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STUDY ON THE TAXONOMY OF THE LITTLE-KNOWN BEE TAXA BELONGING TO THE SUPERFAMILY APOIDEA (HYMENOPTERA), SOME BIOLOGICAL AND ECOLOGICAL CHARACTERISTICS OF STINGLESS BEES FROM VIETNAM

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LIST OF THE PUBLICATIONS RELATED TO THE DISSERTATION

1. **Tran N.T.**, Engel M.S., Truong L.X., Nguyen L.T.P., 2022, First occurrence of the little-known genus *Noteriades* (Hymenoptera, Megachilidae) from Vietnam: discovery of a new species and a key to the Southeast Asian fauna, *ZooKeys*, 1102, pp. 191-200.

2. Engel M.S., Nguyen L.T.P., **Tran N.T.**, Truong T.A., Motta A.F.H., 2022, A new genus of minute stingless bees from Southeast Asia (Hymenoptera, Apidae), *ZooKeys*, 1089, pp. 53-72.

3. **Tran N.T.**, Engel M.S., Nguyen C.Q., Tran D.D., Nguyen L.T.P., 2023, The bee genus *Anthidiellum* Cockerell in Vietnam: Descriptions of five new species and the first male of *Anthidiellum coronum* (Hymenoptera, Megachilidae), *ZooKeys*, 1144, pp. 171-196.

4. **Tran N.T.**, Truong L.X., Ljubomirov T., Nguyen L.T.P., 2021, First record of the bee genus *Bathanthidium* (*Bathanthidium* s. str.) Mavromoustakis (Hymenoptera: Megachilidae) from Vietnam: Description of a new species and a key to species, *Journal of Hymenoptera Research*, 88, pp. 51-60.

5. **Tran Thi Ngat**, Truong Xuan Lam, Hoang Gia Minh, Nguyen Thi Phuong Lien, 2020, Honeybee products as potential bioindicators for heavy metal contamination in Northern Vietnam, *Journal of Biotechnology*, 18(2), pp. 373-384.

6. **Tran Thi Ngat**, Dang Thi Hoa, Nguyen Thi Phuong Lien, Phan Thi Giang, Truong Thanh Truc, 2023, A contribution to the taxonomic knowledge of the genus *Thrinchostoma* (*Thrinchostoma* s. str.) Saussure (Hymenoptera: Halictidae) from Vietnam, with new records of three species and a key to species, *Academia Journal of Biology*, 45(1), pp. 23-33.

7. **Tran Thi Ngat**, Nguyen Thi Phuong Lien, Truong Xuan Lam, 2020. Study on the composition and distribution of bees (Hymenoptera: Apoidea) from Northern. Proceedings of the foury five years scientific conference of the Vietnam Academy of Science and Technology: 86-95.

GENERAL INFORMATION

1. The urgency of the dissertation

Vietnam is one of the most biodiversity centers in Southeast Asia. However, studies on biodiversity, species composition, distribution, and biological characteristics of organisms from Vietnam still have many gaps and many unresolved issues, especially wild bees.

Up to now, more than 20,000 bee species belonging to seven families have been discovered worldwide. Besides the taxon with large species numbers, there are taxa with only very few species, even only one species, and relatively narrow distribution, such as genera of tribe Meliponini, genus *Elaphropoda*, *Euaspis*, *Thrinchostoma*,... (Michener, 2007). The information on their taxonomy and distribution are quite limited.

The stingless bee is the smallest group of honey-producing bees belonging to the family Apidae (tribe Meliponini), distributed mainly in tropical and subtropical areas.

There are more than 500 stingless bee species belonging to 40 genera of this tribe in the world. In Vietnam, an estimated about 16 species and four genera have been recorded. They source honey and pollen from nature, so they reflect the actual environmental conditions where they live. Keeping bees in areas contaminated with heavy metals can affect the quality of their products. Using products contaminated with metals in large enough concentrations will cause poisoning, significantly affecting the health of consumers (Kabata-Pendias & Mukherjee, 2007). However, up to now, there is little research on the biological and ecological characteristics of stingless bees in Vietnam, including nest structure, developmental morphology of phases, or the content of heavy metals in their products.

Based on the above situation, I carry out this research topic.

2. Explain the terms

The little-known taxa are taxa that have been little studied in terms of taxonomy, biology, and ecology.

3. Objectives of the study

Determine the bee species composition and distribution of little-known taxa belonging to the superfamily Apoidea and provide some biological and ecological characteristics of stingless bees in Vietnam.

4. Research content

Content 1: Study on the classification and distribution of little-known taxa belonging to the superfamily Apoidea in Vietnam;

Content 2: Study on some biological and ecological characteristics of stingless bees in Vietnam.

5. Scientific and practical basis of the thesis

5.1. Scientific significance

Providing scientific data on the classification and distribution of little-known taxa belonging to the superfamily Apoidea as well as the biological and ecological characteristics of stingless bees in Vietnam.

5.2. Practical significance

The discovery of little-known taxa (superfamily Apoidea) shows the high diversity of the species composition of the bee Vietnamese fauna. Researching their distribution has provided conservation managers with basic information about habitat distribution, thereby serving as a basis for building conservation plans, especially for scientific and economic value taxa. In addition, this research also has important implications for the process of domesticating and developing bee colonies, thereby creating products that bring high economic value, helping to improve the lives of local people.

CHAPTER 1. OVERVIEW

1.1. Reports on little-known bee taxa belonging to superfamily Apoidea in the world

1.1.1. Study on the taxonomy of little-known bee taxa in the world

Within the framework of this thesis, little-known genera belonging to the four families Apidae, Halictidae, Megachilidae, and Melittidae, that have been recorded in the Oriental region are focused on research.

Family Apidae

According to Michener (2007), the family Apidae includes more than 5,000 described species belonging to the three subfamilies Apinae, Nomaninae, and Xylocopinae. Of those, the tribes of the two subfamilies Nomaninae and Xylocopinae have genera with large species numbers or with small number of species but are not found in the Oriental region. Therefore, only genera of the subfamily Apinae are considered to be studied here.

*** Subfamily Apinae**

Tribe Anthophorini

Engel (2018) reported the tribe Anthophonini in the world. Among them, three genera (*Habropoda*, *Elaphropoda*, and *Varthemapistra*) are found in the Oriental region with the number of species fluctuating between 1-55 species.

Tribe Melectini

This tribe includes more than 200 species of nine genera that have been described in the world. Among them, two genera (*Thyreus* and *Tetralonioidella*) are known from the Oriental region. Genus *Thyreus* has a very large number of species and recording a total of 19 species of the genus *Tetralonioidella* (Alqarni et al., 2014; Engel & Michener, 2012; Michener, 2007; Onuferko et al., 2021; Rightmyer & Engel, 2003).

Tribe Ctenoplectrini

According to Michener (2007), this tribe includes a total of 21 species of two genera (*Ctenoplectra* and *Ctenoplectrina*). The genus *Ctenoplectrina* is found only in tropical Africa. Genus *Ctenoplectra* includes 19 species and is distributed in the Oriental region.

Tribe Meliponini

This tribe has about 500 species of 40 genera that have been recorded in the world (Ascher & Pickering, 2022; Engel, 2022). Among them, nine genera have a relatively limited number of species and are known from the Oriental region, including *Geniotrigona*, *Heterotrigona*, *Homotrigona*, *Lepidotrigona*, *Lisotrigona*, *Papuatrigona*, *Pariotrigona*, *Tetragonula*, and *Wallacetrigona*.

Family Halictidae

This family has a total of about 4,500 species belonging to three subfamilies: Halictinae, Nomiinae, and Rophitinae. Most of the genera of the subfamily Rophitinae are not found in the Oriental region.

*** Subfamily Halictinae**

The subfamily Halictinae includes three tribes: Augochlorini, Halictini, and Nomioidini, of which the first tribe is not found in the Oriental region.

Tribe Halictini

Six genera belonging to the tribe Halictini are recorded from the Oriental region, but only two genera with a relatively limited number (*Eupetersia* and *Thrinchostoma*).

Tribe Nomioidini

This tribe includes about 90 species of three genera, of which only two genera (*Ceylalictus* and *Nomioides*) are recorded in the Oriental region.

*** Subfamily Nomiinae**

This subfamily includes two tribes. Tribe Dieunomiini with nine species of a unique genus distributed only in the Nearctic region and tribe Nomiini with about 600 species of 22 genera. Recording ten genera belonging to the tribe Nomiini found in the Oriental region, of which seven genera range in number from 3 to 60 species (Ascher & Pickering, 2022).

Family Megachilidae

This family includes about 4000 species belonging to four subfamilies: Fideliinae, Pararhophitinae, Lithurginae, and Megachilinae (Danforth et al., 2013).

***Subfamily Fideliinae**

This subfamily includes two tribes: Pararhophitini and Fideliini, but only the first tribe has a genus distributed in the Oriental region. Specifically, the genus *Pararhophites* comprises three species found in Afrotropical region, the Palearctic, and the Oriental region (Ascher & Pickering, 2022).

*** Subfamily Lithurginae**

This subfamily includes two tribes: Lithurgini and Protolithurgini (the latter only found in fossil form). In the tribe Lithurgini, only the genus Lithurgus is distributed in the Oriental region. In Southeast Asia, only two species of this genus have been discovered (Ascher & Pickering, 2022).

*** Subfamily Megachilinae**

It is one of the most diverse subfamilies of the family Megachilidae with four tribes: Anthidiini, Dioxyini, Megachilini, and Osmiini.

Tribe Anthidiini

This tribe includes about 900 species in 46 genera. According to statistical results, there are 14 genera with numbers ranging from 1–65 species found in the Oriental region.

Tribe Dioxyini

Eight genera of this tribe have been discovered, of which only *Aglaoapis* is known in the Oriental region. This genus is very rare and not found in Southeast Asia.

Tribe Megachilini

This tribe consists of four genera, of which two genera with large number of species. The remaining two genera *Noteriades* and *Radoszkowskiana* include 16 and 4 species, respectively.

Tribe Osmiini

Six genera in this tribe are found in the Oriental region. However, three genera (*Heriades*, *Hoplitis*, and *Osmia*) are too large in species number, ranging from 100–400 species. The remaining three genera are *Chelostoma*, *Protosmia*, and *Pseudoheriades*. Among them, the latter has never been recorded in Southeast Asia.

*** Subfamily Pararhophitinae**

This subfamily is rare in the family Megachilidae because only one genus (*Pararhophites*) has been recorded. This genus includes three species, among them, one species is known from the Palearctic Region, another species from the Ethiopian region and the remaining species are found in the Oriental region (Ascher & Pickering, 2022; Michener, 2007).

Family Melittidae

Meliitidae is a small family, consisting of only about 200 species belonging to three subfamilies: Dasypodainae, Meganomiinae, and Melittinae. The two first subfamilies are only known from the Ethiopian region. Subfamily Melittinae has about 100 species of three genera, of which two genera (*Macropis* and *Melitta*) are found in this region (Ascher & Pickering, 2022; Michener, 2007).

1.1.2. Study on some biological and ecological characteristics of stingless bees

Study on some biological characteristics of stingless bees

Stingless bees are receiving much attention from scientists as well as beekeepers and become a commercial farming trend in many countries such as Malaysia, Indonesia, Thailand, etc.

Lepidotrigona flavibasis is one of five species in the L. ventralis group. This species is known from southern China (Yunnan and Hainan provinces), and the Southeast Asian countries (Cambodia, Laos, Malaysia, and Thailand) (Wu, 2000; Lee et al., 2016). This species brings high economic efficiency because pollinating for tropical and subtropical plants such as litchi, longan,

chestnut, and honey of *L. flavibasis* has better quality than honey of *Apis cerana cerana* or *A. dorsata* (Wu et al. 2020).

Study on some ecological characteristics of stingless bees

The relationship between the environmental conditions and the flight activities of stingless bees: The flight activities of *Melipona bicolor bicolor* in Cunha, Atlantic Forest was studied (Hilário et al., 2000). In Southeast Asia, this issue is of the greatest interest in Indonesia (Salatnaya et al., 2000; Atmowidi et al., 2018; Wicaksono et al., 2020).

Content of heavy metals in stingless bee products: In the world, this issue is receiving a lot of attention in Brazil, Nigeria,…In Southeast Asia, this issue is more concerned in Malaysia, one of the countries developing beekeeping in the region.

1.2. Reports on little-known bee taxa belonging to superfamily Apoidea in Vietnam

1.2.1. Study on the taxonomy of little-known bee taxa

Studies on the classification of wild bee species have only been interested by a few authors and the number of articles is not much (Le Xuan Hue, 2008; 2010; Long et al., 2012; Nguyen Phuong Minh et al., 2017a; 2017b; 2017c; Tran et al., 2017; Tran & Nguyen, 2018).

So far, 88 species and 25 genera belonging to 4 families (including Apidae, Colletidae, Halictidae, and Megachilidae) have been recorded from Vietnam (Ascher & Pickering, 2022). The above studies just list species, lack of illustrations, or have but at a limited level.

In the past few years, in-depth research on each genus has been initially conducted but really limited (Nguyen et al., 2016; Tran et al., 2016; Tran et al., 2017).

1.2.2. Study on the biological and ecological characteristics of stingless bees

Study on the biological characteristics of stingless bees

Studies on the biological characteristics of bees in general and bees in particular in Vietnam are very limited. Chinh et al. (2005) recorded the nest structure of three stingless bee species: *Lisotrigona carpenteri*, *Tetragonula laeviceps*, and *Lepidotrigona ventralis* in Cuc Phuong National Park and its buffer zone.

Study on the ecological characteristics of stingless bees

The relationship between the environmental conditions and the flight activities of stingless bees: In Vietnam, this issue is still quite new. Up to now, there has been no study on temperature and humidity conditions on the flight activities of the *Lepidotrigona flavibasis*.

Content of heavy metals in stingless bee products: Up to now, there has not been a study on this issue.

CHAPTER 2. STUDYING OBJECT AND METHODS

2.1. Object for studying

Little-known bee taxa belonging to the superfamily Apoidea in Vietnam.

2.2. Methods for studying

2.2.1. Times for studying: 2019-2023

2.2.2. Sites for studying: The research was conducted mainly in National Parks, Nature Reserves, Species and Habitat Conservation Areas of Vietnam.

2.2.3. Field sampling methods

Insect net, malaise trap, collecting nest, inheritance method, method of consulting experts, method of processing and preserving honey bee samples in the laboratory, and method of identification are used in this study.

2.2.4. Methods to observe biological and ecological characteristics of stingless bees

2.2.4.1. Methods to observe biological characteristics of stingless bees

Studying about the nest construction: Measure, record and photograph the outside and inside construction of the nest.

Observing development stages: Using three colonies of *Lepidotrigona flavibasis* to observe the development of egg, larva, and pupa. Every day, opening a cell to observe, note, and photograph the morphology and development of the stages.

2.2.4.1. Methods to observe ecological characteristics of stingless bees

Observation of the the flight activities of stingless bees: Using a colony of *Lepidotrigona flavibasis* to observe the flight activities (entry and exit hive). A total observed day is 15 sunny days, observed time is 1 minute/1 hour, from 7 a.m. to 5 p.m. during day, from April to June. Observing and counting the number of times entry and exit of their hive. Recording the temperature and humidity of each observation time.

Analysis of heavy metal content in stingless bee products: In this study, a total of six samples (three honey and three pollen samples) of a colony *Lepidotrigona flavibasis* in Hanoi were collected in three months (April to June). All collected samples were dried at 120°C for 24 hours and 0.5 grams of each dried sample for chemical analysis. The object of this study was the concentration of five highly toxic heavy metals (As, Cd, Hg, Pb, and Sn) in honey and pollen samples. The analysis of the samples has been carried out at the Quality Assurance and Testing Center 1, Directorate for Standards, Metrology and Quality, using the ICP- MS mass spectrometer method (EPA, 2007).

2.2.5. Methods of image and data processing

Illustrations were taken under a Nikon SMZ800N connected to an ILCE-5000L/WAP2 camera and combined with Helicon Focus v7 software. The images and the points on distributed map are processed by Photoshop CS6 software. The data were processed using IBM SPSS Statistics 20 software.

CHAPTER 3. RESULTS

3.1. Taxonomy and distribution of little-known bee taxa belonging to superfamily Apoidea in Vietnam

3.1.1. The composition of little-known bee taxa in Vietnam

Results recorded 44 little-known bee species of 18 genera belonging to 4 families (Apidae, Halictidae, Megachilidae, and Melittidae) in Vietnam. Among them, a genus of the family Apidae, a subtribe, and seven species of the family Megachilidae as new to science are discovered. In addition, five genera and 11 species were recorded for the first time in Vietnam.

Table 3.1. Composition and distribution of little-known bee taxa belonging to superfamily Apoidea in Vietnam

No.	Scientific name	Distribution area	Individual number	Percentage of number of individuals
FAMILY APIDAE				
Tribe Anthophorini				
I	**Genus *Elaphropoda***			
1	*Elaphropoda khasiana* (Schulz, 1906)	Northeast region	1	0.13
2	*Elaphropoda percarinata* Cockerell, 1930	Northeast region	1	0.13
3	*Elaphropoda* sp.1	Northeast region, South central region	6	0.79

4	*Elaphropoda* sp.2	Northwest region	1	0.13
II	**Genus *Habropoda***			
5[c]	*Habropoda disconota* Lieftinck, 1974	Northeast region	2	0.26
6[c]	*Habropoda tumidifrons* Lieftinck, 1974	Northeast region	25	3.31
7	*Habropoda* sp.1	South central region, Central Highlands region	18	2.38
8	*Habropoda* sp.2	Northwest region	8	1.06
Tribe Ctenoplectrini				
III	**Genus *Ctenoplectra***			
9	*Ctenplectra chalybea* Smith, 1857	Northeast region, Northwest region, Red river delta	25	3.31
10	*Ctenoplectra* sp.	Northeast region, Northwest region	3	0.40
Tribe Melectini				
IV	**Genus *Tetralonioidella***			
11[b]	*Tetralonioidella pendleburyi* Cockerell, 1926	Central Highlands region	16	2.12
Tribe Meliponini				

V**	**Genus *Ebaiotrigona***			
12	*Ebaiotrigona carpenteri* (Engel, 2000)	Northeast region, Northwest region, North central region	193	25.56
VI	**Genus *Homotrigona***			
13	*Homotrigona apicalis* (Smith, 1857)	Northwest region,Central Highlands region	15	1.99
VII	**Genus *Lepidotrigona***			
14	*Lepidotrigona flavibasis* (Cockerell, 1929)	Northeast region, Northwest region, Red river delta , North central region	63	8.34
15	*Lepidotrigona terminata* (Smith, 1878)	South central region and Southeast region	20	2.65
16	*Lepidotrigona* sp.	Northeast region,	10	1.32
VIII	**Genus *Tetragonula***			
17	*Tetragonula laeviceps* (Smith 1857)	Northeast region, Northwest region, North Central region, South Central region,	62	8.21

		Central Highlands region		
18	*Tetragonula gressitti* (Sakagami, 1978)	Northwest region	15	1.99
FAMILY HALICTIDAE				
IX	**Genus *Thrinchostoma***			
19[b]	*Thrinchostoma flaviscapus* Bülthgen, 1926	Northeast region	6	0.79
20[c]	*Thrinchostoma tonkinense* Blüthgen, 1926	Northeast region, Central Highlands region	18	2.38
21[b]	*Thrinchostoma sladeni* Cockerell, 1913	Northwest region	1	0.13
22[b]	*Thrinchostoma yunnanense* Niu and Zhu, 2016	Northeast region	2	0.26
FAMILY MEGACHILIDAE				
Tribe Anthidiini				
X	**Genus *Anthidiellum***			
23[***]	*Anthidiellum* (*Clypanthidium*)	Northeast region	1	0.13

	nahang Tran, Engel & Nguyen, 2023			
24***	*Anthidiellum* (*Pycnanthidium*) *ayun* Tran, Engel & Nguyen, 2023	Central Highlands region	86	11.39
25[b]	*Anthidiellum* (*Pycnanthidium*) *carinatum* (Wu, 1962)	Northeast region, Northwest region, Central Highlands region	18	2.38
26***	*Anthidiellum* (*Pycnanthidium*) *chumomray* Tran, Engel & Nguyen, 2023	Central Highlands region	1	0.13
27***	*Anthidiellum* (*Pycnanthidium*) *flavaxilla* Tran, Engel & Nguyen, 2023	Central Highlands region	9	1.19
28***	*Anthidiellum* (*Pycnanthidium*) *cornu* Tran, Engel & Nguyen, 2023	Central Highlands region	2	0.26
29[b]	*Anthidiellum* (*Pycnanthidium*) *coronum* (Wu, 2004)	Central Highlands region	7	0.93
XI[a]	**Genus *Bathanthidium***			

30[b]	*Bathanthidium binghami* (Friese, 1901)	Central Highlands region	31	4.11
31[***]	*Bathanthidium paco*, Tran & Nguyen, 2021	Northwest region	3	0.40
XII	**Genus *Euaspis***			
32	*Euaspis aequicarinata* Pasteels, 1980	Northeast region, Central Highlands region	3	0.40
33	*Euaspis diversicarinata* Pasteels, 1980	Northeast region, Red River Delta	2	0.26
34	*Euaspis polyensia* Vachal, 1903	Northeast region, Northwest region, North Central region, Central Highlands region	30	3.97
XIII[a]	**Genus *Pachyanthidium***			
35[b]	*Pachyanthidium lachrymosum* (Smith, 1879)	Central Highlands region	12	1.59
XIV[a]	**Genus *Pseudoanthidium***			

36[b]	*Pseudoanthidium orientale* (Bingham, 1897)	Northeast region	1	0.13
XV	**Genus *Trachusa***			
37[b]	*Trachusa formosana* (Friese, 1917)	Northeast region	3	0.40
38	*Trachusa vietnamensis* Flaminio & Quaranta, 2021	Central Highlands region	1	0.13
39	*Trachusa* sp.1	Northeast region	1	0.13
40	*Trachusa* sp.2	Central Highlands region	1	0.13
41	*Trachusa* sp.3	Central Highlands region	1	0.13
Tribe Megachilini				
Subtribe Noteriadina[*]				
XVI[a]	**Genus *Noteriades***			
42[***]	*Noteriades hangkia* Tran, Engel & Nguyen, 2022	Northeast region, Northwest region, Central Highlands region	9	1.19
Tribe Osimiini				
XVII[a]	**Genus *Chelostoma***			

43[b]	*Chelostoma aureocinctum* (Bigham, 1897)	Northwest region, Central Highlands region	21	2.78
FAMILY MELITTIDAE				
XVIII	**Genus *Macropis***			
44	*Macropis hedini* Alfken, 1936	Northwest region	1	0.13

Note: * New subtribe, ** New genus, *** New species, [a] New recorded genus for Vietnamese fauna, [b] New recorded species for Vietnamese fauna, [c] Endemic species of Vietnam

3.1.2. Diagnosis and distribution of little-known bee taxa belonging to superfamily Apoidea in Vietnam

The information on type species, diagnosis, and distribution maps of each genus are given. In addition, diagnostic characteristics, illustrations, and distribution of recorded species are also presented.

Observing the distribution map of the genera, most species were recorded mainly in the North and Central Highlands of Vietnam. Most species have a narrow distribution area, only recorded in some provinces.

The results show that the altitude zone 600-1000 m encountered the most species (30 species), the altitude zone 100-300 m (17 species), the altitude zone 300-600 m (11 species), the altitude zone 1000-1600 m (10 species), the altitude zone 10-100 m (5 species) and least in the altitude zone 1600-2600 m (2 species).

3.1.3. Identification key to families, genera and species recorded in Vietnam

The identification key to the family belonging to the superfamily Apoidea, the identification key to the subfamilies, tribes, and genera of the

family Apidae, family Megachilidae, and the identification key to the species of some genera in Vietnam (including at least three species) were built.

3.2. Some biological and ecological characteristics of stingless bees in Vietnam

3.2.1. Some biological characteristics of stingless bees in Vietnam

3.2.1.1. Nest structure characteristics of stingless bees

It can be seen that two species in the same genus have different nest structures. However, two species in different genera have part of the nest structure the same, but the remaining structure is different.

**** Nest structure of Lepidotrigona flavibasis* (Cockerell, 1929)**

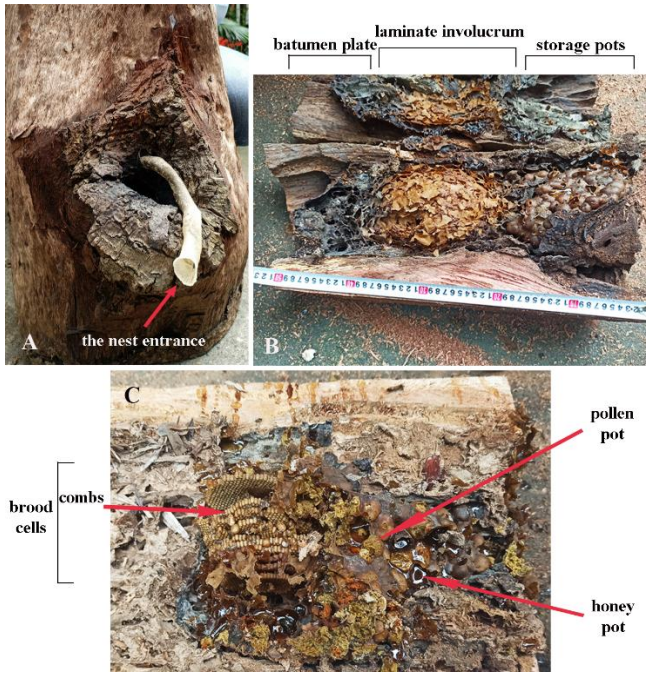

Figure 3.85. Nest structure of *Lepidotrigona flavibasis*
Nest entrance. B, C. Nest internal structure.

**** Nest structure of Lepidotrigona terminata* Smith, 1878**

Figure 3.86. Nest structure of *Lepidotrigona terminata*
A. Nest entrance. B, C. Nest internal structure

**** Nest structure of Tetragonula laeviceps* (Smith, 1857)**

Figure 3.87. Nest structure of *Tetragonula laviceps*
A. Nest entrance. B. Nest internal structure.
C. Queen checking brood cells

*** *Nest structure of Tetragonula gressitti* (Sakagami, 1978)**

Figure 3.88. Nest structure of *Tetragonula gressitti*
Nest entrance. B. Brood cells. C. Nest internal structure.

3.2.1.2. Morphological characteristics of the developmental stages of Lepidotrigona flavibasis (Cockerell, 1926)

Figure 3.89. Egg stage of *Lepidotrigona flavibasis*
A. Brood cell. B. Egg on first day.
C. Egg on third day. D. Egg on forth day. Scale bar: 1mm.

Table 3.7. Measurement of the developmental stages of *Lepidotrigona flavibasis*

Developmental stage	**Size (mm)**	
	Length	**Width**
Eggs (n=32)	0.8 - 1.1 0.91 ± 0.10	0.3 - 0.4 0.35 ± 0.04
Larvae (n=33)	1.1 - 6.9 4.50 ± 1.88	0.35 - 1.94 1.24 ± 0.49
Pupa (n=34)	3 - 3.6 3.39 ± 0.22	2 - 2.3 2.1 ± 0.10
Adult (n=36)	4.9 - 5.5 5.16 ± 0.17	3.4 - 3.7 3.57 ± 0.11

Note: n is the number of experimental individuals.

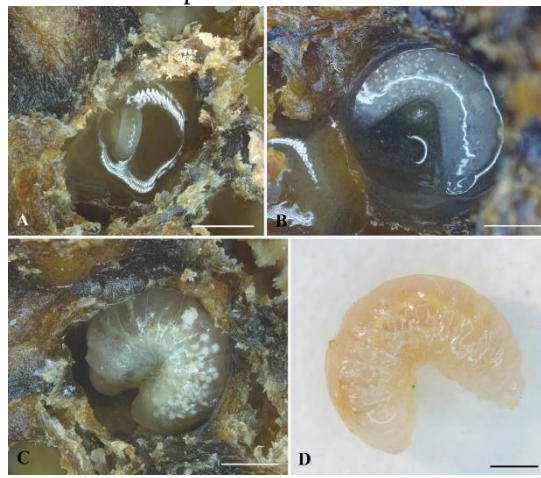

Figure 3.90. Larvae stage of *Lepidotrigona flavibasis*.
A. Newly hatched larvae. B. Larvae suck food. C. The last instar larva is located inside the nest hole. D. Late instar larvae observed by stereomicroscope. Scale bar: 1mm.

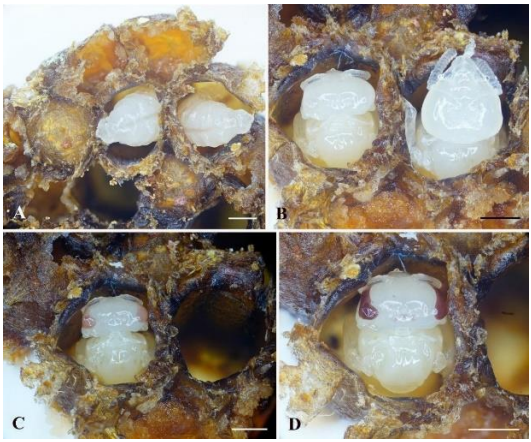

Figure 3.91. Pupa stage of *Lepidotrigona flavibasis*
A. Prepupa. B-D. Pupa. Scale bar: 1mm.

3.2.2. Some ecological characteristics of Lepidotrigona flavibasis (Cockerell, 1929)

3.2.2.1. Relationship between the flight activities and temperature, humidity

* Natural enemies and food source of *Lepidotrigona flavibasis*

The initial results of the study show that three species as the main enemies of the *Lepidotrigona flavibasis*: the gecko *Hemidactylus frenatus*, the leaf-cutter bee *Megachile disjuncta*, and the black soldier fly *Hermetia illucens*. Identifying three species of plants are the food sources of *Lepidotrigona flavibasis* in the study area: longan *Dimocarpus longan* Lour., Moss Roses *Portulaca grandiflora* Hook. and the corn *Zea mays* L.

* Relationship between the flight activities and temperature, humidity

When flying outside the nest, they may find food sources, and collect pollen, propolis or honey, and the number of individuals in this activity is much higher than that in carrying garbage activity. The number of individuals leaving the nest in this case recorded a relatively stable number of individuals from 7:00 a.m. to 2:00 p.m. and decreased after 2:00 p.m. to 5:00 p.m. However, the activity of flying out without carrying trash occurs most

strongly at 8:00 a.m. to 9:00 a.m. and 12:00 p.m. to 1:00 p.m. (2 individuals/minute).

Flight activities returning to the nest include carrying pollen, carrying propolis, and carrying honey activities. Pollen and propolis collection activities with a low number of individuals (1 individual/minute). In contrast, honey collection activity takes place strongly. The number of individuals collecting honey increased rapidly from 7:00 a.m. to 9:00 a.m. and stabilized at 10:00 a.m. to 2:00 p.m. (2 individuals/minute), then gradually decreased.

The results can be seen that the activity of stingless bees is proportional to the temperature, specifically their activities take place actively when the temperature gradually increases. However, their activities tend to decrease at high temperatures and low humidity. In addition, when humidity is too high, worker bees are very inactive. In particular, when it rains, worker bees stay inside the nest, use stored food sources, and do not fly out to search for food at all.

3.2.2.2. Content of heavy metals in honey and pollen of Lepidotrigona flavibasis and propose some directions for protecting their habitat

Analysis results showed that the content of five heavy metals was not detected in the honey sample of *Lepidotrigona flavibasis,* and the content of these metals in pollen was very low at the research site. However, the appearance of As, Cd, and Pb in pollen samples indicates a trend of increasing these metals in the environment at the site of the bee colony. Currently, the surrounding environment has not had a clear impact on the bees, nor has it negatively affected product quality, but it is also a signal for people to pay attention.

CONCLUSION AND RECOMMENDATION

CONCLUSION

1. Recording 44 little-known bee species of 18 genera belonging to four families Apidae, Halictidae, Megachilidae, and Melittidae in Vietnam. Among them, a new subtribe, a new genus, and seven new species were discovered. In addition, five genera and 11 species are newly recorded for Vietnamese bee fauna. Most species are recorded mainly in the North and Central Highlands, and the suitable altitude range of them is 600-1000 m.

2. The nest structure of four stingless bee species belonging to two genera *Lepidotrigona* and *Tetragonula* are recorded. *Lepidotrigona flavibasis* is a common species from Northern Vietnam and its flight activity depends on temperature and humidity. No heavy metals are detected in honey samples, but determination As, Cd, Pb with low content in pollen samples.

RECOMMENDATION

1. Continue to clarify the taxonomic position of unidentified species.

2. Further research is needed on the biological and ecological characteristics of other stingless bee species.

3. Conduct research on experimental breeding of stingless bee species with high economic potential.

CONTRIBUTIONS OF THE DISSERTATION

1. Identifying the species composition and distribution of little-known taxa belonging to the superfamily Apoidea from Vietnam for the first time, among them discovering a new subtribe, a new genus, and new species for science, and newly recorded species for the Vietnamese bee fauna.

2. Providing new data on the biological characteristics of Vietnamese stingless bees including nest structure, especially the morphology of the developmental stages of stingless bee *Lepidotrigona flavibasis* for the first time. Adding new data on some ecological characteristics of this species, such as the relationship between their flight activity and temperature and humidity conditions, and also the information about the content of five heavy metals in their products (honey and pollen).