HOKKAIDO UNIVERSITY

Title	Faunal Makeup of Macrolepidopterous Moths in Nopporo Forest Park, Hokkaido, Northern Japan, with Some Related Notes
Author(s)	Sato, Hiroaki; Fukuda, Hiromi
Citation	Environmental science, Hokkaido : journal of the Graduate School of Environmental Science, Hokkaido University, Sapporo, 8(1), 93-120
Issue Date	1985-07-31
Doc URL	https://hdl.handle.net/2115/37177
Type	departmental bulletin paper
File Information	8(1)_93-120.pdf

Hokkaido University Collection of Scholarly and Academic Papers : HUSCAP

Environ. Sci., Hokkaido	8 (1)	93~120	June 1985

Faunal Makeup of Macrolepidopterous Moths in Nopporo Forest Park, Hokkaido, Northern Japan, with Some Related Notes

Hiroaki Sato and Hiromi Fukuda

Department of Biosystem Management, Division of Environmental Conservation, Graduate School of Environmental Science, Hokkaido University, Sapporo, 060, Japan

Abstract

Macrolepidopterous moths were collected in Nopporo Forest Park to disclose the faunal makeup. By combining this survey with other from Nopporo, 595 species were recorded, comprising of roughly 45% of all species discovered in Hokkaido to date. The seasonal fluctuations of a species diversity were bimodal, peaking in August and November. The data obtained had a good correlation to both lognormal and logseries distributions among various species-abundance models. In summer, it was found that specialistic feeders dominated over generalistic feeders. However, in autumn, generalistic feeders dominated, most likely because low temperature shortened hours for seeking host plants on which to lay eggs.

Key Words: Nopporo Forest Park, Macrolepidoptera, Species diversity, Species-abundance model, Generalist, Specialist

1. Introduction

Nopporo Forest Park, which has an area of approximately 2,000 ha and is adjacent to the city of Sapporo, contains natural forests representing the temperate and boreal features of vegetation. In recent years, however, the environment surrounding this park has increasingly been urbanized and many old trees of a conifer, *Abies sachalinensis*, have died. The natural forests are currently changing to semi-natural forests. Consequently, it is ecologically worthwhile to survey the present fauna of macrolepidoptera which is a typical phytophagous assemblage in Nopporo Forest Park.

The present paper deals with the faunal makeup of the macrolepidopterous moths, with some ecological information such as a species diversity and species-abundance relationships. Additionally, the abundance of euryphagous moths in winter will also be discussed by the hypothesis of Levins and MacArthur (1969).

2. Study Area and Methods

A sampling of moths was conducted in Nopporo Forest Park (43°25′N, 141°32′E) which neighbors the city of Sapporo (Figure 1). According to Tatewaki and Igarashi

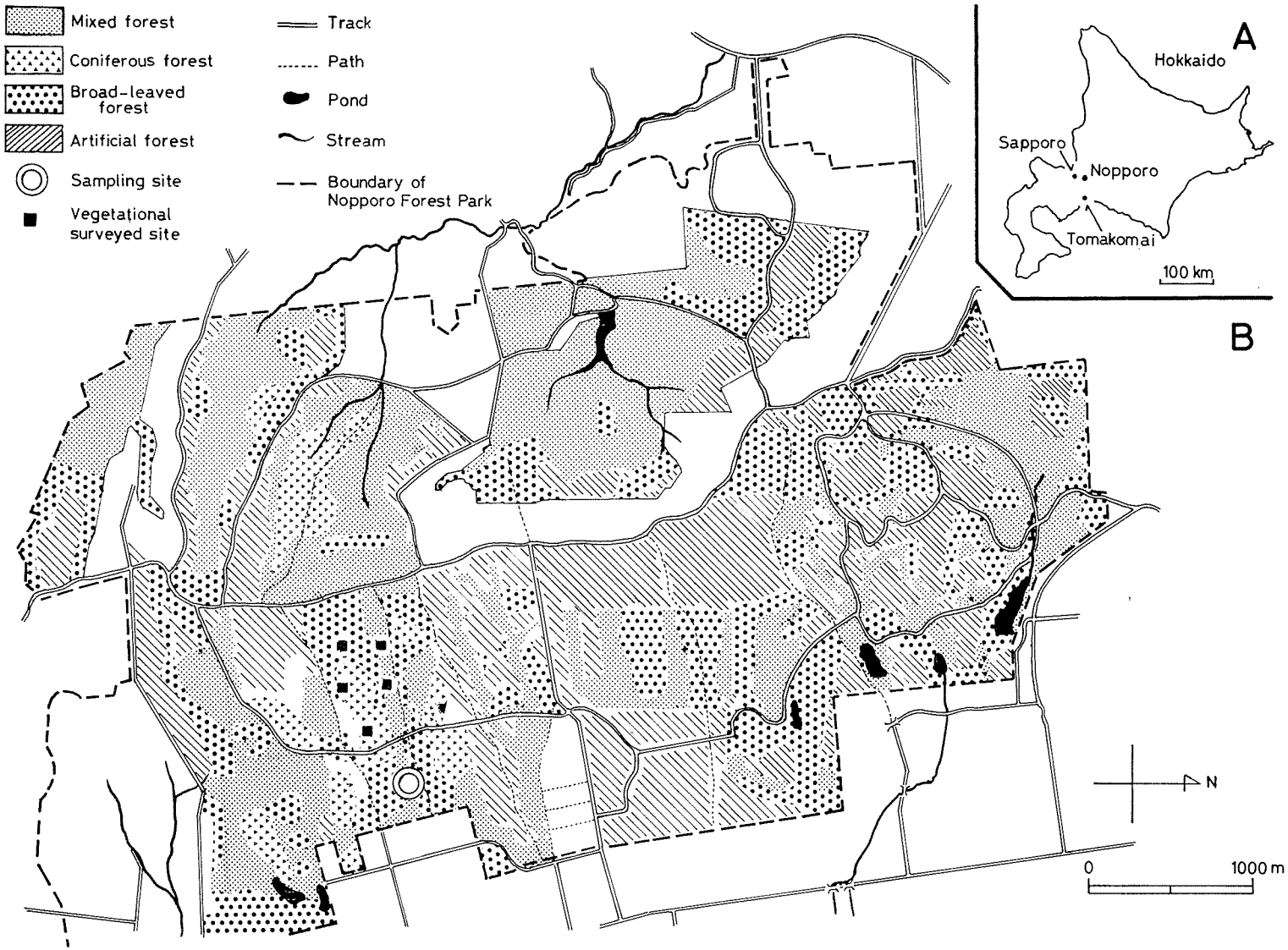

Figure 1. Location (A) and topography (B) of Nopporo Forest Park.

(1973), the general vegetation of Nopporo Forest Park consists of coniferous forests (dominated by *Abies sachalinensis*), broad-leaved forests (*Fraxinus mandshurica* var. *japonica*, *Quercus mongolica* var. *grosseserrata*, *Ulmus davidiana* var. *japonica*, *Betula platyphylla* var. *japonica*), and mixed forests (*Abies sachalinensis*, *Ulmus laciniata*, *Morus bombycis*, *Magnolia obovata*, *Magnolia kobus* var. *borealis*, *Sorbus commixta*, *Acer mono*, *Prunus ssiori*, *Tilia japonica*).

The sampling site was chosen in a mixed forest stand. The stratification diagram obtained from six 20×20 m quadrats is presented in Figure 2. The predominant species of each layer were as follows (Ishikawa, unpub.): herbaceous layer (less than 2 m in height), *Cephalotaxus harringtonica* var. *nana*, *Pachysandra terminalis*, *Rhus ambigua*, *Shizophragma hydrangeoides*, *Dryopteris crassirhizoma*, *Dryopteris austriaca*, *Chloranthus japonicus*, *Sasa senanensis*, *Abies sachalinensis*, *Fraxinus lanuginosa*, *Prunus ssiori*; shrub layer (2 to 8 m), *Fraxinus lanuginosa*, *Sorbus commixta*, *Prunus ssiori*, *Abies sachalinensis*, *Acer japonicum*, *Acer mono*; subtree layer (8 to 15 m), *Abies sachalinensis*, *Magnolia obovata*, *Fraxinus lanuginosa*, *Tilia japonica*, *Sorbus commixta*, *Prunus ssiori*; tree layer (15 to 25 m), *Abies sachalinensis*.

The sampling was conducted on July 1-3, August 3-6, September 3-6, October

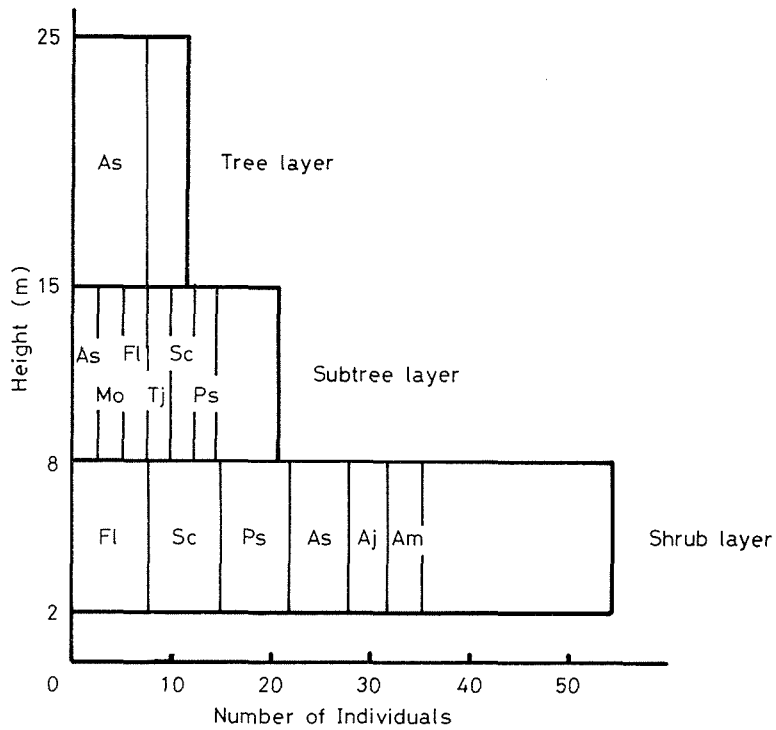

Figure 2. Stratification diagram at the sampling site (based on Ishikawa, unpub.). Aj: *Acer japonicum*, Am: *Acer mono*, As: *Abies sachalinensis*, Fl: *Fraxinus lanuginosa*, Mo: *Magnolia obovata*, Ps: *Prunus ssiori*, Sc: *Sorbus commixta*, Tj: *Tilia japonica*.

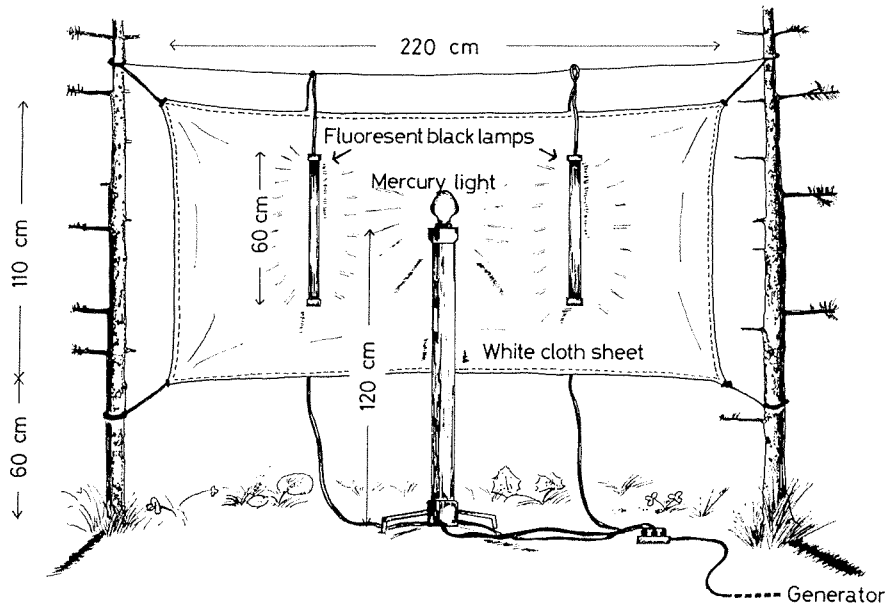

Figure 3. Sampling apparatus. The mercury light and two fluorescent black lamps were 20 W/50 Hz and 40 W/50 Hz, respectively. The power-source, a portable generator, was 30 m away from the sampling site.

3–6, and November 3–6, 1982. During each sampling a 20-watt mercury light and two 40-watt fluoresent black lamps screened with a 120×240 cm white cloth were fixed at a height of 120 cm (Figure 3). Moths lured to the lights were captured on the white cloth continuously from sunset to sunrise with an insect net and poison-bottles containing potassium cyanide. This paper examines moths of the following 16 families: Hepialidae, Limacodidae, Thyrididae, Drepanidae, Thyatiridae, Geometridae, Epiplemidae, Lasiocampidae, Bombycidae, Saturniidae, Sphingidae, Notodontidae, Lymantriidae, Arctiidae, Nolidae and Noctuidae. Tiny moth families such as Pyralidae and Tortricidae were omitted due to difficulties in identification.

3. Results and Discussion

Faunal makeup

In the below list of the species obtained in the present survey, the following items are presented: scientific name; total number (total=males+females); monthly number given for males (M) and females (F) separately; notes on the distribution for some species; and month given in Roman numerals. Monthly number of individuals is omitted when only one specimen was collected.

Family **HEPIALIDAE**

1. *Korscheltellus fusconebulosus* (De Geer). 1=1+0. M VII.

Family **LIMACODIDAE**

2. *Narosoideus flavidorsalis* (Staudinger). 1=1+0. M VIII.

3. *Phrixolepia sericea* Butler. 1=0+1. F VIII.
4. *Austrapoda dentata* (Oberthür). 108=97+11. M VIII 97; F VIII 11.
5. *Latoia sinica* (Moore). 73=71+2. M VII 3, VIII 68; F VII, VIII.
6. *Ceratonema sericea* (Bulter). 56=55+1. M VIII 55; F VIII.

Family **THYRIDIDAE**

7. *Pyrinioides aureus* Butler. 5=5+0. M VIII 5.

Family **DREPANIDAE**

8. *Agnidra scabiosa* (Butler). 3=3+0. M VII 3.
9. *Nordstromia grisearia* (Staudinger). 8=8+0. M VIII 6, IX 2.
10. *Sabra harpagula* (Esper). 1=1+0. M VIII.
11. *Drepana curvatula* (Borkhausen). 1=1+0. M VIII.
12. *Callidrepana palleola* (Motschulsky). 100=98+2. M VIII 92, IX 6; F VIII, IX.
13. *Auzata superba* (Butler). 84=72+12. M VIII 69, IX 3; F VII 11, IX.
14. *Oreta pulchripes* Butler. 55=55+0. M VII 10, IX 45.
15. *O. turpis* Butler. 3=3+0. M IX 3.

Family **THYATIRIDAE**

16. *Macrothyatira flavida* (Butler). 34=31+3. M VII 2, VIII 29; F VII, IX 2.
17. *Habrosyne dieckmanni* (Graeser). 1=0+1. F VII.
18. *Tethea ampliata* (Butler). 1=1+0. M VII.
19. *T. consimilis* (Warren). 11=10+1. M VII 6, VIII 4; F VII.
20. *Togaria suzukiana* Matsumura. 24=21+3. M X 21; F X 3.
21. *Parapsestis argenteopicta* (Oberthür). 118=117+1. M VII 116, VIII: F VII.
22. *Mimopsestis basalis* (Wileman). 99=99+0. M VII 99.

Family **GEOMETRIDAE**

Subfamily OENOCHROMINAE

23. *Alsophila japonensis* (Warren). 92=92+0. M XI 92.
24. *Inurois punctigera* (Prout). 2=0+2. F XI 2.
25. *I. fletcheri* Inoue. 1=1+0. M XI.

Subfamily GEOMETRINAE

26. *Pachyodes superans* (Butler). 78=69+9. M VIII 59, IX 10; F VIII 9.
27. *Agathia carissima* Butler. 1=1+0. M VII.
28. *Geometra papilionaria* (Linnaeus). 48=47+1. M VIII 47; F VIII.
29. *G. sponsaria* (Bremer). 1=1+0. M VIII.
30. *G. dieckmanni* Graeser. 72=72+0. M VIII 70, IX 2.
31. *Gelasma fuscofrons* Inoue. 13=12+1. M VII 9, VIII 3; F VII.
32. *Nipponogelasma immunis* (Prout). 5=5+0. M VIII 5.
33. *Hemithea aestivaria* (Hübner). 6=5+1. M VIII 5; F VIII.
34. *Diplodesma ussuriaria* (Bremer). 2=2+0. M VII, VIII.
35. *D. takahashii* Inoue. 2=2+0. M VII 2.
36. *Comibaena amoenaria* (Oberthür). 170=167+3. M VIII 167; F VIII 3.
37. *Comostola subtiliaria* (Bremer). 97=77+20. M VII 8, IX 69; F VII, IX 19.

Subfamily STERRHINAE

38. *Timandra* spp.. 23=19+4. M VII 4, VIII, IX 14; F VII, IX 3.
39. *Problepsis plagiata* (Butler). 2=1+1. M VII; F VII.
40. *Scopula nigropunctata* (Hufnagel). 10=7+3. M VII 7; F VII 3.
41. *S. modicaria* (Leech). 19=18+1. M VIII 18; F VIII.
42. *S. takao* Inoue. 1=1+0. M VII.
43. *S. umbelaria* (Hübner). 14=13+1. M VII 13; F VII.
44. *S. confusa* (Butler). 1=1+0. M VIII.
45. *S. pudicaria* (Motschulsky). 1=1+0. M VII.
46. *S. tenuisocius* Inoue. 12=10+2. M VII 10; F VIII 2.
47. *S. prouti* Djakonov. 7=6+1. M VII 3, VIII 3; F VIII.
48. *S. ignobilis* (Warren). 22=20+2. M VIII 20; F VIII 2.
49. *Idaea foedata* (Butler). 1=1+0. M VIII.
50. *I. biselata* (Hufnagel). 87=65+22. M VII 15, VIII 29, IX 21; F VIII, IX 21.
51. *I. effusaria* (Christoph). 50=48+2. M VIII 48; F VIII 2.

Subfamily LARENTIINAE

52. *Acasis exviretata* Inoue. 2=1+1. M VIII; F VIII.
53. *Trichobaptria exsecuta* (Felder & Rogenhofer). 4=4+0. M VII, VIII 3.
54. *Leptostegna tenerata* Christoph. 65=62+3. M VII 6, VIII 56; F VIII 3.
55. *Tyloptera bella* (Butler). 64=58+6. M VII 8, VIII 47, IX 3; F VII, VIII 5.
56. *Brabira artemidora* (Oberthür). 35=34+1. M VII 5, VIII 29; F VIII.
57. *Xanthorhoe biriviata* (Borkhausen). 5=4+1. M VII, VIII 3; F VIII.
58. *X. designata* (Hufnagel). 3=3+0. M VII, VIII, IX.
59. *X. muscicapata* (Christoph). 3=2+1. M VII 2; F VII.
60. *Orthonama obstipata* (Fabricius). 2=1+1. M IX; F IX.
61. *Glaucorhoe unduliferaria* (Motschulsky). 2=2+0. M VIII 2.
62. *Euphyia cineraria* (Butler). 1=0+1. F VII.
63. *Electrophaes corylata* (Thunberg). 82=63+19. M VII 63; F VII 19.
64. *E. recens* Inoue. 12=11+1. M VIII 11; F VIII.
65. *Epirrhoe supergressa* (Butler). 2=2+0. M VII 2.
66. *Photoscotosia atrostrigata* (Bremer). 13=11+2. M VII, IX 9, XI; F IX 2.
67. *Calleulype whitelyi* (Butler). 28=18+10. M VIII 18; F VIII 10.
68. *Eucosmabraxas placida* (Butler). 233=175+58. M VIII 160, IX 15; F VIII 31, IX 27.
69. *E. evanescens* (Butler). 3=3+0. M VIII 3.
70. *Eulithis ledereri* (Bremer). 24=19+5. M VIII 19; F VIII 5.
71. *E. convergenata* (Bremer). 45=41+4. M VIII 40, IX; F VIII 4.
72. *Gandaritis fixseni* (Bremer). 41=34+7. M VIII 4, IX 29, X; F IX 6, X.
73. *G. agnes* (Butler). 10=5+5. M VIII 5; F VIII 5.
75. *Ecliptopera umbrosaria* (Motschulsky). 108=87+21. M VII 14, VIII 72, IX; F VII, VIII 19, IX.
76. *E. capitata* (Herrich-Schäffer). 8=7+1. M VII 3, VIII 4; F VIII.
77. *E. pryeri* (Butler). 2=0+2. F VIII, IX.

78. *Eustroma reticulatum* (Denis & Schiffermüller). 21=11+10. M IX 11; F IX 10.
79. *E. inextricata* (Walker). 98=92+6. M VII 80, VIII, IX 11; F VII 2, IX 4.
80. *E. aerosum* (Butler). 30=27+3. M VII 4, VIII 23; F VIII 2, IX.
81. *E. melancholicum* (Butler). 23=19+4. M VII 13, VIII 3, IX 3; F VII, IX 3.
82. *Lobogonodes erectaria* (Leech). 45=20+25. M VII 9, VIII 7, IX 4; F VII 3, VIII 4, IX 18.
83. *Sibatania mactata* (Felder & Rogenhofer). 11=10+1. M VII 8, VIII, IX; F VII.
84. *Plemyria rubiginata* (Denis & Schiffermüller). 19=17+2. M VIII 2, IX 15; F IX 2.
85. *Dysstroma korbi* Heydemann. 1=1+0. M IX.
86. *D. corussaria* (Oberthür). 2=2+0. M IX 2.
87. *Pennithera comis* (Butler). 35=28+7. M X 28; F X 7.
88. *Operophtera brumata* (Linnaeus). 101=101+0. M XI 101.
89. *O. relegata* Prout. 29=29+0. M XI 29.
90. *Epirrita autumnata* (Borkhausen). 16=7+9. M XI 7; F XI 9.
91. *E. viridipurpurescens* (Prout). 26=3+23. M XI 3; F XI 23.
92. *Hydrelia shioyana* (Matsumura). 3=3+0. M VII 2, VIII.
93. *H. nisaria* (Christoph). 9=9+0. M VII 8, VIII.
94. *H. flammeolaria* (Hufnagel). 7=7+0. M VII 6, VIII.
95. *Asthena amurensis* (Staudinger). 5=5+0. M VII 5.
96. *A. nymphaeata* (Staudinger). 20=18+2. M VII 16, VIII 2; F VIII 2.
97. *A. sachalinensis* (Matsumura). 77=70+7. M VII 7, VIII 63; F VII 2, VIII 5.
98. *Laciniodes denigratus* Warren. 24=15+9. M VII 7, VIII 5, IX 3; F VII 6, IX 3.
99. *Perizoma saxeum* (Wileman). 181=110+71. M VIII 8, IX 102; F VII 5, IX 66.
100. *P. fulvida* (Butler). 5=0+5. F IX 5.
101. *Eupithecia absinthiata* (Clerck). 6=3+3. M IX 3; F IX 3.
102. *E. interpunctaria* Inoue. 6=2+4. M VIII, IX; F IX 4.
103. *E. jinboi* Inoue. 4=3+1. M VII 3; F VII.
104. *E. selinata* Herrich-Schäffer. 2=0+2. F IX 2.
105. *E. tripunctaria* Herrich-Schäffer. 2=0+2. F VIII 2.
106. *Chloroclystis v-ata* (Haworth). 14=3+11. M VIII 3; F VII 2, VIII 9.
107. *C. excisa* (Butler). 1=1+0. M XI.

Subfamily ENNOMINAE

108. *Abraxas* spp.. 442=416+26. M VII 184, VIII 232; F VII 5, VIII 21.
109. *Lomaspilis marginata* (Linnaeus). 64=63+1. M VII 63; F VII.
110. *Lomographa simplicior* (Butler). 303=296+7. M IX 296; F IX 7.
111. *L. bimaculata* (Fabricius). 112=104+8. M VII 102, VIII 2; F VII 8.
112. *L. temerata* (Denis & Schiffermüller). 2=0+2. F VII, VIII.
113. *L. subspersata* (Wehrli). 8=6+2. M VII 6; F VII 2.
114. *Myrteta angelica* Butler, 62=45+17. M VII 41, VIII 4; F VII 13, VIII 4.
115. *M. unio* (Oberthür) 129=122+7. M VII 122; F VII 7.
116. *Cabera exanthemata* (Scopoli). 1=1+0. M VII.
117. *C. purus* (Butler). 6=4+2. M VII, VIII 3; VII, VIII.
118. *C. griseolimbata* (Oberthür). 22=19+3. M VII 4, VIII 15; F VII, VIII 2.

119. *Parabapta aetheriata* (Graeser). *72=55+17. M VII 55; F VII 17.*
120. *Synegia ichinosawana* (Matsumura). 2=1+1. M IX; F IX.
121. *Crypsicometa incertaria* (Leech). 2=2+0. M VII, IX.
122. *Cystidia stratonice* (Stoll). 1=1+0. M VIII.
123. *Metabraxas clerica* Butler. 87=83+4. M VII 30, VIII 52, IX; F VII, VIII 3.
124. *M. paucimaculata* Inoue. 9=9+0. M X 9.
    In Hokkaido this species is sparsely distributed in south-western areas. In Nopporo Forest Park, however, this moth can be caught comparatively easily.
125. *Cleora insolita* (Butler). 52=35+17. M VII 35; F VII 17.
126. *Alcis medialbifera* Inoue. 154=142+12. M IX 142; F IX 12.
127. *A. pryeraria* (Leech). 1=0+1. F VIII.
128. *Ramobia basifuscaria* (Leech). 37=26+11. M X 26; F X 11.
129. *R. mediodivisa* Inoue. 267=266+1. M X 266; F X.
130. *Deileptenia ribeata* (Clerck). 92=85+7. M VII 3, VIII 24, IX 58; F VIII, IX 6.
131. *Hypomecis roboraria* (Denis & Schiffermüller). 27=26+1. M VII 23, VIII 3; F VII.
132. *H. lunifera* (Butler). 80=80+0. M VIII 80.
133. *H. punctinalis* (Scopoli). 143=139+4. M VII 132, VIII 7; F VII 3, VIII.
134. *Microcalicha fumosaria* (Leech). 3=2+1. M VIII 2; F VIII.
135. *M. sordida* (Butler). 4=4+0. M VII 4.
136. *Calicha ornataria* (Leech). 11=10+1. M VII 10; F VII.
137. *Phthonosema tendinosaria* (Bremer). 6=6+0. M VII 4, VIII 2.
138. *Paradarisa consonaria* (Hübner). 4=3+1. M VII 3; F VII.
139. *Heterarmia costipunctaria* (Leech). 9=8+1. M VII 8; F VII.
140. *Cusiala stipitaria* (Oberthür). 1=1+0. M VII.
141. *Ectropis bistortata* (Goeze). 33=29+4. M VII 2, VIII 27; F VIII 4.
142. *E. obliqua* (Prout). 5=4+1. M VII 4; F VII.
143. *E. aigneri* Prout. 33=30+3. M VII 29, VIII; F VII 3.
144. *Parectropis extersaria* (Hübner). 144=134+10. M VII 134; F VII 9, VIII.
145. *Aethalura nanaria* (Staudinger). 139=132+7. M VII 132; F VII 7.
146. *A. ignobilis* (Butler). 16=15+1. M VII 15; F VII.
147. *Xandrames dholaria* Moore. 1=1+0. M VIII.
148. *X. latiferaria* (Walker). 5=5+0. M VII, VIII 4.
149. *Scionomia anomala* (Butler). 22=18+4. M IX 18; F IX 4.
150. *S. mendica* (Butler). 68=50+18. M VII 35, IX 15; F VII 12, IX 6.
151. *S. parasinuosa* Inoue. 2=2+0. M IX 2.
152. *Larerannis orthogrammaria* (Wehrli). 79=79+0. M IX 79.
153. *Pachyerannis obliquaria* (Motschulsky). 3=3+0. M XI 3.
154. *Erannis golda* Djakonov. 130=130+0. M XI 130.
155. *E. defoliaria* (Clerck). 15=15+0. M XI 15.
156. *Erebomorpha fulguraria* Walker. 3=3+0. M VII 3.
157. *Colotois pennaria* (Linnaeus). 5=1+4. M XI; F XI 4.
158. *Angerona prunaria* (Linnaeus). 7=6+1. M VIII 6; F VIII.
159. *Menophra atrilineata* (Butler). 13=13+0. M VIII 13.

160. *M. senilis* (Butler). 84=84+0. M VII 82, IX 2.
161. *Epholca arenosa* (Butler). 50=47+3. M VII 47; F VII 3.
162. Ennomos autumnaria (Werneburg). 81=79+2. M IX 79; F VIII, IX.
163. *Zethenia albonotaria* (Bremer). 20=20+0. M VII 20.
164. *Z. rufescentaria* Motschulsky. 13=11+2. M VII 11; F VII 2.
165. *Zanclidia testacea* (Butler). 50=38+12. M VIII 38; F VIII 12.
166. *Ocoelophora lentiginosaria* (Leech). 9=8+1. M VII 8; F VII.
167. *Eilicrinia wehrlii* Djakonov. 53=44+9. M VII 31, VIII 13; F VII 8, VIII.
168. *Selenia tetralunaria* (Hufnagel). 189=181+8. M VIII 181; F VIII 8.
169. *Hyperapeira parva* (Hedemann). 23=23+0. M VIII, IX 22.
170. *Garaeus mirandus* (Butler). 3=2+1. M VII 2; F VII.
171. *G. specularis* Moore. 12=12+0. M IX 12.
172. *Endropiodes abjectus* (Butler). 7=7+0. M VIII 7.
173. *Plagodis dolabraria* (Linnaeus). 14=11+3. M VII 11; F VII 3.
174. *Seleniopsis evanescens* (Butler). 35=26+9. M VII 4, VIII 18, IX 4; F VIII 6, IX 3.
175. *Cepphis advenaria* (Hübner). 13=9+4. M VII 9; F VII 4.
176. *Ourapteryx maculicaudaria* (Motschulsky). 139=131+8. M VIII 85, IX 46; F VIII 4, IX 4.
177. *Tristrophis veneris* (Butler). 1=1+0. M VIII.

Family **EPIPLEMIDAE**

178. *Epiplema moza* (Butler). 18=14+4. M VII 6, IX 8; F VII 2, IX 2.

Family **LASIOCAMPIDAE**

179. *Philudoria potatoria* (Linnaeus). 38=33+5. M VII 3, VIII 30; F VII, VIII 3, IX.
180. *P. albomaculata* (Bremer). 1=1+0. M VII.
181. *Somadasys brevivenis* (Butler). 46=45+1. M VII 45; F VIII.
182. *Odonestis pruni* (Linnaeus). 15=15+0. M VIII 15.
183. *Dendrolimus superans* (Butler). 1=1+0. M VIII.
184. *Cyclophragma undans* (Walker). 1=1+0. M VIII.
185. *Poecilocampa populi* (Linnaeus). 7=5+2. M XI 5; F XI 2.
186. *Malacosoma neustria* (Linnaeus). 5=5+0. M VIII 5.

Family **BOMBYCIDAE**

187. *Bombyx mandarina* (Moore). 7=7+0. M IX, X 6.

Family **SATURNIIDAE**

188. *Rhodinia fugax* (Butler). 13=9+4. M X 9; F X 4.
189. *Caligula boisduvalii* (Eversmann). 86=83+3. M X 83; F X 3.
190. *Actias artemis* (Bremer & Grey). 23=23+0. M VII 23.
191. *Aglia tau* (Linnaeus). 4=4+0. M VII 4.

Family **SPHINGIDAE**

192. *Meganoton scribae* (Austaut). 3=3+0. M VIII 3.
193. *Dolbina tancrei* Staudinger. 15=15+0. M VIII 15.
194. *Marumba gaschkewitschii* (Bremer & Grey). 35=29+6. M VII 8, VIII 21; F VII 2, VIII 4.

195. *M. jankowskii* Oberthür. 14=10+4. M VII 9, VIII; F VII 4.
196. *Callambulyx tatarinovii* (Bremer & Grey). 39=39+0. M VII 23, VIII 16.

Family **NOTODONTIDAE**

197. *Stauropus fagi* (Linnaeus). 1=0+1. F VII.
198. *Quadricalcarifera punctatella* (Motschulsky). 5=5+0. M VII, VIII 4.

This species is common in southern Hokkaido but rare around Sapporo, because the food plant genus *Fagus* is not distributed in this region.

199. *Cnethodonta grisescens* Staudinger. 3=3+0. M VIII 3.
200. *Urodonta viridimixta* (Bremer). 54=51+3. M VII 31, VIII 20; F VIII 3.
201. *Nerice bipartita* Butler. 51=51+0. M VII 2, VIII 49.
202. *N. davidi* Oberthür. 3=3+0. M VII, VIII 2.
203. *Hupodonta corticalis* Butler. 2=2+0. M VIII, IX.
204. *H. lignea* Matsumura. 59=51+8. M VIII 50, IX; F VIII 8.
205. *Zaranga permagna* (Butler). 1=1+0. M VIII.
206. *Shaka atrovittatus* (Bremer). 10=10+0. M VII 2, VIII 8.
207. *Lophocosma atriplaga* (Staudinger). 1=1+0. M VII.
208. *Rabtala cristata* (Butler). 6=4+2. M VII 4; F VII 2.
209. *R. splendida* (Oberthür). 1=1+0. M VII.
210. *Torigea straminea* (Moore). 1=1+0. M VII.
211. *Mimopydna pallida* (Butler). 1=1+0. M VIII.
212. *Notodonta albicosta* (Matsumura). 2=2+0. M VII, VIII.
213. *Peridea gigantea* Butler. 11=11+0. M VIII 11.
214. *P. oberthueri* (Staudinger). 9=8+1. M VIII 8; F VIII.
215. *P. graeseri* (Staudinger). 3=3+0. M VIII 3.
216. *Suzukiana cinerea* (Butler). 3=3+0. M VII, VIII 2.
217. *Leucodonta bicoloria* (Denis & Schiffermüller). 1=1+0. M VII.
218. *Semidonta biloba* (Oberthür). 18=18+0. M VII 6, VIII 12.
219. *Microphalera grisea* Butler. 44=44+0. M VII 6, VIII 38.
220. *Epodonta lineata* (Oberthür). 26=24+2. M VII 2, VIII 22; F VII, VIII.
221. *Hexafrenum leucodera* (Staudinger). 4=4+0. M VII 2, VIII 2.
222. *Hagapteryx admirabilis* (Staudinger). 18=18+0. M VII, VIII 17.
223. *Ptilodon jezoensis* (Matsumura). 5=5+0. M VII 5.
224. *P. robusta* (Matsumura). 3=3+0. M VII 2, VIII.
225. *Fusapteryx ladislai* (Oberthür). 2=2+0. M VIII 2.
226. *Lophontosia cuculus* (Staudinger). 1=1+0. M VII.
227. *Ptilophora nohirae* (Matsumura). 81=66+15. M XI 66; F XI 15.
228. *P. jezoensis* (Matsumura). 1=1+0. M X.

According to Inoue *et al.* (1982), *P. jezoensis* appears earlier than *P. nohirae* seasonally in the coexisting area, which consists with the present survey.

229. *Himeropteryx miraculosa* Staudinger. 16=16+0. M X 16.
230. *Togepteryx velutina* (Oberthür). 17=17+0. M VII 13, VIII 4.
231. *Spatalia dives* Oberthür. 3=3+0. M VIII 3.
232. *Gonoclostera trimoniorum* (Bremer). 2=2+0. M VII, VIII.

233. *Clostera anachoreta* (Denis & Schiffermüller). 3=1+2. M VIII; F VIII 2.
234. *C. anatomosis* (Linnaeus). 2=2+0. M VII 2.

Family **LYMANTRIIDAE**

235. *Calliteara pudibunda* (Linnaeus). 43=43+0. M VII 43.
236. *Cifuna locuples* Walker. 4=3+1. M VIII 3; F VIII.
237. *Neocifuna eurydice* (Butler). 2=0+2. F IX 2.
238. *Orgyia thyellina* Butler. 3=3+0. M VIII, IX 2.
239. *Arctornis l-nigrum* (Müller). 39=34+5. M VIII 34; F VIII 5.
240. *A. chichibense* (Matsumura). 3=3+0. M VIII 3.
241. *Lymantria monacha* (Linnaeus). 309=305+4. M VIII 292, IX 13; F VIII 4.
242. *Euproctis similis* (Fuessly). 24=20+4. M VII 20; F VII 4.
243. *E. piperita* Oberthür. 62=45+17. M VII 9, VIII 36; F VIII 17.

Family **ARCTIIDAE**

344. *Pelosia noctis* (Butler). 1=0+1. F VIII.
245. *Eilema griseola* (Hübner). 10=3+7. M VII, VIII 2; F VIII 7.
246. *E. okanoi* Inoue. 8=4+4. M VIII 3, IX; F IX 4.
247. *E.* spp.. 45=35+10. M VIII 35; F VIII 10.
248. *E. cribrata* (Staudinger). 246=229+17. M VII 229; F VII 17.
249. *Agylla gigantea* (Oberthür). 4=4+0. M VII 4.
250. *A. collitoides* (Butler). 50=44+6. M VII 44; F VII 6.
251. *Lithosia quadra* (Linnaeus). 102=80+22. M VIII 80; F VIII 22.
252. *Bizone hamata* Walker. 110=108+2. M VIII 108; F VIII 2.
253. *Melanaema venata* Butler. 70=60+10. M VIII 59, IX; F VIII 10.
254. *Miltochrista aberrans* Butler. 35=26+9. M VIII 26; F VIII 9.
255. *M. miniata* (Forster). 165=150+15. M VIII 150; F VIII 15.
256. *M. pulchra* Butler. 6=5+1. M VIII 5; F VIII.
275. *Stigmatophora flava* (Bremer & Grey). 2=1+1. M VIII; F VIII.
258. *Spilosoma luteum* (Hufnagel). 3=3+0. M VIII 3.
259. *S. seriatopunctata* Motschulsky. 8=7+1. M VII 6, VIII; F VIII.
260. *S. obliquizonata* (Miyake). 2=1+1. M VIII; F VIII.
261. *S. punctaria* (Stoll). 6=6+0. M VII 6.
262. *Rhyparioides nebulosus* Butler. 66=53+13. M VIII 53; F VIII 13.
263. *Arctia caja* (Linnaeus). 5=5+0. M IX 5.

Family **NOLIDAE**

264. *Nola aerugula* (Hübner). 1=1+0. M VIII.
265. *Meganola fumosa* (Butler). 1=1+0. M VIII.
266. *Mimerastria mandschuriana* (Oberthür). 1=1+0. M VIII.

Family **NOCTUIDAE**

Subfamily PANTHEINAE

267. *Anacronicta nitida* (Butler). 6=6+0. M VII, VIII 5.
268. *A. caliginea* (Butler). 4=1+3. M VII; F VIII 3.
269. *Colocasia jezoensis* (Matsumura). 126=100+26. M VIII 100; F VIII 26.

Subfamily ACRONICTINAE

270. *Belciades niveola* (Motshulsky). 13=13+0. M VII 7, VIII 6.
271. *Moma alpium* (Osbeck). 9=7+2. M VII 6, VIII; F VII, VIII.
272. *M. fulvicollis* (Lattin). 3=2+1. M VII 2; F VIII.
273. *Acronicta major* Bremer. 8=4+4. M VIII 4; F VIII 4.
274. *Triaena cuspis* (Hübner). 2=2+0. M VII, VIII.
275. *T. leucocuspis* (Butler). 2=2+0. M VIII 2.
276. *Hylonycta catocaloida* (Graeser). 1=1+0. M VIII.
277. *H. hercules* (Felder & Rogenhofer). 5=3+2. M VII, VIII 2; F VII, VIII.
278. *Viminia rumicis* (Linnaeus). 34=30+4. M VIII 30; F VIII 4.
279. *Subleuconycta palshkovi* (Filipjev). 2=2+0. M VII 2.
First time to be discovered in western Hokkaido.
280. *Craniophora ligustri* (Denis & Schiffermüller). 11=10+1. M VII 10; F VIII.
281. *C. praeclara* (Graeser). 3=1+2. M VIII; F VIII 2.
282. *C. pacifica* Filipjev. 1=1+0. M VIII.
283. *C. jankowskii* (Oberthür). 11=11+0. M VII, VIII 10.

Subfamily BRYOPHILINAE

284. *Cryphia griseola* (Nagano). 3=2+1. M IX 2; F IX.
285. *Stenoloba jankowskii* (Oberthür). 4=3+1. M VIII 3; F VIII.

Subfamily NOCTUINAE

286. *Euxoa oberthueri* (Leech). 2=1+1. M VIII; F VIII.
287. *Agrotis ipsilon* (Hufnagel). 3=3+0. M XI 3.
288. *A. exclamationis* (Linnaeus). 1=1+0. M VII.
289. *Ochropleura praecurrens* (Staudinger). 2=2+0. M IX 2.
290. *O. triangularis* Moore. 1=1+0. M IX.
291. *O. plecta* (Linnaeus). 2=1+1. M VII; F VIII.
292. *Hermonassa arenosa* (Butler). 14=14+0. M VIII 5, IX 9.
293. *Sineugraphe exusta* (Butler). 4=1+3. M VIII; F IX 3.
294. *S. disgnosta* (Boursin). 7=1+6. M X; F IX 5, X.
295. *Diarsia deparca* (Butler). 8=5+3. M VII, IX 4; F IX 3.
296. *D. canescens* (Butler). 10=9+1. M VII, IX 2, X 3, XI 3; F IX.
297. *D. ruficauda* (Warren). 3=3+0. M VII 3.
298. *Xestia c-nigrum* (Linnaeus). 15=15+0. M VII 4, IX 11.
299. *X. fuscostigma* (Bremer). 1=1+0. M IX.
300. *X. efflorescens* (Butler). 18=17+1. M IX 17; F IX.
301. *X. semiherbida* (Walker). 2=2+0. M VIII 2.
302. *Anaplectoides virens* (Butler). 8=8+0. M VIII 5, IX 3.

Subfamily HADENINAE

303. *Polia nebulosa* (Hufnagel). 4=3+1. M VIII 3; F VIII.
304. *Sarcopolia illoba* (Butler). 1=1+0. M IX.
305. *Mythimna turca* (Linnaeus). 3=3+0. M VIII 3.
306. *Aletia flavostigma* (Bremer). 2=2+0. M VII 2.

307. *Pseudaletia separata* (Walker). 4=1+3. M IX; F IX, XI 2.

Subfamily CUCULLIINAE

308. *Daseochaeta viridis* (Leech). 615=614+1. M X 613, XI; F X.
309. *Teratoglaea pacifica* Sugi. 2=0+2. F XI 2.
310. *Dasycampa castaneofasciata* (Motschulsky). 17=16+1. M XI 16; F XI.
311. *Xanthia togata* (Esper). 5=4+1. M X 4; F XI.
312. *X. tunicata* Graeser. 19=19+0. M X 17, XI 2.
313. *X. japonago* (Wileman & West). 2=2+0. M X 2.
314. *Telorta edentata* (Leech). 31=6+25. M X, XI 5; F XI 25.
315. *T. divergens* (Butler). 3=3+0. M X 2, XI.
316. *Antivaleria viridimacula* (Graeser). 26=15+11. M X 2, XI 13; F XI 11.
317. *Meganephria extensa* (Butler). 7=6+1. M X 5, XI; F X.

Subfamily AMPHIPYRINAE

318. *Apamea hampsoni* Sugi. 6=6+0. M VII 6.
319. *Oligia fodinae* (Oberthür). 1=1+0. M VIII.
320. *Sapporia repetita* (Butler). 1=1+0. M VII.
321. *Xenapamea pacifica* Sugi. 12=12+0. M VIII 12.
322. *Hydraecia amurensis* Staudinger. 27=26+1. M IX 26; F IX.
323. *Amphipoea ussuriensis* (Petersen). 1=0+1. F IX.
324. *Gortyna fortis* (Butler). 8=7+1. M X 7; F X.
325. *Triphaenopsis jezoensis* Sugi. 1=1+0. M IX.
326. *T. postflava* (Leech). 4=2+2. M IX 2; F VIII, IX.
327. *Euplexia lucipara* (Linnaeus). 3=3+0. M VII 3.
328. *E. vinacea* Sugi. 1=1+0. M VII.
329. *E. illustrata* Graeser. 1=1+0. M VII.
330. *E. bella* (Butler). 5=2+3. M IX 2; F IX 3.
331. *E. aureopuncta* Hampson. 47=45+2. M VII 2, VIII 43; F VIII 2.
332. *Axylia putris* (Linnaeus). 2=2+0. M VII 2.
333. *Trachea atriplicis* (Linnaeus). 1=1+0. M VII.
334. *T. lucilla* Sugi. 1=1+0. M VIII.
335. *Karana laetevirens* (Oberthür). 1=1+0. M VIII.
336. *Pygopteryx suava* Staudinger. 44=44+0. M IX 44.
337. *Athetis albisignata* (Oberthür). 4=3+1. M VII 3; F VII.
338. *A. lineosa* (Moore). 1=1+0. M VIII.
339. *Amphipyra pyramidea* (Linnaeus). 17=13+4. M VIII 4, IX 7, X 2; F VIII, IX 3.
340. *A. erebina* Butler. 3=2+1. M VIII 2; F IX.
341. *A. schrenckii* Ménétriès. 31=24+7. M VIII 3, IX 21; F VIII 3, IX 4.
342. *Cosmia unicolor* (Staudinger). 21=16+5. M VIII 10, IX 2, X 4; F VIII 3, X 2.
343. *C. cara* (Butler). 14=12+2. M VIII 12; F VIII 2.
344. *C. restituta* Walker. 35=26+9. M VIII 19, IX 7; F VIII 8, IX.
345. *C. camptostigma* (Ménétriès). 3=2+1. M VIII 2; F VIII.
346. *C. exigua* (Butler). 69=37+32. M VIII 23, IX 14; F IX 32.

347. *C. pyralina* (Denis & Schiffermüller). 32=25+7. M VIII 25; F VIII 7.
348. *C. moderata* (Staudinger). 4=4+0. M VIII 4.
349. *Dimorphicosmia variegata* (Oberthür). 81=73+8. M VIII 72, IX; F VIII 2, IX 6.
350. *Chasminodes* spp.. 919=639+280. M VIII 619, IX 20; F VIII 223, IX 55, X 2.
351. *C. atrata* (Butler). 77=66+11. M VIII 64, IX 2; F VIII 11.
352. *Chytonix albonotata* (Staudinger). 3=3+0. M VIII 3.
353. *C. subalbonotata* Sugi. 12=12+0. M VII 12.
354. *Oligonyx vulnerata* (Butler). 1=0+1. F VIII.
355. *Eucarta amethystina* (Hübner). 2=2+0. M VII, VIII.
356. *E. arctides* (Staudinger). 1=1+0. M VIII.
357. *Prometopus flavicollis* (Leech). 2=1+1. M VIII; F VIII.
358. *Callopistria repleta* Walker. 1=1+0. M VII.
359. *Sphragifera sigillata* (Ménétriès). 1=1+0. M VIII.

Subfamily SARROTHRIPINAE

360. *Nolathripa lactaria* (Graeser). 1=0+1. F VIII.

Subfamily CHLOEPHORINAE

361. *Earias pudicana* Staudinger. 1=1+0. M VIII.
362. *E. jezoensis* Sugi. 1=1+0. M VII.
363. *Gelastocera exusta* Butler. 6=5+1. M VII 5; F VII.
364. *Macrochthonia fervens* Butler. 40=23+17. M VII 14, IX 9; F IX 17.
365. *Sinna extrema* (Walker). 5=4+1. M VII, VIII 3; F VII.

Subfamily ACONTIINAE

366. *Enispa lutefascialis* (Leech). 1=1+0. M VIII.
367. *E. leucosticta* Hampson. 4=4+0. M VIII 4.
368. *Aventiola pusilla* (Butler). 19=14+5. M VIII 14; F VIII 5.
369. *Holocryptis ussuriensis* (Rebel). 2=2+0. M IX 2.
370. *H. nymphula* (Rebel). 12=9+3. M VII 6, IX 3; F IX 3.
371. *Perynea subrosea* (Butler). 2=2+0. M VIII 2.
372. *Trisateles emortualis* (Denis & Schiffermüller). 1=1+0. M VIII.
373. *Micardia argentata* Butler. 2=2+0. M VII 2.
374. *M. pulchra* Butler. 3=3+0. M VII 3.
375. *Lithacodia numisma* (Staudinger). 13=13+0. M VII 7, VIII 6.
376. *L. pygarga* (Hufnagel). 7=7+0. M VII 2, VIII 5.
377. *L. distinguenda* (Staudinger). 2=1+1. M VIII; F VIII.
378. *L. stygia* (Butler). 1=1+0. M VII.
379. *L. falsa* (Butler). 4=1+3. M VIII; F VIII 3.
380. *L. fentoni* (Butler). 2=2+0. M VII 2.

Subfamily PLUSIINAE

381. *Polychrysia aurata* (Staudinger). 1=1+0. M VII.
382. *P. splendida* (Butler). 3=2+1. M IX 2; F IX.
383. *Macdunnoughia purissima* (Butler). 1=1+0. M XI.
384. *Antoculeora ornatissima* (Walker). 3=3+0. M VII, IX 2.

385. *Autographa gamma* (Linnaeus). 3=1+2. M XI; F IX, X.
386. *A. amurica* (Staudinger). 4=3+1. M VIII, IX, XI; F IX.
387. *Plusia festucae* (Linnaeus). 1=0+1. F VIII.
388. *Diachrysia leonina* (Oberthür). 1=1+0. M VIII.
389. *D. stenochrysis* (Warren). 1=1+0. M VIII.

Subfamily CATOCALINAE

390. *Catocala lara* Bremer. 19=17+2. M VIII 2, IX 15; F IX 2.
391. *C. nupta* (Linnaeus). 13=13+0. M IX 13.
392. *C. electa* (Borkhausen). 1=1+0. M IX.
393. *C. fulminea* (Scopoli). 6=5+1. M VIII 5; F IX.
394. *C. dissimilis* Bremer. 1=1+0. M VIII.
395. *Mocis annetta* (Butler). 1=0+1. F VIII.
396. *Lagoptera juno* (Dalman). 1=1+0. M X.

Subfamily OPHIDERINAE

397. *Lygephila maxima* (Bremer). 1=1+0. M VIII.
398. *Sypnoides hercules* (Butler). 8=6+2. M VIII 6; F VIII 2.
399. *Pangrapta umbrosa* (Leech). 1=1+0. M VIII.
400. *P. vasava* (Butler). 3=2+1. M VIII 2; F VIII.
401. *P. albistigma* (Hampson). 3=3+0. M VIII 3.
402. *Polysciera manleyi* (Leech). 134=120+14. M VII 48, VIII 72; F VII 4, VIII 10.
403. *Lophomilia flaviplaga* (Warren). 1=1+0. M VII.
404. *Gonepatica opalina* (Butler). 1=1+0. M VIII.
405. *Diomea cremata* (Butler). 2=2+0. M VIII 2.
406. *D. jankowskii* (Oberthür). 1=1+0. M VIII.
407. *Scedopla diffusa* Sugi. 1=1+0. M VII.
408. *Laspeyria flexula* (Denis & Schiffermüller). 3=3+0. M VII 3.
409. *Paragona cleorides* Wileman. 3=3+0. M VIII 3.
410. *Rivula sericealis* (Scopoli). 38=28+10. M VII 23, VIII, IX 4; F VII 7, VIII 2, IX.

Subfamily HYPENINAE

411. *Hypena proboscidalis* (Linnaeus). 9=6+3. M VIII 3, IX 3; F VIII, IX 2.
412. *Bomolocha bipartita* Staudinger. 7=6+1. M VII 6; F VII.

Subfamily HERMINIINAE

413. *Hydrillodes funeralis* Warren. 19=13+6. M VII 13; F VII 6.
414. *Hadennia incongruens* (Butler). 1=1+0. M VIII.
415. *Paracolax albinotata* (Butler). 8=7+1. M VII 7; F VIII.
416. *P. fascialis* (Leech). 52=52+0. M VII 3, VIII 49.
417. *Bertula bistrigata* (Staudinger). 7=7+0. M VII 5, VIII 2.
418. *Simplicia rectalis* (Eversmann). 1=0+1. F VIII.
419. *Polypogon gryphalis* (Herrich-Schäffer). 7=7+0. M VIII 7.
420. *Zanclognatha griselda* (Butler). 12=12+0. M VIII 11, IX.
421. *Z. lunalis* (Scopoli). 1=1+0. M VIII.
422. *Z. fumosa* (Butler). 2=2+0. M VII 2.

423. *Z. helva* (Butler). 14=13+1. M 13 VII; F VII.
424. *Z. tarsipennalis* (Treitschke). 5=5+0. M VII, VIII 2, IX 2.
425. *Z. subgriselda* Sugi. 22=18+4. M VIII 18; F VIII 4.
426. *Z. reticulatis* (Leech). 1=1+0. M VIII.
427. *Herminia nemoralis* (Fabricius) 7=7+0. M VII 2, IX 5.
428. *H. arenosa* Butler. 4=4+0. M VII 2, IX 2.
429. *H. tarsicrinalis* (Knoch). 9=9+0. M VII 7, VIII, IX.
430. *Sinarella japonica* (Butler). 12=12+0. M VIII 12.

In total, 12,483 individuals (10,935 males and 1,548 females) of 430 species were collected in the present survey. Except for a few species, such as *Telorta edentata* which contained significantly more females than males, the sex ratio was biased towards males in most species, as reported by Williams (1939) and Yoshida (1981). This is probably because the light is usually more attractive to males than to females (Honda and Tamura, 1977).

The numbers of species and individuals in each family are shown in Table 1. The Geometridae and Noctuidae occupied 75% of the total number of species. A similar result is found in other studies (Williams, 1939; Sakamoto *et al.*, 1977; Yoshida, 1976, 1981). Also these two families exceeded the rest in number of individuals.

Table 1. Faunal comparison at family level between the present survey and Sakamoto *et al.* (1977).

	Present survey				Common		Sakamoto *et al.* (1977)		Total	
	N.S.	R.F.(%)	N.I.	R.F.(%)	N.S.	R.F.(%)	N.S.	R.F.(%)	N.S.	R.F.(%)
Hepialidae	1	0.2	1	0.0	0	0.0	2	0.5	3	0.5
Limacodidae	5	1.2	239	1.9	2	0.9	2	0.5	5	0.8
Thyrididae	1	0.2	5	0.0	0	0.0	0	0.0	1	0.2
Drepanidae	8	1.9	255	2.0	6	2.5	7	1.8	9	1.5
Thyatiridae	7	1.6	288	2.3	5	2.1	9	2.3	11	1.8
Geometridae	155	36.0	6,255	49.4	77	32.5	111	27.6	190	32.0
Epiplemidae	1	0.2	18	0.1	0	0.0	0	0.0	1	0.2
Lasiocampidae	8	1.9	114	0.9	6	2.6	10	2.5	12	2.0
Bombycidae	1	0.2	7	0.0	1	0.4	2	0.5	2	0.3
Saturniidae	4	0.9	126	1.0	4	1.7	7	1.8	7	1.2
Sphingidae	5	1.2	106	0.9	5	2.1	16	4.0	16	2.7
Notodontidae	38	8.8	474	3.8	25	10.7	41	10.3	52	8.7
Lymantriidae	9	2.1	489	3.9	5	2.1	11	2.8	15	2.5
Arctiidae	20	4.7	944	7.6	13	5.6	25	6.3	31	5.2
Nolidae	3	0.7	3	0.0	0	0.0	1	0.3	4	0.7
Noctuidae	164	38.2	3,179	25.5	86	36.8	156	38.8	236	39.5
Total	430	100	12,483	100	235	100	400	100	595	100

N.S.: number of species, N.I.: number of individuals, R.F.: relative frequency.

The predominant species in each month were as follows: *Eilema cribrata* (Arctiidae), *Abraxas* spp., and *Parectropis extersaria* (Geometridae) in July; *Chasminodes* spp. (Noctuidae), *Lymantria monacha* (Lymantriidae), and *Abraxas* spp. (Geometridae) in August; *Lomographa simplicior*, *Perizoma saxeum*, and *Alcis medialbifera* (Geometridae) in September; *Daseochaeta viridis* (Noctuidae), *Ramobia mediodivisa* (Geometridae), and *Caligula boisduvalii* (Saturniidae) in October; *Eranis golda*, *Operophtera brumata*, and *Alsophila japonensis* (Geometridae) in November. From these results we can see that Geometridae was rich in all seasons. It should also be noted that this is not a general characteristic of central Hokkaido, since Yoshida (1981) reported that in Tomakomai Saturniidae and Arctiidae were rich in summer and autumn.

Sakamoto's survey (1977) of Nopporo Forest Park registered 400 moth species (Table 1). Combining the present survey with Sakamoto's, a total of 595 species have been discovered. Of the two surveys, 39.5% (235 species) of the total were found to be common. This is partly due to differences in the sampling schedules. For example, winter geometrid moths, such as *Alsophila japonensis*, *Inurois punctigera*, *I. fletcheri*, *Operophtera brumata*, *O. relegata*, *Epirrita viridipurpurescens*, *Larerannis orthogrammaria*, and *Erranis golda* were more abundant in the present survey. In addition, tiny moth genera such as *Scopula*, *Idaea* (Geometridae), *Zanclognatha*, and *Herminia* (Noctuidae) were collected frequently in the present

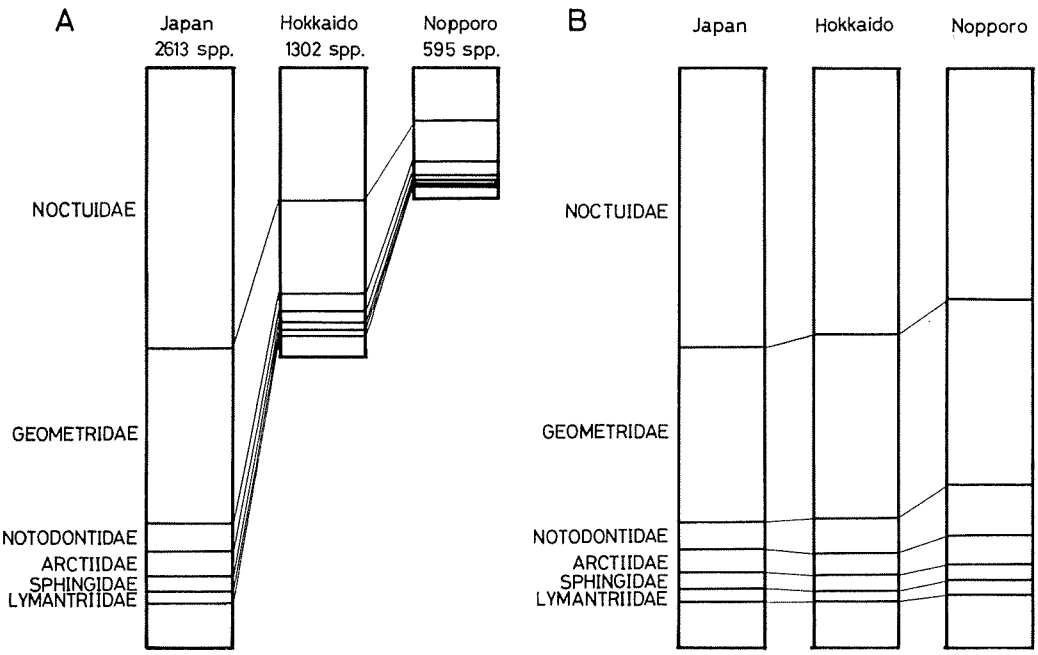

Figure 4. Actual number (A) and relative frequency (B) of species in each family, discovered in the whole of Japan, Hokkaido (both are from Inoue *et al.*, 1982), and Nopporo Forest Park (from the present survey and Sakamoto *et al.*, 1977).

survey but rarely in the Sakamoto's survey. On the other hand, Sakamoto reported diurnal groups such as *Cystidia* (Geometridae) and Macrogrossini (Sphingidae), openland genera such as *Mythimna, Aletia* and *Apamea* (Noctuidae), and spring species such as *Trichopteryx polycommata, T. ustata, Xanthorhoe abraxina, Arichanna albomacularia, Cleora leucophaea* (Geometridae), *Phyllodesma japonica* (Lasiocampidae), *Orthosia munda, O. gothica,* and *O. carpinnis* (Noctuidae).

Figure 4 A shows, in comparing faunal richness of the sixteen families dealt with in this present paper, that approximately 22.8% of the species of Japan (2,613) and 44.5% of Hokkaido (1,302) inhabit Nopporo Forest Park. However, the relative ratios of species-richness of each family are similar among the three sampling scales as shown by Figure 4 B.

Yoshida (1976, 1981) closely surveyed the macrolepidopterous moth fauna in Hokkaido University's Tomakomai Experiment Forest. It is located about 45 km south of Nopporo and consits of natural broad-leaved forests (dominated by *Quercus mongolica* var. *grosseserrata, Kalopanax pictus, Ostrya japonica, Ulmus davidiana* var. *japonica, Acer palmatum* var. *matsumurae*) and coniferous plantations (*Abies sachalinensis,* and *Larix leptolepis*). As shown in Table 2, relative frequency of each family was similar between the two areas. However, the faunal makeup varied considerably so that common species accounted for only 48% (361 species) of the total (750), and only 10 of 97 dominant species[1] were similar (Table 3).

Seasonal fluctuations of a species diversity

The seasonal fluctuations of a species diversity were examined by using the Shannon-Wiener function index H' :

$$p_i = n_i/N$$

$$H' = -\sum p_i \ln p_i$$

where n_i is the number of individuals of i-th species and N is the total number of individuals. The diversity of a community depends not only on species richness but also on the evenness with which the individuals are apportioned among species. The evenness can be expressed by J' (Pielou, 1966) :

$$J' = H'/\ln S$$

where S is the total number of species.

The seasonal fluctuations of a species diversity were bimodal (Figure 5A). The high peak began in July ($H'=4.086$) and extended through August (4.213), the low occurred in October (1.643), and a second peak was reached in November (2.487). Although this fluctuation pattern could be explained by both the evenness and the species richness (Figure 5 B), the decline in September ($H'=3.552$) was mostly due to a decrease of the species richness, and second peak in November mostly due to an increase of the evenness. The low in October was caused partly by the

1) As in Sakuma (1964), a species i was defined as dominant, when $n_i/N-2\sqrt{n_i(N-n_i)N^3} > \bar{n}/N+2\sqrt{\bar{n}(N-\bar{n})N^3}$ (n_i: number of individuals of species i; $\bar{n}$: mean number of individuals per species; confidence limit=0.95).

Table 2. Faunal comparison at family level between Nopporo Forest Park (N. F. P.) and Tomakomai Experiment Forest (T. E. F.) (Yoshida, 1976, 1981).

	N. F. P.		Common		T. E. F.		Total	
	N. S.	R. F. (%)	N. S.	R. F. (%)	N. S.	R. F. (%)	N. S.	R. F. (%)
Hepialidae	3	0.5	0	0.0	0	0.0	3	0.4
Limacodidae	5	0.8	3	0.8	4	0.8	6	0.8
Thyrididae	1	0.2	0	0.0	0	0.0	1	0.1
Drepanidae	9	1.5	8	2.2	8	1.6	9	1.2
Thyatiridae	11	1.8	8	2.2	15	2.9	18	2.4
Geometridae	190	32.0	101	28.0	150	29.0	239	31.9
Epiplemidae	1	0.2	0	0.0	0	0.0	1	0.1
Lasiocampidae	12	2.0	10	2.8	11	2.1	13	1.7
Bombycidae	2	0.3	2	0.6	2	0.4	2	0.3
Saturniidae	7	1.2	4	1.1	6	1.2	9	1.2
Sphingidae	16	2.7	12	3.3	16	3.1	20	2.7
Notodontidae	52	8.7	39	10.9	46	8.9	59	7.9
Lymantriidae	15	2.5	14	3.9	19	3.7	20	2.7
Arctiidae	31	5.2	22	6.1	24	4.7	33	4.4
Nolidae	4	0.7	0	0.0	0	0.0	4	0.5
Noctuidae	236	39.7	138	38.1	215	41.6	313	41.7
Total	595	100	361	100	516	100	750	100

N. S.: number of species, R. F.: relative frequency.

Table 3. Number of dominant species in each family at Nopporo Forest Park (N. F. P.) and Tomakomai Experiment Forest (T. E. F.) (Yoshida, 1981). Definition of dominant species is seen in text.

	N. F. P.	Common	T. E. F.
Limacodidae	3	0	0
Drepanidae	3	0	0
Thyatiridae	2	0	1
Geometridae	37	4	14
Lasiocampidae	0	0	1
Saturniidae	1	1	3
Sphingidae	0	0	4
Notodontidae	2	1	4
Lymantriidae	2	1	1
Arctiidae	6	3	8
Noctuidae	7	0	8
Total	63	10	44

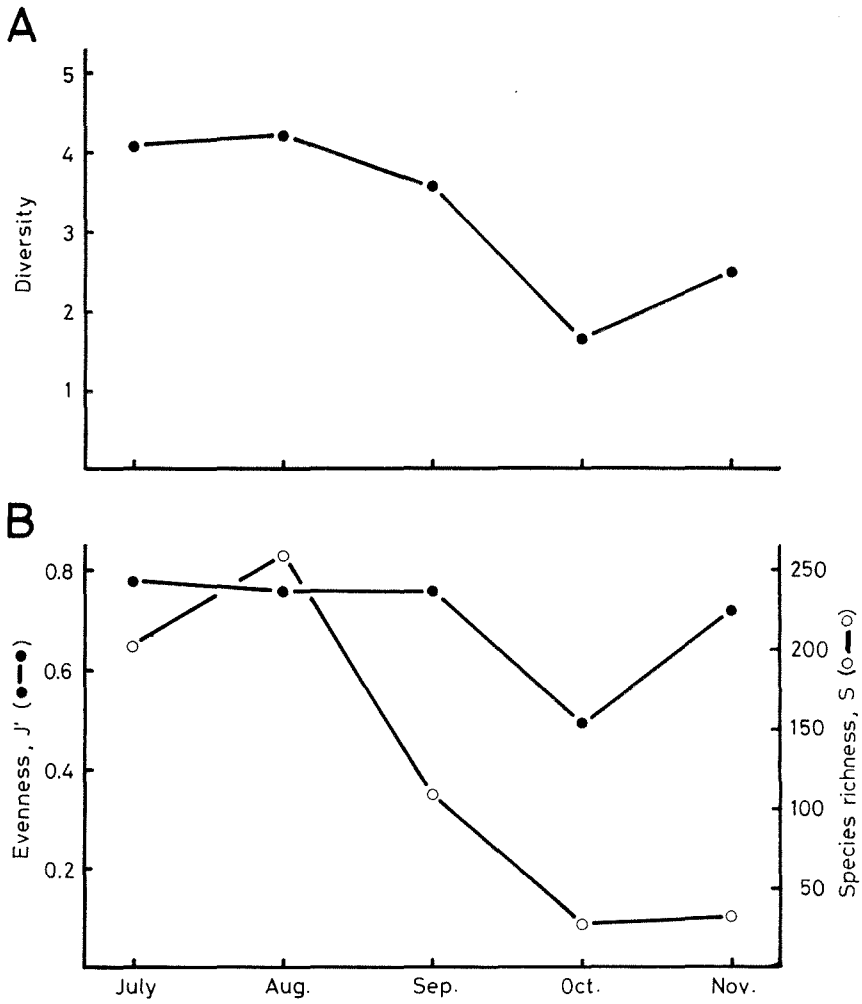

Figure 5. Seasonal fluctuations of species diversity (A), species richness and evenness (B).

predominance of *Daseochaeta viridis* and *Ramobia mediodivisa*.

Yoshida (1980) also reported similar fluctuation of diversity in the Tomakomai Experiment Forest. As a result, the fact that high diversity in the summer was affected mainly by high species richness and that low diversity in early autumn was affected mainly by low evenness is common to both Nopporo and Tomakomai. Furthermore, predominance of genus *Ramobia* led to low evenness in early autumn in both areas (*R. basifuscaria* in Tomakomai).

Species-abundance relationship

Pielou (1975) comprehensively dealt with formulae hitherto proposed, for the species-abundance relationship, and divided them into two groups : resource apportioning models and statistical models. The former is comprised of niche preemption model (Whittaker, 1965, 1972), broken-stick model (MacArthur, 1957, 1960),

and niche overlapping model (MacArthur, 1957, 1960). The latter consists of truncated negative binomial distribution (Brian, 1953), logseries distribution (Fisher *et al.*, 1943), lognormal distribution (Preston, 1948), and Poisson lognormal distribution (Pielou, 1969; Bulmer, 1974). Though Pielou did not take up the harmonic series distribution proposed by Corbet (1941), this doubtless belongs to the statistical models. Out of those models, the Poisson lognormal distribution involves computational difficulties and biologically serious assumptions (Pielou, 1975). In this paper, therefore, the degree of correlation with the data is assessed for the following seven models:

Resource apportioning model:

i) Niche preemption model

$$\log n_r + ar = b \qquad (a,\ b>0)$$

ii) Broken-stick model

$$n_r = \frac{N}{S} \sum_{j=1}^{r} \frac{1}{S-j+1}$$

iii) Niche-overlapping model (corrected by Pielou and Arnarson, 1965)

$$n_r = \frac{\sqrt{S-r+1} - \sqrt{S-r}}{\sqrt{S}} \times N$$

Statistical model:

iv) Truncated negative binomial distribution

$$S_n = \beta \cdot \frac{(k+n-1)!}{(k-1)!\,n!} \cdot \frac{p^n}{(p+1)^{n+k}} \qquad (p,\ k>0)$$

v) Logseries distribution

$$S_n = \frac{\alpha}{n} x^n$$

vi) Harmonic series distribution

$$S_n = \frac{c}{n^m}$$

vii) Lognormal distribution

$$S_n = S_0 \exp\left\{-(\log_2 n - \log_2 n_0)^2 / 2\sigma^2\right\}$$

where r is the rank order of abundance; n_r, the number of individuals of r-th species; N, the total number of individuals in the sample; S_n, the number of species with n individuals; S, the total number of speices in the sample; n_0, the number of individuals of the modal species; σ^2, the variance of the distribution; S_0, maximum value of S_n attained at $n=n_0$; a, b, c, k, m, p, α and β, parameters to be estimated.

The number of species per octave in the lognormal distribution was given not

by the octave method of Preston (1948) but by standardizing the octave (Shinozaki, 1958). Kimoto (1976) summarized the methods for estimating the parameters in each formula. The parameters in the niche preemption model and the harmonic series distribution were obtained each from regression curves ; the truncated negative binomial distribution, by means of Sampford's moment method (Sampford, 1955) ; the logseries distribution, with the tables of Kimoto (1976) ; the lognormal distribution, with the tables of Pearson and Lee (1908) and Lee (1915).

The parameters of the truncated negative binomial distribution could not be estimated, because the present data did not satisfy the following condition required by Sampford (1955) :

$$1-\left[\exp\left\{-\left(m+\frac{s^2}{m}-1\right)\right\}\right]<\left(m+\frac{s^2}{m}-1\right)\Big/m<\ln\left(m+\frac{s^2}{m}\right)$$

where m is a mean number of individuals per species and s^2 is variance. The expected species-abundance curves of other models are presented in Figures 6 to 8. Table 4 shows the correlation with each model by means of chi-square tests, where the expected values of each model are summed by a standardized octave. Three resource apportioning models and the harmonic series distribution had poor correlations. As mentioned by MacArthur (1957, 1960) and May (1975), resource apportioning models can be applied only to a small community of taxonomically homo-

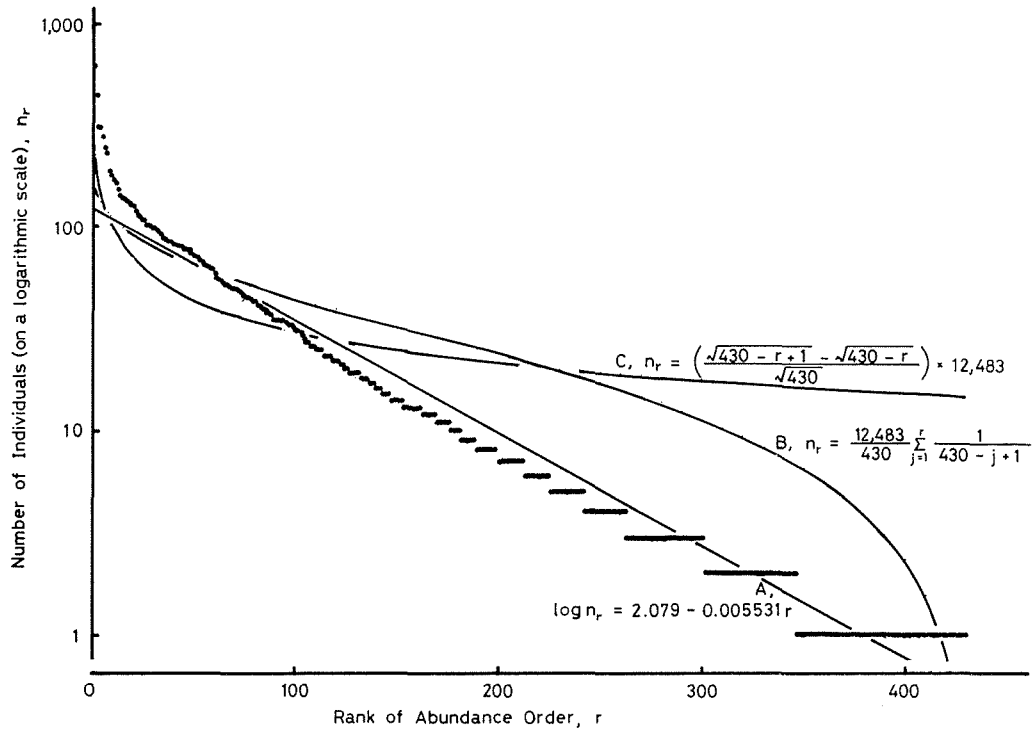

Figure 6. Species-abundance relationship. Solid circles represent observations. Curve A : a niche preemption model, curve B : a broken-stick model, curve C : a niche overlapping model.

genous group, where the species are similar in their resource need and compete with each other. However, the present sample is composed of not only closely related species but also phylogenetically distant species, and thus there is a diversity of food resources, for example, lichens, gymnosperms, angiosperms and dead leaves. This probably explains why the resource apportioning model had a poor correlation with the obtained data.

The present data had a good correlation with the logseries distribution ($0.7<P<0.8$) and the lognormal distribution ($0.05<P<0.1$), as in Bulmer (1974), Fisher

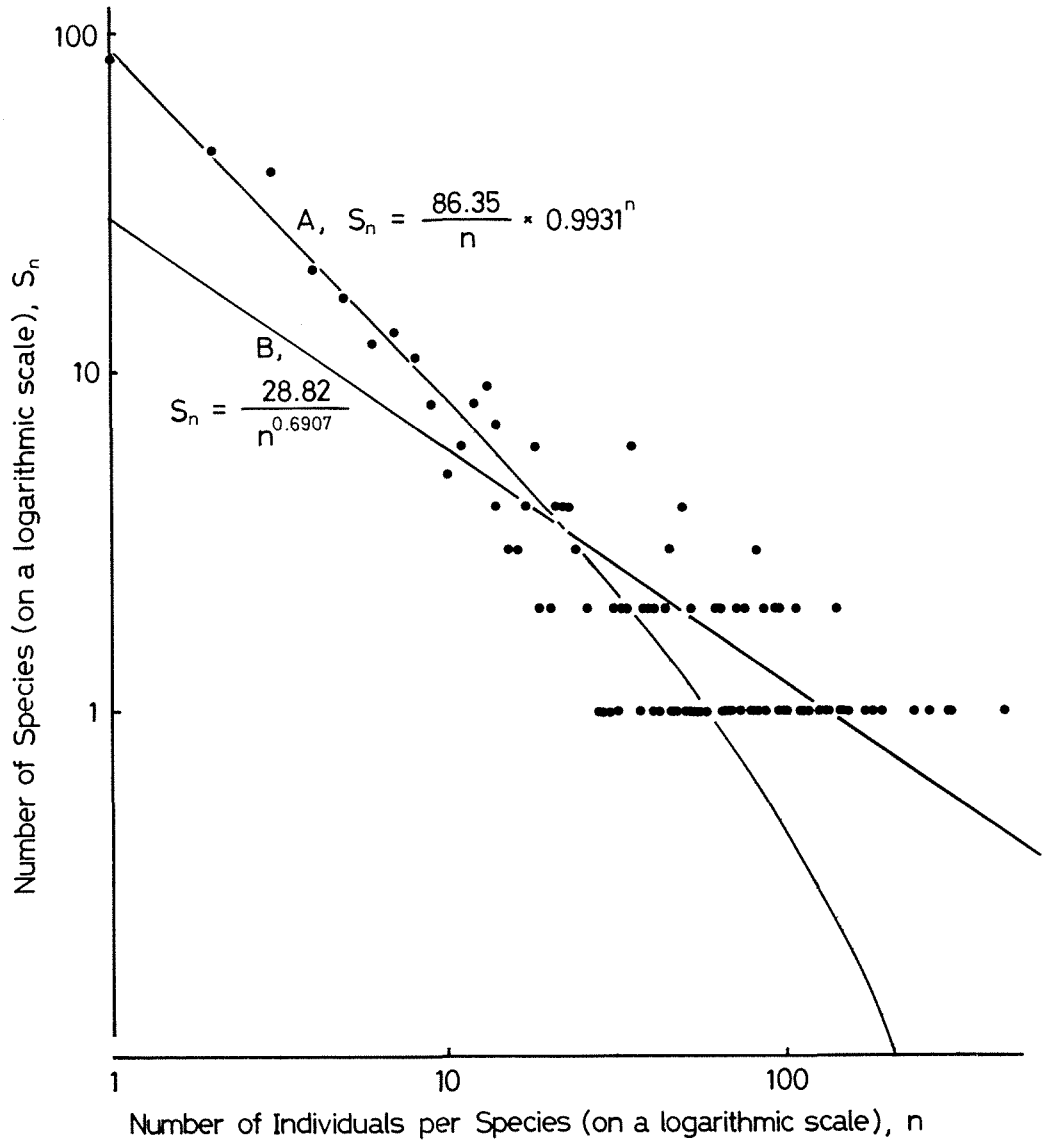

Figure 7. Species-abundance relationship. Solid circles represent observations. Curve A: a logseries distribution, curve B: a harmonic series distribution.

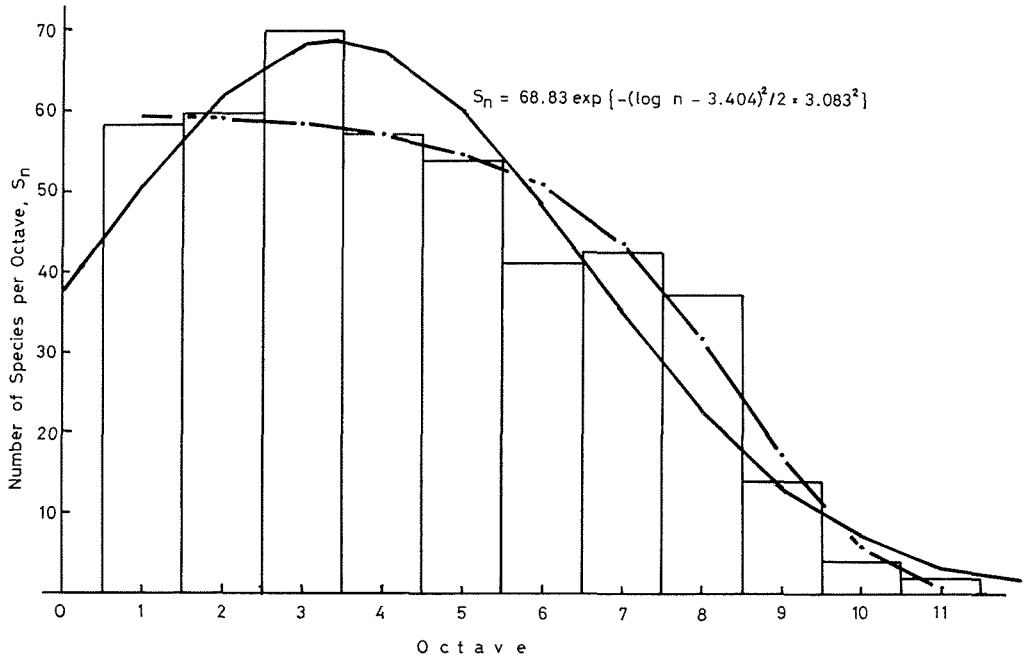

Figure 8. Species-abundance relationship. Histogram represents observations. Solid curve: a lognormal distribution, dash-dotted curve: a logseries distribution.

Table 4. Chi-square tests of correlation with various species-abundance formulae. Expected values from each formula are summed by a standardized octave.

	Niche preemption	Brocken-stick	Niche overlapping	Logseries	Harmonic series	Lognormal
χ^2_{cal}	20.762	334.877	913.818	5.687	1987.359	17.031
Freedom	7	7	4	9	10	10
P	$.001 < P < .01$	$< .001$	$< .001$	$.7 < P < .8$	$< .001$	$.05 < P < .1$

et al. (1943), Preston (1948), Williams (1953), and Yoshida (1981). Between these distributions, however, there was a better correlation to the logseries distribution than the lognormal distribution. When we calculate the mean number of individuals per species, we find that at 29.0 which is between both that of Williams, 65.0, and Yoshida, 19.1.[2] As Morisita (1961) stated, the lognormal distribution is more suitable for a large sample and the logseries, a medium-sized sample. Therefore, our opposite result is not due to a difference in sample size. The better correlation to the logseries distribution is more likely caused by the richness of the species on the low and intermediate octaves (Pielou, 1969).

2) Williams (1953) collected 15,609 individuals of 240 macrolepidopterous moth species in the fields of Rothamsted Experimental Station, England, and Yoshida (1981), 5,157 individuals of 270 species in the Tomakomai Experiment Forest (natural broad leaved), Hokkaido, Japan.

Then, the problem is why the present samples are rich in rare species. There are two possibilities. First, the light-trap method used by Williams (1953) and Yoshida (1981) would have seriously damaged the samples and the rare species, as a result, could not be easily identified, while the abundant species could be identified by comparing with relatively intact samples. On the other hand, the hand-collecting method used in the present research did not damage the samples and even the rare species could be identified without difficulty. Secondly, the richness of rare species may be attributed to vagetational complexity. A habitat, rich in plant species, would provide greater chances for the rare moth species to exist. The light trap Williams (1953) used was set on the margin of an arable field, a small orchard, and a large pasture, where vegetational complexity was fairly low. The natural broad-leaved forest of Yoshida's survey (1981) was dominated by *Quercus mongolica* var. *grosseserrata*, and therefore the vegetational complexity would not have been high (Igarashi and Ogasawara, 1978). The sampling site in the present study, however, is a natural mixed forest of high plant-diversity which would provide a greater chance for rare species to inhabit.

Abundance of euryphagous moth species in the autumn

Table 5 represents the relationship between the host-plant range of moths and the sampling season when the moths were caught. On the basis of Inoue *et al.* (1982), who gave the food habits of moths in Japan, the host plant, except for lichens, mosses, and dead leaves, could be listed for 300 out of 430 species obtained. In accordance with their host-plant ranges, the moths were grouped into two types: specialist and generalist. Following the definition of the two types by Futuyma (1976), the host plants of the specialist range taxonomically within one family and those of the generalist range over two or more families. The season was separated into summer (from July to September) and autumn (from October to November). Since the low temperatures restricted the flight activities of the moth, the host-searching time would be shorter in the autumn than in the summer.

The hypothesis of Levins and MacArthur (1969) explained the occurrence of polyphagy in insects. According to this hypothesis, the shortage of the foraging

Table 5. Seasonal comparison of the number of specialists and generalists. Specialists mean the moth species feeding on one-family plants. Generalists, on two or more families. Bared figures and parenthesized figures are actual numbers and expected numbers of species, respectively.

	Summer (July–Sep.)	Autumn (Oct.–Nov.)	Total
Specialist	250 (242.0)	19 (27.0)	269
Generalist	136 (144.4)	24 (16.0)	160
Total	386	43	429

$\chi^2_{cal} = 7.0793$ (freedom: 1), $.01 < P < .001$.

time will improve the tendency for polyphagy if the environmental conditions such as the predation and the proportion of the available plant do not change through the time and the insects choose their food plants to maximize their expected reproductive value. As shown in Table 5, the chi-square test ($0.001<P<0.01$) indicates that the generalist species prosper more in the autumn than the specialist, and *vice versa* in the summer, which seems to agree with the hypothesis of Levins and MacArthur (1969).

4. Summary

Macrolepidopterous moths were collected in Nopporo Forest Park during two or three successive nights at the beginning of each month from July to November 1982. In total 12,483 individuals (10,935 males and 1,548 females) of 430 species were collected, of which about 75% species belonged to Geometridae and Noctuidae. The combined results of the present and Sakamoto's surveys (Sakamoto *et al.*, 1977) reveal that at least 595 species of macrolepidopterous moths, or approximately 45% of all species discovered in Hokkaido to date, inhabit Nopporo Forest Park. However, the species common to both surveys constituted only 39.5% (235 species) of the total 595 species because of the difference in sampling schedules. The faunal makeup of Nopporo Forest Park was noticeably unlike that of Tomakomai Experiment Forest (Yoshida, 1976, 1981) which is located 45 km south of Nopporo Forest Park.

The seasonal fluctuations of a species diversity were bimodal, with a high peak extending from July to August and a small peak in November. Among the species-abundance curves proposed to date, the present data had the best correlation to the logseries distribution and a good correlation to the lognormal distribution. The better correlation to the former than to the latter was due to the richness of rare species which could be attributed to the hand-collecting method and vegetational complexity. The generalistic feeders seemed to adapt to the autumn better than to the summer, which is seemingly consistent with the hypothesis of Levins and MacArthur (1969).

5. Acknowledgements

We wish to express our sincere thanks to Prof. K. Ito, Graduate School of Environmental Science, Hokkaido University, for his valuable suggestions and encouragements in the course of the present study, and to Dr. S. Higashi for his kind help in this study. Cordial thanks are also due to Dr. T. Kumata, Entomological Institute, Faculty of Agriculture, Hokkaido University, for his suggestions on the sampling method, and Prof. S. Kimoto, Biological Laboratory, School of Medicine, Kurume University, for his kind advice and encouragement.

References

Brian, M. Y. (1953): Species frequencies in random samples from animal populations. *J. Anim. Ecol.*, **22**: 57–64.

Bulmer, M. G. (1974): On fitting the Poisson lognormal distribution to species-abundance data. *Biometrics*, **30**: 101–110.

Corbet, S. C. (1941): The distribution of butterflies in the Malay Peninsula. *Proc. R. Ent. Soc. Lond.*, **16**: 101–116.

Fisher, R. A., Corbet, S. C. and C. B. Williams (1943): The relation between the number of species and the number of individuals in a random sample of an animal population. *J. Anim. Ecol.*, **12**: 42–58.

Futuyma, D. J. (1976): Food plant specialization and environmental predictability in Lepidoptera. *Amer. Natur.*, **110**: 285–292.

Igarashi, T. and S. Ogasawara (1978): Forest structure and permanent-quadrat establishment in the speedway-planned area. In: *Road Planning and Forest Conservation in Hokkaido II* (ed. T. Igarashi), 1–41. Faculty of Agriculture, Hokkaido University, Sapporo.*

Inoue, H., Sugi, S., Kuroko, H., Moriuti, S. and A. Kawabe (1982): *Moths of Japan*. Vol. **1**, pp. 968, Vol. **2**, pp. 556, pls. 392. Kodansha, Tokyo.

Kimoto, S. (1976): *Methods for the Study of Animal Communities I. Diversity and species composition*. Kyoritsu Shuppan, Tokyo. pp. 194.*

Honda, H. and M. Tamura (1977): Biology of *Abraxas* (*Calospilos*) *miranda* Butler (Lepidoptera, Geometridae) I. Difference in the nocturnal activity between the sexes. *Kontyû*, **45**: 121–131.

†Lee, A. (1915): Tables of Gaussian "tail" functions when the "tail" is larger than the body. *Biometrika*, **10**: 208–214.

Levins, R. and R. H. MacArthur (1969): An hypothesis to explain the incidence monophagy. *Ecology*, **50**: 910–911.

MacArthur, R. H. (1957): On the relative abundance of bird species. *Proc. Natio. Acad. Sci.*, **43**: 293–295.

MacArther, R. H. (1960): On the relative abundance of species. *Amer. Natur.*, **94**: 25–36.

May, R. M. (1975): Patterns of species abundance and diversity. In: *Ecology and Evolution of Community* (ed. N. L. Cody and J. M. Diamond), 81–120. Harvard University, Cambridge, Massachusetts.

Morisita, M. (1961): Animal populations. In: *Animal Ecology* (ed. D. Miyaji), 193–292. Asakura Shoten, Tokyo.*

†Pearson, K. and A. Lee (1908): On the generalized probable error in multiple normal correlation. *Biometrika*, **6**: 59–68.

Pielou, E. C. (1966): The measurement of diversity in different types of biological collections. *J. Theoret. Biol.*, **13**: 131–144.

Pielou, E. C. (1969): *An Introduction to Mathematical Ecology*. Wiley-Interscience, New York. pp. 384.

Pielou, E. C. (1975): *Ecological Diversity*. Wiley-Interscience, New York. pp. 165.

Pielou, E. C. and A. N. Arnarson (1965): Correction to one of MacArthur's species-abundance formulas. *Science*, **151**: 592.

Preston, P. W. (1948): The commonness, and rarity, of species. *Ecology*, **29**: 254–283.

Sakamoto, Y., Kadosaki, M., Tamura, S., Watanabe, K., Jyou, Y., Honda, K., Nagasaki, Y. and F. Takashino (1977): *Note on Insect Fauna of Nopporo Forest Park, Hokkaido* (*Odonata. Lepidoptera. Coleoptera. Hemiptera*). Historical Museum of Hokkaido, Nopporo.**

Sakuma, A. (1964): *Statistics in Biology*. Tokyo University Press, Tokyo.*

Sampford, M. R. (1955): The truncated negative binomial distribution. *Biometrika*, **42**: 58–69.

Shinozaki, K. (1958): The structure of dispersion in plant community. In: *Outline of Ecology I. Plant ecology* (ed. M. Numata), 122–229. Kokin-Shoin, Tokyo.*

Tatewaki, M. and T. Igarashi (1973): *Botanical Survey on the Nopporo National Forest, with Special Reference to the Forest Vegetation, Prov. Ishikari, Hokkaido, Japan.* Sapporo Regional Forestry Office, Sapporo. pp. 355.*

Whittaker, R. H. (1965): Dominance and diversity in land plant communities. *Science*, **145**: 250–260.

Whittaker, R. H. (1972): Evolution and measurement of species diversity. *Taxon*, **21**: 213–251.

Williams, C. B. (1939): An analysis of four years captures of insects in a light trap. Part I. General survey; sex proportion; phenonogy; and time of flight. *Trans. R. Ent. Soc. Lond.*, **89**: 78–131.

Williams, C. B. (1953): The relative abundance of different species in a wild animal population. *J. Anim. Ecol.*, **22**: 14–31.

Yoshida, K. (1976): Moth fauna of Tomakomai Experiment Forest of Hokkaido University. *Res. Bull. Coll. Exper. Forests, Coll. Agr., Hokkaido Univ.*, **33**: 457–480.**

Yoshida, K. (1980): Seasonal fluctuation of moth community in Tomakomai Experiment Forest of Hokkaido University. *Res. Bull. Coll. Exper. Forests, Coll. Agr., Hokkaido Univ.*, **37**: 675–685.

Yoshida, K. (1981): Faunal make-up of moths in Tomakomai Experiment Forest, Hokkaido University. *Res. Bull. Coll. Exper. Forests, Coll. Agr., Hokkaido Univ.*, **38**: 181–218.

†: not directly accessible.
*: in Japanese.
**: in Japanese with English summary.

(*Received 31 March 1985*)