INTERNATIONAL JOURNAL OF CONSERVATION SCIENCE
ISSN: 2067-533X Volume 13, Issue 1, January-March 2022: 293-306 www.ijcs.ro

IMPORTANCE OF CONTINUOUS HABITAT-LEVEL MONITORING SURVEY FOR BUTTERFLY CONSERVATION: IDENTIFYING SPECIES OF CONSERVATION CONCERN ON A LOCAL SCALE

Masahiko KITAHARA[1*], Atsushi OHWAKI[1], Taisuke YASUDA[1], Shoichi HAYAMI[2], Saki MAEDA[1]

[1] Division of Natural Environmental Science, Mount Fuji Research Institute, Yamanashi Prefectural Government, Kenmarubi, Fujiyoshida, Yamanashi 403-0005, Japan
[2] Tsuru University, Tahara 3-8-1, Tsuru, Yamanashi 402-8555, Japan

Abstract

To verify the effectiveness of continuous habitat-level monitoring survey in identifying species of conservation concern on a local scale, it has been conducted a continuous monitoring survey over five years for butterfly communities in a local area at the foot of Mount Fuji, a special zone of Fuji-Hakone-Izu National Park in Japan. The results showed that the butterfly community was divided roughly into two species groups (i.e. yearly constant appearing species and yearly sporadic appearing species). The former was characterized by relatively high density with more variability. While, the latter showed the reverse characteristics, suggesting that they are the species more prone to extinction in the area. Among the yearly sporadic appearing species, Red Listed species and the species with characteristics vulnerable to extinction (i.e. uni-voltines and/or larval food specialists) could be thought of particularly as species of conservation concern with high priority and urgency on a local scale. This is evidenced by the fact that, in the continuous monitoring survey conducted previously in nearly the same area, the Red Listed species thought to belong to yearly constant appearing species were all alive in the present survey, but the two Red Listed species thought to belong to yearly sporadic appearing species were already extinct between the both surveys. Consequently, results confirmed the effectiveness of continuous habitat-level monitoring survey in identifying species of conservation concern on a local scale. Thus, it has been recommended continuous monitoring surveys at a local (habitat) level in order to prevent the rapid progression of extinction of local populations.

***Keywords**: Butterfly conservation; Conservation concern; Continuous monitoring; Local extinction; Local scale*

Introduction

Biological monitoring is fundamental to Ecology and Conservation Biology and has contributed greatly to the development of these fields [1-10]. Usually, biological monitoring data has been mainly used to analyze and elucidate population dynamics, community structure and dynamics, and interspecific relationships of living organisms [11-17]. Especially in recent years, changes in the distribution of living organisms (e.g., effects of global warming, invasion and expansion of alien species, etc.) have been clarified by analyzing data on biological monitoring that has been accumulated over many years [18-19]. Further, the importance of long-term monitoring survey on biodiversity conservation has also been stated for a long time [17, 20-21].

* Corresponding author: mkita@mfri.pref.yamanashi.jp

However, based on continuous monitoring data for biological communities, little attempts have been conducted to determine the priority and urgency of conservation at a local level.

In conservation biology, although many studies have been conducted to find out what kind of species to use as an indicator species to promote conservation of natural areas and habitats using monitoring data [22-29], little attempts have yet been made to detect what species is the conservation target species at a local level using monitoring data. On the other hand, one of the main approaches to the conservation of local biodiversity is to simply select Red Listed species and/or the other species with characteristics more prone to extinction as targets and to formulate and practice those conservation action plans [8, 9, 30]. However, it is common that the population situation of Red Listed species etc. differs from region to region, and the situation is often different at regional, national and global levels [31, 32]. Such circumstance is the same for Japanese butterflies that are research subjects in this study, and the situation of endangered species often changes at the national level and the local level [33]. Whilst, the decline and decrease of Japanese butterflies are accelerated by frequent extinction of their local populations [34]. That is, preventing the extinction of their local populations is an urgent task in conserving biodiversity of Japanese butterflies [35]. Thus, in order to ensure conservation of biodiversity at a local level, it is necessary not to simply select and conserve Red Listed species and/or the species with characteristics more prone to extinction, but to detect real conservation species with high priority and emergency at a local level and to conserve them selectively.

In the present study, it has been conducted a continuous monitoring survey over five years for butterfly communities in a local area at the foot of Mount Fuji, a special zone of Fuji-Hakone-Izu National Park in Japan. Based on the results, it has been attempted to detect target species that should be priority conserved according to the actual situation at the local level. Goal of the present study is to verify and demonstrate the effectiveness of continuous habitat-level monitoring survey in detecting true target species of conservation concern that should be priority and emergently conserved at a local level.

Materials and Methods

Study area

The study area was located in a grassland and woodland area (980m a.s.l.) at the northwestern foot of Mount Fuji, a special zone of Fuji-Hakone-Izu National Park in Japan (35°26’54” N, 138°36’46” E). The terrain in this area is almost horizontal, but has irregular undulations with an elevation difference of about 8m. The surface layer of this area is composed of scoria-like lava and volcanic ash resulting from past volcanic eruptions in the Mt. Fuji area. The study area consisted mainly of landscapes such as grasslands, forests, and firebreak belts at the edges (Fig. 1).

The grassland was used as a source of grass for fuel and forage until 60 years ago [36]. After that, it was abandoned, but some became plantations. However, afforestation did not grow, due to severe weather conditions such as strong winds and extremely low temperatures in winter, and soil conditions such as frozen soil, although human management (mowing) was carried out [37]. The management of the plantation (mowing) continued until 2005, but the plantation has been abandoned since then. The grassland at the time of this study (i.e., in 2009) was mostly dominated by poaceous grasses such as *Miscanthus sinensis*, *Arundinella hirta* and *Spodiopogon sibiricus*. Various other herbaceous plant species were also present, including Red Listed plants. Furthermore, in the grassland, several shrub trees such as *Rhamnus davurica*, *Malus toringo*, and *Euonymus sachalinensis* were scattered due to the progress of ecological succession [36].

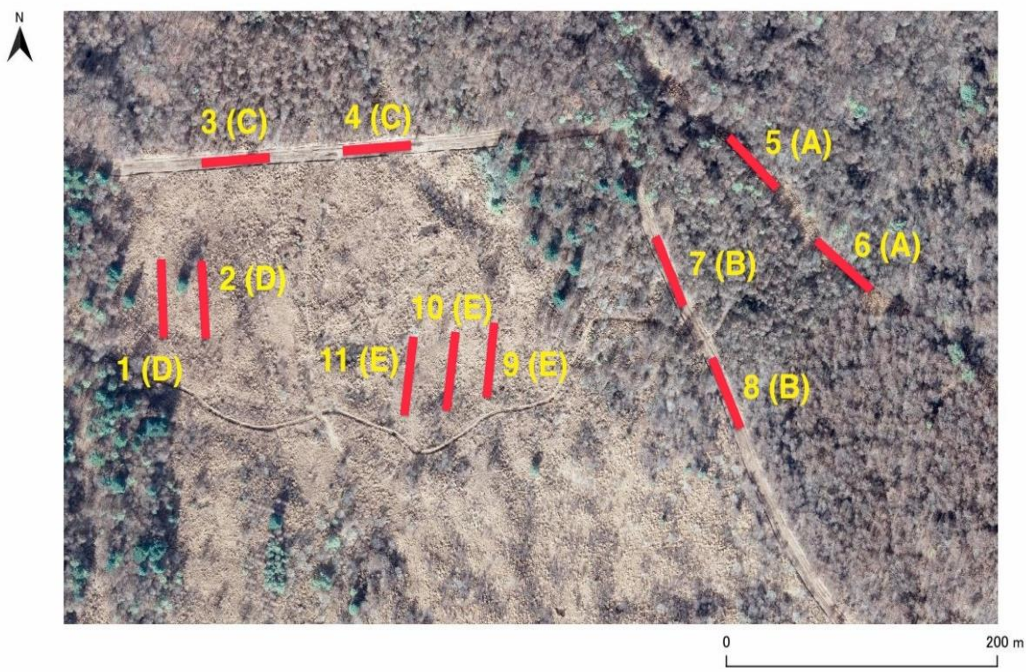

Fig. 1. Aerial view of the study area. The eleven transects set in the area are indicated by red lines. The number and habitat type (in parentheses) of each transect are indicated. See the text for details. The aerial photograph was taken in 2011 by Yamanashi Land Improvement Business Association

The forest adjacent to the grassland consisted of mixed deciduous and coniferous forests and larch (*Larix kaempferi*) plantations. The firebreak belt in the border between the forest and the grassland, or in the forest was about 10m wide (2 km long) and was established in 1959 [38]. Since 1961, all grasses and herbs in the firebreak belt have been mowed and removed annually in late autumn [36].

Within the area, it has been set five habitat types (A to E) of eleven transects (Nos. 1 to 11), each with a length of 50m, based on the differences in their management level and adjacent vegetation as follows (Fig. 1). Type A (two transects of Nos. 5 and 6) was surrounded on both sides by mixed forest of deciduous trees and conifers with a height of 10m and more (treated as "forest - forest") in a firebreak belt with mowing in the fall once a year. Type B (two transects of Nos. 7 and 8) was surrounded on one side by the mixed forest stated above and on the other side by shrubs 3-4 m high in a firebreak belt with mowing (treated as "forest - forest") in the fall once a year. Type C (two transects of Nos. 3 and 4) was surrounded on one side by similar mixed forests to those stated above and on the other side by abandoned grassland stated later (treated as "grassland - forest") in a firebreak belt with mowing in the fall once a year. Type D (two transects of Nos. 1 and 2) was located in abandoned grassland that was mowed every year (1998 to 2005) up to 4 years before the present survey started (treated as "grassland - grassland"). Type E (three transects of Nos. 9, 10, and 11) was located in abandoned grassland that has not been managed (mown) for several decades (treated as "grassland - grassland"). Type D and E transects were at least over 20 meters away from the edge of the nearest forest (Fig. 1). Transects of the same type were located close to each other, 20m to 50m away from other types of transects, but all transects were located within the range of about 550m × 400m (Fig. 1), which is within the range of movement even for sedentary species [39, 40].

Butterfly survey

In each transect, it has been used the line transect method [41, 42], and recorded all adult butterflies observed within about 5m on both sides and in front between 9:00 and 13:00 under fine weather conditions twice a month from May to October in 2011-2015.

Data analysis

As stated above, it has been obtained butterfly community data for five years from 2011 to 2015 in 11 transects of the study area in the present study. Using this community data set, spatial analysis using data among 11 transects (i.e. the relationships between butterfly community structure and adjacent vegetation and management) has already been published elsewhere [39]. In this study, it has been calculated the total number of individuals for each butterfly species recorded at the 11 transects in each year (that is, the number of individuals for each butterfly species recorded throughout the study area in each year), and using this community data set for five years, it has been conducted the temporal analysis of the butterfly community.

To examine the temporal patterns in the butterfly community, it has been used the following parameters in the analysis. The number of individuals for each butterfly species in each year was the total number of individuals recorded in all 11 transects throughout the year. Annual mean number of individuals for each butterfly species was the average of the numbers of individuals in five years (0 value is excluded in the calculation).

In this research, the analysis was mainly carried out based on the differences in the yearly appearance patterns of butterfly species recorded. Specifically, the analysis was carried out by dividing the constituent species into a group of species that appeared yearly constantly (constantly appearing species: abbreviated as CAS) and a group of species that appeared yearly occasionally (sporadic appearing species: abbreviated as SAS). The CAS was defined as the species that the number of years that they appeared was five or four, and the SAS was defined as the species that the number of years that they appeared was one or two.

To examine the relationships between the number of years that each butterfly species appeared and the life-history traits of butterflies, it has been used voltinism, the degree of larval polyphagy, and larval host plant type in the analysis. Voltinism is the number of generations per year for each species and was determined based on the literature [43, 44], and also on the actual data of seasonal changes in the number of individuals of each species observed in the area of the present study. Larval diet breadth (degree of polyphagy) is the range of host plant species used by larvae, and was based on [44, 45]. Referring to previous papers [46 - 48], it has been defined the species of which the larvae feed on ten or less plant species belonging to one taxonomic family as “specialist”, and the species whose larvae feed on more than ten plant species belonging to one taxonomic family, or on a variety of host plants belonging to two or more taxonomic families, as “generalist”. Larval host plant type was divided into three groups (grass feeders, grass and tree feeders, tree feeders) based on [43]. Butterfly species observed in this study were compared to those on the Red List 2019 of Japan [49] and species that corresponded to any of the Red List categories of Japan were determined.

Mann–Whitney U test was used for the significance test of the average values between the groups detected in the analysis. Chi-square test was used for the test of independence between the number of years that each butterfly species appeared and the life-history traits of butterflies.

Results

Characteristics of the butterfly community related to the number of years that butterfly species appeared

Table 1 shows a list of all butterfly species recorded in this study and their information, in decreasing order of the number of years that they appeared. The butterfly community showed a bi-polarization distribution in the relationship between the number of years that butterfly species appeared and the number of butterfly species in each number of years that they appeared (Fig. 2a), indicating that the butterfly community is divided roughly into CAS and SAS.

The mean value of the annual mean numbers of individuals was significantly different between CAS (mean ± SD: 21.00 ± 27.80, range: 1.75-146.6, n = 35) and SAS (mean ± SD: 1.96 ± 1.54, range: 1.00-5.50, n = 24) (Mann–Whitney *U* test: $U = 185$, $Z = -3.626$, $p < 0.001$) (Fig. 2b).

The mean value of the coefficients of variations of the numbers of individuals in five study years was significantly different between CAS (mean ± SD: 0.550 ± 0.216, range: 0.188-1.126, n = 35) and SAS (mean ± SD: 0.218 ± 0.340, range: 0-0.849, n = 9 (In this analysis, the species that the number of years that they appeared was 1 were excluded due to the CV values of them could not be calculated) (Mann–Whitney *U* test: $U = 87$, $Z = -2.051$, $p < 0.05$) (Fig. 2c).

Table 1. List of butterfly species recorded in the present study, and the number of individuals recorded in each year, number of years of apperance, annual mean number of individuals, the coefficient of variations, and the other chracteristics in each of all butterfly species recorded.

No.	Species	Number of individuals recorded						Number of years of appearance	Annual mean number of individuals 1)	Coefficient of variations (CV) 2)	Number of generations per yaer 3)	Larval food breadth 4)	Host plant type 5)	Red Listed species 6)
		2011	2012	2013	2014	2015	Total							
1	*Minois dryas*	86	141	110	188	208	733	5	146.60	0.350	1	G	Gr	
2	*Parnara guttata*	24	97	20	94	82	317	5	63.40	0.603	M	G	Gr	
3	*Ypthima argus*	44	92	37	55	44	272	5	54.40	0.404	M	G	Gr	
4	*Argynnis paphia*	36	30	45	89	61	261	5	52.20	0.453	1	G	Gr	
5	*Plebejus argus*	79	60	32	26	37	234	5	46.80	0.473	1	G	Gr・T	○
6	*Fabriciana adippe*	41	27	48	50	16	182	5	36.40	0.399	1	S	Gr	
7	*Leptalina unicolor*	15	32	46	50	34	177	5	35.40	0.388	1	S	Gr	○
8	*Argyronome ruslana*	24	20	32	57	28	161	5	32.20	0.452	1	S	Gr	
9	*Eurema mandarina*	32	48	19	21	39	159	5	31.80	0.384	M	G	Gr・T	
10	*Fixsenia mera*	7	38	41	41	15	142	5	28.40	0.570	1	S	T	
11	*Ochlodes venatus*	10	29	30	26	37	132	5	26.40	0.379	1	G	Gr	
12	*Polygonia c-aureum*	19	26	32	23	28	128	5	25.60	0.193	M	S	Gr	
13	*Lampides boeticus*	10	36	28	12	3	89	5	17.80	0.769	M	G	Gr・T	
14	*Argyronome laodice*	4	17	22	34	6	83	5	16.60	0.740	1	S	Gr	○
15	*Ochlodes ochraceus*	6	13	26	10	13	68	5	13.60	0.552	1	G	Gr	
16	*Pieris melete*	12	13	12	10	10	57	5	11.40	0.118	M	G	Gr	
17	*Pieris nesis*	14	12	12	13	6	57	5	11.40	0.275	M	G	Gr	
18	*Gonepteryx maxima*	11	17	13	13	1	55	5	11.00	0.546	1	S	T	○
19	*Colias erate*	5	12	2	4	7	30	5	6.00	0.635	M	G	Gr・T	
20	*Nephargynnis anadyomene*	7	3	3	6	10	29	5	5.80	0.509	1	S	Gr	
21	*Limenitis glorifica*	14	4	5	3	3	29	5	5.80	0.803	2	S	T	
22	*Damora sagana*	3	5	2	9	8	27	5	5.40	0.565	1	S	Gr	
23	*Parnassius citrinarius*	5	2	6	9	4	26	5	5.20	0.498	1	S	Gr	
24	*Everes argiades*	6	3	1	3	3	16	5	3.20	0.559	M	G	Gr	
25	*Papilio machaon*	1	4	1	2	1	9	5	1.80	0.724	M	G	Gr・T	
26	*Libythea lepita*	2	0	20	12	5	39	4	9.75	0.822	1	G	T	
27	*Argyreus hyperbius*	1	11	4	7	0	23	4	5.75	0.743	M	G	Gr	
28	*Limenitis camilla*	12	3	2	0	1	18	4	4.50	1.126	2	G	T	
29	*Brenthis daphne*	0	6	1	1	9	17	4	4.25	0.929	1	S	Gr	○
30	*Pelopidas jansonis*	1	0	8	3	4	16	4	4.00	0.736	2	S	Gr	
31	*Papilio dehaanii*	8	2	0	4	1	15	4	3.75	0.826	M	G	T	
32	*Lycaena phlaeas*	2	5	3	0	1	11	4	2.75	0.621	M	S	Gr	
33	*Papilio xuthus*	2	2	0	1	3	8	4	2.00	0.408	M	G	T	
34	*Pieris rapae*	0	3	2	2	1	8	4	2.00	0.408	M	G	Gr	
35	*Nymphalis xanthomelas*	2	2	2	1	0	7	4	1.75	0.286	1	G	T	

No.	Species	Number of individuals recorded						Number of years of appearance	Annual mean number of individuals[1)]	Coefficient of variations (CV)[2)]	Number of generations per yaer[3)]	Larval food breadth[4)]	Host plant type[5)]	Red Listed species[6)]
		2011	2012	2013	2014	2015	Total							
36	*Aeromachus inachus*	5	12	9	0	0	26	3	8.70	0.405	1	S	Gr	○
37	*Artopoetes pryeri*	0	0	2	4	7	13	3	4.30	0.581	1	S	T	
38	*Thoressa varia*	0	3	2	0	1	6	3	2.00	0.500	2	G	Gr	
39	*Rapala arata*	0	3	0	1	2	6	3	2.00	0.500	2	G	Gr•T	
40	*Zizeeria maha*	0	0	4	1	1	6	3	2.00	0.866	M	S	Gr	
41	*Neptis sappho*	1	3	0	2	0	6	3	2.00	0.500	M	G	Gr•T	
42	*Pelopidas mathias*	1	1	0	0	3	5	3	1.67	0.691	M	G	Gr	
43	*Celastrina argiolus*	2	0	2	0	1	5	3	1.67	0.346	M	G	Gr•T	
44	*Curetis acuta*	0	1	3	0	1	5	3	1.67	0.691	2	G	Gr•T	
45	*Callophrys ferrea*	1	2	0	1	0	4	3	1.33	0.433	1	G	T	
46	*Erynnis montana*	0	8	0	3	0	11	2	5.50	0.643	1	S	T	
47	*Daimio tethys*	0	2	0	8	0	10	2	5.00	0.849	2	S	Gr	
48	*Isoteinon lamprospilus*	0	4	4	0	0	8	2	4.00	0.000	1	S	Gr	
49	*Gonepteryx aspasia*	0	3	0	3	0	6	2	3.00	0.000	1	S	T	
50	*Kirinia fentoni*	0	2	0	0	1	3	2	1.50	0.471	1	G	Gr	○
51	*Hesperia florinda*	0	1	0	0	1	2	2	1.00	0.000	1	S	Gr	○
52	*Japonica lutea*	0	0	1	1	0	2	2	1.00	0.000	1	S	T	
53	*Chrysozephyrus smaragdinus*	0	1	0	1	0	2	2	1.00	0.000	1	G	T	
54	*Inachis io*	0	1	0	1	0	2	2	1.00	0.000	1	G	Gr	
55	*Potanthus flavus*	0	0	4	0	0	4	1	4.00	–	2	G	Gr	
56	*Favonius orientalis*	0	0	0	4	0	4	1	4.00	–	1	G	T	
57	*Speyeria aglaja*	4	0	0	0	0	4	1	4.00	–	1	G	Gr	
58	*Papilio macilentus*	0	1	0	0	0	1	1	1.00	–	2	S	T	
59	*Papilio maackii*	0	0	1	0	0	1	1	1.00	–	2	S	T	
60	*Shirozua jonasi*	0	0	0	1	0	1	1	1.00	–	1	G	T	
61	*Parantica sita*	0	0	0	0	1	1	1	1.00	–	M	G	Gr	
62	*Neptis philyra*	1	0	0	0	0	1	1	1.00	–	1	G	T	
63	*Araschnia burejana*	0	0	0	0	1	1	1	1.00	–	2	G	Gr	
64	*Polygonia c-album*	1	0	0	0	0	1	1	1.00	–	2	G	T	
65	*Kaniska canace*	1	0	0	0	0	1	1	1.00	–	2	G	Gr	
66	*Vanessa cardui*	0	1	0	0	0	1	1	1.00	–	M	G	Gr	
67	*Vanessa indica*	0	1	0	0	0	1	1	1.00	–	M	G	Gr	
68	*Hestina assimilis*	0	0	0	0	1	1	1	1.00	–	M	S	T	
69	*Mycalesis gotama*	0	0	1	0	0	1	1	1.00	–	M	G	Gr	
Total number of individuals		562	865	700	910	750	3787							
Number of species		42	51	44	40	44	69							

1) The value is calculated excluding the year of 0 value, 2) Coefficient of variations of the numbers of individuals in the respective years, 3) 1: uni-voltines, 2: bi-voltines, M: multi-voltines, 4) S (specialists): the species whose larvae feed on ten or less plant species within a taxonomic family, G (generalists): the species which the larvae feed on more than ten plant species within a taxonomic family, or on a variety of host plants belonging to two or more taxonomic families, 5) Gr: grass feeders, Gr•T: grass and tree feeders, T: tree feeders, 6) ○: the species that corresponded to any of the Red List categories of Japan.

Relationships between the number of years that butterfly species appeared and the life-history traits of butterflies in the butterfly community

The chi-square test of independence was significant between the number of years that butterfly species appeared and voltinism (number of generations per year) in each species (χ^2 = 17.939, $p < 0.05$), indicating that there was a relevance between the two variables (Fig. 3a). The maximum number of uni-voltine species was recognized in the species that the number of years that appeared was 5. Although the maximum number of multi-voltine species was also recognized in the species that the number of years that appeared was 5, one of the second species numbers of multi-voltines was recognized in the species that the number of years that appeared was 1.

The chi-square test of independence was not significant between the number of years that butterfly species appeared and larval diet breadth (degree of polyphagy) in each species (χ^2 = 6.145, $p > 0.05$), indicating that there was not a relevance between the two variables (Fig. 3b). In other words, this suggests the possibility that both CAS and SAS contained similar ratios of generalist and specialist species.

The chi-square test of independence was significant between the number of years that butterfly species appeared and larval host-plant type in each species (χ^2 = 22.456, p < 0.01), indicating that there was a relevance between the two variables (Fig. 3c). In grass feeders, the maximum number of species was recognized in the species that the number of years that appeared was 5. The second number of species was recognized in the species that the number of years that appeared was 1. In tree feeders, the maximum number of species was recognized in the species that the number of years that appeared was 1. In grass and tree feeders, the maximum number of species was recognized in the species that the number of years that appeared was 3.

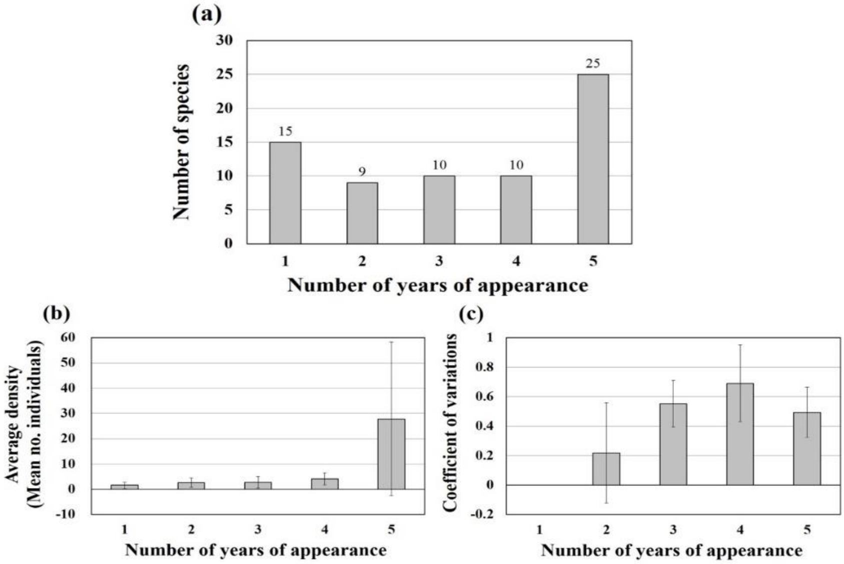

Fig. 2. Relationships between number of years of appearance and number of species (a), annual average density (b), and coefficient of variations of the annual densities of the 5 years (c) in the butterfly community

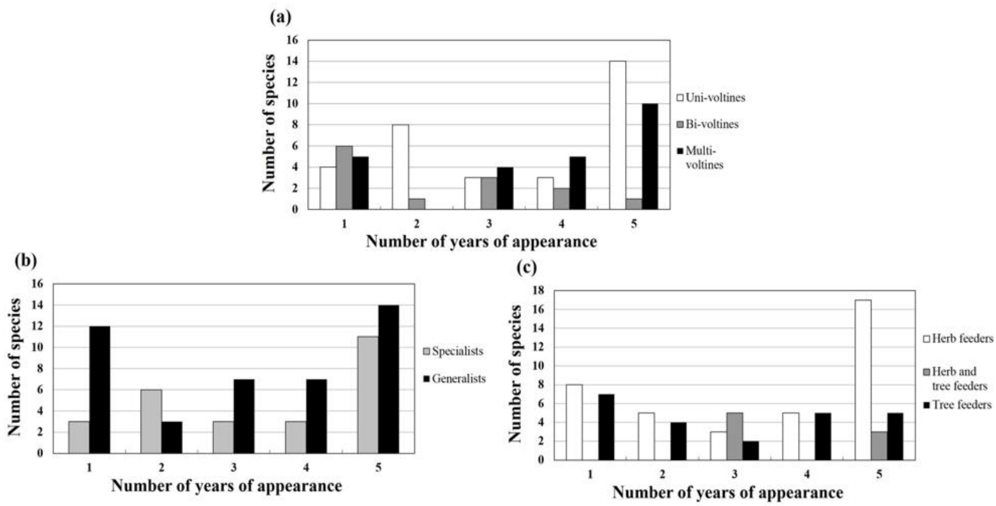

Fig. 3. Frequency distributions of voltinism (a), larval food breadth (b), and larval host-plant type (c) in each number of years of appearance

Number of years of occurrence and annual population fluctuation patterns in the Red Listed species of the butterfly community

In the present study, eight Red Listed butterfly species authorized by Ministry of the Environment of Japan [49] were recognized (Table 1). Of these, four species were in those that the number of years of occurrence was 5, one species in those that the number of years of occurrence was 4, one species in those that the number of years of occurrence was 3, and 2 species in those that the number of years of occurrence was 2. There were no Red Listed species in those that the number of years of occurrence was 1.

Figure 4 shows annual population fluctuation patterns in the 8 Red Listed species stated above. There were roughly two species groups. One is that with relatively high density and appeared almost every year, but variable population fluctuations (*Plebejus argus*, *Leptalina unicolor*, *Argyronome laodice*). The other is that with relatively low density and appeared occasionally, but stable population fluctuations (*Hesperia florinda*, *Kirinia fentoni*, *Brenthis daphne*, *Aeromachus inachus*, *Gonepteryx maxima*).

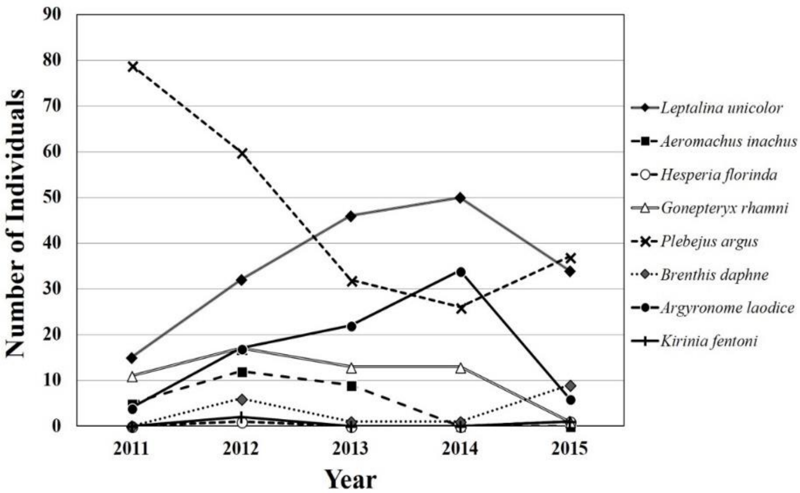

Fig. 4. Changes in the annual number of individuals for 5 years in the eight Red Listed species recorded in the present study

Discussion

In promoting the conservation of biodiversity, it is an important issue to identify which species are target for proceeding with conservation [4, 8, 9, 22, 23, 25-29, 50-52]. Usually, Red Listed species and the other species with characteristics more prone to extinction are selected as targets, and the conservation action plans are formulated and practiced [8, 9]. However, it is almost common for Red Listed species to differ at national and regional levels [31, 32], and in this respect, it is not necessarily easy process to identify the target species for conservation. Also, in the case of Japanese butterflies related to the present study, the Red List of the country and the Red List of each prefecture are usually partially different, and the Red List is quite different for each prefecture [33]. That is, it is usual that the risk of species extinctions varies from region to region, and the identification of target species for conservation considering priority and urgency should be considered at a local level.

In the present study, by conducting a continuous monitoring survey over five years, it became clear that the butterfly community consisted mainly of CAS and SAS with different characteristics. As a matter of course, the existence of these two species groups was undetectable by a monitoring survey for several years and had been clarified for the first time as a result of a continuous monitoring survey over five years. To date, although the classification of species groups with different characteristics within a community has been known and discussed in many studies (e.g., generalists vs. specialists [53 - 56], *r*-strategists vs. *K*-strategists [55 - 60], core spp. vs. satellite spp. [61], little is known about the species grouping in this study (i.e., CAS vs. SAS), probably due to the scanty of long-term monitoring survey at a community and a local level. However, species groupings almost identical to those in this study were also obtained in a few butterfly studies [62, 63]. Therefore, the existence of permanent and occasional appearing species groups (CAS and SAS) obtained in this study could be a fairly general pattern on the temporal aspect of butterfly communities. Dapporto treated these groups as core and satellite species groups on the time dimension [61, 63].

In the present study, the SAS were featured by relatively low density with less variability and sporadic occurrence. The probability of local extinction is generally higher in lower abundance and smaller populations [8, 9]. Thus, the features are thought to be those more prone to extinction. In addition to this, the SAS included two Red Listed species, and many uni-voltine and/or larval food specialist species, which are also species groups with characteristics that are thought to be prone to extinction [8, 9]. Thus, the SAS (especially Red Listed spp., uni-voltine spp., and larval food specialist spp. therein) can be thought of as priority and urgent species for conservation in this area. In the area of the present study, it is judged that two Red Listed species (*Pyrgus maculatus* and *Leptidea amurensis*) which could not be recorded in this study have been extinct during the past 15 years. Before that, it has been conducted a similar survey (i.e., a butterfly monitoring survey for four years, between 1998 and 2001) in almost the same area as this study. From the results of the survey, it was found that the two already extinct Red Listed species stated above were remarkably low density at that time and sporadic appearance from year to year, consistent with the characteristics of the SAS. This evidences that SAS are actually the species that are more prone to extinction and have high priority and urgency for conservation.

On the other hand, despite showing larger population variability, the CAS had relatively high densities and occurred constantly. Thus, the CAS can be considered as species that maintained population every year and continued to inhabit well in this area. Therefore, it is predicted that, as far as the current habitat conditions are maintained in this area, the CAS will maintain the populations stably in the future. From these points, although the CAS included five Red Listed species, and many uni-voltine and/or larval food specialist species, which are species groups with characteristics that are thought to be prone to extinction [8, 9], it is judged that the urgency and priority of conservation at the present time are lower definitely in the CAS than in the SAS.

As described above, it has been suggested to detect highly urgent and priority conservation target species at a local (habitat) level (i.e., SAS (especially Red Listed spp., uni-voltine spp., and larval food specialist spp. therein)) through a continuous monitoring survey over five years. To date, conservation of living organisms has been carried out mainly and preferentially for Red Listed species and species with characteristics more prone to extinction (e.g., species with low reproductive rate, species with specialized niches) in targeted areas [8, 9]. However, in the present study, results showed that the Red Listed species and the species with characteristics prone to extinction within the CAS appeared almost every year at high densities and continued to inhabit well in the habitat of the study area. In the past monitoring survey stated above it has been also found that most of the Red Listed species within the CAS stated above occurred at high densities and almost every year, suggesting that, in habitats with their suitable conditions, even Red Listed species and species with characteristics prone to extinction have stable local populations with low urgency and priority for conservation. Accordingly, in conservation of living organisms, it has been don`t progress conservation actions simply targeting Red Listed species and/or species with characteristics more prone to extinction, but need to detect the conservation target species that fit the actual situation at a local (habitat) level and to proceed with conservation actions for them.

In addition, in recent years in Japan, the decline and decrease of butterflies have progressed rapidly due to the accelerated extinction of their local populations [34]. That is, the most important matter and action in terms of conservation of Japanese butterflies are to prevent frequent extinction of their local populations. In this regard, the survey conducted in this study (i.e., a continuous monitoring survey at a local level) has shown the potential to detect true target species for conservation depending on the actual situation of butterfly populations and communities in a local area.

Thus, the continuous monitoring survey can be considered as important research as the first step to promote the conservation of the current Japanese butterflies. Consequently, it has been recommended continuous monitoring surveys at a local (habitat) level that have the potential to detect the true species of conservation concern in a local area, in order to prevent the rapid progression of extinction of local populations.

Acknowledgments

Many thanks for the members of the Mount Fuji Research Institute of Yamanashi Pref, for their suggestions, help, and cooperation for this study. This work was supported in part by both Grants-in-Aid for Scientific Research (B) (no. 17310138) and for Scientific Research (C) (no. 20510221) from the Japan Society for the Promotion of Science (JSPS) to M. Kitahara.

References

[1] R.F. Noss, *Indicators for monitoring biodiversity: a hierarchical approach*, **Conservation Biology**, **4**, 1990, pp. 355-364.
[2] C. Kremen, A.M. Merenlender, D.D. Murphy, *Ecological monitoring: a vital need for integrated conservation and development programs in the tropics*, **Conservation Biology**, **8**, 1994, pp. 388-397.
[3] E. Pollard, T.J. Yates, **Monitoring Butterflies for Ecology and Conservation: The British Butterfly Monitoring Scheme**, Springer Science & Business Media, 1994.
[4] T.R. New, **Butterfly Conservation,** 2nd edition, Oxford University Press, Oxford, 1997.
[5] W.R. Turner, *Citywide biological monitoring as a tool for ecology and conservation in urban landscapes: the case of the Tucson Bird Count*, **Landscape and Urban Planning**, **65**, 2003, pp. 149-166.
[6] I.F. Spellerberg, **Monitoring Ecological Change**, Cambridge University Press, 2005.
[7] J.D. Nichols, B.K. Williams, *Monitoring for conservation*, **Trends in Ecology & Evolution** **21**, 2006, pp. 668-673.
[8] R.B. Primack, **Essentials of Conservation Biology,** 5th edition, Sinauer Associates Inc., Sunderland, Massachusetts, USA, 2010.

[9] R.B. Primack, **A primer of Conservation Biology**, 5th edition, Sinauer Associates Inc., Sunderland, Massachusetts, USA, 2012.

[10] F.B. Goldsmith, **Monitoring for Conservation and Ecology (Vol. 3)**, Springer Science & Business Media, 2012.

[11] R.T. Holmes, T. W. Sherry, F. W. Sturges, *Bird community dynamics in a temperate deciduous forest: long-term trends at Hubbard Broo*, **Ecological Monographs**, **56**, 1986, pp. 201-220.

[12] G.R. Potts, N.J. Aebischer, *Population dynamics of the Grey Partridge Perdix perdix 1793–1993: monitoring, modelling and management*, **Ibis**, **137**, 1995, pp. S29-S37.

[13] A. Loison, R. Langvatn, *Short-and long-term effects of winter and spring weather on growth and survival of red deer in Norway*, **Oecologia**, **116**(4), 1998, pp. 489-500.

[14] J.M. Gaillard, M. Festa-Bianchet, N.G. Yoccoz, A. Loison, C. Toigo, *Temporal variation in fitness components and population dynamics of large herbivores*, **Annual Review of Ecology and Systematics**, **31**, 2000, pp. 367-393.

[15] J.H. Brown, T.G. Whitham, S.M. Ernest, C.A. Gehring, *Complex species interactions and the dynamics of ecological systems: long-term experiments*, **Science**, **293**, 2001, pp. 643-650.

[16] J. Gurnell, L.A. Wauters, P.W. Lurz, G. Tosi, *Alien species and interspecific competition: effects of introduced eastern grey squirrels on red squirrel population dynamics*, **Journal of Animal Ecology**, **73**, 2004, pp. 26-35.

[17] A.E. Magurran, S.R. Baillie, S.T. Buckland, J.M. Dick, D.A. Elston, E.M. Scott, R.I. Smith, P.J. Somerfield, A.D. Watt, *Long-term datasets in biodiversity research and monitoring: assessing change in ecological communities through time*, **Trends in Ecology & Evolution**, **25**, 2010, pp. 574-582.

[18] G.R. Walther, E. Post, P. Convey, A. Menzel, C. Parmesan, T.J.C. Beebee, J.M. Fromentin, O. Hoegh-Guldberg, F. Bairlein, *Ecological responses to recent climate change*, **Nature**, **416**, 2002, pp. 389-395.

[19] L. Brotons, S. Herrando, M. Pla, *Updating bird species distribution at large spatial scales: applications of habitat modelling to data from long-term monitoring programs*, **Diversity and Distributions**, **13**, 2007, pp. 276-288.

[20] B. Blossey, *Before, during and after: the need for long-term monitoring in invasive plant species management*, **Biological Invasions**, **1**, 1999, pp. 301-311.

[21] D.B. Lindenmayer, *Future directions for biodiversity conservation in managed forests: indicator species, impact studies and monitoring programs*, **Forest Ecology and Management**, **115**, 1999, pp. 277-287.

[22] C. Kremen, *Assessing the indicator properties of species assemblages for natural areas monitoring*, **Ecological Applications**, **2**, 1992, pp. 203-217.

[23] K.S. Brown, *Diversity, disturbance, and sustainable use of Neotropical forests: insects as indicators for conservation monitoring*, **Journal of Insect Conservation**, **1**, 1997, pp. 25-42.

[24] T.R. New, *Are Lepidoptera an effective ‘umbrella group‘ for biodiversity conservation?*, **Journal of Insect Conservation**, **1**(1), 1997, pp. 5-12.

[25] G.E. Canterbury, T.E. Martin, D.R. Petit, L.J. Petit, D.F. Bradford, *Bird communities and habitat as ecological indicators of forest condition in regional monitoring*, **Conservation Biology**, **14**, 2000, pp. 544-558.

[26] A. Helm, I. Hanski, M. Pärtel, J. Hilty, A. Merenlender, *Faunal indicator taxa selection for monitoring ecosystem health,* **Biological Conservation**, **92**, 2000, pp. 185-197.
[27] V. Carignan, M.A. Villard, *Selecting indicator species to monitor ecological integrity: a review,* **Environmental Monitoring and Assessment**, **78**, 2000, pp. 45-61.
[28] A. K. Whitfield, M. Elliott, *Fishes as indicators of environmental and ecological changes within estuaries: a review of progress and some suggestions for the future,* **Journal of Fish Biology**, **61**, 2002, pp. 229-250.
[29] E.C. Underwood, B.L. Fisher, *The role of ants in conservation monitoring: if, when, and how,* **Biological Conservation**, **132**, 2006, pp. 166-182.
[30] M. Yago, *Recent developments and future perspectives in entomology: Conservation biology and nature conservation,* **Japanese Journal of Entomology (New series)**, **21**, 2018, pp. 48-58. (in Japanese with English abstract)
[31] U. Gärdenfors, *Classifying threatened species at national versus global levels,* **Trends in Ecology & Evolution**, **16,** 2001, pp. 511-516.
[32] U. Gärdenfors, C. Hilton-Taylor, G.M. Mace, J.P. Rodríguez, *The application of IUCN Red List criteria at regional levels,* **Conservation Biology**, **15**, 2001, pp. 1206-1212.
[33] * * * Association of Wildlife Research & Office of EnVision Environmental Conservation, **Search System of Japanese Red Data**, http://jpnrdb.com/, Accessed 18 Jan. 2021.~~Accessed 12 Feb. 2019~~ (!!!).
[34] Y. Nakamura, *Conservation of butterflies in Japan: status, actions and strategy,* **Journal of Insect Conservation**, **15**, 2011, pp. 5-22.
[35] M. Ishii, *The nature of Japan and the Red Listed insects,* **Nature and Insects**, **40**, 2005, pp. 2-9 (in Japanese).
[36] M. Kubo, T. Kobayashi, M. Kitahara, A. Hayashi, *Seasonal fluctuations in butterflies and nectar resources in a semi-natural grassland near Mt. Fuji, central Japan,* **Biodiversity and Conservation**, **18**, 2009, pp. 229-246.
[37] M. Kubo, J. Matutani, A. Hayashi, *Factors of the failure of planting in Uenohara-area at the foot of Mt. Fuji,* **Bulletin of the Yamanashi Forestry and Forest Products Research Institute**, **24**, 2005, pp. 61–67 (in Japanese with English summary).
[38] A. Ohwaki, S. Hayami, M. Kitahara, T. Yasuda, *The role of linear mown firebreaks in conserving butterfly diversity: Effects of adjacent vegetation and management*, **Entomological Science**, **21**, 2018, pp. 112-123.
[39] I. Hanski, M. Kuussaari, M. Nieminen, *Metapopulation structure and migration in the butterfly Melitaea cinxia*, **Ecology**, **75**, 1994, pp. 747–762.
[40] O. Lewis, C. Thomas, J. Hill, M. Brookes, T. P. Crane, Y. Graneau, J. Mallet, O. Rose, *Three ways of assessing metapopulation structure in the butterfly Plebejus argus,* **Ecological Entomology**, **22**, 1997, pp. 283-293.
[41] E. Pollard, T.J. Yates, **Monitoring Butterflies for Ecology and Conservation**, Chapman & Hall, London, 1993.
[42] M. Ishii, *Transect counts of butterflies,* **Decline and Conservation of Butterflies in Japan II** (Editors: O. Yata, K. Ueda), The Lepidopterological Society of Japan & the Nature Conservation Society of Japan, 1993, pp. 91-101 (in Japanese with English summary).
[43] K. Unno, J. Aoyama, **The Butterflies of Japan,** Shougakukan, Tokyo, Japan, 1981 (in Japanese).

[44] H. Fukuda, E. Hama, T. Kuzuya, A. Takahashi, M. Takahashi, B. Tanaka, H. Tanaka, M. Wakabayashi, Y. Watanabe, **The Life Histories of Butterflies in Japan**, Vol. I – IV, Hoikusha, Osaka, Japan, 1982, 1983, 1984a, b (In Japanese with English summary).

[45] S. Endo, I. Nihira, **Larval Food of Japanese Butterflies,** Group 'Tamamushi', Tokyo, Japan, 1990 (in Japanese).

[46] M. Kitahara, K. Fujii, *Biodiversity and community structure of temperate butterfly species within a gradient of human disturbance: an analysis based on the concept of generalist vs. specialist strategies,* **Researches on Population Ecology**, **36**, 1994, pp. 187-199.

[47] M. Kitahara, K. Fujii, *Analysis and understanding of butterfly community composition based on multivariate approaches and the concept of generalist/specialist strategies*, **Entomological Science**, **8**, 2005, pp. 137-149.

[48] M. Kitahara, K. Sei, K. Fujii, *Patterns in the structure of grassland butterfly communities along a gradient of human disturbance: fur59ther analysis based on the generalist/specialist concept,* **Population Ecology**, **42**, 2000, pp. 135-144.

[49] * * * Ministry of the Environment of Japan, **Red List of Japanese Insects in 2019 version,** https://ikilog.biodic.go.jp/Rdb/booklist, [Accessed 18 Jan. 2021]

[50] M. Vaira, *Anurans of a subtropical montane forest in northwestern Argentina: ecological survey and a proposed list of species of conservation concern,* **Biodiversity and Conservation**, **11**, 2002, pp. 1047-1062.

[51] O. Tudor, R.L.H. Dennis, J.N. Greatorex-Davies, T.H. *Sparks, Flower preferences of woodland butterflies in the UK: nectaring specialists are species of conservation concern,* **Biological Conservation**, **119**, 2004, pp. 397-403.

[52] A. Sorace, M. Gustin, *Bird species of conservation concern along urban gradients in Italy*, **Biodiversity and Conservation**, **19**, 2010, pp. 205-221.

[53] R.H. MacArthur, R. Levins, *The limiting similarity, convergence, and divergence of coexisting species,* **The American Naturalist**, **101**, 1967, pp. 377-385.

[54] R. Levins, **Evolution in Changing Environments: Some Theoretical Explorations**, Princeton University Press, Princetom, NJ, 1968.

[55] R.H. MacArthur, **Geographical Ecology: Patterns in the Distribution of Species**, Harper & Row, New York, 1972.

[56] E. R. Pianka, **Evolutionally Ecology**, 4th edition, Harper & Row, New York, 1988.

[57] R.H. MacArthur, E.O. Wilson, **The Theory of Island Biogeography**, Princeton University Press, Princeton, NJ, 1967.

[58] E.R. Pianka, *On r- and K-selection,* **The American Naturalist**, **104**, 1970, pp. 592-597.

[59] T.R.E. Southwood, *Habitat, the templet for ecological strategies?*, **Journal of Animal Ecology**, **46**, 1977, pp. 337-365.

[60] T. R. E. Southwood, *Bionomics strategies and population parameters,* **Theoretical Ecology: Principles and Applications,** Editor: R.M. May, Blackwell Scientific Publications, Oxford, 1981, pp. 30-52.

[61] I. Hanski, *Dynamics of regional distribution: the core and satellite species hypothesis,* **Oikos**, **38**, 1982, pp. 210-221.

[62] M. Kitahara, *Annual species appearance patterns in a local butterfly community during early growing seasons,* **Japanese Journal of Environmental Entomology and Zoology**, **8**, 1997, pp. 178-191.

[63] L. Dapporto, *Core and satellite butterfly species on Elba island (Tuscan Archipelago, Italy). A study on persistence based on 120 years of collection data*, **Journal of Insect Conservation**, **13**, 2009, pp. 421-428.

Received: March 3, 2021
Accepted: February 10, 2022