

論文 (Original Article)

Butterfly fauna in and near the Ogawa Forest Reserve

INOUE Takenari¹⁾

Abstract

A total of 97 butterfly species were identified from the Ogawa area during 233 days of field survey conducted in 1996-2002. The species included 16 Hesperidae, 8 Papilionidae, 7 Pieridae, 30 Lycaenidae, 23 Nymphalidae, 1 Libytheidae, 1 Danaidae and 11 Satyridae. Of these, 17 were regarded as threatened species in Ibaraki Prefecture and 7 in the whole of Japan. Also, 10 species that prefer primary forest or natural types of grassland as their habitats were identified. I estimated that approximately 100 butterfly species, i.e. 94 % of the fauna of Ibaraki Prefecture, live in the Ogawa area at present. This rich butterfly fauna may be afforded by the land mosaic of the present area consisting of various types of forest, marshland, pastureland and farmland. It may also be closely related with the traditional human land use in agriculture and forestry, which have been practiced on a small scale in the present area until very recently.

Key words : butterfly fauna, Ogawa Forest Reserve, Ibaraki Prefecture, land mosaic, threatened species, butterfly conservation

Introduction

For a long time, "Ogawa area" (the Ogawa Forest Reserve and its vicinity) has been known as one of the most famous insect collecting sites in the Kanto district, central Japan (Keihin Konchu Dokokai, 1975). In the present area, three studies of butterfly community covering the whole flight season have previously been carried out. Shiota (1990, 1992) conducted transect recordings in 1989 located in four different environments: logging road, farmland, pastureland and forest floor, and recorded 69 species. Maetô and Makihara (1999) examined insect catches in Malaise traps set in six different types of forest: old-growth natural forest, young (1 site) and old (3 sites) secondary forests and a coniferous plantation in 1996, and recorded 30 species. Inoue (2003) studied chronosequential changes in butterfly communities after clear-cutting from 1997 through 2001. In the last study, a transect method was used at 11 census sites, composed of successive stages of forest development: grassland, cutover land, very young (2 sites), middle (2 sites), old (mature; 2 sites) and old-growth (3 sites) forests. A total of 86 butterfly species were recorded.

All previous reports, however, did not focus upon the whole butterfly fauna. Here I report all butterfly species observed during 1996-2002 and also review previous literature as a contribution to current knowledge regarding insect assemblages in and around the Ogawa area.

Study Area and Methods

Study Area

The study area is located at the southern edge of the Abukuma Mountains, in Kitaibaraki City, northern part of Ibaraki Prefecture, central Japan (36°56' N, 140°35' E, 580 - 800 m above sea level). The mean annual air temperature in Ogawa is 10.7 °C, the highest monthly mean is 22.6 °C (August) and the lowest -0.9 °C (January). The mean annual precipitation is approximately 1900 mm (Nakashizuka and Matsumoto, 2002). In the past, the forests in this area had been subjected to human activities such as burning, cattle grazing and clear-cutting for fuel wood (Nakashizuka and Matsumoto, 2002). Thus, the landscape of the study area corresponds to that of "satoyama" in a broad sense (Ishii, 2001), consisting of old-growth natural forests, secondary forests, Japanese-cedar and Japanese-cypress plantations, and small farms. The common tree species in the natural forests in and around the study area are *Quercus crispula*, *Q. serrata*, *Fagus crenata*, *F. japonica* (Fagaceae), *Carpinus* spp. (Betulaceae), and *Acer* spp. (Aceraceae) (Nakashizuka and Matsumoto, 2002). In the present report, the "Ogawa area" includes following localities (subsections): Ogawa, Sadanami, Sakaizawa, Shimokawa, Ushikubiri, Oshoyama, Nando, Kameyachi, Yamanokami, Yataro-zaka, Matsuzakayama and Sarugajo (Fig. 1); but "Hanazono", the downstream area of the Hanazono River was excluded from the

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1) Department of Forest Entomology, Forestry and Forest Products Research Institute (FFPRI), 1 Matsunosato, Tsukuba, Ibaraki 305-8687, Japan;
e-mail : taisei@ffpri.affrc.go.jp



Fig. 1. Map of the Ogawa area and its vicinity. SD: Sadanami, SK: Sakaizawa, SH: Shimokawa, OG: Ogawa, U: Ushikubiri, OS: Oshoyama, N: Nando, K: Kameyachi, YM: Yamanokami, M: Matsuzakayama, YT: Yataro-zaka, SR: Sarugajo. The research area of the present study was located between Yataro-zaka and Sadanami.

study area. This is because no evergreen broad-leaved trees (except for a few shrubs) have been found in the Ogawa area but a few of those trees (e.g. *Quercus acuta*) were scattered in the Hanazono area.

Faunal survey

To identify the butterfly fauna of the Ogawa area, adult butterflies were observed during every flight season (April to October) from 1996 through 2002. Field observations were conducted for a total of 233 days (approximately 1135 h). I walked in various environments of the Ogawa area recording the species and the number of individuals for all adult butterflies sighted within approximately 10 m of either side. The time spent for each observation was also recorded. Observations were conducted between 6:00 and 18:30 local time. Total number of the individuals of each species recorded each year was divided by the annual observation time (h) in order to calculate the annual adult density of each species. Since distinction between *Pieris melete* (Menetries) and *P. nesis* (Fruhstorfer) and that between *Neope goschkevitschii* (Menetries) and *N. nipponica* Butler is very difficult in the field (Kawazoe and Wakabayashi, 1976), I recorded them as *Pieris* spp. and *Neope* spp., respectively. I captured a few individuals of each species with an insect net and deposited them as specimens in the collection of FFPRI.

Information on past records of butterflies in the Ogawa area and in Ibaraki Prefecture was derived from the

literature (cf. Tables 3 and 4).

Ecological classification of the butterfly species

All identified butterfly species were classified into forest or grassland species (Tanaka, 1998) and also into generalist (multivoltine and polyphagous species), specialist (univoltine and oligophagous species) and other (intermediate) species (Kitahara and Fujii, 1994 with minor modifications conducted by Inoue (2003)) (Table 1). Moreover, I picked out some "typical natural forest (or grassland) species" (Inoue, 2003) and threatened species of Ibaraki Prefecture (Ibaraki Prefecture, 2000) and Japan (Ministry of the Environment, 2000) from all species identified (Table 1). Further details of this classification are presented in Inoue (2003).

Results and Discussion

1. Present butterfly fauna of the Ogawa area

Approximately 80 species were recorded each year and a total of 95 operational species were identified throughout the seven observation years (Table 1). In fact, 97 real species were identified, because each two *Pieris* and *Neope* species that were not distinguished in the field were collected each year.

Seventy (74 %) and 25 (26 %) species were classified as forest and grassland species, respectively (Tables 1 and 2). Because about 64 % of all Japanese butterfly species are regarded as forest species (Tanaka, 1988), the percentage of forest species in the Ogawa area was higher than in whole of Japan, and slightly higher than in Ibaraki Prefecture (about 69 %, based on Sasaki, 1993). This is because the whole butterfly fauna of Japan includes many specific grassland species (e.g. species that live in alpine meadow) and that of Ibaraki Prefecture includes some very rare grassland species (e.g. *Melitaea scotosia* Butler and *Zizina otis* (Fabricius), that had been collected only a few times).

Sixteen Hesperidae, eight Papilionidae, six Pieridae (in fact, seven), 30 Lycaenidae, 23 Nymphalidae, one Libytheidae, one Danaidae and ten (in fact, 11) Satyridae species were identified (Table 1).

The family Hesperidae included many grassland species and the number of specialists and generalists in the family were nearly even. Most of the papilionid species were forest generalists. The family Lycaenidae included many hairstreaks, most of which were forest specialists. The family Nymphalidae included six fritillaries and most of them were specialists, but the number of specialists and generalists in this family were even. Most of the satyrid species were forest generalists.

The most abundant forest species was either *Pieris* spp. or *Lethe diana* every year. The densities of *Eurema hecabe* and *Neptis sappho* were the next highest. As for the grassland species, *Colias erate* had the highest density, followed by *Minois dryas*, *Pieris rapae* and *Lycaena phlaeas*. These species

Table 1. List of the butterfly species observed by the field research during the adult flight season (April-October) in 1996-2002. Their characteristics and their adult densities are shown.

Species	Characteristics										Density (no. adults / observation time (h))									
	Habitat 1)	Host plants 2)	Volinism 3)	Strategy 4)	Status in Red Data List		Typical natural forest or grassland species 7)	1996	1997	1998	1999	2000	2001	2002	1996-2002					
					Ibaraki 5)	Japan 6)														
Hesperiidae																				
<i>Pyrgus maculatus</i> (Bremer & Grey) チャマダラセセリ	G	O	2	R	CR+EN	T	0.1348	0.0068	0.0171	0.0165	0.0249	0.0384	0.0774	0.0291						
<i>Erynnis montanus</i> (Bremer) ミヤマセセリ	F	O	1	Sp			0.5169	0.6918	0.7197	0.3988	0.6877	0.7674	0.7446	0.6238						
<i>Dainio lehyis</i> (Menetries) ダイミヨウセセリ	F	O	2				0.2247	0.0548	0.2399	0.1289	0.0648	0.0384	0.0774	0.1216						
<i>Bibasis aquilina</i> (Speyer) キバナセセリ 8)	F	O	1	Sp			0.0225	0.0068	0.0	0.0	0.0	0.0	0.0	0.0018						
<i>Chocopaes heijamintii</i> (Guerin-Meneville) アオバセセリ	F	O	2				0.1798	0.0068	0.0943	0.2247	0.1096	0.1151	0.0	0.1172						
<i>Leptadina unicolor</i> (Bremer & Grey) キンイモチモンジセセリ	G	O	1	Sp	NT		0.1348	0.1096	0.3727	0.1850	0.3090	0.4700	0.2998	0.2705						
<i>Aeromachus inachus</i> (Menetries) ホシチャバナセセリ	G	O	1	Sp	VU	T	0.0	0.0411	0.0214	0.0165	0.0349	0.0192	0.0193	0.0238						
<i>Thymelicus leoninus</i> (Butler) スジグロチャバナセセリ	G	O	1	Sp	NT		0.0899	0.0342	0.0386	0.0099	0.0449	0.0767	0.0193	0.0352						
<i>Ochlandes venatus</i> (Bremer & Grey) コキマダラセセリ	G	P	1	R		T	0.0	0.0548	0.0300	0.0430	0.0150	0.0288	0.0193	0.0317						
<i>Ochlandes ochraceus</i> (Bremer) ヒメキマダラセセリ	F	P	1				0.3371	0.2329	0.2142	0.5452	0.3090	0.4029	0.8220	0.3991						
<i>Thoressa varia</i> (Murray) コチャバナセセリ	F	P	2	Ge			0.3146	0.4863	0.7626	0.4394	0.2243	0.5276	0.3578	0.4696						
<i>Potanthus flavus</i> (Murray) キマダラセセリ	G	P	1	Ge			0.0225	0.0685	0.1542	0.1057	0.0997	0.1439	0.1257	0.1119						
<i>Polytremis pellucida</i> (Murray) オオチャバナセセリ	G	P	2	Ge			0.0	0.0822	0.0900	0.0297	0.0748	0.0959	0.1547	0.0749						
<i>Pelopidas jansoni</i> (Butler) ミヤマチャバナセセリ	G	O	2	Ge			0.0	0.0137	0.0171	0.0066	0.0100	0.0288	0.0097	0.0123						
<i>Pelopidas mathias</i> (Fabricius) チャバナセセリ	G	P	M	Ge			0.0	0.0137	0.0043	0.0231	0.0498	0.0	0.0387	0.0211						
<i>Parnara guttata</i> (Bremer & Grey) イモチモンジセセリ	G	P	M	Ge			0.0	2.5000	0.5612	0.2049	0.0947	0.6139	0.8703	0.6441						
Papilionidae																				
<i>Papilio machaon</i> Linnaeus キアゲハ	G	P	M	Ge			0.1348	1.1027	0.5569	0.3237	0.2791	0.2878	0.2611	0.4450						
<i>Papilio xuthus</i> Linnaeus ナミアゲハ	F	P	2-M	Ge			0.0674	0.1507	0.0857	0.0089	0.0249	0.0192	0.0193	0.0502						
<i>Papilio helenus</i> Linnaeus モンキアゲハ 8)	F	P	2	Ge			0.0	0.0	0.0129	0.0066	0.0	0.0	0.0	0.0044						
<i>Papilio protenor</i> Cramer クロアゲハ	F	P	2	Ge			0.1348	0.0137	0.0300	0.0264	0.0	0.0096	0.0193	0.0229						
<i>Papilio maackianus</i> Janson オナカアゲハ	F	O	2	Ge			0.6966	0.0822	0.2485	0.2907	0.0698	0.1631	0.0774	0.2009						
<i>Papilio dehaanii</i> C. & R. Felder カラスアゲハ	F	P	2	Ge			0.4270	0.1712	0.3899	0.3866	0.1694	0.1631	0.1547	0.2811						
<i>Papilio maackii</i> Menetries ミヤマカラスアゲハ	F	O	2	Ge			0.3820	0.1233	0.3813	0.2808	0.1296	0.3933	0.1547	0.2573						
<i>Graphium scarpodon</i> (Linnaeus) アオスジアゲハ 8)	F	P	2	Ge			0.0	0.0	0.0	0.0	0.0	0.0192	0.0	0.0018						
Pieridae																				
<i>Colias erate</i> (Esper) モンキチョウ	G	P	M	Ge			3.2360	4.0685	1.2467	1.5363	1.9186	1.7938	2.1950	2.0204						
<i>Eurema hecabe</i> (Linnaeus) キチョウ	F	P	M	Ge			0.4719	0.8151	1.2424	1.6883	0.8073	0.7770	1.2957	1.1613						
<i>Gonepteryx aspasia</i> (Menetries) スジボンヤマキチョウ	F	O	1	Sp	R		0.0	0.0205	0.0171	0.0165	0.0150	0.0096	0.0097	0.0150						
<i>Pieris (Artogeia) rapae</i> (Linnaeus) モンシロチョウ	G	P	M	Ge			0.1798	0.7466	0.9425	0.4758	0.5083	1.7842	1.5471	0.8186						
<i>Pieris (Artogeia) spp.</i> スジグロシロチョウ類 9)	F	P	M	Ge			1.7753	3.6507	5.0768	5.2698	3.9867	5.0935	4.8928	4.6118						
<i>Anthocharis scabronus</i> Butler ツマキチョウ	G	P	1	Ge			0.1798	0.1233	0.0685	0.0496	0.0698	0.0863	0.1064	0.0802						
Lycanidae																				
<i>Narathura japonica</i> (Murray) ムラサキシジミ	F	P	2	Ge			0.0	0.0753	0.1157	0.1784	0.1047	0.0384	0.1257	0.1145						
<i>Artiopeetes pyperi</i> (Murray) ウラコマダラシジミ 8)	F	O	1	Sp			0.0	0.0	0.0043	0.0	0.0050	0.0096	0.0	0.0026						
<i>Coreana stygiana</i> (Butler) ウラキンシジミ 8)	F	O	1	Sp			0.0	0.0	0.0043	0.0	0.0050	0.0096	0.0	0.0026						
<i>Shirazua jonasii</i> (Janson) ムモンアカシジミ	F	O	1	Sp	R		0.0	0.0342	0.0086	0.0165	0.0797	0.0959	0.2031	0.0520						
<i>Japanica lutea</i> (Hewitson) アカシジミ	F	O	1	Sp			0.0	0.0274	0.1671	0.1057	0.0349	0.0288	0.0193	0.0767						
<i>Japanica saepesstrata</i> (Hewitson) ウラミアアカシジミ	F	O	1	Sp			0.0	0.0	0.0043	0.0198	0.0150	0.0192	0.0	0.0106						

<i>Avitiguis attilia</i> (Bremer) ミズイロナガシジミ	F	P	1					0.1348	0.0068	0.3342	0.3007	0.1246	0.0480	0.0387	0.1850
<i>Avitiguis butleri</i> (Fenton) ウスイロナガシジミ	F	O	1	R				0.0	0.0	0.0	0.0165	0.0	0.0096	0.0	0.0053
<i>Avaragi enthaea</i> (Janson) オナガシジミ	F	O	1	Sp				0.0225	0.1233	0.0728	0.0694	0.0548	0.0671	0.0580	0.0714
<i>Itatsume orsedace</i> (Butler) ウラクロンシジミ	F	P	1	Sp				0.0	0.0137	0.0728	0.1553	0.0100	0.0384	0.0677	0.0696
<i>Wagino signatus</i> (Butler) ウラミスジシジミ	F	O	1	Sp				0.0	0.0	0.0386	0.0066	0.0	0.0	0.0	0.0097
<i>Neozephyrus japonicus</i> (Murray) ミドリシジミ	F	O	1	Sp				0.0	0.0411	0.0300	0.0132	0.0050	0.0	0.0	0.0159
<i>Chrysozephyrus brilliantinus</i> (Staudinger) アイノミドリシジミ	F	O	1	Sp				0.0225	0.0	0.0	0.0430	0.1047	0.0863	0.1644	0.0537
<i>Sibatani-zephyrus</i> <i>fujiisanus</i> (Matsumura) フジミドリシジミ	F	O	1	Sp				0.0	0.0	0.0	0.0033	0.0	0.0096	0.0	0.0018
<i>Favonius taxila</i> (Bremer) ジョウザンミドリシジミ	F	O	1	Sp				0.0	0.0205	0.0129	0.0089	0.0050	0.0	0.0	0.0088
<i>Favonius orientalis</i> (Murray) オオミドリシジミ	F	O	1	Sp				0.0	0.1096	0.1071	0.0496	0.1346	0.2398	0.0	0.0952
<i>Favonius jizoensis</i> (Matsumura) エゾミドリシジミ	F	O	1	Sp				0.0899	0.0959	0.1499	0.1024	0.0	0.0767	0.0193	0.0628
<i>Raphala arata</i> (Bremer) トラフシジミ	F	P	2	Ge				0.1124	0.0068	0.0171	0.0231	0.0349	0.0192	0.0097	0.0238
<i>Fraxinea mera</i> (Janson) ミヤマカラスシジミ(8)	F	O	1	Sp				0.0	0.0	0.0086	0.0066	0.0199	0.0192	0.0097	0.0097
<i>Callophrys ferrea</i> (Butler) コツバメ	F	P	1	Sp				0.0899	0.0342	0.0214	0.0760	0.1047	0.2110	0.0387	0.0740
<i>Lycæna phlaeas</i> (Linnaeus) ベニシジミ	F	O	M					2.3820	1.2534	0.5484	0.6410	0.5831	0.7098	0.9767	0.7957
<i>Taraxa hamada</i> (H.Druce) コイシシジミ	F	O	M					0.0	0.1644	0.6598	0.1421	0.0498	0.1055	0.2321	0.2344
<i>Niphanda fusca</i> (Bremer & Grey) クロンシジミ(8)	F	O	1	Sp				0.0	0.0	0.0	0.0	0.0299	0.0192	0.0193	0.0088
<i>Lampides boeticus</i> (Linnaeus) ウラナミシジミ	G	P	M	Ge				0.0	0.0	0.0	0.0033	0.0	0.0	0.0	0.0009
<i>Pseudizeeria naha</i> (Kollar) ヤマトシジミ	G	O	M					0.0	0.1918	0.1157	0.1289	0.3389	0.0480	0.0870	0.1551
<i>Celastrina argiolus</i> (Linnaeus) ルリシジミ	F	P	M					0.4944	0.8425	0.9425	0.3932	0.5731	0.4604	0.5512	0.6203
<i>Celastrina sugitani</i> (Matsumura) スギタニルリシジミ	F	P	1	Ge				0.0	0.1781	0.1457	0.0463	0.1595	0.2014	0.1644	0.1269
<i>Everses argiades</i> (Pallas) ツバメシジミ	G	P	M					1.0562	0.1849	0.2313	0.3304	0.4983	0.5372	0.4835	0.3842
<i>Plebejus argus</i> (Linnaeus) ヒメシジミ	G	P	1	Ge				0.0	0.2671	0.1842	0.0496	0.0150	0.0096	0.0290	0.0916
<i>Caretis acuta</i> Moore ウラギンシジミ	F	P	2	Ge				0.0225	0.0342	0.0300	0.0496	0.0498	0.0096	0.0483	0.0388
Libytheidae															
<i>Libythea celtis</i> (Litcharding) テングチョウ	F	O	1	Sp				0.1348	0.0685	0.0043	0.0198	0.0698	0.0	0.0677	0.0388
Danaidae															
<i>Parantica sita</i> (Kollar) アサギマダラ	F	P	2	Ge				0.0	0.0342	0.0214	0.0264	0.0748	0.0192	0.0483	0.0352
Nymphalidae															
<i>Argyrogonome laodice</i> (Pallas) ウラギンシジミヒョウモン	F	P	1	Sp				0.0	0.0479	0.1585	0.0363	0.0498	0.0576	0.0290	0.0652
<i>Argyrogonome nelsana</i> (Motschulsky) オオウラギンシジミヒョウモン	F	O	1	Sp				0.1348	0.0753	0.1242	0.1256	0.0847	0.1343	0.1834	0.1190
<i>Damona sagana</i> (Doubleday) メスグロヒョウモン	F	O	1	Sp				0.0225	0.0274	0.0214	0.0165	0.0299	0.0480	0.0097	0.0238
<i>Nymphargyris anadyomene</i> (C. & R. Felder) クモガタヒョウモン	F	O	1	Sp				0.0674	0.3630	0.2014	0.1553	0.1844	0.1631	0.1257	0.1912
<i>Argyrenis pophia</i> (Linnaeus) ミドリヒョウモン	F	O	1	Sp				0.1573	0.4178	0.2056	0.2742	0.3588	0.4221	0.4641	0.3198
<i>Fabriciana adippe</i> (Denis & Schiffermüller) ウラギンヒョウモン	G	O	1	Sp				0.0	1.0890	0.1714	0.1421	0.2492	0.4700	0.4158	0.3401
<i>Limnitis glorifica</i> (Fruhstorfer) アサマイチモンジ	F	O	2	Ge				0.0	0.0205	0.0471	0.0330	0.0498	0.0288	0.0290	0.0352
<i>Limnitis camilla</i> (Linnaeus) イチモンジチョウ	F	P	2	Ge				0.2921	0.4658	0.2356	0.3073	0.3140	0.3165	0.2031	0.3049
<i>Nymphis sappho</i> (Pallas) コミスジ	F	P	M	Ge				1.8427	0.5205	0.9896	1.8238	0.8372	0.5372	0.6865	1.0917
<i>Nymphis philyra</i> Menetries ミスジチョウ	F	P	1	Sp				0.0	0.0548	0.0428	0.0793	0.0299	0.0288	0.0483	0.0453
<i>Nymphis atania</i> (Bremer & Grey) オオオミスジ	F	O	1	Sp				0.3371	0.0411	0.0343	0.0496	0.0748	0.0576	0.0677	0.0634
<i>Araschnia borejana</i> Bremer サカハチチョウ	F	O	2	Ge				0.0674	0.0137	0.0300	0.0562	0.0797	0.0576	0.0483	0.0493
<i>Polygona e-aureum</i> (Linnaeus) キタテハ	G	O	M					0.5843	0.4452	0.3727	0.2841	0.2641	0.5180	0.5415	0.3762
<i>Polygona e-album</i> (Linnaeus) シー・タテハ	F	P	2	Ge				0.1124	0.1301	0.1671	0.1553	0.0947	0.1151	0.2224	0.1445
<i>Nymphalis xanthomalas</i> (Denis & Schiffermüller) ヒオドリシチョウ	F	P	1	Ge				0.0449	0.0959	0.0471	0.0231	0.0797	0.0863	0.1547	0.0661
<i>Kaniska canace</i> (Linnaeus) ルリタテハ	F	P	M	Ge				0.3146	0.1712	0.3127	0.2115	0.1346	0.1343	0.2707	0.2159
<i>Inachis io</i> (Linnaeus) クジャクチョウ	G	P	2	Ge				0.9663	0.6027	0.7926	0.2511	0.2392	0.3549	0.4158	0.4582

<i>Cynthia cardui</i> (Linnaeus) ヒメアカカタテハ	G	P	M	Ge	0.0	0.2065	0.0171	0.0165	0.0449	0.1055	0.0580	0.0573
<i>Vanessa indica</i> (Herbst) アカカタテハ	G	P	2-M	Ge	0.0449	0.3151	0.2442	0.0562	0.0847	0.0671	0.1064	0.1383
<i>Dichorragia nesimachus</i> (Doyere) スミナガン	F	O	2		0.1124	0.0274	0.0728	0.2081	0.0449	0.0288	0.0290	0.0916
<i>Apatura metis</i> Freyer コムラサキ	F	P	1		1.3933	0.5342	0.2956	0.2379	0.1993	0.5276	0.2514	0.3542
<i>Hesitia porsimilis</i> (C. & R. Felder) コマダラチヨウ8)	F	O	2		0.0	0.0	0.0	0.0063	0.0	0.0	0.0	0.0009
<i>Sasakia charonida</i> (Hewitson) オオムラサキ8)	F	O	1	Sp	0.0	0.0068	0.0043	0.0066	0.0	0.0	0.0	0.0035
Satyridae												
<i>Ypthima argus</i> Butler ヒメウラナミジャノメ	F	P	2	Ge	0.7416	0.3356	0.2613	0.2280	0.6478	0.7002	0.4448	0.4062
<i>Minois dryas</i> (Scopoli) ジャノメチヨウ	G	P	1		0.2022	1.6233	1.0882	0.6013	1.8289	1.2566	1.4601	1.1728
<i>Zophressa callipetris</i> (Butler) ヒメキマダラヒカガ	F	O	1	Sp	0.1348	0.0205	0.0771	0.0727	0.0548	0.0288	0.0290	0.0582
<i>Lethe diana</i> (Butler) クロヒカガ	F	P	M	Ge	2.2921	1.0616	1.9750	2.3590	1.2458	1.8983	1.3247	1.7931
<i>Lethe sicelis</i> (Hewitson) ナミヒカガ	F	P	2	Ge	0.2247	0.0959	0.1499	0.1883	0.1296	0.1343	0.0193	0.1392
<i>Ningita schrenckii</i> (Menetries) オオヒカガ	F	P	1		0.5843	0.1233	0.2313	0.0430	0.0449	0.0096	0.0097	0.1075
<i>Mycalesis francisca</i> (Stoll) コジャノメ	F	O	2		0.0	0.0	0.0	0.0033	0.0199	0.0384	0.0097	0.0088
<i>Mycalesis gotama</i> Moore ヒメジャノメ	F	P	2-M	Ge	0.4494	0.2123	0.1371	0.0727	0.0399	0.1055	0.1064	0.1190
<i>Neope</i> spp. キマダラヒカガ類9)	F	P	2	Ge	0.7191	0.4041	0.5484	0.9846	0.5930	0.5276	0.6189	0.6652
<i>Melanitis phedime</i> (Cramer) クロコノマチヨウ	F	O	2		0.0	0.0	0.0	0.0033	0.0100	0.0	0.0	0.0026
Numbers of species observed												
Numbers of observation days												
Total observation time (h)												
					56	80	85	90	84	84	78	95
					11	34	45	51	36	25	31	233
					44.50	146.00	233.42	302.67	200.67	104.25	103.42	1134.92

1) Character of habitat (Tanaka, 1988). F: Forest species; G: Grassland species; *Pieris* spp. was treated as a forest species according to Inoue (2003).

2) Range of acceptable larval host plants. O (oligophagy): species whose larvae had been reported feeding on 10 or fewer plant species belonging to one taxonomic family; P (polyphagy): species whose larvae had been reported feeding on more than 10 plant species belonging to one taxonomic family, or on a variety of host plants belonging to two or more taxonomic families; C: carnivorous; M: myrmecophile. One carnivorous (*Taraka hamada*) and one myrmecophile (*Niphanida fusca*) species were treated as oligophagous species.

3) Number of generations per year. M: three or more.

4) Adaptive strategy (modified Kitahara and Fujii, 1994). Ge: generalist species; Sp: specialist species.

5) R: Rare (Near Threatened) species (Ibaraki Prefecture, 2000).

6) CR+EN: "Critically Endangered" or "Endangered"; VU: "Vulnerable"; NT: "Near Threatened" species (Ministry of the Environment, 2000).

7) T: Typical natural forest (or grassland) species (Inoue, 2003). Species which were given 8 or higher points of the "habitat preference" for stage (primary stage) by Tanaka (1988).

8) Species which could not be observed during the transect counts conducted by Inoue (2003).

9) *Pieris* spp. (*P. malete* (Menetries) and *P. nesis* (Fruhstorfer)) and *Neope* spp. (*N. gosshweitschii* (Menetries) and *N. niponica* Butler) was treated as a single species in the field.

appeared to be the dominant forest and grassland species in the Ogawa area. Besides these dominant species, the densities of *Erynnis montanus*, *Ochlodes ochraceus*, *Thoressa varia*, *Parnara guttata*, *Papilio machaon*, *Celastrina argiolus*, *Everes argiades*, *Polygonia c-aureum*, *Inachis io*, *Apatura metis*, *Ypthima argus* and *Neope* spp. were also high (Table 1). Most of these species (except *L. diana*, *I. io* and *O. ochraceus*) had also high densities in Mt. Tsukuba, Ibaraki Prefecture ("Area A and B" of Kitahara and Fujii, 1994). On the other hand, densities of both hairstreaks and fritillaries, the two typical specialist groups, were relatively low. Most of hairstreaks and fritillaries had also low densities in Mt. Tsukuba (Kitahara and Fujii, 1994). In addition to the hairstreak species, *Bibasis aquilina*, *Papilio helenus*, *Graphium sarpedon*, *Lampides boeticus*, *Niphanda fusca*, *Hestina persimilis*, *Sasakia charonda* and *Melanitis phedima* were observed only in one, two or three of the seven observation years. The densities of these species were also low. *P. helenus*, *G. sarpedon*, *L. boeticus* and *M. phedima* may be nonnative species in this area, and *B. aquilina*, *N. fusca* and *S. charonda* are the species that listed in Red Data Book of Ibaraki Prefecture (Table 1).

Of the 70 forest species, 27 specialists and 22 generalists were recognized, and of the 25 grassland species, four specialists and 11 generalists were recognized (Table 2). The mean density of all specialists (for 7 years, mean=0.085, $n=31$) was significantly lower than that of all generalists (mean=0.527, $n=33$; $t=2.828$, $P<0.01$). Also, the density of forest specialists (mean=0.073, $n=27$) was significantly lower than that of forest generalists (mean=0.560, $n=22$; $t=2.235$, $P<0.05$), but the densities of grassland specialists (mean=0.167, $n=4$) and grassland generalists (mean=0.460, $n=11$) did not differ significantly ($t=1.510$, $P>0.05$).

Ten "typical natural forest (or typical natural grassland) species", which prefer primary forest or natural types of grassland (natural and semi-natural grassland, i.e. relatively undisturbed one) as their habitats (Inoue, 2003) were identified from the Ogawa area. Of the 22 threatened butterfly species of Ibaraki Prefecture (Ibaraki Prefecture, 2000), 13 forest and four grassland species were observed. Also, seven

Table 2. The criteria used for the classification of the butterfly species observed in the field research conducted in 1996-2000 into various types. The numbers of species are shown.

Character of habitat	Range of acceptable larval food resources	Voltinism	
		Univoltine	Multivoltine
Forest			
70 (73.7 %)	oligophagous	27 (specialist)	11
	polyphagous	10	22 (generalist)
Grassland			
25 (26.3 %)	oligophagous	4 (specialist)	5
	polyphagous	5	11 (generalist)

species listed in the threatened insects of Japan (Ministry of the Environment, 2000) were identified (Table 1). The richness of threatened or typical natural forest/grassland species indicates extraordinary value of this area from the viewpoint of butterfly conservation.

2. Other butterfly species recorded in the Ogawa area in the past

Beside the species identified in the above-mentioned field survey, six species have been reported based on reliable collection data from the Ogawa area in the past (Table 3). *Fixsenia w-album* was recorded in 1999 from Sadanami (Inoue and Okochi, 2000). Since this is the only record of this species from Ibaraki Prefecture, the species should be very rare in and near the present area. *Favonius yuasai* and *Isoteinon lamprospilus* have not been collected since 1970's in the present area. These two species, however, are still likely to occur in the study area, because I have collected both species within 10 Km of Ogawa in recent years (Inoue, 2001; Inoue, unpublished). *Eurema laeta* has not been recorded since 1989 in and near the Ogawa area, but it has been collected occasionally from other localities within Ibaraki Prefecture (Inoue, 2001). It is difficult to judge whether this species survives in the Ogawa area or not. *Lycaeides argyrognomon* and *Nymphalis antiopa* have not been recorded in recent years either from the Ogawa area as well as from other localities in Ibaraki Prefecture. They were very rare species even in the past, and therefore

Table 3. List of the butterfly species that have been reported based on reliable collection data from the Ogawa area in the past.

Species	No. of individuals collected	Year of collection	Locality	Source
<i>Fixsenia w-album</i> (Knoch) カラスシジミ	1	1999	Sadanami	Inoue and Okochi (2000)
<i>Favonius yuasai</i> Shirozu クロミドリシジミ	1	1973	Oshoyama	Takahashi (1974)
<i>Isoteinon lamprospilus</i> C. & R. Felder ホソバセセリ	1	1963	Sadanami	Shiota (2002)
	1	1968	Oshoyama	Shiota et al. (1971)
	1	1979	Sadanami	Nozaki et al. (1980)
<i>Eurema laeta</i> (Boisduval) ツマグロキチョウ	1	1989	Ogawa area	Shiota (1990)
<i>Lycaeides argyrognomon</i> (Bergstrasser) ミヤマシジミ 1)	1	1985	Sadanami	Takahashi (1994)
<i>Nymphalis antiopa</i> (Linnaeus) キベリタテハ	3	1963	Oshoyama and Matsuzakayama	Shiota et al. (1971); Nozaki et al. (1980); Shiota (2002)

1) Records of *L. argyrognomon* collected in 1963 from Ogawa (Shiota et al., 1971) were retracted (Shiota, 1997).

Table 4. List of the butterfly species that had been reported from the Ogawa area without reliable collection data, or the species that had been reported from Hanazono (as "Hanazono", "Hanazono-yama" or "Hanazono-keikoku") rather than the Ogawa area in the past.

Species	Year of collection	Locality	Source
<i>Thymelicus sylvaticus</i> (Bremer) ヘリグロチャバネセセリ	before 1954	Hanazono-yama	Shiota (1976)
	1969	Hanazono-yama	Nozaki et al. (1980)
	1971-72	Hanazono-keikoku	Kawashima (1973)
	?	Ogawa area	Keihin Konchu Dokokai (1975)
<i>Fabriciana nerippe</i> (C. & R. Felder) オオウラギンヒョウモン	?	Ogawa area	Keihin Konchu Dokokai (1975)
<i>Nymphalis vaualbum</i> (Denis & Schiffermuller) エルタテハ	1945-1955	near Hanazono-yama	Ibaraki-shinbun co. (1985)
	1966	Hanazono-yama	Shiota et al. (1971); Nozaki et al. (1980)
<i>Neptis rivularis</i> (Scopoli) フタスジチョウ	1976	between Hanazono and Hanawa	Kato (1990)
<i>Speyeria aglaja</i> (Linnaeus) ギンボシヒョウモン	?	Hanazono-yama	Shiota et al. (1971); Nozaki et al. (1980)
<i>Brenthis daphne</i> (Denis & Schiffermuller) ヒョウモンチョウ	1992	Sadanami	Hirasawa (1992)

they may not survive in the present area.

Five other species have also been reported from the Ogawa area without reliable collection data, or as collected from Hanazono (as "Hanazono", "Hanazono-yama" or "Hanazono-keikoku") rather than the Ogawa area (Table 4). Since *T. sylvaticus*, *F. nerippe*, *N. vaualbum*, *N. rivularis* and *S. aglaja* have not been collected in the last 20 years or more, they may have become extinct in or near the Ogawa area, or some of them may have been wrongly identified, e.g., female of *T. leoninus* could be mistaken for *T. sylvaticus* in the past records from Ibaraki Prefecture. *B. daphne* was recorded in 1992 from Sadanami with a collection data (Hirasawa, 1992). This is the only record of the species from Ibaraki Prefecture, but the species has not been recorded from the southern part of the Abukuma Mountains (Fujioka, 1981). Therefore the occurrence of this species in the Ogawa area is doubtful.

I estimate that 100-101 butterfly species live in the Ogawa area now, because 97 species were recorded in the present study, three (*F. w-album*, *F. yuasai* and *I. lamprospilus*) were likely to occur and one (*E. laeta*) may still survive in the Ogawa area.

3. Concluding remarks

Sasaki (1993), having made an extensive examination of the literature, reported 117 butterfly species present in Ibaraki Prefecture. Inoue (2001) added four species to Sasaki (1993), increasing the total record to 121. This number of species includes both stray species and native species undiscovered over the last 20 years or more. At present, approximately 100 butterfly species may live in the Ogawa area. If the number of very rare (very difficult to observe) species is subtracted from the prefectural fauna, there are 106 species currently present (Inoue, 2001). Thus, about 94 % of all species of Ibaraki Prefecture live in this area. Hiura (1973) distinguished habitats for butterflies in relation to the degree of human impact: primitive (primary), afforested, rural, suburban and urban stages. He showed that the species richness of butterflies was

highest at the afforested stage, and suggested that the highest diversity of butterflies at this stage was due to a mosaic of vegetation patches (Hiura, 1973, 1976). The rich butterfly fauna of the Ogawa area, including a considerable number of threatened species, may be due to mosaic nature of the landscape (e.g. Ishii et al., 1995; Ishii, 1996a; Natuhara et al., 1998, 1999) of the present area, consisting of various types of forest, marshland, pastureland and also farmland. Moreover, the faunal richness may be closely related with the traditional land management in agriculture and forestry (e.g. Hama et al., 1989; Yata and Ueda, 1993; Ishii et al., 1995; Tanaka and Arita, 1996; Ae et al., 1996; Kitahara and Sei, 2001), which have been practiced on a small scale in the present area until very recently. Recent declines of many Japanese butterfly species, e.g. *Luehdorfia puziloi* (Erschoff), *Shijimiaeoides divinus* (Fixsen), *Melitaea scotosia* Butler and *Fabriciana nerippe* (C. & R. Felder), are believed to be closely related with the cessation of traditional coppicing and mowing practices (Sibatani, 1989; Ishii, 1996b). These traditional practices keep earlier successional stages and supply habitats, containing abundant foods of adults (e.g. nectar and sap) and larvae, for coppice and grassland butterfly species. Like many other rural communities in Japan, depopulation and aging are progressing rapidly in the present area. Some species, therefore, especially those that live mainly in (moderately) farmed grassland (e.g. pastureland), may be destined to become extinct if we will not take appropriate actions. For example, during the last six years, the number of *Plebejus argus* has been dwindling (Table 1).

Celastrina sugitanii, one of the typical natural forest species, and also threatened species of Ibaraki Prefecture, is commonly observed in an old secondary forest in the Ogawa area (Inoue, 1998, 2003) illustrating an unintended but a remarkable example of a forestry practice, which has preserved the habitat of a rare butterfly. Several trees of *Aesculus turbinata*, the larval host trees of this butterfly in this forest, appear to be older than the other predominant tree species, suggesting that they were left intact at the last harvest cutting (Inoue, 1998). These trees

had probably been retained to preserve nesting sites of wild honey bees (tree hollows) and/or to secure supply of the nuts, which were used to be utilized as food during famines (Inoue, 1998). Selective cutting of secondary forest and/or modifications such as artificial gap formation (Maetô and Makihara, 1999) may be needed to make appropriate habitat of butterflies.

Inoue (2003) proposed a practical forestry-based plan to conserve butterfly diversity based on the results of chronosequential research conducted in the Ogawa area.

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小川学術参考林(茨城県北茨城市)とその周辺のチョウ類相

井上 大成¹⁾

要 旨

茨城県北茨城市の小川学術参考林とその周辺地域(小川地域)で、1996年～2002年までチョウ類相を調査した。成虫の主要飛翔時期に233日(約1135時間)の野外調査を行った結果、97種が記録された。科別の内訳は、セセリチョウ科16種、アゲハチョウ科8種、シロチョウ科7種、シジミチョウ科30種、タテハチョウ科23種、テングチョウ科1種、マダラチョウ科1種、ジャノメチョウ科11種だった。これらのうち、17種(森林性13種、草原性4種)は茨城県の、7種(森林性2種、草原性5種)は環境省のレッドデータリスト掲載種だった。また、生息場所として原生林を好むと考えられる種が6種、自然草原を好むと考えられる種が4種記録された。文献調査の結果とあわせて、この地域には現在約100種のチョウが生息していると推定されたが、これは実質的に茨城県でみられるチョウ全種の約94%にあたる。この地域がこのような豊富なチョウ類相をもつ背景とチョウ類の保護について議論した。

キーワード：チョウ類相、小川学術参考林、茨城県、ランドモザイク、希少種、チョウの保護

1) 森林総合研究所森林昆虫研究領域 〒305-8687 茨城県つくば市松の里1 e-mail: taisei@ffpri.affrc.go.jp