Evaluating the efficiency of baited pitfall traps covered with mesh panels for sampling dung beetles

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Đánh giá hiệu quả của bẫy hố có mồi nhử với lưới bảo vệ trong thu mẫu bọ hung ăn phân

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ABSTRACT

Baited pitfall traps represent a widely utilized method for dung beetle sampling. The effectiveness of this approach can be influenced by various factors, such as the type of bait used, trap size, and modifications to trap components. An important challenge during trapping is the inadvertent capture of non-target animals (such as: frogs, lizards, snakes, small rodents, and spiders), a concern that becomes more pronounced if endangered species are involved. To address these issues, incorporating a mesh panel into pitfall traps can help prevent unwanted intrusions. In this study, we assess the efficiency of baited pitfall traps covered with 2 cm mesh panels (BPTMP) for sampling dung beetles in tropical karst ecosystems within the Huu Lien Nature Reserve (northern Vietnam), comparing them with typical baited pitfall traps (BPT). The result revealed no significant differences in the species composition of dung beetles between the two trap types. Although the abundance of large-bodied dung beetles was significantly lower in BPTMPs compared to trap BPTs, the overall abundance and diversity of dung beetles did not significantly differ between the two trap types. Therefore, we strongly recommend adopting this sampling technique in studying on the diversity of dung beetles.

Từ khóa:
Bẫy hố có mồi nhử, bọ hung ăn phân, các loại bẫy hố, Khu bảo tồn thiên nhiên Hữu Liên.

TÓM TẮT

Bẫy hố có mồi nhử được sử dụng phổ biến để thu thập bọ hung ăn phân. Hiệu quả bẫy có thể bị ảnh hưởng bởi nhiều yếu tố, bao gồm loại mồi sử dụng, kích thước của bẫy và việc điều chỉnh các thành phần bẫy. Tuy nhiên, vấn đề quan trọng của phương pháp này là việc thu được các mẫu động vật khác không phải là mục tiêu của nghiên cứu, ví dụ: ếch, thằn lằn, rắn, loài gặm nhấm nhỏ và nhện; đặc biệt lo ngại hơn nếu các loài động vật đó có nguy cơ tuyệt chủng. Để giải quyết những vấn đề này, việc sử dụng tấm lưới bao phủ miệng hộp chứa mẫu của bẫy hố có thể giúp ngăn chặn việc các loài động vật khác sa bẫy. Nghiên cứu được thực hiện để đánh giá hiệu quả của việc sử dụng bẫy hố được phủ bằng tấm lưới có đường kính mắt lưới 2 cm (BPTMP) để thu thập bọ hung ăn phân trong hệ sinh thái núi đá vôi tại Khu bảo tồn thiên nhiên Hữu Liên (miền Bắc Việt Nam) trên cơ sở so sánh kết quả thu mẫu bằng các bẫy hố điển hình (BPT). Kết quả cho thấy không có sự khác biệt đáng kể về thành phần loài bọ hung giữa hai loại bẫy. Mặc dù sự phong phú của bọ hung ăn phân kích thước lớn tại bẫy BPTMP thấp hơn đáng kể so với bẫy BPT, nhưng mức độ phong phú tổng thể và đa dạng của quần xã bọ hung không có sự khác biệt có ý nghĩa thống kê giữa hai loại bẫy. Do đó, kỹ thuật lấy mẫu bằng bẫy BPTMP được đề xuất sử dụng khi thực hiện các nghiên cứu về đa dạng của quần xã bọ hung ăn phân.

1. INTRODUCTION

Dung beetles (Coleoptera: Scarabaeinae) are integral components of terrestrial ecosystems, playing pivotal roles in nutrient cycling and soil health by decomposing animal dung [1, 2]. Their ecological significance extends beyond mere decomposition, as they also serve as vital indicators of ecosystem health and environmental disturbances [1]. Even subtle disruptions in undisturbed forest ecosystems have been demonstrated to exert profound effects on dung beetle populations, underscoring their remarkable sensitivity to environmental changes [1].

In the realm of ecological research focused on dung beetles, baited-pitfall traps represent indispensable tools, offering practical and cost-effective means of sampling these insects [3, 4]. These traps typically comprised of containers placed at ground level and filled with a preserving fluid to capture and retain collected specimens, have undergone various modifications aimed at enhancing their efficiency and capture rates [5, 6]. Modifications such as incorporating barriers, drift-fences, funnels, roofs, and specialized baits have been introduced to optimize trap performance [7]. However, the effectiveness of pitfall traps can be influenced by numerous factors including bait type, trap size, and overall sampling methodologies. The accumulation of plant litter within traps presents a significant challenge, potentially leading to biased results due to obstruction. Moreover, unintended captures of non-target animals, particularly endangered species, raise concerns, emphasizing the importance of minimizing such occurrences [8, 9].

To address these challenges and improve dung beetle sampling efficacy, the integration of mesh panels into pitfall traps has emerged as a promising strategy. Mesh panels have the potential to prevent unwanted intrusions from plant litter and non-target captures, thereby enhancing trap efficiency and facilitating the acquisition of more accurate biodiversity data. The present study seeks to investigate the impact of mesh panel modifications on dung beetle sampling efficiency by comparing traditional pitfall traps with modified traps incorporating mesh panels. Specifically, our research aims to assess how the addition of mesh panels influences the capture of various dung beetle species, taking into consideration factors such as species composition, abundance, and diversity. Through a thorough evaluation of the effectiveness of these modified traps, our study endeavors to provide valuable insights into improving dung beetle sampling methods for ecological research and biodiversity assessments, ultimately contributing to a deeper understanding of the roles and dynamics of dung beetles in terrestrial ecosystems.

2. RESEARCH METHODS

2.1. Study area

The study was conducted in 2022 at Huu Lien Nature Reserve (21°37'–21°45'N, 106°19'–106°26'E), located in Lang Son Province, North Vietnam. The reserve covers 10,640 ha and is characterized by limestone karst, with a majority of the area (93%) being forested, situated at an elevation range of 200-400 m above sea level [10]. Two valleys bisect the limestone karst, with the highest summit being Mount Kheng at 638 m. Huu Lien also includes freshwater ecosystems with two main streams (Buc and An) and four lakes (Giangca, Deolong, Landat, and Lanty) [11]. The reserve boasts high biodiversity, with 794 vascular plant species, 57 mammal species, 23 reptile species, and 14 amphibian species. Notably, the critically endangered Huu Lien Tiger Gecko (*Goniurosaurus huuliensis*) was recently discovered in the region [12]. Despite its rich natural resources, Huu Lien has experienced disturbances, particularly due to clear-cutting for shifting agriculture. As a result, the reserve hosts various habitat types, including different forest types, meadows, and agricultural land [13].

2.2. Dung beetle sampling

We conducted a comparative study using two types of baited-pitfall traps to evaluate their efficiency in capturing dung beetles

within primary forests at elevations ranging from 200 to 400 meters above sea level in Huu Lien Nature Reserve. A total of 50 baited traps were deployed, with 25 of the first type (trap 1- BPT, lacking a mesh panel) and 25 of the second type (trap 2- BPTMP, equipped with a mesh panel) (Fig. 1). These traps were strategically positioned at intervals of at least 150 meters to ensure a representative sample of dung beetles. Each trap comprised a plastic bucket buried to its rim in the soil, filled with 0.5 litters of 70% ethanol, and baited with a 1:1 mixture of buffalo and pig dung.

(A) **(B)**

Figure 1. Baited-pitfall traps placed in primary forests

A – typical baited pitfall trap (BPT), B - baited pitfall traps covered with mesh panels (BPTMP)

Dung beetles were collected in a standardized manner at 25 trapping sites over two collection trips. The first trip occurred between September and October 2021, while the second trip took place between May and June 2022. At each site, traps were set up for a 72-hour period during the trapping phase, with checks conducted twice daily at 6:00 AM and 6:00 PM. During these checks, we collected trapped dung beetles to determine their activity patterns and released any other animals (such as snakes, lizards, frogs, and spiders) that had accidentally fallen into the traps. Subsequently, dung beetle collections were consolidated to obtain a single sample per trap for analysis.

For dung beetle species identification, we utilized identification keys from various sources including [14-18] the list of Vietnamese dung beetles documented in [19], and cross-referenced with the reference collections of Vietnamese dung beetles in [20]. The three main functional groups including tunnelers, dwellers, and rollers were followed in [21].

2.3. Data analysis

Statistical analyses were carried out in R software. Species accumulation curves were used to assess the completeness of dung-beetle sampling across the two trap types. We performed generalized linear models (GLM) [22] using Poisson distribution to test for differences in species richness, abundance, and diversity among the two trap types. Species diversity was measured by Shannon–Wiener index H', calculated using the following equation:

$H = \sum_{i=1}^{s}[(pi) \times \ln(pi)]$.

where,

pi = proportion of total sample represented by species i (Divide no. of individuals of species i by total number of trapping sites);

s = number of species = species richness.

3. RESULTS

In total, 691 individuals of 22 species were sampled and identified from the 25 trapping sites in primary forests of the Huu Lien Nature Reserve. Sampling completeness was > 99.5% for dung beetle communities captured in both BPT and BPTMP (Figure 2).

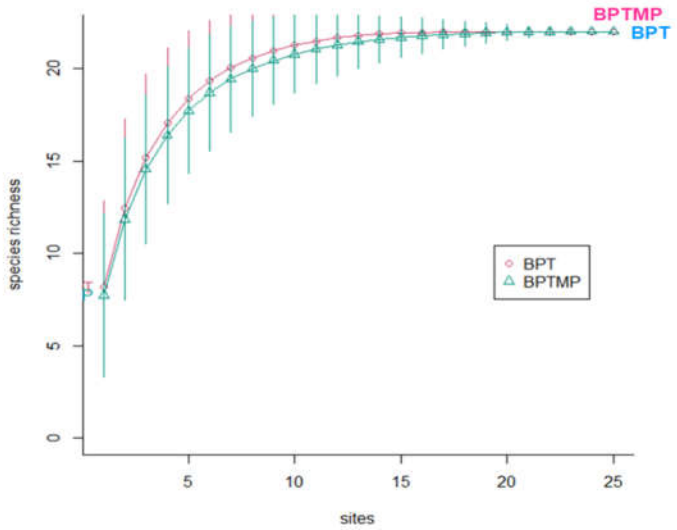

Figure 2. Species accumulation curves of dung beetles in the two pitfall traps BPT and BPTMP

The dung beetles were distributed across 7 genera: *Copris* (118 individuals, 3 species), *Synapsis* (16 individuals, 1 species), *Catharsius* (29 individuals, 1 species), *Onthophagus* (434 individuals, 13 species), *Liatongus* (11 individuals, 1 species), *Paragymnopleurus* (14 individuals, 1 species), and *Aphodius* (69 individuals, 2 species) (Table 1).

Table 1. Numbers of each dung beetle species collected across the two traps

Species	BPT	BPTMP	Total
Aphodius elegans Allibert, 1848 (*)	**8**	**14**	**22**
Aphodius mirificus (Balthasar, 1932) (*)	**4**	**43**	**47**
Catharsius molossus (Linnaeus,1758)	**22**	**7**	**29**
Copris magicus (Harold, 1881)	**39**	**3**	**42**
Copris reflexus (Fabricius,1787)	**10**	**11**	**21**
Copris szechouanicus (Balthasar, 1958)	**45**	**10**	**55**
Liatongus gagatinus (Hope,1831)	**5**	**6**	**11**
Onthophagus sp.1	**6**	**9**	**15**
Onthophagus sp.2	**18**	**15**	**33**
Onthophagus sp.3	**16**	**17**	**33**
Onthophagus sp.4	**6**	**7**	**13**
Onthophagus sp.5	**6**	**9**	**15**
Onthophagus dorsofasciatus (Fairmaire,1893)	**75**	**90**	**165**
Onthophagus jeannelianus (Paulian,1945)	**17**	**23**	**40**
Onthophagus luridipennis (Boheman, 1858)	**10**	**19**	**29**
Onthophagus luridipennis (Boheman, 1858)	**4**	**5**	**9**
Onthophagus orientalis (Harold, 1868)	**6**	**7**	**13**
Onthophagus phanaeiformis (Boucomont, 1914)	**5**	**6**	**11**
Onthophagus strandi (Balthasar, 1935)	**5**	**7**	**12**
Onthophagus trituber (Wiedemann, 1823)	**22**	**24**	**46**
Paragymnopleurus brahminus (Waterhouse, 1890) (**)	**2**	**12**	**14**
Synapsis tridens (Sharp, 1881)	**12**	**4**	**16**
Total	**343**	**348**	**691**

Note: Typical baited pitfall traps (lacking a mesh panel): BPT, and baited pitfall traps covered with mesh panels: BPTMP; (*) and (**) indicate species that are dwellers and rollers, respectively; species without asterisks are tunnelers.

Species richness, abundance, and diversity (Shannon index) did not show significant differences between BPT and BPTMP in the whole dung-beetle community. However, the abundance of the large dung-beetle tunnelers (body length > 10 mm) significantly differed between the two trap types, with the total abundance in BPT being nearly 5-fold higher compared to BPTMP, while the abundance of rollers and dwellers in BPTMP was 6-fold and 5-fold higher, respectively, compared to BPT (Fig. 3, Table 2).

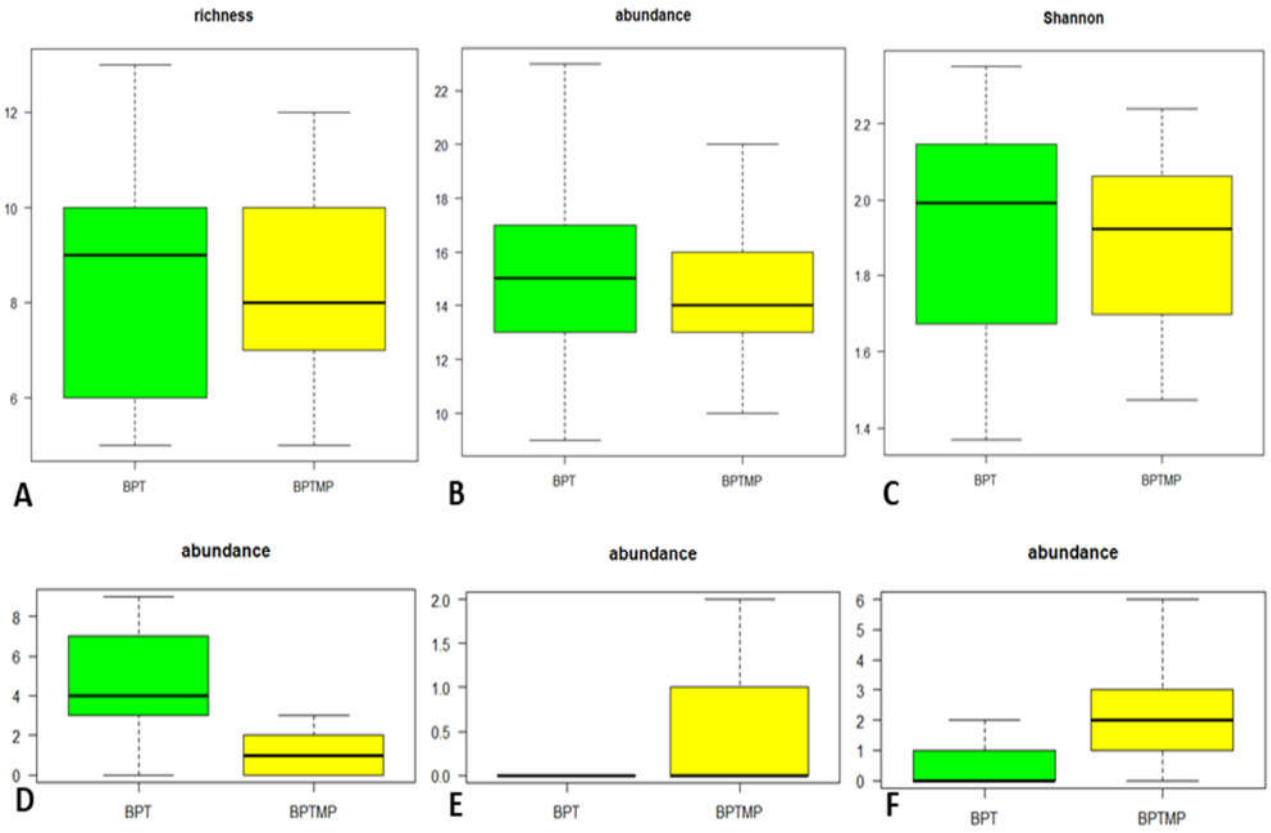

Figure 3. Boxplots showing species richness, abundance, and Shannon diversity index of whole dung *beetle community (A, B, C) and large Tunnelers (D), Rollers (E) and Dwellers (F) in two trap types: typical baited pitfall traps (lacking a mesh panel): BPT, and baited pitfall traps covered with mesh panels: BPTMP*

Table 2. GLM for species richness, abundance, and Shannon diversity index of whole dung-beetle community and the three functional groups between both traps: BPT and BPTMP. Test statistics (z-value) and *p*-values are presented

	z-value	*p*-value
A. Whole dung-beetle community		
Species richness	0.000	1
abundance	-0.098	0.092
Shannon diversity index	-0.063	0.950
B. Rolling dung-beetle community		
Abundance	5.442	< 0.001
C. Large-bodied tunneling dung beetles		
Abundance	4.237	< 0.001
D. Dwelling dung beetles		
Abundance	5.114	< 0.001

4. DISCUSSION

The effectiveness of various traps in sampling dung beetles has been extensively studied. Previous research conducted in Bornean tropical forests has qualitatively demonstrated that both baited pitfall traps and flight interception traps captured complementary aspects of the dung beetle community [23]. ONG et al. (2021) [24] further expanded on this by revealing that these two trap types captured communities with different functional traits, with baited pitfall traps capturing more functionally diverse communities. This suggests that employing a combination of both baited pitfall traps and flight interception traps is beneficial for assessing dung beetle composition across different habitat types. However, previous studies have overlooked minor modifications in trap designs.

Our study fills this gap by providing the first quantitative comparison of community composition and taxonomic diversity of dung beetles in tropical karst forests in Vietnam, using two variations of baited pitfall traps (BPT and BPTMP). Our results indicate a significantly higher abundance of rolling and dwelling dung beetle communities in BPTMP traps. In contrast, BPTs are more effective at sampling the functional group of large tunnelers, including species like *Copris szechouanicus*, *Copris magicus*, *Synapsis tridens*, and *Catharsius molossus*, which are crucial for ecosystem functioning due to their role in dung removal in tropical forests [25, 20]. Therefore, considering that each trap can target communities associated with specific dung types, we recommend using a combination of BPT and BPTMP traps for studies linking dung beetle functional groups to ecosystem functions such as dung removal and burial in tropical primary forests over limestone.

For biodiversity surveys assessing dung beetle species composition across various habitat types [26], it is recommended to utilize a combination of different traps to ensure a comprehensive sampling of the entire community. Although our study revealed differences in abundance between trapping methods for certain species groups, overall species richness, abundance, and diversity did not significantly differ between BPT and BPTMP traps. This suggests that while specific trapping methods may excel in capturing certain species or groups, they may not influence the overall diversity of dung beetle communities significantly. Thus, we recommend the use of BPTMP traps over BPT traps to minimize incidental trapping of other animals in tropical primary forests over limestone. These findings emphasize the importance of selecting appropriate trapping techniques tailored to the target species or groups of interest. By employing more efficient trapping methods, researchers can obtain more representative data on dung beetle communities, enhancing our understanding of their ecological roles and informing conservation strategies aimed at preserving their populations and habitats.

5. CONCLUSION

Our study contributes to the understanding of dung beetle ecology and trapping methodologies in tropical forest ecosystems. By highlighting the effectiveness of different trapping methods and their implications for species composition, abundance, and diversity, our research provides valuable insights that can guide future studies and conservation efforts aimed at preserving dung beetle biodiversity and ecosystem function in primary forest habitats. Further research is needed to understand the factors contributing to differences in trap success between BPT and BPTMP, including trap design, bait

attractiveness, environmental conditions, and habitat preferences of dung beetle species, as well as interspecific interactions and ecological processes within dung beetle communities.

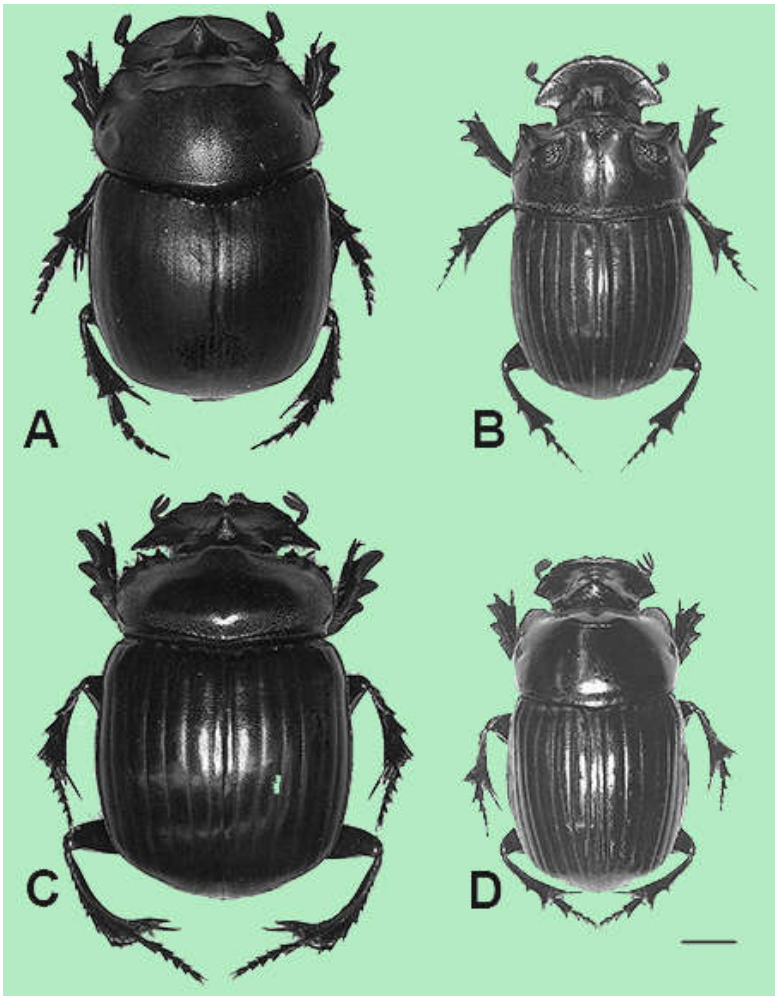

Figure 4. Habitus of large-bodied tunnelers in BPTs

A-Catharsius molossus, B-Copris magicus, C-Synapsis tridens, and D-Copris szechouanicus

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REFERENCES

[1]. Nichols E., Larsen T., Spector S., Davis A. L., Escobar F., Favila M. & Network T. S. R. (2007). Global dung beetle response to tropical forest modification and fragmentation: a quantitative literature review and meta-analysis. Biological conservation. 137(1): 1-19.

[2]. Gardner T. A., Hernández M. I., Barlow J. & Peres C. A. (2008). Understanding the biodiversity consequences of habitat change: the value of secondary and plantation forests for neotropical dung beetles. Journal of applied ecology. 45(3): 883-893.

[3]. Woodcock B. A. (2005). Pitfall trapping in ecological studies. Insect sampling in forest ecosystems. 37-57.

[4]. Santos S. A., Cabanas J. E. & Pereira J. A. (2007). Abundance and diversity of soil arthropods in olive grove ecosystem (Portugal): Effect of pitfall trap type.

European Journal of Soil Biology. 43(2): 77-83.

[5]. Jud P. & Schmidt-Entling M. H. (2008). Fluid type, dilution, and bitter agent influence spider preservation in pitfall traps. Entomologia experimentalis et applicata. 129(3): 356-359.

[6]. Knapp M. & Ruzicka J. (2012). The effect of pitfall trap construction and preservative on catch size, species richness and species composition of ground beetles (Coleoptera: Carabidae). European Journal of Entomology. 109(3): 419-426.

[7]. Brown G. R. & Matthews I. M. (2016). A review of extensive variation in the design of pitfall traps and a proposal for a standard pitfall trap design for monitoring ground-active arthropod biodiversity. Ecology and evolution. 6(12): 3953-3964.

[8]. Buchholz S., Kreuels M., Kronshage A., Terlutter H. & Finch O. D. (2011). Bycatches of ecological field studies: bothersome or valuable?. Methods in Ecology and Evolution. 2(1): 99-102.

[9]. Lange M., Gossner M. M. & Weisser W. W. (2011). Effect of pitfall trap type and diameter on vertebrate by-catches and ground beetle (Coleoptera: Carabidae) and spider (Araneae) sampling. Methods in Ecology and Evolution. 2(2): 185-190.

[10]. Anon (1990). Investment plan for Huu Lien Nature Reserve, Huu Lung district, Lang Son province. Lang Son: Lang Son Provincial People's Committee.

[11]. Tordoff A. W., Tran Q. B., Nguyen D. T. & Le M. H. (eds)., 2004. Sourcebook of existing and proposed protected areas in Vietnam. Second edition. Hanoi: BirdLife International in Indochina and the Ministry of Agriculture and Rural Development.

[12]. Orlov N. L., Ryabov S. A., Nguyen T. T., Nguyen Q. T. & Ho T. C. (2008). A new species of Goniurosaurus (Sauria: Gekkota: Eublepharidae) from north Vietnam. Russian Journal of Herpetology. 15(3): 229-244.

[13]. Lunde D. P., Nguyen T. S. & Musser G. G. (2007). A survey of small mammals from Huu Lien Nature, Lang Son Province, Vietnam. Mammal Study. 32: 155-168.

[14]. Balthasar V. (1963). Monographie der Scarabaeidae und Aphodiidae der Palaearktischen und Orientalischen Region. Coleoptera: Lamellicornia. Band 1. Allgemeiner Teil, Systematischer Teil: 1. Scarabaeinae, 2. Coprinae (Pinotini, Coprini). Verlag der Tschechoslowakischen Akademie der Wissenschaften. Prag.

[15]. Bui V. B., Dumack K. & Bonkowski M. (2018). Two new species and one new record for the genus Copris (Coleoptera: Scarabaeidae: Scarabaeinae) from Vietnam with a key to Vietnamese species. European Journal of Entomology. 115: 167-191.

[16]. Bui V. B. & Bonkowski M. (2018). Synapsis puluongensis sp. nov. and redescription of S. horaki (Coleoptera: Scarabaeidae), with a key to Vietnamese species. Acta Entomologica Musei Nationalis Pragae. 58(2): 407-418.

[17]. Ochi T. & Kon M. (2017). Notes on the coprophagous scarab-beetles (Coleoptera, Scarabaeidae) from Southeast Asia. XXVIII. A new genus and three new subgenera of the genus Parascatonomus. Giornale Italiano di Entomologia. 14: 775-792.

[18]. Paulian R. (1945). Faune de l'Empire Français III. Coléoptère Scarabéides de l'Indochine. Première partie. Paris.

[19]. Kabakov O. N. & Napolov A. (1999). Fauna and ecology of Lamellicornia of subfamily Scarabaeinae (Scarabaeidae, Coleoptera) of Vietnam and some parts of adjacent countries: South China, Laos and Thailand. Latvijas entomologs. 37: 58-96.

[20]. Bui V. B., Ziegler T. & Bonkowski M. (2020). Morphological traits reflect dung beetle response to land use changes in tropical karst ecosystems of Vietnam. Ecological Indicators. 108(105697): 1-9.

[21]. Hayes L., Mann D. J., Monastyrskii A. L. & Lewis O. T. (2009). Rapid assessments of tropical dung beetle and butterfly assemblages: contrasting trends along a forest disturbance gradient. Insect Conservation Diversity. 2: 194-203.

[22]. Nelder J. A. & Wedderburn R. W. (1972). Generalized linear models. Journal of the Royal Statistical Society Series A: Statistics in Society. 135(3): 370-384.

[23]. Davis A. J., Holloway J. D., Huijbregts H., Krikken J., Kirk-Spriggs A. H. & Sutton S. L. (2001). Dung beetles as indicators of change in the forests of northern Borneo. Journal of applied ecology. 38(3): 593-616.

[24]. Ong X. R., Hemprich-Bennett D., Gray C. L., Kemp V., Chung A. Y. & Slade E. M. (2022). Trap type affects dung beetle taxonomic and functional diversity in Bornean tropical forests. Austral Ecology. 47(1): 68-78.

[25]. Gray C. L., Slade E. M., Mann D. J. & Lewis O. T. (2014). Do riparian reserves support dung beetle biodiversity and ecosystem services in oil palm-dominated tropical landscapes?. Ecology and evolution. 4(7): 1049-1060.

[26]. Alonso L. E. & Larsen T. H. (Eds.). (2013). A Rapid Biological Assessment of the Upper Palumeu River Watershed (Grensgebergte and Kasikasima) of Southeastern Suriname. Conservation International. Arlington.