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CASE REPORT

PATHOLOGY/BIOLOGY

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Searching the Soil: Forensic Importance of Edaphic Fauna After the Removal of a Corpse

ABSTRACT: Arthropods at different stages of development collected from human remains in an advanced stage of decomposition (following autopsy) and from the soil at the scene are reported. The corpse was found in a mixed deciduous forest of Biscay (northern Spain). Soil fauna was extracted by sieving the soil where the corpse lay and placing the remains in Berlese–Tullgren funnels. Necrophagous fauna on the human remains was dominated by the fly Piophilidae: *Stearibia nigriceps* (Meigen, 1826), mites Ascidae: *Proctolaelaps epuraeae* (Hirschmann, 1963), Laelapidae: *Hypoaspis (Gaeolaelaps) aculeifer* (Canestrini, 1884), and the beetle Cleridae: *Necrobia rufipes* (de Geer, 1775). We confirm the importance of edaphic fauna, especially if the deceased is discovered in natural environs. Related fauna may remain for days after corpse removal and reveal information related to the circumstances of death. The species Nitidulidae: *Omosita depressa* (Linnaeus, 1758), Acaridae: *Sancassania berlesei* (Michael, 1903), Ascidae: *Zerconopsis remiger* (Kramer, 1876) and *P. epuraeae*, Urodinychidae: *Uroobovella pulchella* (Berlese, 1904), and Macrochelidae: *Glyptholaspis americana* (Berlese, 1888) were recorded for the first time in the Iberian Peninsula.

KEYWORDS: forensic science, forensic entomology, human corpse, edaphic fauna, *Stearibia nigriceps, Glyptholaspis americana, Hypoaspis (G.) aculeifer, Proctolaelaps epuraeae, Sancassania berlesei, Uroobovella pulchella, Zerconopsis remiger*

A corpse generates new biological processes that evolve according to the environment in which it is found as it produces important changes in the soil (1). The natural inhabitants of undisturbed soils disappear and new organisms take their place, resulting in a new ecosystem dominated by the cadaveric fauna (1,2). The study of the dynamics of colonization, development, and succession patterns of necrophagous fauna on a corpse or carrion is at the heart of medico-criminal entomology (2). Moreover, for corpses found in advanced stages of decomposition, arthropods may provide the only method available for estimating a minimum postmortem interval (PMI) (3). It should be noted, however, that the estimate of PMI for a corpse in an advanced stage of decomposition may be unreliable as successional waves elapse over time and numerous environmental factors come into play that may diminish the accuracy of the estimate (3,4). Indeed, corpses in an advanced stage of decomposition can provide important information relating to succession periods rarely reported (5–8).

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This paper presents the first forensic case where arthropods have been collected from a corpse in an advanced stage of decomposition in the Basque Country (north of Spain) and where soil biota has been previously studied under natural conditions (9,10). This was the first chance to gather important information about arthropods associated with a body in an advanced stage of decomposition in this area and it highlights the need to carefully examine a broad perimeter adjacent to the human remains to avoid losing, ignoring, or underestimating critical forensic evidence.

Material and Methods

Case Description

In August 2003, the remains of a young man were discovered near the edge of a mixed deciduous forest in a rural area of Biscay (northern Spain). The corpse was lying on the ground, completely dressed, reduced to a skeleton bearing the remains of dried soft tissue, and covered with mites and insects. The deceased had last been seen alive 3 months prior to the discovery of the corpse. Unfortunately, the body had already been removed from the scene before authorization was received from the magistrate to collect entomological evidence. Nevertheless, evidence was eventually gathered from the site following removal of the corpse and this included organisms of forensic interest.

Methodology

A medico-legal autopsy was performed by the Forensic Pathology Service of Bilbao in accordance with international standards (11).

Beetles, fly larvae, and mites were collected from the skeletal remains held at the Forensic Pathology Service and preserved in 70% ethanol.

Nine (3 × 3) samples of ground litter and soil (500 cc/sample, taken to a depth of 5 cm) were collected from the scene and sieved. Large arthropods were removed with forceps, and soil mesofauna was extracted from aliquots of the sieved soil (100 cc) using Berlese–Tullgren funnels (12). All fauna was preserved in 70% ethanol for later identification.

Approximately half of the fly larvae collected from the corpse and the soil at the scene were incubated at 23°C in natural daylight in the laboratory to confirm their identification (13). The remaining maggots (n = 20) were placed in hot water for 1 min before preservation in 80% ethanol (14).

Results and Discussion

The autopsy revealed the existence of a skull injury, 1 cm in diameter, with significant hematoma in the corresponding area of the brain. Evidence suggested that death had been caused by a violent attack.

The site was a mixed deciduous forest with an adequate preservation of the canopy and ground cover, extremely closed, dark, and wet. These forests are relict in the area because of intensive farming activities (15). A diagram with weather data collected from the nearest meteorological station is included in Fig. 1.

A total of 29 species was collected and identified from soil samples taken at the crime scene; there was a direct correspondence between the five species collected from the corpse after autopsy that were also present in the soil samples (Table 1).

The corpse was covered in the larvae of Piophilidae (Diptera). The maggots were active in the soil samples together with pupae, and adults were emerging from the soil. Specimens reared from larvae collected in soil confirmed the consistency of the evidence. Adults emerging from the soil and the reared larvae were identified as *Stearibia nigriceps* (Meigen, 1826), the dominant fly found in the removed corpse. In simulations previously carried out using pigs in northern Spain, this species has been found in lower frequency and abundance than the similar species *Piophila casei* (Linnaeus, 1758), the cheese skipper (16).

The presence of *Necrobia rufipes* (de Geer, 1775) (Coleoptera, Cleridae), in both the corpse and in the soil was also noteworthy; adults were reared from preimaginal stages collected from the soil. In addition, adults of *Necrobia violacea* (Linnaeus, 1758) were also collected from soil samples. Other beetle larvae were found in the soil but rearing in the laboratory proved unsuccessful.

Finally, three mite species were collected from the corpse and their presence was confirmed in the soil. The most abundant mite species on the corpse was *Proctolaelaps epuraeae* (Hirschmann, 1963) (Mesostigmata, Ascidae), a species previously cited associated with *Epuraea fuscicollis* (Stephens, 1832) (Coleoptera, Nitidulidae) in Europe (17). We also found adults of *Hypoaspis (Gaeolaelaps) aculeifer* (Canestrini, 1884) (Mesostigmata, Laelapidae) and one deutonymph of the phoretic mite *Uroobovella pulchella* (Berlese, 1904) (Mesostigmata, Urodinychidae). The absence of other species on the remains may be explained by the long delay between the corpse being found and permission being granted for the collection of evidence in the morgue. The complementary information reported from the soil may be of importance for future forensic cases. We therefore give a detail list of all the species and instars found in this research in Table 1.

Despite some previous research carried out in our region, there is still a lack of knowledge concerning the distribution of local necrophagous species and their biology. This makes it difficult to formulate precise conclusions based on the morphology of the corpse and the structure of the community. The numerous factors that influence the dynamics of the decomposition process can

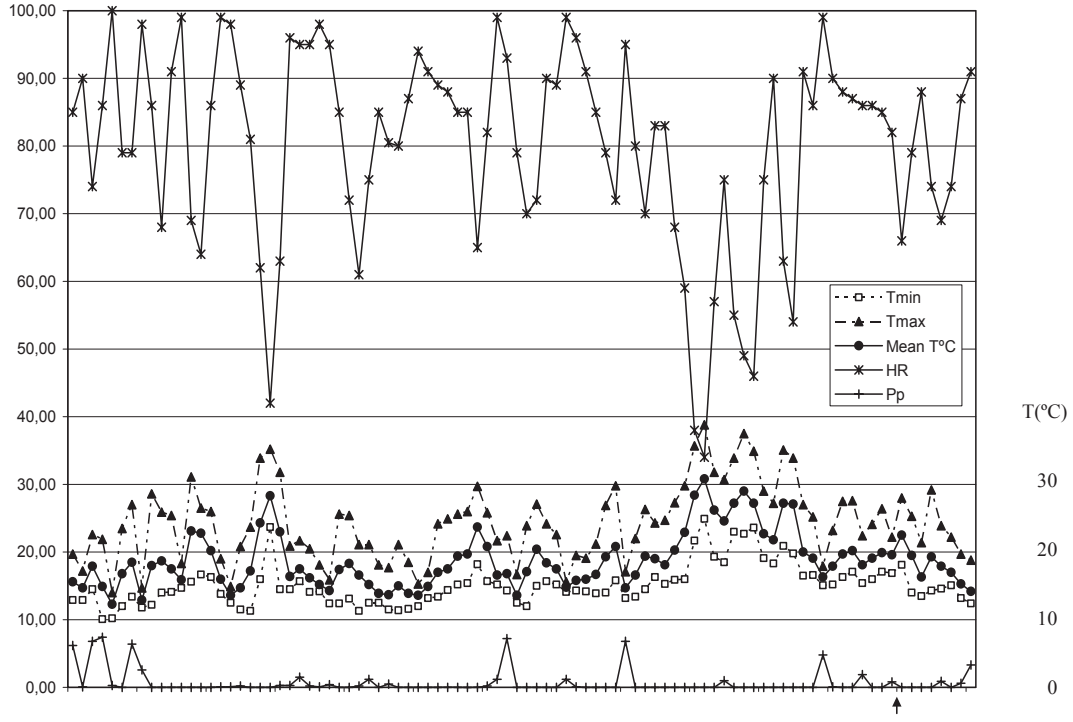

FIG. 1—*Ombrotermic diagram after data recorded at the closest meteorological station. T, temperature; min, minimum; max, maximum; HR, relative humidity (%); Pp, precipitation (mm/m^2);* ↑ *corpse discovery day.*

TABLE 1—*Species collected from soil samples extracted at the scene (soil) and directly from the corpse.*

Order	Family	Species	Corpse	Soil	NR
Diptera	Piophilidae	*Stearibia nigriceps* (Meigen, 1826)	L Ad	L P Ad	BC
Coleoptera	Cleridae	*Necrobia rufipes* (de Geer, 1775)	Ad	L P Ad	
		Necrobia violacea (Linnaeus, 1758)		Ad	
	Histeridae	*Carcinops pumilio* (Erichson, 1834)		Ad	
		Margarinotus (*Paralister*) *ignobilis* (Marseul, 1854)		Ad	
	Nitidulidae	*Omosita colon* (Linnaeus, 1758)		Ad	IP
		Omosita depressa (Linnaeus, 1758)		Ad	
	Silphidae	Unidentified larvae		L	
	Staphylinidae	*Acrotona aterrima* (Gravenhorst, 1802)		Ad	
		Atheta (Atheta) coriaria (Kraatz, 1858)		Ad	BC
		Dimetrota cinnamoptera (Thomson, 1856)		Ad	
		Carpelimus (Trogophloeus) corticinus (Gravenhorst, 1806)		Ad	BC
		Gyrohypnus fracticornis (O. Muller,1776)		Ad	BC
		Habrocerus capillaricornis (Gravenhorst, 1806)		Ad	BC
		Lithocharis ochracea (Gravenhorst, 1802)		Ad	
		Oligota parva (Kraatz, 1858)		Ad	
		Philonthus discoideus (Gravenhorst, 1802)		Ad	
		Platystethus arenarius (Geoffroy, 1785)		Ad	
		Rugilus orbiculatus (Paykull, 1789)		Ad	
Collembola	Unidentified species		Ad		
Astigmata	Acaridae	*Sancassania berlesei* (Michael, 1903)		N Ad	IP
Oribatida	Camisiidae	*Platynothrus peltifer* (C.L. Koch, 1839)		Ad	
	Mycobatidae	*Minunthozetes semirufus* (C.L. Koch, 1841),		Ad	
Mesostigmata	Ascidae	*Proctolaelaps epuraeae* (Hirschmann, 1963)	Ad	N Ad	IP
		Zerconopsis remiger (Kramer, 1876)		Ad	IP
	Laelapidae	*Hypoaspis (G.) aculeifer* (Canestrini, 1884)	Ad	N Ad	BC
	Urodinychidae	*Uroobovella pulchella* (Berlese, 1904)	Ad	N Ad	IP
	Parasitidae	*Paragamasus* sp.		N	
	Macrochelidae	*Glyptholaspis americana* (Berlese, 1888)		Ad	IP
Chilopoda	Unidentified species		Ad		
Diplopoda	Unidentified species		Ad		
Isopoda	Unidentified species		Ad		

L, larvae; P, pupae; Ad, Adult; NR, new record; BC, Basque Country; IP, Iberian Peninsula.

significantly impact the succession models (3,4). Nevertheless, observations of arthropod fauna associated with human remains in advanced stages of decomposition are not frequently reported in scientific literature. Indeed, this is the first time that a detailed list of species of forensic interest associated with human remains in an advanced stage of decomposition (nearly skeletonized) has been recorded in the Basque Country (north of Spain).

Although 10 days had passed since the removal of the corpse, the same species extracted from the corpse itself were also identified in soil samples taken from where the corpse had been found. The community was dominated by larvae of *S. nigriceps* (fly identified after incubation). Pupae and emerging adults of this species were also present in the soil and this helped to substantiate the evidence collected at the scene. *S. nigriceps* is recognized as an important forensic indicator, arriving late in the decomposition process, usually after saponification (18,19). Larvae of this species have been previously reported in Venice (6), with a PMI estimated at 2 months. The community structure was also consistent with a previous case reported from the Hawaiian Islands of a corpse in an advanced stage of decomposition (5). In both cases, only third instars of the Piophilidae were found on the corpses (5,6). We also collected adults emerging from the soil that confirm at least one complete development cycle of the fly in the soil and fits well with the estimated PMI (3 months).

With respect to the seasonality of the community structure, we should note that *Margarinotus ignobilis* (Marseul, 1854), rarely found in late summer, supports the estimated time of death, given at the end of May or beginning June. The presence of *Carcinops pumilio* (Erichson, 1834) confirms an advanced stage of decomposition, and the complete development of the Piophilidae, with adults emerging from the soil, is in accordance with a minimum PMI estimation of 2 months, which is consistent with a simulation recently performed in our region (unpublished data).

However, the lack of complementary records of environmental data prior to the removal of the corpse prevents a more accurate estimation of this interval. Therefore, further simulations using animal models are needed in our region.

Mites are usually overlooked in forensic research, although they are present in nearly every stage of decomposition and are directly associated with other species of forensic interest (20). The most abundant mite species collected from the corpse, *P. epuraeae*, is a phoretic mite from Nitidulidae previously described (17); *U. pulchella* also uses insects for phoresis. *H. (G.) aculeifer* is known as a generalist predator of soil invertebrates (21) and is used in the biological control of soil pests (22). Furthermore, the presence of all the developmental stages of *P. epuraeae* supports a long-term association of the mite with the remains. From cases in Belgium, the coexistence of *Proctolaelaps* and *Hypoaspis* (23) as well as the presence of *Sancassania berlesei* (Michael, 1903) have been reported previously. This third species has also been identified in conditions similar to those of the case described here, that is, on a corpse exposed to high levels of humidity for 3–3.5 months (23).

In this paper, we confirm both an association of some mite species with a specific period of decomposition and the potential for using mites as indicators of environmental conditions (20,23).

While oribatids are the dominant group of mites in our natural soils (9,10), they usually disappear during the decomposition of a corpse (24). Accordingly, in this case, when comparing the oribatid fauna collected from the soil immediately adjacent to the corpse with that inhabiting undisturbed soils in the same area, significant

differences were found. More than 30 species had previously been collected from undisturbed soils from mixed deciduous forests in this area (9,10). However, of these species, only two were found in the soil samples taken from the location where the corpse was discovered and they were poorly represented. Notably, one of them, *Platynothrus peltifer* (C.L. Koch, 1839), is a species that typically remains in disturbed soils (9,10) and, moreover, has previously been identified on dog carcasses in Tennessee (USA) (25). The relevance of these species in forensic research should therefore be more fully explored.

The case reported here provides novel information regarding the structure of the arthropod community associated with a corpse in an advanced state of decomposition; at the same time, it adds to the overall body of knowledge, having identified species not previously reported from this geographical area. Specifically, in this paper, *Omosita depressa* (Linnaeus, 1758) (26), together with *P. epuraeae* (Hirschmann, 1963), *S. berlesei* (Michael, 1903), *Zerconopsis remiger* (Kramer, 1876), *U. pulchella* (Berlese, 1904), and *Glyptholaspis americana* (Berlese, 1888) are recorded for the first time in the Iberian Peninsula. Table 1 includes references to the additional new records for our region.

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