https://www.biodiversityjournal.com - Edizioni Danaus
Biodiversity Journal, 2025, 16 (2): 259–269 - **Article**
https://doi.org/10.31396/Biodiv.Jour.2025.16.2.259.269

Biodiversity Journal
ISSN 2039-0394 (Print Edition)
ISSN 2039-0408 (Online Edition)

Seven years fixed-point observation of nocturnal moths by light-trap in western Honshu, Japan: dataset description, assemblage characterization, and consideration of the period required for elucidating fauna

Yoshihiro Senda[1,*], Toshinori Takashiba[2], Jôji Enoki[1] & Shingo Nakamura[1,†]

[1]Hiwa Museum of Natural Science, Hiwa 1119–1, Hiwa, Shôbara City, Hiroshima 727–0301 Japan
[2]Mori 2922, Tôjo, Shôbara City, Hiroshima 729–5456 Japan
*Corresponding author, e-mail: geostix666@gmail.com; ORCID https://orcid.org/0000-0001-8507-1075
[†]Deceased author

ABSTRACT Elucidating the insect fauna of a specific area presents often a challenging task, necessitating thorough surveys that account for seasonal fluctuations and other pertinent factors. To efficiently outline the local insect fauna, it is imperative to amass information regarding the necessary survey effort in diverse regions and environments. In this study, we have conducted analyses of diversity and phenology using the collected data which is gathered from 55,834 individuals of 1,156 species over seven years of fixed-point observation since 2015. Additionally, we have contemplated the requisite survey effort to comprehend the moth fauna in agroecosystems within the hilly and mountainous regions of western Honshu. Dominant species assemblages of each year were significantly divided into two main groups through clustering analysis using the Bray-Curtis index. Based on the ACE and Chao 1 estimators, approximately 1,200 species could potentially be found in this area. An analysis of the data revealed that conducting a survey from March to December for five years would likely encompass approximately 90% of the species present. This occurrence data has been compiled into a Darwin Core dataset, and a dataset description is provided in this paper.

KEY WORDS Agroecosystem; biodiversity; Bray-Curtis index; Chûgoku Region; insect fauna; museum collection.

Received 05.05.2025; accepted 15.06.2025; published online 30.06.2025

INTRODUCTION

It is widely recognised that nocturnal insects exhibit a strong attraction to (artificial) light sources. This method capitalises on this behaviour and finds applications in scientific research, pest control, and recreational insect collecting. This method serves as an indispensable tool for faunal surveys, allowing the efficient capture of nocturnal insects, particularly moths, which attract a considerable number of individuals. The quantity of moths drawn to light is known to be influenced by lunar phases; a higher number of individuals are attracted during the new moon (Williams, 1939; Williams & Singh, 1951). Jonason et al. (2014) noted that temperature is related to the number of individuals attracted.

Elucidating the insect fauna of a specific area is often a challenging task, requiring comprehensive surveys that take into account seasonal dynamics and other relevant factors. Morishima & Ohnuma (2001) argued that a survey period of three or more years is essential to outline the fauna adequately.

Nevertheless, the necessary timeframe varies depending on the environment, region, study area, and the number of investigators involved. Therefore, it is crucial to accumulate information on the required survey effort in different regions and environments to outline the local insect fauna efficiently. This information should encompass necessary timeframes, survey frequency, and environmental considerations to yield optimal results. Besides, moth fauna have been suggested as useful environmental indicators (e.g., Halloway, 1985; Martel & Mauffette, 1997; Tateiwa et al., 2012). As mentioned above, mostly nocturnal moths are attracted by light sources. Consequently, the elucidation of a required survey effort to understand the nocturnal moth fauna of an area using light traps would facilitate a speedy and accurate environmental assessment of the area.

Since 2015, the second and last authors, Takashiba and Nakamura, have conducted a fixed-point survey of nocturnal moths using a light trap. The data from 2015 to 2021 have been previously published as a species list (Nakamura & Takashiba, 2016, 2018, 2019; Nakamura et al., 2020, 2021, 2022). Based on this dataset, we hypothesised that it would be feasible to estimate the required survey effort needed to understand the moth fauna in agroecosystems within the hilly and mountainous regions of western Honshu. In this paper, we conduct analyses of diversity and phenology using the data and contemplate the necessary survey effort to comprehend the moth fauna. Furthermore, this extensive dataset holds significant potential for biodiversity information. To facilitate widespread use, we have compiled the data as a Darwin Core dataset, describing it comprehensively in this paper.

MATERIAL AND METHODS

Study area

The study area (Fig. 1) is located in northeastern Hiroshima Prefecture, western Honshu, Japan (34.967025°N, 133.202167°E, alt. 600 m), amidst agricultural land mainly comprising chrysanthemum fields and rice fields. The area is encompassed

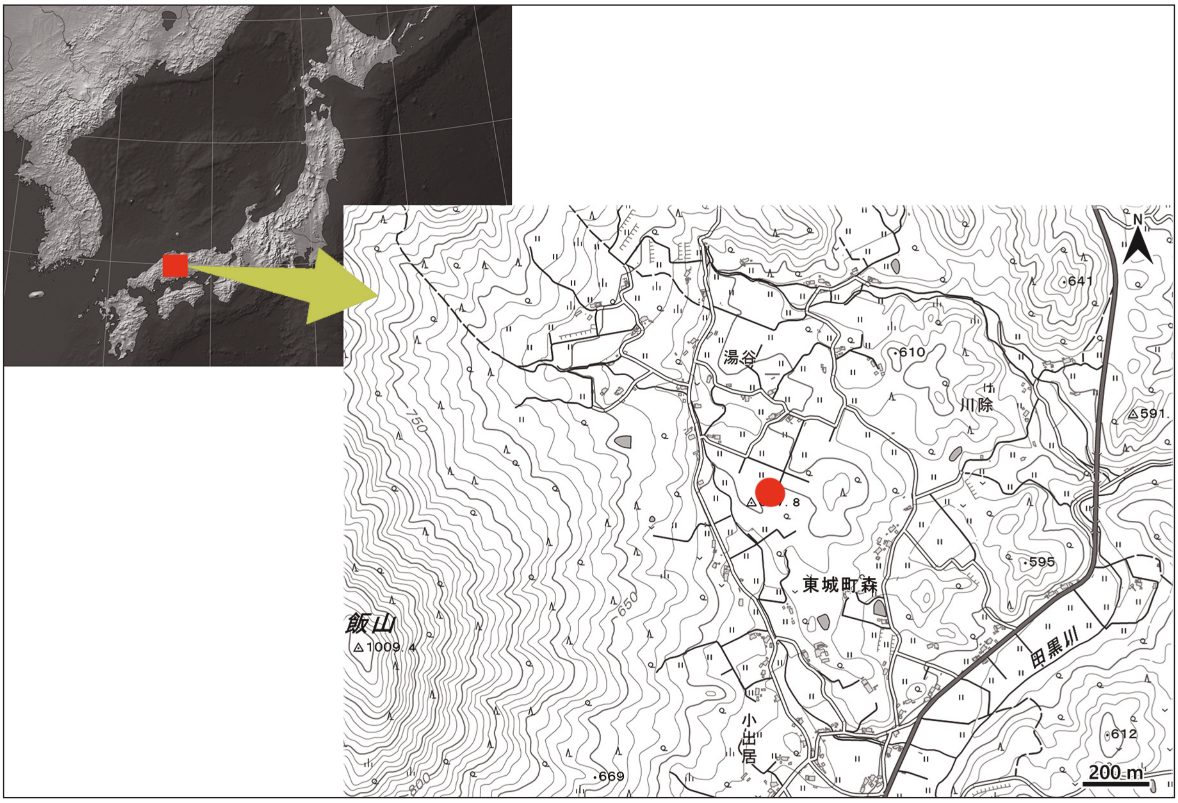

Figure 1. Study area: Hiroshima Prefecture, western Honshu, Japan. The circle indicates where the light trap was set.

by secondary deciduous broadleaved forests and coniferous plantations. Mean annual precipitation and temperature are 1,600–2,000 mm and 10–11 °C (-1–0 °C in the coldest month and 22–23 °C in the warmest month), respectively. Additionally, this area encounters snowfall, with an average maximum snow depth of 20–30 cm. Climate data for the area were sourced from the website of digital national land information (https://nlftp.mlit.go.jp/ksj/gml/data list/Ksj Tmplt-G02-v3_0.html).

Collection and identification

All specimens were collected using Sure Insect Light Trap (Ishizaki Electric Mfg. Co., Ltd.). A 30 W black light of the trap was turned on immediately after sunset, and the moths captured by the trap were collected next morning. The macro-moths covered were included in the following 14 superfamilies: Hepialoidea, Tineoidea, Yponomeutoidea, Gelechioidea, Zygaenoidea, Cossoidea, Tortricoidea, Thyridoidea, Pyraloidea, Lasiocampoidea, Bombycoidea, Drepanoidea, Geometroidea and Noctuoidea. Most of the specimens were identified by the pictorial books (Kishida, 2011a, b; Hirowatari et al., 2013; Nasu et al., 2013), but a part of the specimens were identified by Mr. Keitaro Eda and Dr. Rikio Sato. Most of the specimens are deposited in Hiwa Museum of Natural Science, Shôbara, Japan.

Analysis

All calculations were performed using R v.4.2.2 (R Core Development Team, 2022).

To infer the total species richness of the nocturnal moths at the study site, the sample-based species accumulation curves were estimated based on ACE and Chao 1 estimators. These estimators were calculated using ace, chao, and specaccum function in the package vegan (Oksanen et al., 2022).

The dissimilarity of the 29 dominant species (which is the total of the top 10 dominant species in each year; Table 1) among different years was calculated using the Bray-Curtis index. A dendrogram derived from the Ward method was drawn based on this index. Permutational multivariate analyses of variance (PERMANOVA) was performed to assess whether the assemblage composition of dominant species differed between branches of cluster. Calculation of Bray-Curtis index and PERMANOVA were performed with vegdist function and adonis2 function in the package vegan (Oksanen et al., 2022).

RESULTS

Dataset description

General description. This contribution focuses mainly on the diversity of nocturnal moths at the point of the northeastern area of Hiroshima Prefecture, western Honshu, Japan. Moreover, this dataset was utilized to infer the necessary survey effort required to outline nocturnal moth fauna in agroecosystems in the hilly and mountainous region of western Honshu. The number of individuals observed for each species between 2015 and 2021 is arranged chronologically by day.

Sampling description. The study site is a farm land located northeastern area of Hiroshima Prefecture, western Honshu, Japan. All nocturnal moths were collected using Sure Insect Light Trap (Ishizaki Electric Mfg. Co., Ltd.). A 30 W black light of the trap was turned on immediately after sunset, and the moths captured the trap were collected next morning. Most of the specimens are deposited in Hiwa Museum of Natural Science, Shôbara, Japan.

Geographic coverage. We surveyed at Yudani, Mori, Tôjô-chô, Shôbara-shi, Hiroshima Pref., 34.967025°N, 133.202167°E, alt. 600 m (Fig. 1).

Taxonomic coverage. Insecta: Lepidoptera. In total, 14 superfamilies, 30 families, 670 genera and 1,156 species were collected at the study site by light trap.

Temporal coverage. Main survey can be divided into following periods:

1) 1 May 2015–24 Dec. 2015
2) 3 Jan. 2016–31 Dec. 2016
3) 1 Jan. 2017–30 Dec. 2017
4) 17 Jan. 2018–22 Dec. 2018
5) 11 Feb. 2019–30 Dec. 2019
6) 7 Jan. 2020–28 Dec. 2020
7) 3 Jan. 2021–10 Dec. 2021

Rank	2015 Species (No. of specimens)	2016 Species (No. of specimens)	2017 Species (No. of specimens)	2018 Species (No. of specimens)
1	*Spilarctia seriatopunctata* (359)	*Crambus humidellus* (440)	*Chionarctia nivea* (524)	*Chiasmia defixaria* (886)
2	*Crambus perlellus* (267)	*Chionarctia nivea* (257)	*Chiasmia defixaria* (414)	*Chionarctia nivea* (617)
3	*Crambus humidellus* (265)	*Spilarctia seriatopunctata* (214)	*Spilosoma lubricipedum* (295)	*Arichanna gaschkevitchii* (377)
4	*Chionarctia nivea* (241)	*Saturnia japonica* (156)	*Alcis angulifera* (195)	*Barsine aberrans* (315)
5	*Spilosoma lubricipedum* (232)	*Spodoptera depravata* (131)	*Xestia c-nigrum* (181)	*Spilosoma lubricipedum* (172)
6	*Spilosoma punctarium* (146)	*Xestia c-nigrum* (112)	*Xestia semiherbida* (170)	*Numenes albofascia* (159)
7	*Saturnia japonica* (133)	*Mythimna turca* (82)	*Arichanna gaschkevitchii* (165)	*Hermonassa cecilia* (154)
8	*Barsine striata* (112)	*Athetis stellata* (81)	*Mythimna turca* (164)	*Macrobrochis staudingeri* (153)
9	*Arichanna gaschkevitchii* (111)	*Spilosoma lubricipedum* (80)	*Clanis bilineata* (158)	*Mythimna turca* (152)
10	*Spodoptera depravata* (106)	*Cifuna locuples* (80)	*Saturnia japonica* (140)	*Abraxas miranda* (151)
Rank	2019 Species (No. of specimens)	2020 Species (No. of specimens)	2021 Species (No. of specimens)	Whole period Species (No. of specimens)
1	*Chiasmia defixaria* (472)	*Chiasmia defixaria* (500)	*Chionarctia nivea* (438)	*Chiasmia defixaria* (2853)
2	*Arichanna gaschkevitchii* (397)	*Spilosoma lubricipedum* (412)	*Spilosoma lubricipedum* (345)	*Chionarctia nivea* (2255)
3	*Barsine striata* (200)	*Barsine striata* (394)	*Hermonassa cecilia* (342)	*Arichanna gaschkevitchii* (1745)
4	*Hermonassa cecilia* (189)	*Arichanna gaschkevitchii* (366)	*Xestia c-nigrum* (326)	*Spilosoma lubricipedum* (1691)
5	*Malacosoma neustrium* (174)	*Chionarctia nivea* (329)	*Mythimna turca* (287)	*Hermonassa cecilia* (1190)
6	*Euthrix albomaculata* (162)	*Hermonassa cecilia* (306)	*Arichanna gaschkevitchii* (280)	*Spilarctia seriatopunctata* (1059)
7	*Spilosoma lubricipedum* (155)	*Abraxas niphonibia* (223)	*Euthrix albomaculata* (221)	*Mythimna turca* (1022)
8	*Mythimna turca* (125)	*Barsine pulchra* (208)	*Macrobrochis staudingeri* (198)	*Xestia c-nigrum* (904)
9	*Tethea ampliata* (124)	*Euthrix albomaculata* (162)	*Barsine aberrans* (182)	*Barsine striata* (896)
10	*Chionarctia nivea* (123)	*Crambus perlellus* (154)	*Chariaspilates formosaria* (179)	*Crambus humidellus* (840)

Table 1. Top ten dominant species and its numbers of individuals observed in each year and whole period.

Usage licence: Creative Commons Public Domain Waiver (CC-Zero)

Data resources.
Data package title: Moth collecting data in Mori, Tojo, Hiroshima
Resource link: https://doi.org/10.15468/8baqfh
Number of datasets: 2
Data set name: MoriMoth-events_table
Data format: Darwin Core

Description:

Column label	Column description
eventID	An identifier for the Event.
samplingProtocol	The methods used during an Event.
samplingEffort	The amount of effort expended during an Event.
sampleSizeValue	A numeric value for a measurement of the size (time duration, length, area, or volume) of a sample in a sampling Event.
sampleSizeUnit	The unit of measurement of the size (time duration, length, area, or volume) of a sample in a sampling Event.
eventDate	The date during which an Event occurred.
eventTime	The time during which an Event occurred.
startDayOfYear	The earliest integer day of the year on which the Event occurred (1 for January 1, 365 for December 31, except in a leap year, in which case it is 366).
eventRemarks	Comments or notes about the Event.
country	The name of the country or major administrative unit in which the Location occurs.
countryCode	The standard code for the country in which the Location occurs.
stateProvince	The name of the next smallest administrative region than country (state, province, canton, department, region etc.) in which the Location occurs.
municipality	The full, unabbreviated name of the next smallest administrative region than county (city, municipality etc.) in which the Location occurs.
verbatimLocality	The original textual description of the place.
locationID	An identifier for the set of Location information.
decimalLatitude	The geographic latitude of the study site.
decimalLongitude	The geographic longitude of the study site.
geodeticDatum	The geographic information system (GIS) upon which the geographic coordinates given in decimalLatitude, decimalLongitude and meterElevation are based.
type	The type of the resource.
ownerInstitution-Code	The acronym in use by the institution having ownership of the objects or information referred to in the record.

Data set name: MoriMoth-occurrence_table
Data format: Darwin Core
Description:

Column label	Column description
eventID	An identifier for the Event.
occurrenceID	An identifier for the Occurrence
basisOfRecord	The specific nature of the data record.
individualCount	The number of individuals represented present at the time and location of the Occurrence.
organismQuantity	A number or enumeration value for the quantity of Organisms.
organism-QuantityType	The type of quantification system used for the quantity of Organisms.
occurrenceStatus	A statement about the presence or absence of a Taxon at a Location.
scientificName	The full scientific name.
vernacularName	The common name in Japan
kingdom	A scientific name of the kingdom in which the taxon is classified.
phylum	A scientific name of the phylum in which the taxon is classified.
class	A scientific name of the class in which the taxon is classified.
order	A scientific name of the order in which the taxon is classified.
family	A scientific name of the family in which the taxon is classified.
infraspecific-Epithet	The name of the lowest or terminal infraspecific epithet.
taxonRank	The taxonomic rank of the taxon.
recordedBy	A name of people who collected the specimen.
identifiedBy	A name of people who identified the specimen.
type	The type of the resource.

Moth fauna

In total, 55,834 individuals belonging to 1,156 species were captured. The majority of species were from two families: Noctuidae (37.1%) and Geometridae (23.8%). The most abundant species was *Chiasmia defixaria* (Walker, 1861) (Geometridae: Ennominae), accounting for 2,853 individuals (5.12%). Rank abundance curve is shown in Fig. 2.

The top ten dominant species in the whole period accounted for 25.9% (14,455 individuals; see Table 1 for details) of the total number of individuals. Approximately one-third of all species were rare, with 213 species being singletons (18.4%) and 118 being doubletons (10.2%).

Nine endangered species are observed as follows: *Actias gnoma* (Butler, 1877) (Saturniidae: Saturniinae), *Laelia coenosa sangaica* Moore, 1877 (Lymantriidae), *Catocala actaea* Felder et Rogenhofer, 1874, *Catocala lara lara* Bremer, 1861, *Catocala nagioides* Wileman, 1924 (all Noctuidae: Catocalinae), *Hypena claripennis* (Butler, 1878) (Noctuidae Hypeninae), *Capsula spargani* (Esper, 1790), *Lacanobia aliena amurensis* (Staudinger, 1901) and *Virgo confusa* Kishida et Yoshimoto, 1991 (all Noctuidae: Hadeninae). Three of these (*A. gnoma*, *Lae. coenosa* and *Cap. spargani*) use wetland plants as hosts. Another three species (*H. claripennis*, *L. aliena amurensis* and *V. confusa*) inhabit grasslands. One of *Catocala* species, *Cat. actaea*, uses *Quercus acutissima* as hostplant, which is common in secondary forest of the hilly and mountainous regions of Honshu.

The observed species number reached 80% of the total in the fourth year and 90% in the fifth year.

	2015	2016	2017	2018	2019	2020	2021
Species	496	586	621	692	658	585	594
Specimens	5,851	5,302	8,048	10,723	7,905	8,514	9,491
Added species	—	238	135	124	86	41	36
Accumulated species	496	734	869	993	1,079	1,120	1,156

Table 2. Numbers of species and individuals observed in each year.

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Species	9	11	44	114	438	677	622	622	483	211	102	41
(2015)	–	–	–	–	(152)	(258)	(126)	(173)	(104)	(21)	(46)	(7)
(2016)	(5)	(2)	(10)	(11)	(187)	(245)	(169)	(175)	(119)	(84)	(28)	(11)
(2017)	(2)	(4)	(5)	(5)	(139)	(288)	(190)	(250)	(143)	(78)	(25)	(3)
(2018)	(1)	(3)	(10)	(56)	(169)	(321)	(276)	(293)	(249)	(77)	(37)	(19)
(2019)	(0)	(1)	(5)	(37)	(126)	(323)	(308)	(244)	(188)	(75)	(16)	(23)
(2020)	(2)	(5)	(18)	(17)	(81)	(271)	(286)	(243)	(145)	(70)	(27)	(9)
(2021)	(3)	(7)	(26)	(41)	(14)	(280)	(231)	(268)	(181)	(71)	(32)	(8)
(Average per years)	2.6	3.7	12.3	27.8	124.0	283.7	226.6	235.1	161.3	68.0	30.1	11.4
Species collected only the month	0	0	5	8	6	12	18	13	5	11	9	8
Specimens	18	67	238	482	3,377	12,167	9,488	10,046	5,717	3,685	790	258

Table 3. Numbers of species and individuals observed in each month. Numbers in parentheses indicate the number of specimens in each year.

Sample-based species accumulation curve is shown in Fig. 3, based on ACE and Chao 1 estimators. It is estimated that approximately 1,200 species of nocturnal moths inhabit the survey area.

Assemblage dynamics

Both the number of species and individuals were highest in 2018, with 692 species and 10,723 individuals recorded, respectively (Table 2). June exhibited the highest species richness, with a total of 677 species (Table 3). Species abundance during the year exhibited a clear peak in the beginning from March (Fig. 4). Although fewer species were caught in March and December, 11.3% and 19.5% of the observed species were observed in only those months, respectively (Table 3).

The most abundant species was *C. defixaria* as mentioned above, but dominant species changed in composition every year (Table 1). As shown in Fig. 5, the cluster analysis supported two main clusters. One cluster comprises assemblages for each year 2015 and 2016. The other cluster consists of assemblages for each year from 2017 to 2021. Dominant species assemblages significantly differed between two clusters (PERMANOVA, $r^2 = 0.53$, $p < 0.05$).

DISCUSSION

The yearly shift in dominant species is intriguing phenomenon. The result of clustering indicates two distinct groups: 2015–2016 and 2017–2021 (Fig. 5). This pattern suggests the possibility of drastic environmental changes occurring in the surrounding area of the study site. Alternatively, it might indicate capture pressure. However, there is no data available to support these speculations. It is implying that this phenomenon might be common, because similar yearly species changes were observed by Choi et al. (2022). On the other hand, it is established that populations of lepidopteran insects undergo more or less periodic oscillations (Royama, 1984; Liebhold et al., 1996). A part of periodical oscillation of each species possibly ob-

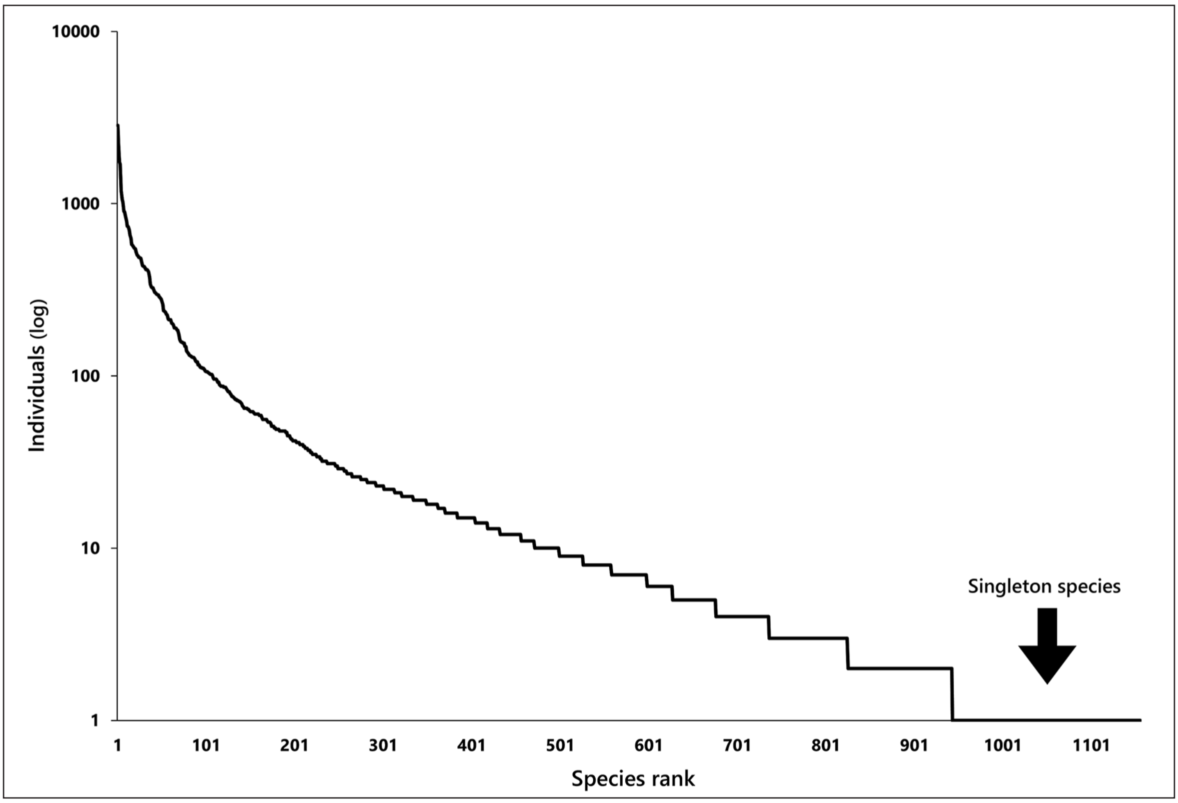

Figure 2. Rank abundance curve of moths (1,156 species, 55,834 individuals) collected during the survey period.

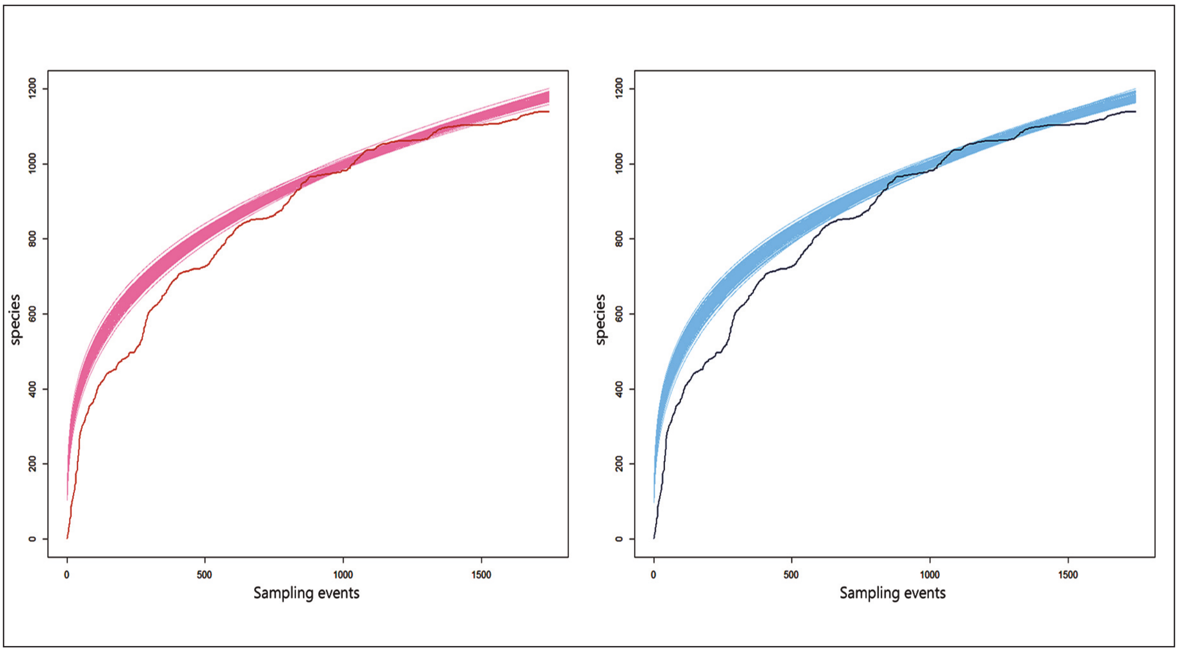

Figure 3. Sample-based species accumulation curves, comparing the observed (darker line) and estimated (paler line) numbers, based on ACE (left) and Chao 1 (right) estimators.

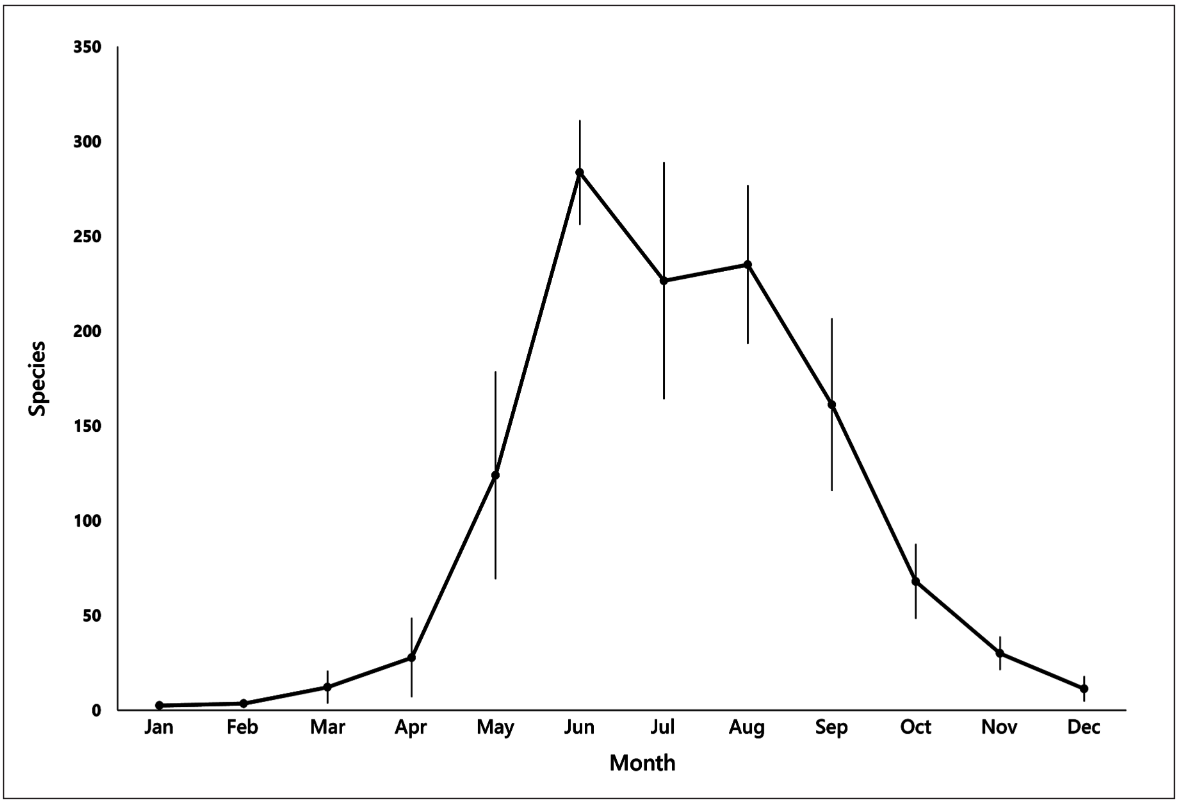

Figure 4. Monthly dynamics in the average number of moth species captured each month over the course of seven years. Error bars mean 95% confidence interval.

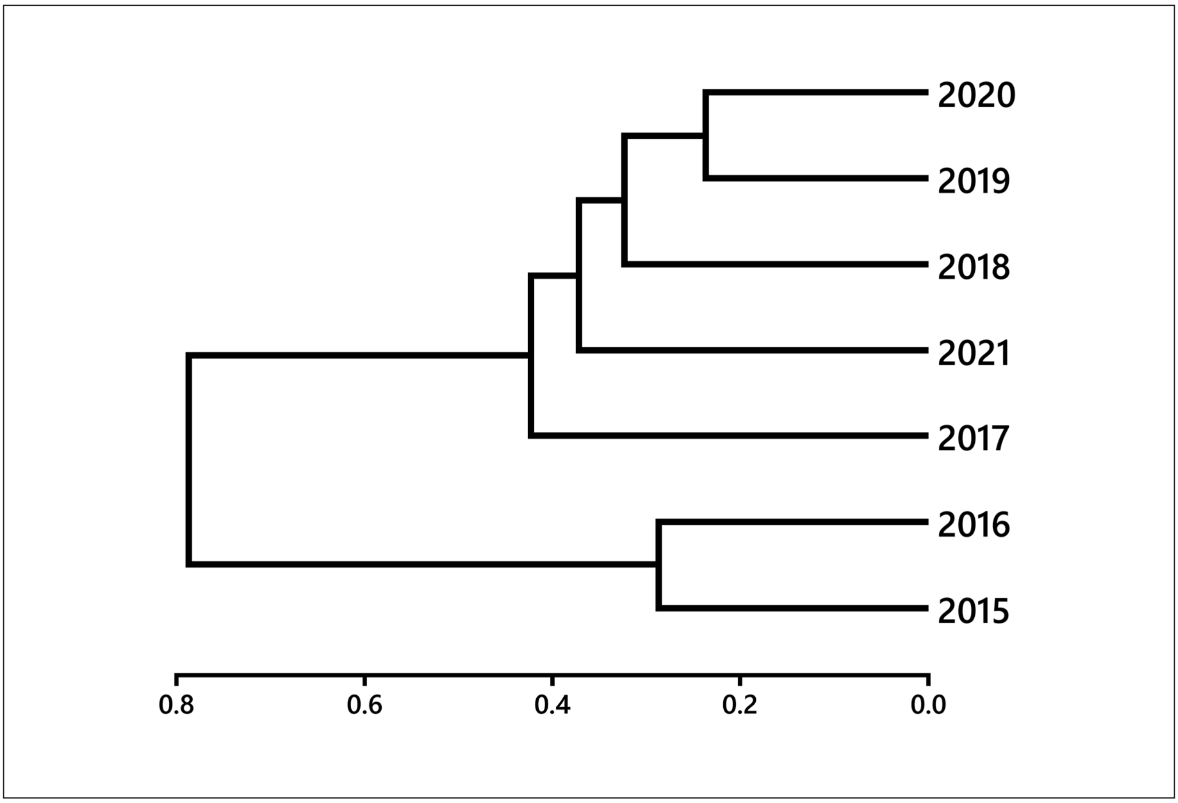

Figure 5. Dominant species assemblages similarity among the years. The dendrogram illustrated from the results of the cluster analysis using Bray-Curtis index.

served as yearly changes of dominant species. It is necessary to investigate more long-term dynamics of assemblage, which leads to understand this phenomenon. Additionally, it is required further research in the future because environmental factors are not adequately assessed. We hope that the published dataset will facilitate further research on this phenomenon.

We evaluated the survey efforts required to elucidate the local fauna of nocturnal moth. Our first evaluation focused on the survey period within the year. Species richness is higher during the warm season, whereas peculiar species emerge during the cold season (Table 3, Fig. 4). As a results, 11.3% and 19.5% of the observed species were observed in only March and December, respectively. Thus, it is presumed that surveys should be conducted from March to December to comprehend species diversity and phenology.

The second evaluation considered the survey duration. Morishima & Ohnuma (2001) discussed that more than three years are necessary to elucidate the insect fauna. In this study, data analysis revealed that 90% of the species obtained during the survey were captured within a five-year timeframe. This result supports the previous study. Consequently, it is suggested that a single survey period should span three to five years, at least. Nevertheless, the required survey duration will inevitably vary depending on the region, environment, and employed light sources.

In addition, a more profound understanding of the relationship among lunar phases, weather, and the number of observed species would enable more efficient surveys. Since a greater number of individuals are attracted to light during the new moon (Williams, 1939; Williams & Singh, 1951), choosing survey times accordingly might be more efficient.

According to Jonason et al. (2014), it is suggested that weather conditions exert a greater influence. Unfortunately, the present study lacks the necessary data for analysing such relationships. At least, this study could serve as an informative indicator for fauna survey and assessments in agroecosystems in the hilly and mountainous regions of western Honshu, Japan.

ACKNOWLEDGEMENTS

We appreciate Dr. Keiko Kishimoto-Yamada (Faculty of Advanced Science and Technology, Ryukoku University, Japan), Dr. Hiroyuki Yoshitomi (Ehime University Museum, Japan) for reviewing the draft; Dr. Kota Sakagami (Hyogo Prefectural Technology Center for Agriculture, Forestry and Fisheries) for giving helpful advice; Mr. Keitaro Eda (Yokohama City, Japan) and Dr. Rikio Sato (Niigata City, Japan) for supporting species identification.

REFERENCES

Choi S.W., An J.S., Lee J.Y. & Koo K.A., 2022. Spatial and temporal changes in moth assemblages along an altitudinal gradient, Jeju-do island. Scientific Reports, 12: 20534. https://doi.org/10.1038/s41598-022-24600-z

Halloway J.D., 1985. Moths as indicator organisms for categorising rain forest and monitoring changes and regenerating processes. In: Chadwick A.C. & Sutton SL (eds.). Tropical Rain-Forest: The Leeds Symposium. Philosophical and Literary Society, Leeds, pp. 235–242.

Hirowatari T., Nasu Y., Sakamaki Y. & Kishida Y., 2013. The standard of moths in Japan III. Gakken, Tokyo, 450 pp.

Jonason D., Franzén M. & Ranius T., 2014. Surveying moths using light traps: effects of weather and time of year. PLoS ONE, 9: e92453. https://doi.org/10.1371/journal.pone.0092453

Kishida Y., 2011a. The standard of moths in Japan I. Gakken, Tokyo, 412 pp.

Kishida Y., 2011b. The standard of moths in Japan II. Gakken, Tokyo, 416 pp.

Liebhold A.M., Kamata N., Jacob T., 1996. Cyclicity and synchrony of historical outbreaks of the beech caterpillar, *Quadricalcarifera punctatella* (Motschulsky) in Japan. Population Ecology, 38: 87–94. https://doi.org/10.1007/BF02514974

Martel J. & Mauffette Y., 1997. Lepidopteran communities in temperate deciduous forests affected by forest decline. Oikos, 78: 48–56.

Morishima K. & Ohnuma T., 2001. Period required for elucidating plant flora and insect fauna. Japanese Journal of Environmental Entomology and Zoology, 12: 1–4.

Nakamura S. & Takashiba T., 2016. The moths from Mori, Tojyo-cho, Shobara-city, Hiroshima Prefecture. Collected by light trap. Miscellaneous Reports of the Hiwa Museum for Natural History, 57: 23–70.

Nakamura S. & Takashiba T., 2018. The moths from Mori, Tojyo-cho, Shobara-city, Hiroshima Prefecture. Collected by light trap (II). Miscellaneous Reports of the Hiwa Museum for Natural History, 59: 1–73.

Nakamura S. & Takashiba T., 2019. The moths from Mori, Tojyo-cho, Shobara-city, Hiroshima Prefecture. Collected by light trap (III). Miscellaneous Reports of the Hiwa Museum for Natural History, 60: 1–79.

Nakamura S., Takashiba T. & Enoki J., 2020. The moths from Mori, Tojyo-cho, Shobara-city, Hiroshima Prefecture. Collected by light trap (IV). Miscellaneous Reports of the Hiwa Museum for Natural History, 62: 49–164.

Nakamura S., Takashiba T. & Enoki J., 2021. The moths from Mori, Tojyo-cho, Shobara-city, Hiroshima Prefecture. Collected by light trap (V). Miscellaneous Reports of the Hiwa Museum for Natural History, 63: 59–136.

Nakamura S., Takashiba T. & Enoki J., 2022. The moths from Mori, Tojyo-cho, Shobara-city, Hiroshima Prefecture. Collected by light trap (VI). Miscellaneous Reports of the Hiwa Museum for Natural History, 64: 19–94.

Nasu Y., Hirowatari T. & Kishida Y., 2013 The standard of moths in Japan. IV. Gakken Education Publishing, Tokyo, 552 pp.

Oksanen J., Simpson G.L., Blanchet F.G., Friendly M., Kindt R., Legendre P., Minchin P.R., O'Hara R.B., Simpson G.L., Solymos P., Stevens M.H.H., Szoecs E., Wagner H., Barbour M., Bedward M., Bolker B., Borcard D., Carvalho G., Chirico M., Caceres M., Durand S., Evangelista H.B.A., FitzJohn R., Friendly M., Furneaux B., Hannigan G., Hill, M.O., Lahti L., McGlinn D., Ouellette M.-H., Cunha E.R., Smith T., Stier A., Braak C.J.F.T. & Weedon J., 2022. Vegan: Community Ecology Package. R Package version 2.6-4. https://cran.rproject.org/web/packages/vegan/index.html.

R Core Development Team, 2022. R: a language and environment for statistical computing. https://www.R-project.org/

Royama T., 1984. Population dynamics of the spruce budworm *Choristoneura fumiferana*. Ecological Monographs, 54: 429–462. https://doi.org/10.2307/1942595

Tateiwa K., Hirowatari T., Ikeuchi K., Jinbo U., Kishimoto T. & Ishii M., 2012. Evaluation of forest

ecosystems in Odaigahara using moth assemblages. Japanese Journal of Environmental Entomology and Zoology, 12: 55–74.
Williams C.B., 1939. An analysis of four years captures of insects in a light trap. Part I. General survey; sex proportion; phenology; and time of flight. Transactions of the Royal Entomological Society of London, 89: 79–131. https://doi.org/10.1111/j.1365-2311.1939.tb00738.x
Williams C.B. & Singh B., 1951. Effect of moonlight on insect activity. Nature, 167: 853. https://doi.org/10.1038/167853a0