

Review

Global Biodiversity of the Family Lecithoceridae (Gelechioidea) with a Brief Historical Review

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Abstract: The family Lecithoceridae (Lepidoptera, Gelechioidea) is one of the more poorly known groups of microlepidoptera, even though it is a highly diverse group containing more than 1430 known species so far. During the last two decades since the end of the 20th century, the author has intensively studied the family Lecithoceridae, especially for the less explored areas including southern Asia and the Oceanian and Afrotropical regions. Throughout these studies, the author (often with his co-authors) described the new subfamily Crocanthinae Park, 2015, 32 new genera, and over 540 new species of the family. In this article, a historical review for the taxonomic works of the family since the comprehensive study by Gozmány is briefly summarized, with a comparison of the number of genera/species of each subfamily, and the number of the species by the subfamily in each region of the world. All available information on the phylogeny, biology, morphological characters of subfamilies, and zoogeographical remarks for the distribution of family are listed and discussed.

Keywords: Lepidoptera; Lecithoceridae; review; taxonomy; world



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1. Introduction

Our knowledge of the biodiversity on our planet is quite limited and skewed because we are still neglecting important biological heritage in many unexplored areas such as Africa and Southeast Asia, including the southern Pacific Islands. Biodiversity is a basic element of an ecosystem and the natural capital for our life and economic property. For the sustainable use of biodiversity, the discovery of new living organisms on our planet is also an urgent and important task, as valuable as its conservational activity.

The family Lecithoceridae (Lepidoptera, Gelechioidea) is one of the poorly studied groups of microlepidoptera, although it is a highly diverse lepidopteran group, with over 1430 known species belonging to 129 genera worldwide as shown in Table 1. Adults of the family are mostly nocturnal with mono-colored wings, except most of the *Crocanthes* Meyrick, 1886 species which have relatively bright colored wings as in Figure 1. Since various early researchers including Walker [1,2], Walsingham [3], Lower [4,5], and Meyrick [6–13] named about 450 species, Gozmány [14] described more than 80 species, and more than 150 species were described from China [15–21]. In addition, during last two decades, the author (often with his co-authors) described more than 540 new species and 32 new genera from the Oriental, Oceanian, and Afrotropical regions [22–24], as shown in Table 2.

Table 1. Number of the genus and species of the family Lecithoceridae.

Subfamily	No. of Genera	No. of Species (%)
Ceuthomadarinae	1	8 (0.6%)
Lecithocerinae	77	792 (55.2%)
Torodorinae	45	544 (37.9%)
Crocanthinae	6	91 (6.3%)
	129	1435 (100%)

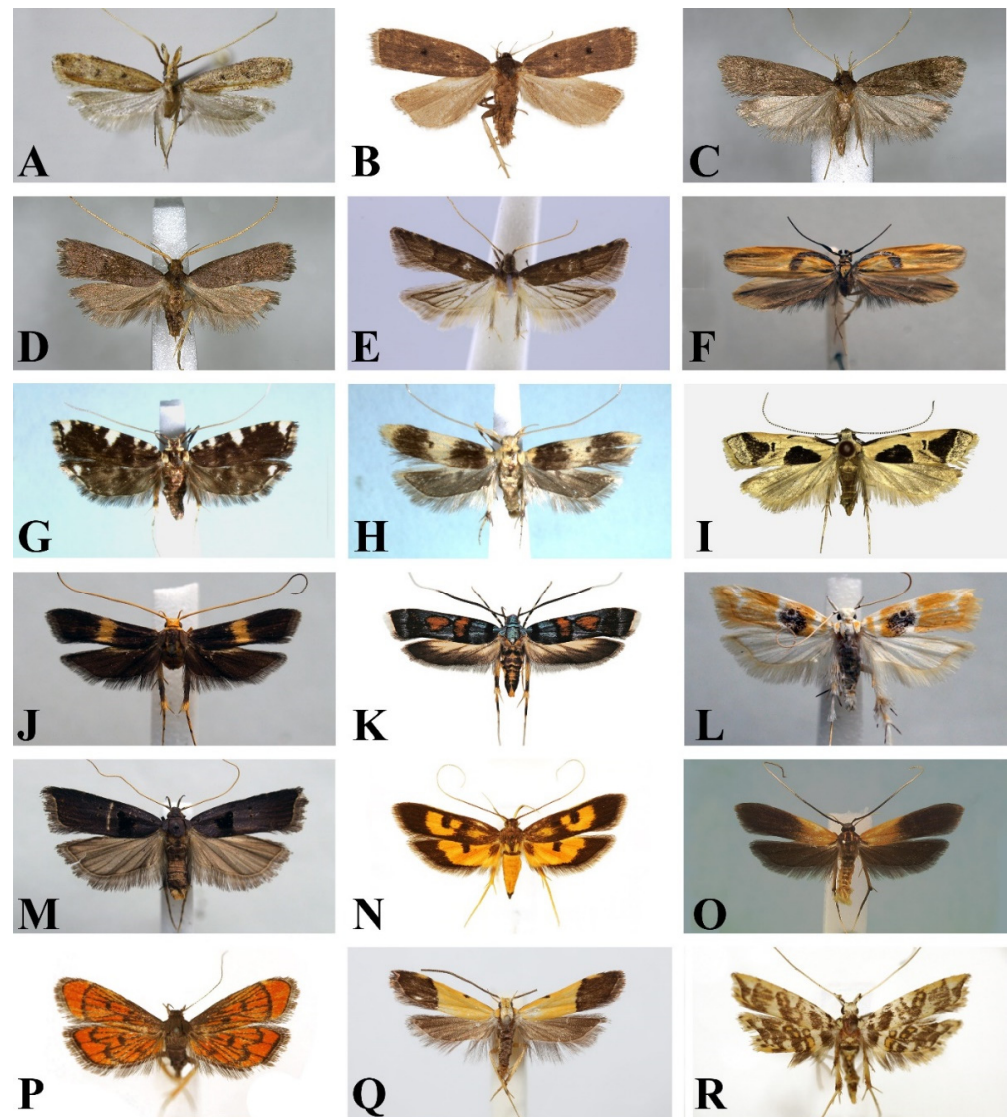


Figure 1. Adults of representative species of the family Lecithoceridae: (A) *Frisilia triturrata* Meyrick; (B) *Lecithocera distigmatella* (Zeller); (C) *Homaloxestis cholopsis* Meyrick; (D) *Lecithocera aulias* Meyrick; (E) *Lecithocera pakiaensis* Park; (F) *Tisis sabahensis* Park; (G) *Torodora karismata* Park; (H) *Caveana diemski* Park; (I) *Deltoplastis gyroflexa* Park and Wang; (J) *Thubana stenosis* Park; (K) *Tiriza leucotella* Walker; (L) *Torodora epicharis* Park; (M) *Torodora fuscobasalis* Park; (N) *Pacificulla esdiparki* Park; (O) *Lamprista emmeli* Park; (P) *Gonaepa pyrchorda* Meyrick; (Q) *Crocantes micradelpha* (Lower); (R) *Crocantes pancala* (Turner).

However, this family still needs more thorough studies, as we have continued to find many new species in the last decades. Such incomplete taxonomic representation is probably due to the lack of specialists on the family and the non-economic importance of the larvae, which mostly feed on dead material [14,24,25].

2. Material and Methods

Of the published papers about the taxonomic and faunal studies on the family Lecithoceridae and its related groups, this review was conducted mainly based on publications after the Palaearctic Lecithoceridae compiled by Gozmány [14]. Only some available biological data for larval foods were cited from Ghesquière [25] and a few other reporters including Komai et al. [26]. All the references for the information on descriptions of the

genera and the subfamilies are provided, but those related to the species are not analyzed and listed, except for only a few necessary data.

3. Synopsis of the Family Lecithoceridae

3.1. General

The family Lecithoceridae contains small- to medium-sized moths with a wingspan of 9 mm–25 mm and is one of the poorly studied groups. Due to the similarity of the wing pattern of adults, the identification of the species should mostly be conducted by the examination of the genitalia. Larvae usually feed on non-living material and organisms, with only few reports on the feeding on living organisms. The family is widely distributed throughout the world, except the Nearctic and Neotropical, regions in which only a single species is known so far. Such an incomplete taxonomic representation is probably due to lack of specialists and that moths do not have any economic significance, because the larvae are mostly not associated with crops or forests and feed on non-living material and organisms. The monograph of the subfamily Crocanthinae with 87 known species belonging to 6 genera was first published by the author [23], and that of the subfamily Torodorinae was recently published by Park et al. [24], with about 570 known species worldwide.

3.2. Morphology

The family Lecithoceridae can be defined by the following apomorphies: antennae usually longer than forewing in length and the mesial process of gnathos of male genitalia laterally compressed and always downturned. Gozmány [14] suggested that these characters support the Lecithoceridae as a monophyletic group, separating it from other related families. However, a recent study of the Afrotropical fauna confirmed that the antenna is not always longer than the forewing. This means that one of the synapomorphic properties of Lecithoceridae, the antennal length always longer than the forewing length, is no longer valid. Thus, the morphological-character-based phylogenetic trees for lepidopteran families including Lecithoceridae, suggested by various authors [27–29], may need some re-considerations.

The generic key for the family given by Gozmány [14], not referring the genus *Crocantthes*, was mainly dependent on the wing venation, especially the presence or the absence of M_2 of the hind wing, and on the presence or the absence of the spinose zones on the abdominal tergites. His ideal four major groups are: (1) M_2 present in the hindwing and with spinous zones on abdominal tergites; (2) M_2 present in the hindwing and lacking abdominal spinous zones; (3) M_2 absent in the hindwing and with spinous zones on abdominal tergites; and 4) M_2 absent in the hindwing and lacking abdominal spinous zones. Some of the valid genera separated by the venational character do not correlate to the genital characters. Moreover, many of the early described genera by Meyrick [7,10,13] and by Gozmány [14] were often described as monotypic, based on a single species. However, the generic assignment in the family could have been better if based on a combination of the characters, taking into account the shape of wings, venation, and the male genital characters.

3.3. Division of Subfamilies of the Family

The family was divided into three subfamilies by Gozmány [14]: Ceuthomadarinae Gozmány, 1978, based on *Ceuthomadarus* Mann, 1864; Lecithocerinae Le Marchand, 1947, based on *Lecithocera* Herrich-Schäffer, 1853; and Torodorinae Gozmány, 1978, based on *Torodora* Meyrick, 1894. The principal characters separating the previous three subfamilies are the proboscis and the bridge-like structure of the valva in the male genitalia. However, the subfamily Crocanthinae was additionally established by Park [23], based on the genus *Crocantthes* and its related genera, including *Pacificulla* Park, 2013 as shown in Figure 2.

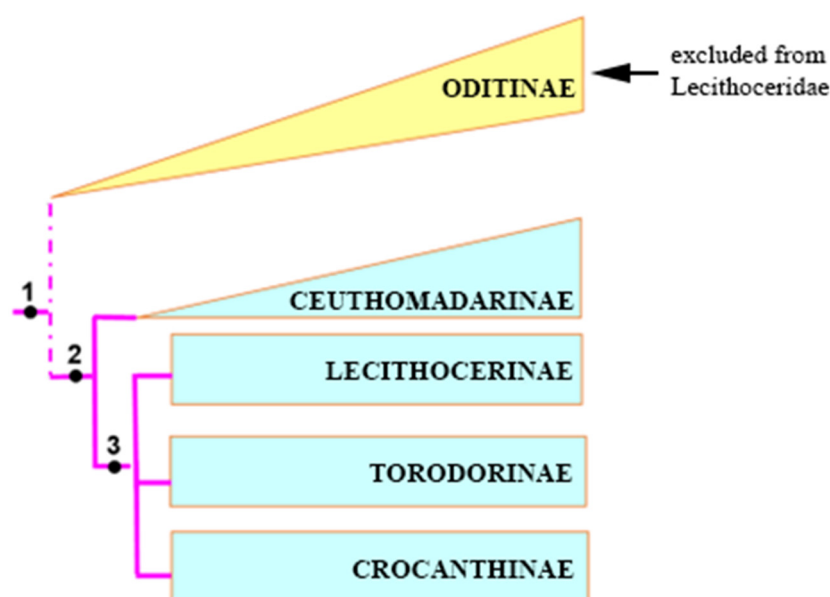


Figure 2. Diagram of the divisions of the subfamilies of Lecithoceridae (Park et al., 2022 [24]).

The subfamily Ceuthomadarinae is a small subfamily and can be distinguished from the other subfamilies based on the absence of a proboscis. Only eight species are known to be restricted in the Palaearctic Region.

The subfamily Lecithocerinae is the most diverse group of the family with about 800 species known (about 55% of all known species) belonging to 77 genera. The most diverse genus of the subfamily is *Lecithocera*, with more than 300 known species. Many of the species which were originally placed in the genus *Lecithocera* by Meyrick from 1894 to 1935 [6–13] and the species listed in *Lecithocera* by Clarke [30] were already transferred to other genera or to other subfamilies. All the *Lecithocera* species described by Viette from 1955 to 1985 from Madagascar were also transferred to the subfamily Torodorinae [31]. The generic assignment of many species which were originally placed in *Lecithocera* still remains uncertain. The subfamily Lecithocerinae can be defined and distinguished from Torodorinae by the presence of a bridge-like structure connecting the tegumen and the valval costa of the male genitalia.

The subfamily Torodorinae is the second largest subfamily among the 4 subfamilies, comprising 570 species belonging to 45 genera worldwide. The subfamily was established by Gozmány [14] based on the genus *Torodora*. Among the known species of the subfamily, more than 400 species are known from the Oriental Region, 120 species from the Afrotropical Region, 30 species from the Palaearctic Region, and only 2 species (*Torodora wauensis* Park, 2010 and *Thubana brunalis* Park, 2015) are known from the Oceanian and from Australian Region, respectively. Park [24] noted that it is surprising to find *Torodora* species from Papua New Guinea because no *Torodora* species was previously known to extend its range as far south as the Australian Region or to be present on any of the islands in the Pacific Ocean. The subfamily can be defined by the absence of a bridge-like structure connecting the tegumen and valval costa and by the uncus being usually thorn-like, directed caudally in the male genitalia, whereas in Lecithocerinae the uncus is only with basal lobes and the costal bar is well developed.

The subfamily Crocanthinae was established by Park [22], based on the genus *Crocantthes* and five related genera: *Aprosoesta* Turner, 1919; *Gonaepa* Walker, 1866; *Pacificulla*; *Lamprista* Park, 2013; and *Hanara* Park, 2013. None of the previous researchers including Gozmány [14] had attempted to place *Crocantthes* and related genera in any of the three known subfamilies (Ceuthomadarinae, Lecithocerinae, and Torodorinae) until Park [22] established the new subfamily. The synapomorphies of the subfamily include relatively bright-colored wings, hind wing often with similar markings like those of the forewing,

and gnathos absent or remarkably reduced in the male genitalia. Of the 91 known species, only 2 species are overlapped in the Australian and Oceanian regions, showing very high endemism, although these figures might inadequately reflect the actual diversity of species in the regions.

3.4. Biology

Adults of the family are mostly nocturnal, except for a few brightly colored species, e.g., *Issikiopteryx* Moriuti, 1973, or *Crocantthes* species. Larvae usually feed on non-living material and organisms [25,26,32]. Only a few reports on the larval feeding habit are available: two species of Lecithocerinae (*Homaloxestis myeloxesta* Meyrick, 1932 and *Lecithocera thiodora* (Meyrick, 1914)); three species of Torodorinae (*Athymoris martialis* (Meyrick, 1935), *Deltoplastis apotatis* (Meyrick, 1932), and *Halolaguna sublasta* (Gozmány, 1978)) were reared from dead leaves of several unknown broadleaf trees in Japan [26]; *Lecithocera corythaeola* Meyrick, 1934, as a feeder of *Coffea* sp. (Rubiaceae) [12]; *Ptilothyris serangota* Meyrick, 1930, feeding on *Hibiscus* sp. (Malvaceae); and *Torodora iresia* (Meyrick, 1911), feeding on *Anopyxis ealensis* De Wilde (Rhizophoraceae) [25] from the Afrotropical region.

3.5. Phylogeny

Since *Lecithocera* was established based on the type species *Carcina luticornella* Zeller, 1839, placed in the family Oecophoridae, species of the family were commonly referred to as species of the family Gelechiidae [10,27–29] in the early years. Marchand [33] grouped them in a newly established subfamily Lecithocerinae of Gelechiidae, and Clarke [34] established a new family, Timyridae, based on the genus *Timyra* Walker, 1864, placing the lecithocerid genera in Timyridae which was later synonymized with Lecithoceridae [14]. Hodges [35] reassigned Lecithocerinae as a subfamily of Gelechiidae, but its familial status as Lecithoceridae has been supported by most recent researchers [14,18,30,32,36–40]. Many of the early described species have been removed from the genera to which they had been originally assigned to related genera by previous authors, including Gozmány [14] and Park et al. [24], owing to the structural differences including the labial palpus, venation, presence or absence of the tergal spinose zones, and the configuration of the genital organs. On the other hand, several different phylogenetic analyses of Gelechioidea conducted in the recent decades, the analysis using morphology by Kaila [41], using molecular data by Wang and Li [42], and using both by Heikkilä et al. [43] and Sohn et al. [44], while the exact topologies are not quite the same, are generally supported as a sister-group relationship between Lecithoceridae and Autostichidae. However, so far in the above phylogenetic studies, the subfamilial relationship of the family still reveals some problems and is not obviously grouped, as well as in the traditional subdivision of the family by morphological characters.

3.6. Zoogeographical Remarks

Six terrestrial zoogeographic regions of the world were proposed by Wallace [45], namely: Palaearctic, Oriental, Nearctic, Ethiopian, Neotropical, and Australian regions. These divisions have been widely used for the comparison of distributions and taxonomic relationships of vertebrate and other animal taxa. However, according to the recently updated regions by Holt et al. [46], it was divided into 11 zoogeographic regions, separating the Oceanian region from the Australian region and Madagascan region from Ethiopian region, and some others (Figure 3).



Figure 3. Division of the world zoogeographical regions [24,47].

The total number of the known species of the family worldwide, excluding the Nearctic and Neotropical regions, comes to 1430 species, as summarized in Table 2. Of them, more than 970 species (>66%) were described from the Oriental region, and the next are the Afrotropical (=Ethiopian region) and Madagascan regions with 188 known species (about 13%), and the Palaearctic region with about 90 species [48]. The relatively small percentage for the Palaearctic region is because of the distributional allocation of species which was generally based on the type locality. A number of species reported with their type localities from near the border between the Palaearctic and Oriental regions and the northern area of the Indo-China Peninsular were often counted for the Oriental region. However, Nepal and Bhutan were counted in the Palaearctic region, even though the standard faunal boundaries of these areas zoogeographically belong to the Oriental region. Therefore, the data do not highly correspond to their real distributional range. There is no overlapping effect between faunal regions for widespread species, and such species are always treated only in the region of the original type locality.

Table 2. Number of species by subfamily and region of the family Lecithoceridae in the world.

	OR	PA	AF + MA	AU	OC	Subtotal
Ceuthomadarinae	-	8	-	-	-	8
Lecithocerinae	581	26	68	28	89	792
Torodorinae	389	30	120	2	3	544
Crocantinae	3	-	-	17	71	91
Total	973 (67.8%)	64 (4.5%)	188 (13.1%)	47 (3.3%)	163 (11.3%)	1435 (100%)

OR: Oriental region; PA: Palaearctic region; AF: Afrotropical region; MA: Madagascan region; AU: Australian region; OC: Oceanian region.

It is generally known that the Oriental region is a distributional center of the family, but the Afrotropical fauna can be closer to the Oriental region or over it when the areas are fully explored. The known number of the moths from the Oriental region is also far from the real count, because southern Asia, including Malaysian Borneo and islands of Indonesia, is still poorly explored.

During the last two decades, 31 new genera of the family Lecithoceridae were described from the Oriental and Afrotropical regions by Park [22,24] and 1 genus by Cho [49] (18 genera of Lecithocerinae, 8 genera of Torodorinae, and 3 genera of Crocantinae), as summarized in the Table 3.

Table 3. New genera of the family Lecithoceridae described during last two decades.

Subfamily/Genus	Type Locality	Type Species
LECITHOCERINAE		
<i>Corymbus</i> Park, 2019	Kenya	<i>C. deprinsi</i> Park and Aarvik, 2019
<i>Crinellus</i> Park, 2012	PNG	<i>C. eremicus</i> Park, 2012
<i>Furcalis</i> Park, 2018	Cameroon	<i>F. triodonta</i> Park, 2018
<i>Halista</i> Park, 2020	Philippines	<i>H. batillosa</i> Park and Kim, 2020
<i>Hamatina</i> Park, 2011	Indonesia, Papua	<i>H. hematoma</i> (Diakonoff, 1954)
<i>Lacuniola</i> Park, 2012	PNG	<i>L. hadrorhacha</i> Park, 2012
<i>Mireana</i> Park, 2020	Philippines	<i>M. tawitawiensis</i> Park and Kim
<i>Neopectinimura</i> Park, 2010	PNG	<i>N. neckeri</i> Park, 2010
<i>Neotimyra</i> Park, 2011	PNG	<i>N. senara</i> Park, 2011
<i>Notiosus</i> Park, 2018	Cameroon	<i>N. cupripennis</i> Park, 2018
<i>Onnuria</i> Park, 2011	PNG	<i>O. xanthochlora</i> Park, 2011
<i>Paniculata</i> Park, 2018	Cameroon	<i>P. weberi</i> Park, 2018
<i>Pectinimura</i> Park, 2008	Philippines	<i>P. montatilis</i> Park and Byun, 2008
<i>Scolizona</i> Park, 2011	Indonesia, Papua	<i>S. rhinoceros</i> (Diakonoff, 1954)
<i>Strombiola</i> Park, 2011	PNG	<i>S. papuana</i> Park, 2011
<i>Sulciolus</i> Park, 2012	Indonesia, Papua	<i>S. pachystoma</i> (Diakonoff, 1954)
<i>Thailepidonia</i> Park, 2007	Thailand	<i>T. yoshiyasui</i> Park, 2007
<i>Thrombialis</i> Park, 2020	Uganda	<i>T. sylvestrana</i> Park and Koo
TORODORINAE		
<i>Caveana</i> Park, 2010	Thailand	<i>C. diemseoki</i> Park, 2010
<i>Chrysonasma</i> Park, 2008	Philippines	<i>C. cassiterota</i> (Meyrick, 1923)
<i>Notialis</i> Park, 2009	Philippines	<i>N. sigmatis</i> Park, 2009
<i>Lepidozonates</i> Park, 2013	Taiwan	<i>L. viciniolus</i> Park, 2013
<i>Heppernalis</i> Park, 2013	Indonesia, Sulawesi	<i>H. decorella</i> Park, 2013
<i>Parkiana</i> Cho, 2020	Madagascar	<i>P. matutinalis</i> Cho and Agassiz, 2020
<i>Spiniola</i> Park, 2022	Malawi	<i>S. hanaro</i> Park, 2021
<i>Thubdora</i> Park, 2018	Rep. Congo	<i>T. acutalis</i> Park, 2018
<i>Triviola</i> Park, 2010	Thailand	<i>T. puiensis</i> Park, 2010
<i>Viperinus</i> Park, 2021	Kenya	<i>V. orbiosus</i> Park, 2021
<i>Woonpaikia</i> Park, 2010	Thailand	<i>W. villosa</i> Park, 2010
CROCANTHINAE		
<i>Hannara</i> Park, 2013	PNG	<i>H. buoloensis</i> Park, 2013
<i>Lamprista</i> Park, 2013	PNG	<i>L. emmeli</i> Park, 2013
<i>Pacificulla</i> Park, 2013	PNG	<i>P. flaviagera</i> Park, 2013

In the Oceanian and Australian regions, about 210 species of the family are known, with 47 species from the Australian region and 163 species of the Oceanian region [23,47]. The Australian and Oceanian regions are geographically very close to each other, but the species composition of Lecithoceridae in the two regions quite differs from each other. Among a total of 90 known species of Crocanthinae, 71 species are known only in the Oceanian region, 17 species are known only in the Australian region, and only 2 species are overlapping in both regions [23,47]. This means that the subfamily represents very high endemism, although these figures might inadequately reflect the actual diversity of species in the regions because of the limited samplings.

In the Nearctic and Neotropical regions, a single species, *Lecithocera oblitella* Felder and Rogenhofer, 1875, has been known so far, but the generic assignment of this species remains doubtful. In addition, Diakonoff [28] cited the distribution of *Lecithocera fausta* Meyrick, 1910 as “? Brazil, Argentina”, but he referred that the occurrence of the species in South America seems to be improbable.

In the Afrotropical and Madagascan regions, a total of 188 species of the family Lecithoceridae are known, belonging to 11 genera [30]. The subfamily Torodorinae in these regions is much richer in species than Lecithocerinae (about 70 species). However, this rather low

number of the known species from these regions is far from reflecting reality, as suggested by the comparison with more than 990 species known to occur in the Oriental region. In fact, the available data for the Afrotropical and Madagascan regions were based on very limited material, and the little work that had been conducted until the author started to study this fauna from 2018 [30]. On the other hand, a total of 23 lecitocerid species were described from Madagascar by Viette since 1954, originally placing these in *Idiopteryx* Walsingham, 1881 or *Lecithocera*, but all the species were transferred to other genera or families [31].

In the last five years, five genera of Lecithocerinae (*Paniculata* Park, 2018; *Furcalis* Park, 2018; *Notiosus* Park, 2018; *Corymbus* Park, 2019; and *Thrombialis* Park, 2021) and four genera of Torodorinae (*Thubdora* Park, 2018; *Viperinus* Park, 2021; *Spiniola* Park, 2022; and *Parkiana* Cho, 2020) were described from Africa by Park and Park with co-authors. Thus, the number of species inhabiting these regions can be expected to be at least more than 10 times greater than that corresponding to our current knowledge.

4. Conclusions

According to phylogenetic analyses of Gelechioidea conducted during recent decades [41–44,50], the family Lecithoceridae is generally supported as the sister-group of Autostichidae but the exact topologies are not quite the same. Several genera of the subfamily Lecithocerinae are grouped with one Torodorinae species, while some Ceuthomadarinae species are grouped with Crocanthinae species. As noted in the above phylogenetic studies, the subfamilial relationship of the family still reveals some problems and cannot obviously be grouped as well as in the traditional subdivision of the family by morphological characters. Therefore, further studies using morphology and molecules together are needed to clarify the relationships of the subfamilies or the reassignment of the generic status.

The fauna of the family Lecithoceridae in the Afrotropical region, as an example, has been poorly explored, with 196 known species by the comparison of more than 990 species in the Oriental region. This rather low number is only because of the very limited material available for study and the little work that has been conducted until the author started to study this fauna in recent years. There is no doubt that the number of species of Lecithoceridae is very far from the real count and can be closer to the Oriental region or even exceeding it when the areas are fully explored. This is also the same situation as in the southern area of Asia.

As one of the interesting results, none of the known species of Lecithoceridae from the African continent have been found in Madagascar so far, even though the island is close to this continent. The fauna of Madagascar could be another example showing a very high level of endemism despite the relative proximity with a large neighboring area. In the case of the Australian and Oceanian regions, only 2 species of the 91 known species are overlapping in both regions. Therefore, it is considered that the family Lecithoceridae represents remarkably high endemism, although these figures might inadequately reflect the actual diversity in these regions.

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Abbreviations

MGCL	McGuire Center of Lepidoptera and Biodiversity: University of Florida: Gainesville, USA.
MfN	Zoologisches Museum für Naturkunde, Humboldt-Universität, Berlin, Germany.
MNHN	Museum national d’Histoire naturelle, Paris, France.
NHMO	The Natural History Museum, University of Oslo, Oslo, Norway.
NHMUK	The Natural History Museum, London, UK.
NKU	Nankai University: Tienjin, China.
RMNH (=NCB)	Rijksmuseum van Natuurlijke Historie, Leiden, The Netherlands.
ZMUC (=ZMCD)	Zoological Museum, University of Copenhagen, Denmark.
USNM	US National Museum of Natural History, Wash. D.C., USA.

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