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Paederus dermatitis' Case Incidence and Paederus Beetle (*Coleoptera: Staphylinidae*) Abundance in Nekemte, Western Ethiopia

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Abstract

This study aims to assess Paederus Dermatitis (PD) case incidence and Paederus Beetle (PB) prevalence in Nekemte, western Ethiopia. To assess PD case incidence and patients' belief of the disease, the passive case detection method was used. That is, patients who presented to Wollega University (WU) campus clinic and Nekemte town (NT) communal house health center (Cheleleki Health Center) during six months from June to November 2022 were assessed using self-reported patient history and clinical features diagnosis. Concurrently, PD vector infestation-prone public residential areas, particularly the WU compass dormitory and NT common residential areas (condominiums), were surveyed for PB by hand and sticky trap collection methods. A total of 131 patients presented to the campus clinic and communal house health center. The PD patients were presented to the health facilities every month from June to November, with the peak incidence in September that coincided with the trend and peak months of PB abundances. The peak PD incidence and PB abundance were simultaneously observed during the rainy months, particularly in September after heavy rains. It should be considered by public health workers in selecting PD and PB control time via public health education and other optional intervention measures.

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INTRODUCTION

Paederus dermatitis (PD) is caused by pederin ($C_{25}H_{45}O_9N$) when a *Paederus* beetle (PB), the causative agent of PD, is accidentally crushed against the skin (Ali et al., 2013; Uzunoğlu et al., 2016; Vinobaba et al., 2020). Taxonomically, *Paederus* beetles belong to the class *Insecta*, order Coleoptera, family *Staphylinidae,* and genus *Paederus* (Vinobaba et al., 2020). The beetles do not sting or bite their victims but release the toxic pederin. Pederin is also released when the beetles are endangered as a defensive response against potential predators (Mbonile, 2011; Veraldi et al.,2013). Pederin causes an acute irritant contact dermatitis known as PD (Uzunoğlu et al., 2016; Vinobaba et al., 2020). In addition to its public health importance, infestation of PB has other economic importance. For instance, a high infestation of PB and severe cases of PD can cause man-hours lost in productivity and school absenteeism (Vijayasankar et al., 2019). The PD

lesions may disappear in about two weeks, but residual scars may persist for a few weeks and become a cosmetic problem, especially when they occur on the faces of women (Uzunoğlu et al. 2016).

Paederus dermatitis commonly affects the exposed areas of the body (Assaf et al., 2010; Lalmalsawma & Pautu, 2017; Motz, 2024; Qadir et al., 2006). Preventing skin exposure to pederin and washing the skin immediately after exposure with soap can prevent PD (Beaulieu & Irish, 2016; Ngatu, 2018; Stanimirović et al., 2013). The primary public prevention and control measure of PD is creating awareness among people and preventing human-beetle contact (Lalmalsawma & Pautu, 2017; Uzunoğlu et al., 2016; Vinobaba et al., 2020; Zargari et al., 2003).

Paederus beetles occur and breed in rotting leaves and soil in warmer areas where there is vegetation (Uzunoğlu et al., 2016; Vinobaba et al., 2020). *Paederus* is a nocturnal insect and is attracted to artificial light sources in residential areas (Baba, 1943; Scot, 1950; Vinobaba et al., 2020). This light attraction inevitably brings the insects indoors and increases contact with humans (Bong et al., 2013).

Many countries have experienced PD outbreaks, including Australia, Malaysia, Japan, Nigeria, Sierra Leone, Kenya, Uganda, Brazil, Argentina, Venezuela, Ecuador, France, and India (Mbonile, 2011; Singh & Yousuf, 2007; Zargari et al., 2003). In East Africa, outbreaks of PD were mostly reported in Kenya and Tanzania (Mbonile, 2011).

In Ethiopia, the PD outbreak was first reported recently in the Bole sub-city of the Ethiopian capital, Addis Ababa (Neamin et al., 2021). The infection of PD is vernacularly known as “Almaze” in Ethiopia. Before this study, there was neither a published report of a PD outbreak in Nekemte nor a public perception of the occurrence of PB in the area. The first report of PD from the sub-city was limited to PD case assessment and did not include the PB survey (Neamin et al., 2021).

Statement of the problem

Paederus dermatitis is an extensively neglected insect-induced skin lesion, especially in the tropics. Often neglected and seldom reported, many go untreated due to unawareness of the skin condition, as they are considered a common skin problem by the residents. Thus, many individuals do not seek treatment and have even ignored the symptoms. Only a small proportion of patients pursue medical care or are self-treated. Several suspected cases had been observed in Nekemte, but the magnitude and manageability of the problem remained unstudied and scientifically unreported. Hence, the rationale for undertaking the present study was the lack of both epidemiological and entomological data on PD and PB in the area. This study was undertaken to fill that gap.

Research questions

1. How to determine the PD case incidence and its vector abundance?
2. Describe the baseline information about spatial and temporal PD case incidence and PB abundance in Nekemte, western Ethiopia.

MATERIALS AND METHODS

Description of the study area

The study was conducted in Nekemte town, the capital of the East Wollega Zone of the Oromia Regional State, western Ethiopia (Figure 1). Nekemte is located about 331 km west of the Ethiopian capital, Addis Ababa. It is situated at an altitude of 2,088 meters above sea level and is geographically located at 9° 5’N and 36° 33’E. The average rainfall is 1200 mm, and the average daily minimum and maximum temperatures are 15°C and 27°C, respectively.

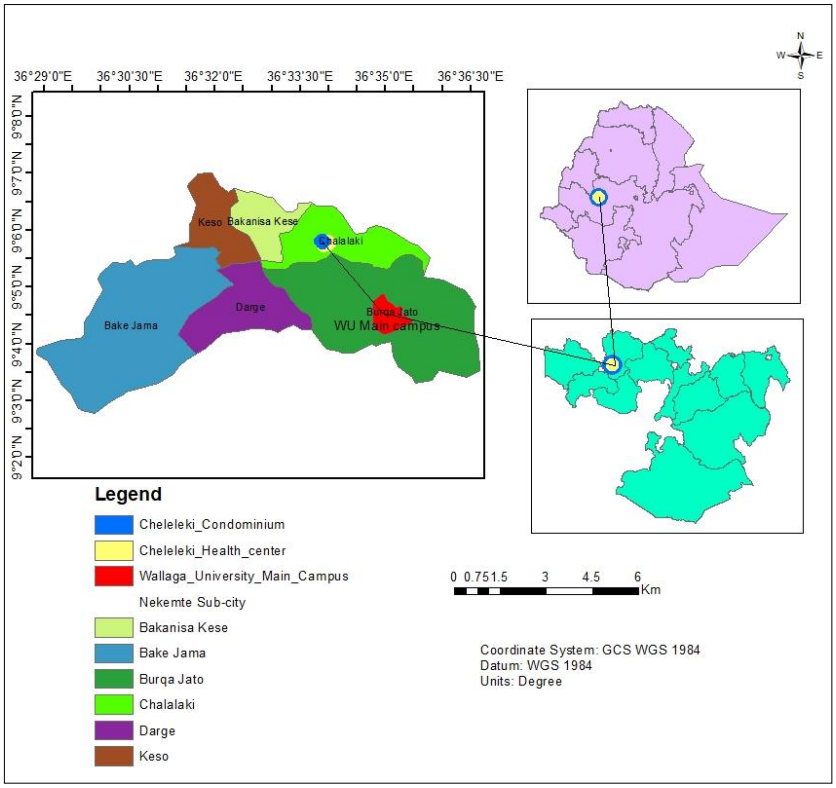

Figure 1. *Geographical location of Nekemte in Ethiopia and Oromia, and the study sites*

Studying design and sampling techniques

To assess PD case incidence, patients' perception of the disease transmission, and its prevention practices, the passive case detection method was used. That is, patients who were presented to Wollega University (WU) main campus clinic and Cheleleki Health Center during six months from June to November 2022 were assessed using self-reported patient history diagnosis. Clinical diagnoses were made by health professionals, and all uncertain cases were not included. In all cases, a questionnaire was completed, which asked for information regarding sex, age, exact place of residence, site of lesion, type of lesion, cause of infection, and patient's perception of PD transmission and prevention practices, which were recorded in detail.

Parallel to the PD epidemiological studies, entomological studies were conducted as well. To determine the abundance of the PD vector in selected vector-infestation-prone public residential - Service areas, particularly at the university campus dormitory and town common residential areas (condominiums) in Nekemte, field surveys of PB were conducted by hand and sticky trap collection methods. The availability sampling method was used to identify PD cases for interview. Beetle infestation-prone residential areas, particularly student dormitories and town communal houses, were targeted purposefully for the beetle collections.

Paederus dermatitis epidemiological data collection

Structured questionnaires were employed to collect self-reported case data from PD patients. In addition, facility-based PD data were also obtained using medical records from purposely selected healthcare facilities, namely Wollega University Student Clinic and Cheleleki Health Care Center. The student clinic is the nearest and most accessible health care service for university students, and

Cheleleki Health Care Center is for the town communal house residents. The questionnaires were prepared in English and translated into the respondents' vernacular language, Afan Oromo. Most people in Nekemte speak Afan Oromo. Demographic and clinical data, including age, sex, residential address, occupation, symptoms of PD, site of infection, perception of PD transmission, and recovery time, were obtained by interviewing each patient using structured questionnaires. Respondents were advised that participation in the study was voluntary, and they could refuse to answer and/or decline participation at any time.

Paederus beetle collection

For beetle collections, two sampling sites were selected, namely the WU campus dormitory and the NT communal house buildings. The chosen sites were considered the main outbreak areas for PD based on information from the town and campus public health care experts. Two blocks of residential areas at the campus, namely student dormitory buildings (designated as SDBa and SDBb) and two blocks of the town communal house buildings (designated as TCHa and TCHb), were sampled based on Bong et al. (2013). PD vector sampling was done by sticky traps according to Bong et al. (2013) and hand collection based on Vinobaba et al. (2020) methods. The beetle collection was conducted for six months during the wet season between June and November 2022. In the area, PD cases and PD beetles were observed during the wet season, coinciding with the main rainy seasons that take place from June to November. Beetle collections were done for three consecutive nights biweekly (fourteen nights) per month, totaling 36 sampling nights.

Sticky traps: A4-sized white sticky traps (n = 864/36 nights) of polypropylene sheets coated with oil were used for capturing *Paederus* beetles. For a single night, 24 traps (6/block X 4blocks) were deployed. The collections were done for three successive nights twice a month for six months. First, PB-infested buildings were surveyed thoroughly with the naked eye. At the two locations, beetles were inspected. On each floor, two sticky traps were deployed under a fluorescent lamp. The traps were suspended 3 m above the floor. The traps were replaced with new traps. After 24 hours, readings were taken daily for three consecutive days, biweekly.

Hand collection

Field surveys of live beetles were conducted using hand-collection methods indoors and outdoors. The *Paederus* beetles were observed and sampled using forceps, test tubes, and torchlight. The collection venues were focused around a fluorescent lamp and rooms where lights were switched on for long hours during the night, according to Uzunoğlu et al. (2016) and Vinobaba et al. (2020). Then, beetles were taken to the WU Applied Entomology and Biomedical Laboratory and preserved in 70% ethanol in labeled vials for later processing and identification. Voucher specimens of the beetles were deposited in the laboratory for identification, counting, and recording. PD beetles were identified at the genus level based on morphological features as described by Maryam et al. (2017).

Data analysis

The statistical analysis tool used in this study was SPSS software (version 26.0 for Windows). The number of PD case incidents and PB in each local site and study month was determined by using descriptive statistics. Variations in PB counts (mean densities) among PB habitats and months were computed using mean comparison and one-way analysis of variance (ANOVA). When statistical differences were detected in ANOVA, the Tukey test was used to separate the means. Differences were considered significant only when p-values were lower than 0.05.

RESULTS AND DISCUSSIONS

Results

Number of *Paederus* dermatitis cases in Nekemte

A total of 131 patients were observed over the six-month study period, visiting the campus student clinic and Cheleleki Health Center. There were 81

male (61.8%) and 50 female (38.2%) patients (Table 1). Their ages ranged from 8 to 40 years (mean age 22.7 ± 0.54 years, median age 22 years). These were 66 patients from the campus dormitory, which is 54.4%, and 65 of them were from town communal houses, accounting for 49.6%. Regarding floor level, the highest number of patients were exposed to PD from the third floor (80.2%), followed by the second floor (13.0%), and the least were from the ground floor (2.3%).

Table 1

PD case incidence by sex and accommodation site

Item	Variables	Frequency (f)	Percentage (%)
Sex	Male	81	61.8
	Female	50	38.2
Accommodation	Campus dormitory	66	54.4
	Communal house	65	49.6
Floor Level	Ground floor	3	2.3
	First floor	6	4.6
	Second floor	17	13.0
	Third floor	105	80.2

The trend of *Paederus dermatitis* case incidence

The peak incidence of PD cases was observed in September (Figure 2). As can be seen from the figure, the peak PD patient visits to health care were in September.

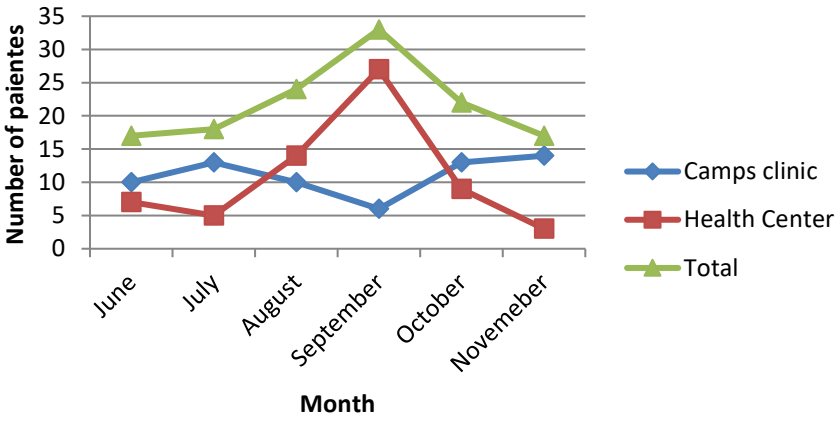

Figure 2. *The trend of Paederus dermatitis case incidences in the Nekemte student clinic and Cheleleki health center over six months in 2022.*

Self-Reported Clinical Features of PD

The patients were asked to show their site of lesions, and it was found that the most exposed site of lesions was (Plate 1) the neck, 107 (81.7%), followed by the face, 19 (14.5%), trunk, and lower extremity, which were less exposed to PD (Table 2). The symptoms of PD were mostly found on the site of kissing lesions, covering about 46.6%, and the next symptoms were vesicles, pustules, and bullae, which covered 29.8%, and most of them recovered in two to three weeks.

Table 2

Clinical features of PD in Nekemte in 2022

Item	Variables	Frequency (f)	Percentage (%)
Site of lesion	Face	19	14.5
	Neck	107	81.7
	Trunk	4	3.1
	Lower extremity	1	0.8
Signs (symptoms) of PD	Linear erythematous plaque	17	13.0
	Vesicles, pustules, and bullae	39	29.8
	Kissing lesions	61	46.6
	Burning sensation and pain	14	10.7
Reported recovery or healing time	1 week	25	19.1
	2-3 weeks	105	80.2
	Not yet known	1	0.8

Perception of patients about PD transmission and exposure

Most of the patients (61.1%) had a perception of PD lesions on their body as it was caused by PD beetles crushed on their site of lesion (Table 3). Some of the patients estimated that their lesion was caused by another kind of insect, and a few of them were not sure about the insect that caused their lesion. Most of the patients (82.4%) reported that they contracted PD mostly during the night period (82.4%). Most of the patients (56.5%) also mentioned that the possible habitat of PD beetles was marshes.

Table 3

Patients' perception of PD transmission in Nekemte

Item	Variables	Frequency (f)	Percentage (%)
How did you contract (get) this lesion (PD)	PD beetle insect crush	80	61.1
	Another insect crush/bite	29	22.1
	Not sure	22	16.8
When did exposure to the *Paederus* beetle occur	Night	108	82.4
	Day	4	3.1
	Both day and night	13	9.9
	Not sure	6	4.6
Do you know the possible habitat of the *Paederus* beetle	Crop fields	7	5.3
	River banks	22	16.8
	Marshes	74	56.5
	Human living environment	28	21.4

Number of *Paederus* beetles by study sites and collection methods

In total, 1,702 beetles were obtained by hand and sticky trap collections (Table 4). The PD vector was collected most abundantly from SDBa (27.1%), followed by TCHb (25.9%), SDBb (24.0%), and TCHa (23.0%) by hand collection. Likewise, a larger number of beetles was also collected from SDBa (26.0%) by sticky trap as compared to the other local sites.

Table 4

Number of Paederus beetle collections from the local sites

Trap Method	SDBa		SDBb		TCHa		TCHb		Total	
	N	%	N	%	N	%	N	%	N	%
Hand collection	284	27.1	251	24.0	241	23.0	271	25.9	1047	100.0
Sticky trap	170	26.0	167	25.5	156	23.8	162	24.7	655	100.0

Key: SDBa: Student dormitory building block a, SDBb: Student dormitory building block b, TCHa: Town communal house building block a, and TCHb: Town communal house building block b.

The trend of *Paederus* Beetle abundance by study months

The beetle was observed every month during the study period (Figure 3). As can be seen from the figure, noticeable monthly differences were seen in densities of the beetle, with the minimum mean density in June and the maximum in September. In both hand and sticky trap collections, the mean densities of the beetle gradually rose during the rainy season from June to September, with their peak mean densities in September, which declined towards the end of the rainy season and the beginning of the dry season in October and November.

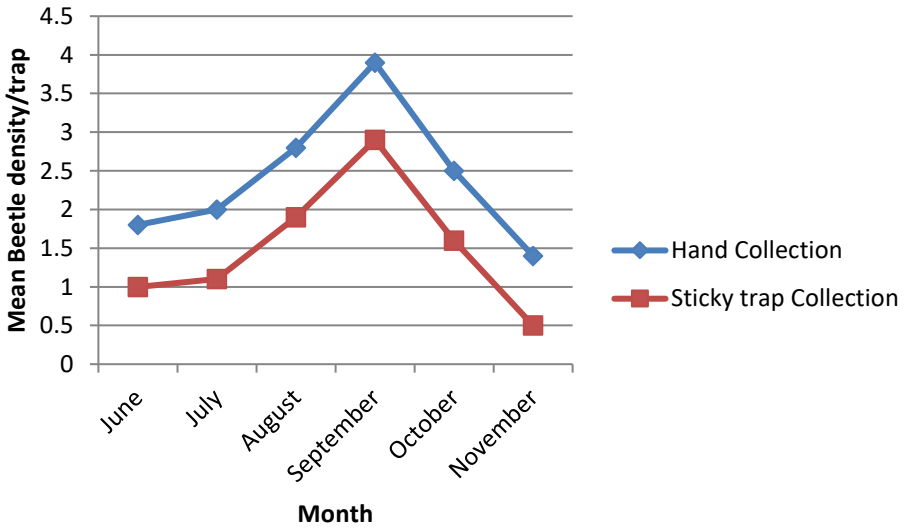

Figure 3. *Mean densities per hand collection per day and sticky trap per night*

Spatial and temporal variations of the beetle distribution

Table 5 presents variations in the spatial and temporal distributions of the mean densities of the beetle. There were no significant differences in the mean densities of the beetles obtained by both hand and sticky trap collections among the local sites ($p > 0.05$). However, significantly higher mean densities of the beetle were observed from the 3rd floor of the residential buildings as compared to the 2nd and the ground floors ($p < 0.05$). Likewise, significantly higher mean densities of the beetle were collected in September as compared to the other study months ($p < 0.05$).

Table 5

Variations in the spatial and temporal distribution of the Paederus beetle in Nekemte

Hand collection					Sticky trap collection				
Character	Variable	Mean+ SEM	F	P	Character	Variable	Mean+ SE	F	P
Local site	SDBa	2.6 ± 0.2	0.738	0.530	Local site	SDBa	1.6 ± 0.1	0.132	0.941
	SDBb	2.3 ± 0.2				SDBb	1.5 ± 0.2		
	TCHa	2.2 ± 0.2				TCHa	1.4 ± 0.2		
	TCHb	2.5 ± 0.2				TCHb	1.5 ± 0.2		
Floor Level	Floor 1	2.3 ± 0.1	14.688	0.000	Floor Level	Floor 1	1.2 ± 0.1	16.225	0.000
	Floor 2	1.8 ± 0.1				Floor 2	1.2 ± 0.1		
	Floor 3	3.2 ± 0.3				Floor 3	2.1 ± 0.2		
Month	Jun	1.8 ± 0.1	14.598	0.000	Month	Jun	1.0 0.1	27.066	0.000
	Jul	2.0 ± 0.2				Jul	1.2 ± 0.1		
	Aug	2.8 ± 0.2				Aug	1.9 ± 0.2		
	Sep	3.9 ± 0.4				Sep	2.9 ± 0.1		
	Oct	2.5 ± 0.2				Oct	1.6 ± 0.1		
	Nov	1.4 ± 0.2				Nov	0.5 ± 0.1		

Key: SDBa: Student dormitory building block a, SDBb: Student dormitory building block b, TCHa: Town communal house building block a, and TCHb: Town communal house building block b.

Discussions

The study shows that 131 patients were presented to a campus student clinic and Cheleleki Health Center in Nekemte during 6 months (June–November 2022). The number of patients is relatively higher than previous reports from the Bole sub-city of Ethiopia (Neamin et al., 2021), which obtained 122 cases over three months. This would be expected because the previous study was conducted for three months. On the other hand, the present case report is lower than previous reports from elsewhere outside Ethiopia. For example, Zargari et al. (2003) reported 156 patients in northern Iran during 6 months from May to October 2001. The difference in the number of PD cases could be explained by variations in the species of the PB in Africa and Asia (Nasir et al., 2015) and associated anthropogenic and environmental factors that directly impact *Paederus* beetle activities and human exposure to PD (Ngatu, 2018).

Results also underline that a greater number of male patients were presented to the health facilities as compared to females. These findings contradict previous reports from Ethiopia and elsewhere in the world (Neamin et al., 2021; Vinobaba et al., 2020), which observed that females are more affected by PD than males. The different results could be attributed to differences in the outdoor activities of males and females, particularly during nighttime in the study area. The minimum and maximum ages of the patients were 8 and 40 years, respectively, with a mean age of 22.7 years, similar to Neamin et al. (2021), who observed that the mean age of patients residing in the Bole districts of Addis Ababa, Ethiopia, was 23.6 years. This shows that PD affects people of all sexes and age groups (Neamin et al., 2021; Ngatu, 2018). The possibility of contracting PD could be attributed to nighttime contact with PB due to outdoor activities (Ngatu, 2018) and occupational exposure to PB during the day (Neamin et al., 2021).

Most of the patients were presented from the campus dormitory as compared to communal houses. These results might be influenced by the location and population size of the residents in the campus dormitory versus the town communal

house. The university campus is located in a suburban area closer to wetlands, marshes, and forest areas, whereas the communal house is located closer to the town center. Thus, location and vegetation cover might affect *Paederus* beetle distribution and, hence, patient flow to the health care systems. Previous studies also showed that the most common habitats of PB are crop fields, riverbanks, marshes, and vegetation areas, from where they migrate to humans' living environments for different reasons (Neamin et al., 2021; Zargari et al., 2003).

Results also underscore that those patients residing on the third floor were the most contracted with PD. This could be expected because *Paederus* beetles are attracted to fluorescent light from their breeding habitats, and fluorescent lights installed on higher buildings will impact the beetles more from a distance than those installed in lower buildings. Infestation of Paederus beetles is enhanced by a bright light source plus high altitude that causes them to invade human shelters, leading to outbreaks of PD (Maryam et al., 2016).

The PD patients were presented to the health facilities every month from June to November, with the peak incidence in September. These months are the major rainy months of the year in Ethiopia. In line with this, previous studies show that the disease was more predominant in the wet season than during the dry season due to the presence of soil moisture suitable for the breeding of PBs (Mbonile, 2011; Neamin et al., 2021; Vinobaba et al., 2020; Zargari et al., 2003). Previous reports indicate that infestation of PB is more severe between May and September, causing high PD outbreaks in Sri Lanka (Vinobaba et al., 2020). Seasonal infestation of PB and incidence of PD warrant further studies in the study setting.

The neck was the predominant site of involvement, and kissing lesion was the most observed type of lesion in the study setting. These findings are consistent with previous studies (Habyebete et al., 2021; Neamin et al., 2021; Vinobaba et al., 2020; Zargari et al., 2003) that reported kissing lesions mainly involving the neck. The present study also shows that the healing time of the lesion was from 2 to 3 weeks. This coincides with the work of Vinobaba et al. (2020), who reported that the healing time of acute skin lesions caused by PD was 10-20 days in Sri Lanka. Similar to the present study, reports from Italy and India indicate that recovery times are 12 to 15 days (Borroni et al., 1991; Vijayasankar et al., 2019), while a different study conducted in Sierra Leone revealed that healing times varied from 14 to 28 days (Qadir et al., 2006).

Most of the patients perceived that the PD beetle crush was the cause of PD lesions and visually identified photographs of the insect vector. This strongly agrees with the fact that PB is the causative agent of PD and collaborates with existing literature (Mbonile, 2011; Uzunoğlu et al., 2016; Vinobaba et al., 2020; Zargari et al., 2003). *Paederus* beetles do not sting, but when crushed against the skin, they cause PD (Mbonile, 2011). The highest number of PD patients reported that accidental contact with PB occurs during the nighttime. These results also agree with previous works (Mbonile, 2011; Uzunoğlu et al., 2016; Vinobaba et al., 2020) that reported that *Paederus* beetles feed and rest on vegetation during the daytime but are attracted to artificial lights in living areas, and exposure is frequent at night.

Results also revealed that the number of *Paederus* beetles obtained from the study setting was variable by local collection site and method. These would be expected because the local sites differ in their location and distance from potential *Paederus* beetle breeding sites such as marshes and wetland areas. Moreover, the difference between hand collections versus sticky trap collections would be attributed to beetle resting, running, feeding, and flying behaviors and warrants further studies. These beetle behaviors and activities affect their catching efficiency and warrant further trap calibration studies.

The *Paederus* beetle was observed every month, with marked monthly variations, with the least density in June and the highest density in September. In hand and sticky trap collections, the mean densities of the beetle gently rose from June

through July and August, and most peaks were observed in September, which declined afterward. These trends of beetle abundance are evidence that local precipitation is the driving force determining the occurrence and abundance of the beetles and the incidence and prevalence of PD in the study settings. In line with these, as described earlier, studies show that PD was more predominant in the wet season than the dry season because of environmental factors favoring the breeding of *Paederus* beetles (Neamin et al., 2021; Vinobaba et al., 2020; Zargari et al., 2003).

Significantly higher mean densities of the beetle were observed from the third floor of the residential buildings, especially in September, as compared to the other study months. Like the present study findings, Vinobaba et al. (2020) observed that residents in higher buildings were more severely affected than those on ground floors in Sri Lanka. The same authors suggested that the flight pattern of *Paederus* beetles toward attractive light sources affects the infestation venues of the beetles. Previous studies (Huang et al., 2009; Maryam et al., 2016; Rahmah & Norjaiza, 2008) also proved that victims of PD were on the top floor levels compared to the lower levels of apartments. Further, wind dispersal of beetles may be a feasible climatic factor for PD outbreaks (Vinobaba et al., 2020). The peak PB mean densities observed in September could be explained by the effect of heavy precipitation in the major rainy season, particularly in June, July, and August. There are heavy rains in Ethiopia, which will decline in the following months and cease during the winter months in December, January, and February.

Recommendations

The PD patients were presented to the health facilities every month from June to November, with the peak incidence in September that coincided with the trend and peak months of PB abundances. This finding should be considered by public health workers in selecting PD and PB control time through public health education and other optional intervention measures. Some of the major recommendations of the study are 1) The Paederus beetle was not identified to the species level and calls for further research, concern, and action. 2) The study period was limited to the wet season of the year in the study setting and did not include the dry season for comparison. 3) Environmental factors that affect PB occurrence and abundance, such as temperature and precipitation, were not measured and included in the study, and should be considered in the future.

Abbreviations

PB: Paederus Beetle, PD: Paederus Dermatitis, SDBa: Student dormitory building block a, SDBb: Student dormitory building block b, TCHa: Town communal house building block a, TCHb: Town communal house building block b.

CRediT authorship contribution statement

Oljira Kenea: Data Curation, Visualization, Investigation, Writing & Reviewing & Editing, **Derartu Zelalem:** Formal analysis, Methodology, Validation resources, **Damtew Bekele**: Conceptualization, Writing—Original Draft, Supervision.

Declaration of competing interests

The authors state that they have no conflicts of interest regarding the publication of this paper.

Ethical approval

The study got approval from the Research Ethics Review Committee of Wollega University (Minutes No: 1080/2022). After they became informed about the objective of the work, written consent was sought from each selected participant, and any participant who was not willing to participate in the study was not forced to do so. Participants in the study were also informed that all data obtained from them would be kept confidential and that their privacy would be protected by ensuring that no names appeared in any part of the repository.

Data availability statement

The data used and/or analyzed in this study are available from the corresponding author on reasonable request.

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