerea*
KF372526	99.8	100	*N. cinerea*
KF372521	87.8	98.22	*Henschoutedenia* sp.
OQ736949	85.8	100	*Pseudophoraspis clavellata*
MH755948	85.8	100	*P. clavellata*
MH755946	85.8	100	*P. clavellata*
MH755945	85.6	100	*P. clavellata*
MH755947	85.3	100	*P. clavellata*
MH755944	85.3	100	*P. clavellata*
OQ736962	85.3	100	*Rhabdoblatta ecarinata*
MK547358	85.3	100	*R. ecarinata*
MK547357	85.3	100	*R. ecarinata*
MK547355	85.2	99.68	*R. ecarinata*
MK547353	85.2	99.68	*R. ecarinata*

The red or American cockroach (Figures 4 and 5b,d) is hypothesized to be native to the tropical regions of Africa, although it has now become one of the cockroaches with the widest global distribution (Beccaloni, 2024; Bell & Adiyodi, 1982). In the Iberian Peninsula, it has been established for a long time, making it very difficult to determine its real temporal origin. It is a species widely distributed throughout most of the Mediterranean Iberian region (Bueno-Marí et al., 2013), being somewhat less common in the northern region. Due to its historical introduction, most references focus on the control of this species rather than its actual range and current distribution. Here we provided additional records for Asturias from biological collections (Figure 3). Notably, most of them came from mines, and the rest came from urban areas.

It is important to note that the brown cockroach *Periplaneta brunnea* Burmeister, 1838 (Figures 4b and 5a,c) is externally quite similar to *P. americana*. This species is also hypothesized to be native to tropical Africa and also spread to the circumtropical area (Beccaloni, 2024). It has been recorded in the Canary Islands (Gangwere et al., 1972), but not in the Iberian Peninsula, so this species could be occurring in continental Spain, passing unnoticed, or could arrive in the forthcoming future. A re-examination of the previously identified *Periplaneta* specimens so far as *P. americana* needs to be done to confirm the absence of misidentification errors. Therefore, we have decided to include *P. brunnea* in the key (Figure 4b) to aid in future identifications and to remark its main diagnostic characters (Figure 5).

Material examined. SPAIN: Asturias: Gijón: 1 *ex*. (JM Álvarez-Castro *leg*. and BOS *deposit*.), summer-1997; Siero: Pola de Siero: 1 *ex*. (J. Fernández-Álvarez *leg*. and BOS *deposit*.), without date, in a square; Aller: Pozo Santiago: 1 *ex*. (F. Alonso *leg*. and BOS *deposit*.),

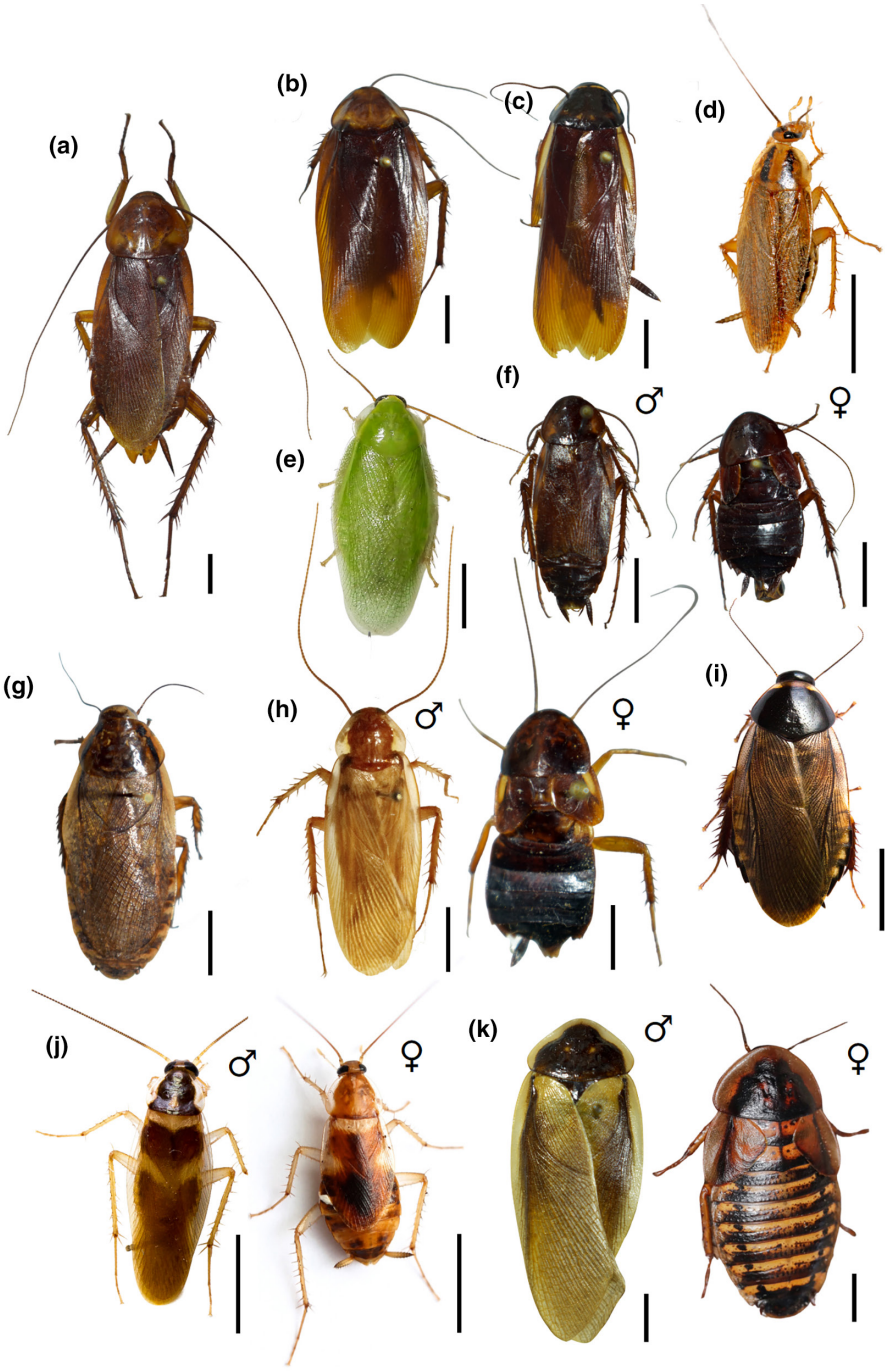

FIGURE 4 Adult specimens of the invasive and introduced cockroaches of the Iberian Peninsula. In species with marked sexual dimorphism, both sexes are represented. (a) *Periplaneta americana*. (b) *P. brunnea*. (c) *P. australasiae*. (d) *Blattella germanica*. (e) *Panchlora nivea*. (f) *Blatta orientalis* (left male, right female). (g) *Nauphoeta cinerea* (specimens from Gijón (Asturias)) (h) *Periplaneta lateralis* (left male from Polígono Industrial Silvota (Asturias), right female). (i) *Pycnoscelus surinamensis*. (j) *Supella longipalpa* (left male, right female). (k) *Blaptica dubia* (left male, right female). [Photos by: (e) Francisco 'Paco' Farriols; (i, j) Brandon Woo; (k) Arturo Iglesias; Rest: From the authors of this work)]. Scale bars: 1 cm.

19-X-2010, in a mine; 3 *ex*. (A. and V. González-García *leg*. and AC *deposit*.), 19-X-2019, in a coal-mining pot; Mieres: Ballesana mine: 1 *ex*. (without *leg*. data and BOS *deposit*.), 1979, in a mine; Mieres: Pozo Barredo: 3 *ex*. (ME Martínez-Felgeroso *leg*. and BOS *deposit*.), 1-XII-1987, in a mine; Mieres: Pozo Barredo: 1 *ex*. (ME Martínez-Felgeroso *leg*. and BOS *deposit*.), 1-XII-2008, in a mine; Mieres: Pozo Barredo: 1 *ex*. (LE Barredo *leg*. and BOS *deposit*.), V-1988, in a mine; Mieres: Pozo Barredo: 1 *ex*. (M. Brañez *leg*. and BOS *deposit*.), without date, in a mine; Mieres: Turón: 1 *ex*. (M. López *leg*. and BOS *deposit*.), 5-XI-2001, in debris; Mieres: Turón: 1 *ex*. (B. Fernández-Perera *leg*. and BOS *deposit*.), 15-XII-2001; Mieres: Turón: Pozo Figaredo: 1 *ex*. (J. Robla *leg*. and AC *deposit*.), 2-VIII-2022, in a coal-mining pot; Morcín: Pozo Monsacro: 1 *ex*. (N. González-Fernández *leg*. and BOS *deposit*.), 18-X-2008, in a mine; Morcín: Pozo Monsacro: 2 *ex*. (Á. Maseda *leg*. and BOS *deposit*.), 18-X-2008, in a mine; Mine: Entrerríos: Pozo Tres Amigos: 1 *ex*. (C. Fernández-Martín *leg*. and BOS *deposit*.), 16-V-1997; Villaviciosa: Argüero: 1 *ex*. (I. Fernández *leg*. and BOS *deposit*.), 15-X-2009.

Periplaneta australasiae Fabricius, 1775

The Australian cockroach (Figure 4c) is an African species that has been recorded in synanthropic environments outside its native range due to the trade (Rehn, 1945). In the Iberian Peninsula, several

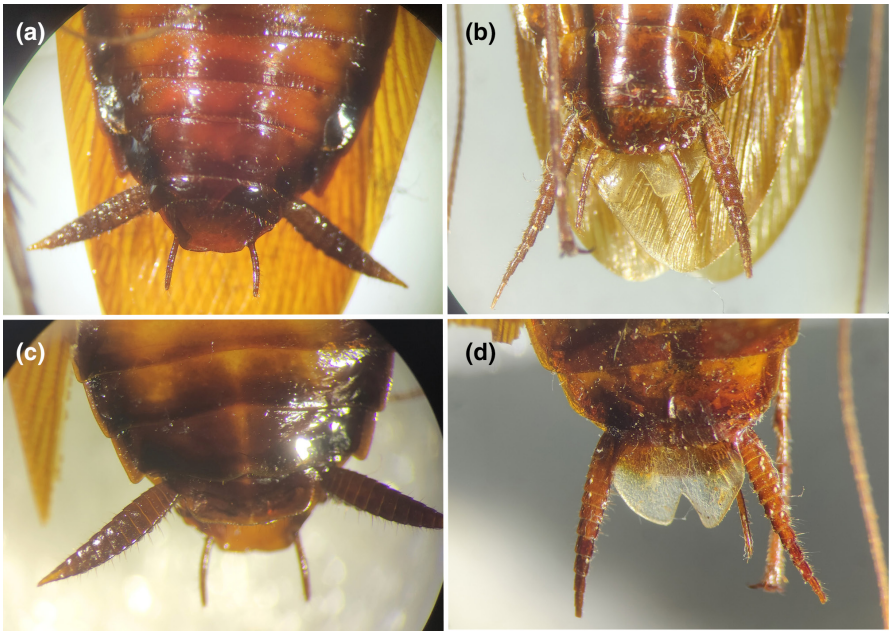

FIGURE 5 Comparison between male specimens of *Periplaneta brunnea* and *P. americana*. Ventral view of (a) *P. brunnea* and (b) *P. americana*, and dorsal view of (c) *P. brunnea* and (d) *P. americana*.

confirmed records exist in Aragón, Madrid, Guipúzcoa, Granada, Salamanca, Málaga and Asturias (Bueno Marí et al., 2018; Pradera & Vega-Martínez, 2023; Pradera et al., 2024). The location of the only known Asturian population is shown in Figure 3 and came from a supermarket store in Gijón.

Periplaneta lateralis (Walker, 1868)

The Turkestan cockroach (=*Shelfordella lateralis* (Walker, 1868); Figure 4h) originates from desert areas in Africa, the Middle East and Central Asia (Beccaloni, 2024). Nevertheless, it has been reported in various countries outside its native range (Pradera et al., 2023). In the Iberian Peninsula, it has been recorded in the Spanish provinces of Almería (Pradera & Carcereny, 2018), Barcelona (Miralles-Núñez et al., 2020), Madrid (Bernal & Viejo, 2023) and Valencia (Pradera et al., 2023). Here we provide the first record of this species in Asturias (extending its distribution on the Iberian Peninsula to the temperate northern areas of Spain; Figure 3). Our specimens were located in an industrial park with a great traffic of goods, people and vehicles from different parts of Spain.

Material examined. SPAIN: Asturias: Siero: Polígono Industrial Silvota: 8 *ex*. males and numerous oothecae (A. Arias *leg*. and BOS *deposit*.), 10-IX-2022 (30T 272475 4811782).

Genus ***Blatta*** L. 1758

Blatta orientalis L. 1758

The origin of the black cockroach (Figure 4f) is unclear, with some authors claiming that it is a North African species, while others say that it originated in the Middle East (Alexander et al., 1991). However, it has also spread worldwide through human activities since the 17th century (Alexander et al., 1991). As with *P. americana*, there is little published information about its distribution on the Iberian Peninsula. Remarkably, some records came from indirect samplings (i.e., Sánchez & Arias, 2021). However, it is presumed to occupy the entire territory. Here we provide additional records for Asturias from biological collections and extra samplings (Figure 3), mostly occurring in urban areas.

Material examined. SPAIN: Asturias: Avilés: 1 *ex*. (R. Rosa *leg*. and BOS *deposit*.), 20-VIII-1997; Avilés: 1 *ex*. (ME Suárez-González *leg*. and BOS *deposit*.), 14-III-2005; Oviedo: 1 *ex*. (P. Cuartas *leg*. and BOS *deposit*.), IV-1986, in a house; Oviedo: 1 *ex*. (without *leg*. data and BOS *deposit*.), 4-VI-1905, in a house; Oviedo: Brooklyn cinema: 1 *ex*. (JM Santa-Eufemia *leg*. and BOS *deposit*.), 8-II-1987; Oviedo: 1 *ex*. (H. Rodríguez-Gutiérrez *leg*. and BOS *deposit*.), 13-IX-1996; Oviedo: 1 *ex*. (C. Aramburu *leg*. and BOS *deposit*.), 14-II-1998; Oviedo: 1 *ex*. (A. Ugalde *leg*. and BOS *deposit*.), 5-V-1988; Oviedo: 1 *ex*. (M. Manzaneque *leg*. and BOS *deposit*.), 13-VI-1993; Oviedo: 1 *ex*. (M. Sélymes *leg*. and BOS *deposit*.), 3-II-1994; Oviedo: 1 *ex*. (R. Martínez *leg*. and BOS *deposit*.), 7-X-1986; Oviedo: Ventanielles: 1 *ex*. (L. Melero *leg*. and BOS *deposit*.), 12-VI-1997; Oviedo: Uría Street: 1 *ex*. (J. Robla *leg*. and AC *deposit*.), 30-VII-2020); Gijón: Cabueñes: 1 *ex*. (JLL Castaño *leg*. and BOS *deposit*.), VII-1997; Gijón: 1 *ex*. (A. García-Parede *leg*. and BOS *deposit*.), IV-1996; Gijón: 2 *ex*. (E. Díaz *leg*. and BOS *deposit*.), 16-V-1996; Gijón: 1 *ex*. (E. Díaz *leg*. and BOS *deposit*.), 29-IV-1996; Gijón: 1 *ex*. (JR Pis-Millán *leg*. and BOS *deposit*.), 18-VI-1988, in a coal container; Gijón: Jardines de la Reina: 1 *ex*. (AI Izquierda *leg*. and BOS *deposit*.), VI-1987; Gijón: Colegiata: 1 *ex*. (MJ Lara-Santos *leg*. and BOS *deposit*.), 19-IX-1987; Candás: 1 *ex*. (L. González *leg*. and BOS *deposit*.), 12-XII-1992; Llanes: Llames de Pria: 1 *ex*. (I. Vigil-Morán *leg*. and BOS *deposit*.), 1-XI-2002; Llanes: Lledias: 1 *ex*. (MJ Llera *leg*. and BOS *deposit*.), 13-IV-1998; Llanes: Póo: 1 *ex*. (MJ Ruiz *leg*. and BOS *deposit*.), 10-V-1980; Siero: Lieres: 1 *ex*. (A. Toraño *leg*. and BOS *deposit*.), 10-XI-2002; Siero: Pola de Siero: 1 *ex*. (A. Palacios-González *leg*. and BOS *deposit*.), 1-VI-1987; Piloña: Lodeña: 1 *ex*. (PA Roibás *leg*. and

BOS *deposit*.), 6-VI-1987; Piloña: Senares: 1 *ex*. (R Lieda-Traniesa *leg*. and BOS *deposit*.), 3-XII-2002, in a bakery; Villaviciosa: Coro llagar: 1 *ex*. (R. Olalla *leg*. and BOS *deposit*.), 20-IX-1997, in a bar; Soto del Barco: 1 *ex*. (Rebeca G. *leg*. and BOS *deposit*.), 4-VII-2008; Mieres: Pozo Barredo: 2 *ex*. (ME Martínez-Felgeroso *leg*. and BOS *deposit*.), 1-XII-1987, in a coal-mining pit.

Family **Blattellidae** Chopard, 1951
Genus ***Blattella*** L. 1758
Blattella germanica L. 1767

The German cockroach (Figure 4d) is another of the three most widely distributed and considered worldwide pest cockroaches. Its native origin was uncertain, although recently some authors have confirmed an Asian one (Tang et al., 2019, 2024). This species is more associated with food pests and also has a wide distribution in the Mediterranean region of the Iberian Peninsula, although the available information about it is very fragmented. However, this species is also assumed to be present on the whole Iberian Peninsula. Here we provided additional records for Asturias from biological collections (Figure 3), mostly from different buildings. It is important to note that some other *Blattella* species with great resemblance to *B. germanica*, like *B. vaga* Hebard, 1935 and *B. asahinai* Mizukubo, 1981, are also considered peridomestic pests and have been introduced to other locations outside their natural range across eastern Asia and north America (Beccaloni, 2024; Jeon et al., 2018; Snoddy & Appel, 2008), so their future detection in the Iberian Peninsula cannot be ruled out.

Material examined. SPAIN: Asturias: Avilés: 1 *ex*. (P. Menéndez *leg*. and BOS *deposit*), 12-VII-1997; Castrillón: Braña: 1 *ex*. (P. García *leg*. and BOS *deposit*.), 15-VIII-1997; Oviedo: Colegio Mayor América: 1 *ex*. (J. Zalana *leg*. and BOS *deposit*.), 25-V-1992; Oviedo: 1 *ex*. (A. Laguna B. *leg*. and BOS *deposit*.), 11-XII-2009; Oviedo: Facultad de Biología: 1 *ex*. (JL González-Vecino *leg*. and BOS *deposit*.), 10-III-1996; Gijón: Colegio (CEI) Cabueñes: 1 *ex*. (R. Pardo-Blanco *leg*. and BOS *deposit*.), 15-V-1987; Gijón: 1 *ex*. (J. Vázquez *leg*. and BOS *deposit*.), 27-XI-2002; Gijón: 1 *ex*. (M.A. Graña *leg*. and BOS *deposit*.), III-1996; Gijón: 1 *ex*. (A. Rubiera-Fueyo *leg*. and BOS *deposit*.), 15-III-2005; Gijón: 1 *ex*. (MJ Suárez-Vallejo *leg*. and BOS *deposit*.), 22-V-1987, in a boiler; Gijón: 1 *ex*. (L. Gutiérrez *leg*. and BOS *deposit*.), V-1998; Gijón: 1 *ex*. (RM García *leg*. and BOS *deposit*.), 13-II-1988; Gijón: Llorea: 1 *ex*. (V. X. Melero *leg*. and BOS *deposit*.), 30-IX-1997; Cudillero: 1 *ex*. (without *leg*. data and BOS *deposit*.), 20-IV-1998; Villaviciosa: 1 *ex*. (G. Alonso *leg*. and BOS *deposit*.), 15-VII-1995.

Family **Pseudophyllodromiidae** Hebard, 1929
Genus ***Supella*** Shelford, 1911
Supella longipalpa Fabricius, 1798

The brown-banded cockroach (Figure 4j) is another cockroach that has adapted well to human structures alongside *B. germanica* (Bell et al., 2007). Its origin could be Africa (Beccaloni, 2024; Nasirian, 2016; Tsai & Chi, 2007), although it has now spread to several parts of the world, making it challenging to trace its history. In the Iberian Peninsula, there are records from Barcelona, Madrid and Seville (Gangwere & Morales Agacino, 1970; García de Viedma, 1969; Pradera & Alexander González, 2023), as well as in the Balearic Islands (Pradera & Alexander González, 2023). Here we provided the first record of this species in Asturias, expanding its distribution to the northern Iberian Peninsula (Figure 3). Two juvenile specimens were located in an urban car park in the centre of a coastal village.

Material examined. **SPAIN**: Asturias: Navia: car parking close to Navia estuary: 2 *ex*. juveniles (A. Arias *leg*. and BOS *deposit*.), 13-IV-2024 (29T 683820 4823021).

3.2.2 | Non-established and accidental cockroaches

Family **Blaberidae** Saussure, 1864
Genus ***Pycnoscelus*** Scudder, 1862
Pycnoscelus surinamensis (L.) 1758

The Surinam cockroach (Figure 4i) is a parthenogenetic species (Roth, 1967) native to the Indomalayan region (Beccaloni, 2024) that has spread to many tropical regions worldwide. It is commonly found in greenhouses and is associated with plant and pot traffic. In the Iberian Peninsula, there is only evidence of specimens found in pots in the province of Barcelona (Pradera & Carcereny, 2018). Since then, it has not been reported again. Its establishment outside areas with more tropical microenvironmental conditions could be unlikely, and more information is necessary to determine whether this species is established in greenhouses on the Iberian Peninsula.

Genus ***Panchlora*** Burmeister, 1838
Panchlora nivea (L.) 1758

The Cuban cockroach or green banana cockroach (Figure 4e) is a species commonly used for captive breeding, originating from tropical and subtropical regions of Cuba, the Caribbean and the southern USA. Escapes have been detected in the Iberian Peninsula, but without confirmation of their current establishment (Miralles-Núñez et al., 2020).

Genus ***Blaptica*** Stål, 1878
Blaptica dubia Serville, 1838

The Dubia cockroach (Figure 4k) is a cockroach species native to South America. However, it has been historically used as live food for reptiles and other animals, leading to reported escapes in other regions of the world. Its establishment has not yet been confirmed in the Iberian Peninsula (Miralles-Núñez et al., 2020).

3.3 | Identification key for introduced synanthropic cockroach species in the Iberian Peninsula

1. Male with two simple, symmetrical and widely separated styles located in the posterolateral corners of a symmetrical or weakly asymmetrical subgenital plate. Female with subgenital plate divided into a pair of valves (bivalvular) by a longitudinal groove (**Blattidae**)	**2.**
— Male with two asymmetrical or symmetrical styles, or one or both absent. Female with subgenital plate not valvular	**6.**
2. Tarsi with well-developed arolium; males and females macropterous	**3.**
— Tarsi with reduced arolium; males macropterous and females brachypterous	**5.**
3. Yellowish pronotum with an edge and two well-contrasted, dark united spots. Costal margin of the forewing with yellowish	***Periplaneta australasiae*** (Figure 4c).
— Yellowish pronotum with border and two joined brown spots not so well contrasted. Forewing concolorous	**4.**
4. Long and slender cerci, especially the apical segments of the male; longer styli; male supranal plate long with a bilobed apex and lacking a setal gland on the first abdominal tergite.	***Periplaneta americana*** (Figure 4a).
— Robust and triangular cerci; shorter styli; male supranal plate short and truncated, but may be notched, and with a setal gland on the first abdominal tergite.	***Periplaneta brunnea*** (Figure 4b).
5. Dark brown colour, with uniformly coloured wings without markings. Males with wings not exceeding the apex of the abdomen.	***Blatta orientalis*** (Figure 4f).
— Light brown colour, with wings with lighter-coloured margins. Males with wings reaching the apex of the abdomen.	***Periplaneta lateralis*** (Figure 4h).
6. Cerci relatively long, tapering and extending well beyond the supra-anal plate	**7.**
— Cerci usually short, not reaching the hind margin of the supra-anal plate	**8.**
7. Sexual dimorphism absent. Pronotum light in colour with, in most specimens, two characteristic dark stripes. Males have tergal glands in tergites 7 and 8 of the abdomen.	***Blattella germanica*** (Figure 4d).
— Sexually dimorphic: Males macropterous, females brachypterous. Pronotum dark in colour, surrounded by two light stripes. Two clear transverse bands on the wings, one at the base and one in the middle. Males without tergal glands in tergites 7 and 8 of the abdomen.	***Supella longipalpa*** (Figure 4j).
8. Body nearly uniform pale green. Macropterous.	***Panchlora nivea*** (Figure 4e).
— Body not green in colour. Macropterous males and macropterous or brachypterous females	**9.**
9. Males macropterous, females brachypterous. Size greater than 3 cm	***Blaptica dubia*** (Figure 4k).
— Macropterous males and females. Size less than or equal to 3 cm	**10.**
10. Pronotum blackish except for a narrow yellow band of variable width along the lateral and anterior margins; the posterior margin of the pronotum forming a definite obtuse angle	***Pycnoscelus surinamensis*** (Figure 4i).
— Pronotum pale with irregular brown blotches in the central area and a submarginal black band on each side; posterior margin of pronotum not angulate, only somewhat broadly protruding	***Nauphoeta cinerea*** (Figure 4g).

4 | DISCUSSION

Synanthropic cockroaches have been considered one of the most significant urban and nuisance pests (Bell et al., 2007). However, it is striking how little scientific information has been published about the distribution, establishment and potential impacts of these insects. In the case of the Iberian Peninsula, there is a notable lack of information about the actual distribution of many species, highlighting the importance of implementing effective monitoring systems. Data from biological collections can help us understand the historical distribution of species (Meineke et al., 2018), as evidenced by the available data from collections concerning various synanthropic species in Asturias. The arrival of new non-native cockroaches in a territory is not uncommon, but it does open a window to what could happen in the future. On the one hand, two new synanthropic cockroaches (i.e., *P. lateralis* and *S. longipalpa*), also known in other parts of the Iberian Peninsula, have been reported for the first time in Asturias, constituting its Iberian northernmost distribution to date. On the other hand, the genetic (100%–99.8% of pairwise identity) and morphological results of the characterization have confirmed the occurrence of *Nauphoeta cinerea* in northern Spain, representing the first established species of the family Blaberidae in the Iberian Peninsula and in Europe. Other members of this family (i.e., *P. surinamensis*, *P. nivea* and *B. dubia*) have not been proven to be established and reproducing in the Iberian Peninsula (Miralles-Núñez et al., 2020; Pradera & Carcereny, 2018), likely due to the need for more tropical conditions. Furthermore, it is important to note that a review of the genetic sequences of *Nauphoeta cinerea* and other cockroach species in Genebank revealed a great scarcity of genetic material available for population studies. Only seven COI sequences and one sequence of the complete mitochondrion genome of the lobster cockroach are available to compare.

Nauphoeta cinerea females can produce around six brood sacs in a lifetime (with 7–39 eggs per sac), with each ootheca taking around one month to incubate and hatch (Corley et al., 1999). Furthermore, this species can reproduce by facultative parthenogenesis when isolated from males (Corley et al., 1999). This has

been confirmed in the established populations in Asturias, where no males have been captured, but a multitude of females capable of reproducing with loaded ootheca have been reported. Due to its high fecundity and effective reproductive strategies, this species can be considered as an ideal invader, capable of rapidly and easily colonizing new territories, as indicated by the abundance of detected juveniles in the studied area. *Nauphoeta cinerea* is considered native to the northeastern African region (i.e., Libya, Egypt, Eritrea and Sudan). From there, and probably through various colonization events on ships, it has been able to reach other parts of the world. There are records of this species in the southwest region of North America, as well as in Central America and certain South American countries (Rehn, 1945). It has also colonized certain island territories, such as Madagascar or the Mauritius Islands, through Arab maritime traffic, or the Asian region or Australia, via Portuguese or Spanish galleons (Rehn, 1945). However, this is the first confirmed record of its establishment across the Euro-Asian continental region. It is interesting to note that almost all previous records date from tropical or subtropical regions, but the northern Iberian Peninsula (Asturias) has a temperate climate. Our results strongly suggest that *N. cinerea* has indeed found a conducive environment to thrive in, given the multi-year abundance of specimens found, including not only adults but also juveniles, that evidence the establishment of reproductive-active populations. Moreover, considering the suggested historical patterns of how this species might have spread across much of the world, we hypothesize that its introduction to Gijón likely occurred through a similar process, possibly via the port of El Musel. With its nocturnal behaviour, it serves as the ideal stowaway and could have arrived in this new area either from its native distribution or from one of the countries where it has been introduced. Nevertheless, we cannot discard the possibility that this species was introduced through alternative pathways. For instance, the population found in Oviedo may be the result of escapes or releases of cockroaches from captivity, potentially for their use as live food for housekeeping reptiles. Thus, for the sake of completeness, more studies are necessary to fully understand not only the introduction pathways but also the evolution and future of the *N. cinerea* reported populations.

5 | CONCLUSIONS

There is still a significant knowledge gap concerning non-native synanthropic cockroaches in the Iberian Peninsula. The recent detection of *N. cinerea* introduces a novel alien species in urban areas. However, the potential impacts of this species and its interactions with both native and non-native fauna remain largely unknown. Additionally, while the pathways of introduction can only be partially elucidated, this finding suggests the possibility of future colonizations across the European continent. The establishment of *N. cinerea* and the insights gained from biological collections underscore the urgency for robust monitoring systems to track known and new populations and gain a better understanding of the actual range of the non-native synanthropic cockroaches worldwide.

AUTHOR CONTRIBUTIONS

Omar Sánchez: Data curation; methodology; investigation; validation; formal analysis; visualization; writing – original draft; writing – review and editing. **Jairo Robla:** Methodology; data curation; investigation; validation; formal analysis; visualization; writing – original draft; writing – review and editing. **Álvaro Pérez-Gómez:** Data curation; investigation; methodology; visualization; writing – original draft; writing – review and editing. **Andrés Arias:** Conceptualization; data curation; formal analysis; investigation; methodology; resources; supervision; validation; visualization; writing – original draft; writing – review and editing.

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CONFLICT OF INTEREST STATEMENT

The authors have no conflict of interest to declare.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are all included in this manuscript. The new genetic sequences generated are openly available in GenBank repository with the accessions numbers PP236019 and PP236020.

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