Faunal Characteristics of Macrolepidopterous Moths in Various Habitats in Tomakomai: Forest Dwellers and Openland Dwellers

By

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苫小牧のいろいろな生息地におけるガ類相
森林性種とオープンランド性種について

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Abstract

Faunal characteristics of macrolepidopterous moths were investigated in various habitats ranging from forest to urban areas in Tomakomai. The faunal make-up in the forest was characterized by the predominance of Geometridae, whereas that in openland and urban areas was predominated by Noctuidae, especially subfamily Noctuinae. Twenty-eight predominant species were classified into three groups, forest, eurytopic and openland species. Adaptive significance of some life history characters in the openland species was discussed.

Key words: Macrolepidopterous moths, Habitat preference, Openland species, Life history character.

Introduction

In a previous paper (YOSHIDA, 1983), faunal characteristics of macrolepidopterous moths were compared among various types of forest in Tomakomai and discussed in relation to larval food habits. The present study extends this survey to openland moths.

SOUTHWOOD (1962) distinguished temporary habitats such as wastelands, fields and arable lands, which are predominated by annual and perennial plants characteristic of early stages of vegetational succession, from permanent habitats predominated by trees of climax forest vegetation.

The present paper reports faunal characteristics of macrolepidopterous moths in openland and urban habitats and discussed the adaptive significance of some life history characters in openland species.

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Methods

Samples were collected from eight stations in Tomakomai City (Fig. 1). Environmental conditions at each station are briefly described below.

Secondary forest (SF): A deciduous broad-leaved forest predominated by *Quercus mongolica* var. *grosseserrata*, *Tilia japonica* and *Acer mono*, through which a highway is running. The trap station was located 60 m inside the forest edge facing the highway.

Openland 1 (OL_1): A yard of the Tomakomai Experiment Forest with sparse vegetation, surrounded by some coniferous and broad-leaved trees.

Openland 2 (OL_2): An area afforested with young white fir trees (*ca.* 1.5 m high) and surrounded by broad-leaved forests.

Openland 3 (OL_3): The edge of the highway, which was constructed after cutting a forest in 1978, two years before the survey year. Both sides of the highway were planted artificially with grasses and herbs. The trap station was located at a distance of 10 m from the forest edge.

Reclaimed land 1 (R_1): A moorland was reclaimed 12 years before the survey year. Vegetation was still sparse, with only some exotic plants (*e.g.* evening-primrose).

Reclaimed land 2 (R_2): This station, which was reclaimed 17 years before the survey year, is situated at a considerable distance from the forest area and near the border of the urban area. Vegetation was thick and predominated by exotic plants such as beach-pea, evening-primrose and reeds.

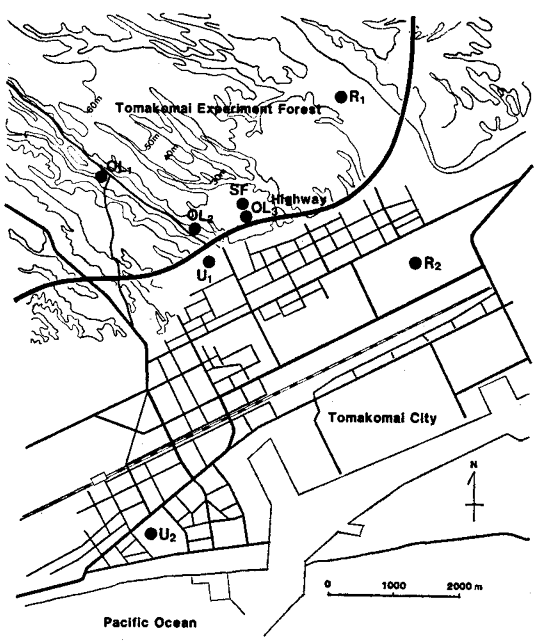

Fig. 1. Location of eight trap stations. SF: secondary forest; OL_1, OL_2, OL_3: openland; R_1, R_2: reclaimed area; U_1, U_2: urban area.

Urban area 1 (U_1): A residential area with gardens and waste lands.

Urban area 2 (U_2): A park area with lawns, flower beds and street trees.

Sampling was made for 3 nights per 10 days from early June to late October at OL_2 and R_1 in 1979 and at OL_1, OL_3, R_2 and U_1 in 1980. At U_2, samples were taken every night from June 1 to October 31 in 1979. The trap employed for this survey was designed to be omnidirectional, and a 6 w fluorescent black light tube provided the light source (detailed in YOSHIDA, 1980), except for the U_2 trap, which was lighted by a 20 w fluorescent lamp.

Results

A total of 7,891 individuals, which belonged to 304 species of 13 families, were collected. Some groups which were difficult to identify, *e.g.* Sterrhinae and Lithosiinae, were omitted from the survey.

1. Classification of habitats

The faunal composition of eight trap stations was compared by a cluster analysis (UPGMA, SNEATH and SOKAL, 1971). The faunal similarities between all possible pairs of eight stations were calculated by WHITTAKER's (1952) percentage similarity index. The resulting dendrogram is shown in Fig. 2. First, the forest station (SF) was separated from the other seven non-forest stations. These were divided further into three groups: the first group consisted of four stations (openland I: OL_1, OL_2, OL_3 and R_1) that were relatively adjacent to the forest; the second one had an open grassland station (openland II: R_2) that was remote from the forest, and the third one contained urban stations (U_1 and U_2).

2. Faunal composition

Fig. 3 shows the faunal make-up at each station in terms of percentages of species and individual numbers at the family level. In the number of species, the

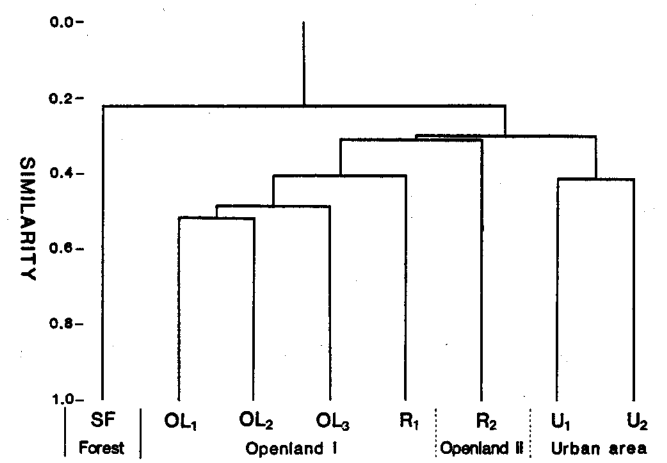

Fig. 2. Relationship similarities of moth faunas among eight trap stations (by UPGMA).

make-up at SF was nearly the same as that observed at other forest stations (YOSHIDA, 1983) and was characterized by two predominant families, Noctuidae and Geometridae, followed by Notodontidae and Arctiidae. On the other hand, at non-forest stations, the predominance of Noctuidae was more conspicuous, which compensated for the percentage decrease of Geometridae, attaining 61.1% at U_2. Notodontidae tended to decrease at R_2 and urban stations, whereas Arctiidae increased in urban areas. In the number of individuals, the faunal difference observed in the number of species between forest and non-forest stations was amplified, i.e., the predominance of Geometridae in the forest and that of Noctuidae in the non-forest areas was more obvious. As for other families, Sphingidae and Notodontidae followed the above two predominant families at SF, whereas Arctiidae

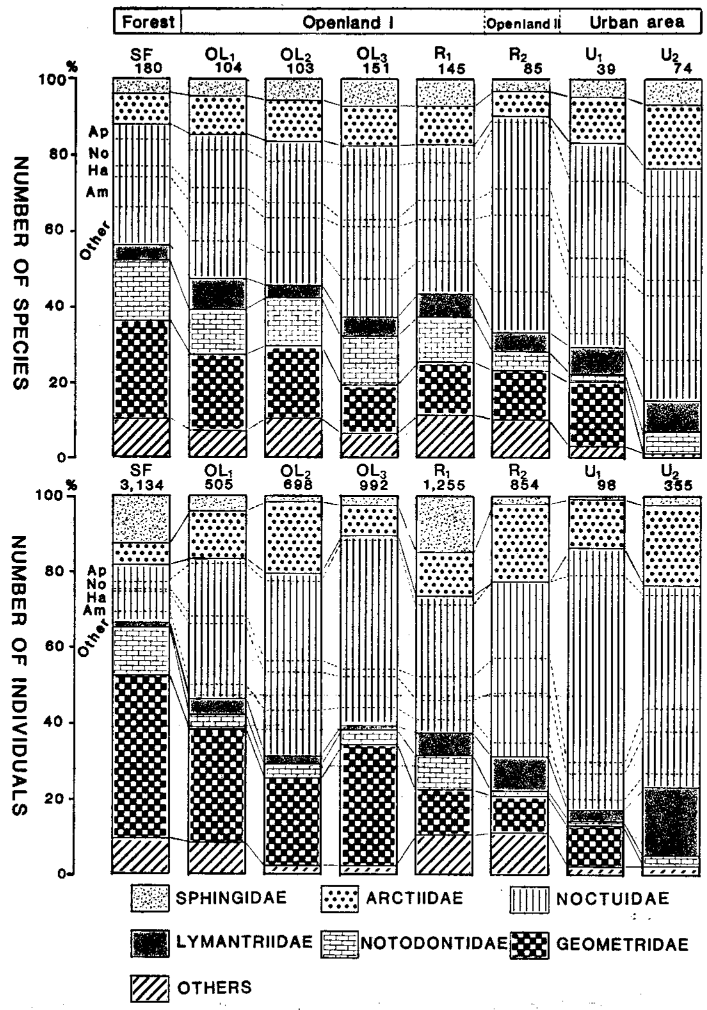

Fig. 3. Comparison of macrolepidopterous faunas at family level among eight trap stations. The classification of subfamilies is shown only in Noctuidae; Ap: Apatelinae, No: Noctuinae, Ha: Hadeninae, Am: Amphipyrinae.

and Lymantriidae occupied a higher percentage in the openland and urban areas. At the subfamily level, Noctuinae was the most predominant subfamily of Noctuidae in the openland and urban areas.

3. Distributional patterns and life history characters of predominant species

In order to examine the distributional patterns of predominant species, the seven top abundant species were chosen from each station. A total of 28 species were regarded as predominant and the relative frequencies of these species at each station are shown in Table 1. Considering also the results of other surveys (YOSHIDA, 1980, 1983), the 28 predominant species were classified into three groups, I (including 8 species), II (8 spp.) and III (12 spp.). Species of group I tended to be distributed predominantly in forest; those of group II were eurytopic and distributed from forest to urban areas; and those of group III were predominant in openland and urban areas.

Som life history characters, larval food, voltinism and overwintering stage, of the 28 species are summarized in Table 1. There are some notable differences in these characters among the three groups with different habitat preferences. The species of group I tend to be monophagous, feeding on arboreal plants, those of group II are polyphagous, utilizing various plants including trees and herbs, and the group III species are polyphagous, occuring on herbaceous plants. All the species belonging to groups I and II are univoltine, whereas those of group III include 5 bivoltine species. Most species of groups I and II overwinter in pupae, whereas the species of group III, as far as known, overwinter in larvae.

Discussion

The species belonging to group I are forest species of which the larvae depend on arboreal plants. The occurrence of these species in openland I may be due to the fact that the trap stations were relatively adjacent to the forest. Although *Lymantria mathura aurora* was collected only at U_2 and R_1 in the present survey, outbreaks of this species are known to occur in broad-leaved forests (INOUE *et al.*, 1982), and therefore they can be regarded as a forest species.

Although the species of group II are generally regarded as eurytopic, there is a considerable variation in habitat preferences among them. *Zethenia albonotaria nesiotis*, *Marumba qaschkewitschii echepron* and *Zethenia rufescentaria* prefer primarily forest environments. In the present survey, *Arctia caja phaeosoma* was very rare at SF but relatively abundant in openland and urban areas. However, this species was predominant in broad-leaved forests in another survey (YOSHIDA, 1983). *Ampelophaga rubiginosa*, which was particularly abundant at R_1 in the present survey, is known to feed on shrubs (*e.g. Hydrangea paniculata*) or vines (*e.g. Ampelopsis brevipedunculata*) (INOUE *et al.*, 1982; MIYATA, 1983) and to be distributed in a relatively broad environmental range from forest edge through openlands to shrubby marshlands (YOSHIDA, unpubl.). It seems unlikely that the wide occurrence of group II species from forest to urban areas is due to their strong ability of flight, because most of the group II species belong to Geometridae

Table 1. Numbers of individuals and the percentages of 28 predominant life history characters. The 7 most abundant species at each

Environment			Forest	Openland I			
			SF	OL_1	OL_2	OL_3	R_1
Group	Trap station	(Family)	N (%)	N (%)	N (%)	N (%)	N (%)
I	*Togepteyrx velutina*	(NT)	93 (2.9)	— —	1 (0.1)	3 (0.2)	7 (0.5)
	Fentonia ocypete	(NT)	30 (2.8)	— —	4 (0.4)	7 (1.7)	35 (2.7)
	Nerice bipartia	(NT)	99 (3.1)	3 (0.6)	7 (0.7)	1 (0.1)	9 (0.7)
	Somadasys brevivenis	(LA)	134 (4.2)	12 (2.5)	1 (0.1)	— —	10 (0.8)
	Parabapta clarissa	(GE)	51 (1.6)	1 (0.2)	— —	40 (3.2)	— —
	Amphipyra erebina	(NO)	118 (3.7)	1 (0.2)	1 (0.1)	4 (0.3)	— —
	Phyllodesma japonica japonica	(LA)	8 (0.2)	14 (2.9)	1 (0.1)	— —	4 (0.3)
	Lymantria mathura aurora	(LY)	— —	— —	— —	— —	15 (1.2)
II	*Zethenia albonotaria nesiotis*	(GE)	636 (19.8)	50 (10.3)	51 (5.1)	45 (3.6)	41 (3.2)
	Zethenia rufescentaria	(GE)	120 (3.7)	48 (9.9)	37 (3.7)	72 (5.7)	60 (4.8)
	Marumba gaschkewitschii echepron	(SP)	320 (10.0)	5 (1.1)	1 (0.1)	4 (0.3)	18 (1.4)
	Amraica superans	(GE)	68 (2.1)	24 (5.0)	48 (4.8)	39 (3.1)	27 (2.1)
	Spilosoma punctaria	(AR)	34 (1.1)	22 (4.5)	25 (2.5)	29 (2.3)	3 (0.2)
	Spilosoma seriatopunctata	(AR)	11 (0.4)	2 (0.4)	10 (1.0)	9 (1.3)	2 (0.2)
	Arctia caja phaeosoma	(AR)	1 —	— —	41 (4.1)	— —	12 (1.0)
	Ampelophaga rubiginosa	(SP)	1 —	— —	— —	— —	165 (13.1)
III	*Agrotis exclamationis informis*	(NO)	6 (0.2)	36 (7.4)	105 (10.5)	159 (12.7)	88 (7.0)
	Agrotis segetum	(NO)	— —	— —	12 (1.2)	2 (0.2)	42 (3.3)
	Heliothis maritima adaucta	(NO)	— —	2 (0.2)	2 (0.2)	17 (3.3)	4 (0.3)
	Xestia ditrapezium	(NO)	— —	3 (0.6)	2 (0.2)	— —	— —
	Xestia c-nigrum	(NO)	1 —	7 (1.4)	27 (2.7)	22 (1.7)	5 (0.4)
	Lygephila maxima	(NO)	3 (0.1)	8 (1.6)	62 (6.3)	1 (0.1)	14 (1.1)
	Spodoptera depravata	(NO)	— —	41 (8.5)	50 (5.0)	11 (0.9)	2 (0.2)
	Aletia conigera	(NO)	1 —	5 (0.1)	2 (0.2)	5 (0.4)	3 (0.2)
	Apamea aguila oriens	(NO)	— —	— —	3 (0.3)	— —	7 (0.6)
	Euproctis subflava	(LY)	— —	— —	— —	— —	22 (1.8)
	Philudoria potatoria mikado	(LA)	— —	— —	— —	— —	4 (0.3)
	Spilosoma niveum	(AR)	— —	— —	4 (0.4)	— —	41 (3.3)

or Arctiidae and possess rather weak flight ability. Most species of this group are polyphagous, feeding on not only woody but also herbaceous plants. This polyphagous nature may facilitate expansion of their habitats.

The species belonging to group III are primarily confined to open grasslands, being feeders on herbaceous plants. Population outbreaks of *Euproctis subflava* occurred frequently in openland habitats, taking place along a railway, in a park and in new residential areas in Tomakomai (YOSHIDA, unpubl.). *Philudoria potatoria mikado*, which feed mainly on reeds, was relatively abundant at R_2, where its food plant was abundant.

HIURA (1973) studied faunal characteristics of butterflies in various environ-

moth species collected at eight trap stations, with a summary of their
trap sation are underlined

Openland II	Urban area		Life history character			
R_2 N (%)	U_1 N (%)	U_2 N (%)	Phagism	Larval food type	Voltinism	Overwintering stage
— —	— —	— —	Monophagy	Tree	Univoltine	Pupae
— —	— —	— —	Monophagy	Tree	Univoltine	Pupae
— —	— —	— —	Monophagy	Tree	Univoltine	Pupae
— —	— —	— —	?	Tree	Univoltine	Pupae
— —	— —	— —	Monophagy	Tree	Univoltine	Pupae
— —	— —	— —	Monophagy	Tree	Univoltine	Egg
— —	1 (1.0)	— —	Polyphagy	Tree	Univoltine	Pupae
— —	— —	13 (3.7)	Polyphagy	Tree	Univoltine	Egg
38 (4.2)	3 (3.1)	— —	Polyphagy	Tree (Herb)	Univoltine	Pupae
15 (1.7)	2 (2.0)	— —	Polyphagy	Tree	Univoltine	Pupae
2 (0.2)	2 (2.0)	— —	Polyphagy	Tree (Herb)	Univoltine	Pupae
3 (0.3)	— —	— —	Monophagy	Shrub	Univoltine	Pupae
2 (0.2)	2 (2.0)	3 (0.8)	Polyphagy	Tree (Herb)	Univoltine	Pupae
8 (0.9)	3 (3.1)	15 (4.2)	Polyphagy	Tree (Herb)	Univoltine	Pupae
5 (0.6)	7 (7.1)	37 (10.4)	Polyphagy	Shrub (Herb)	Univoltine	Larvae
— —	— —	— —	Polyphagy	Shrub	Univoltine	Pupae
44 (4.9)	23 (23.5)	23 (6.5)	Polyphagy	Herb	Bivoltine	?
11 (1.2)	12 (12.2)	30 (8.5)	Polyphagy	Herb	Bivoltine	Larvae
— —	— —	3 (0.8)	Polyphagy	Herb	Bivoltine	?
39 (4.3)	1 (1.0)	2 (0.6)	?	Herb	Univoltine	?
21 (2.3)	6 (6.1)	15 (4.2)	Polyphagy	Herb	Bivoltine	Larvae
10 (1.1)	2 (2.0)	— —	Polyphagy	Herb	Univoltine	Larvae
2 (0.2)	2 (2.0)	20 (5.6)	Polyphagy	Herb	Bivoltine	Larvae
40 (4.4)	1 (1.0)	3 (0.8)	?	?	Univoltine	?
33 (3.7)	3 (3.1)	3 (0.8)	?	?	Univoltine	?
45 (5.0)	1 (1.0)	— —	Polyphagy	Herb (Tree)	Univoltine	Larvae
35 (3.9)	— —	— —	Polyphagy	Herb	Univoltine	Larvae
4 (0.4)	— —	3 (0.8)	Polyphagy	Herb	Univoltine	Larvae

ments and proposed that butterflies inhabiting urban areas possess some life history characters commonly seen in open grassland species, i. e., they are dependent on anthropophytes, being multivoltine and migratory. On the other hand, forest butterfly species depend on natural woody plants and are univoltine and sedentary. Furthermore, the former is represented by Palaearctic or Oriental elements, while the latter is represented by Sino-Japanese elements. Similar differences in life history characters are also seen between forest and openland moth species. A brief discussion on the life history characters of openland species is given below in relation to adaptations to their unpredictable habitats. The life history of forest species will be detailed elsewhere.

Openland moth species are polyphagous and uni- or bivoltine, and overwinter in larvae. Faunal make-up in openland and urban areas is characterized by the abundance of Noctuidae, especially of the subfamily Noctuinae (Fig. 3). This faunal characteristic is clearly seen also in the classification of 28 predominant species as to their habitat preferences (Table 1). Groups I and II included only one noctuid species, while 9 out of the 12 species calssified into group III belonged to Noctuidae, and 4 out of 9 species to Noctuinae. The subfamilies Noctuinae and Hadeninae of Noctuidae are represented especially well in arid grassland zones in the interior of the Eurasian and North American continents (INOUE *et al.*, 1982). Out of the 9 noctuid species in group III, *Agrotis exclamationis informis, A. segetum, Xestia c-nigrum, X. ditrapezium,* are widespread in Eurasia. Six out of the 9 noctuid species have extended their larval food niches to cultivated plants (*e.g.*, *A. exclamationis informis* and *A. segetum* feed on Cruciferae, and *Heliothis maritima adaucta* feeds on Leguminosae). Such characters appear in species possessing more flexible habitat requirements (PIANKA, 1978). Multivoltine life cycles seem to bring out a plasticity that is advantageous for species inhabiting urban environments (HIURA, 1973). The overwintering of half- or full-grown larvae may be an adaptation to utilize biennial plants, which provide them with a high quality food of rosettes shooting in autumn (OKU, 1983). Noctuid moths (OKU, 1978 ; SOUTHWOOD, 1973) or butterflies (HIURA, 1973) inhabiting openland environments have developed long-range migratory ability to adapt to unpredictable habitat conditions, as represented by *Xestia c-nigrum* which migrates from Europe to England (HOLLOWAY, 1967).

In conclusion, these life history characters seen in openland moth species are adaptive for colonizing unpredictable, temporary habitats.

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References

HIURA, I. 1973: Butterflies migrate across the sea. Aoki, Tokyo, 200 pp. (in Japanese).

HOLLOWAY, J. D. 1967: Studies and suggestions on the behavior of moths at light. Proc. Trans. South London Entomol. Nat. Hist. Soc., 31–45.

INOUE, H. *et al.*, 1982: Moths of Japan. Kodansha, Tokyo. Vol. I. 968 pp. (in Japanese).

MIYATA, A. 1983: Handbook of moth ecology. Showado Printing Publishing Division, Nagasaki. Vol. I. 688 pp. (in Japanese with English summary).

OKU, T. 1983: Aestivation and migration in noctuid moths. In "Diapause and life cycle strategies in insects." ed. BROWN, V. K. and I. HODEK. Dr. W. JUNK Publishers, The Hague, Boston, London. 219–231.

OKU, T. and T. KOBAYASHI, 1978: Migratory behaviors and life-cycle of noctuid moths (Insecta, Lepidoptera), with notes on the recent status of migrant species in northern Japan. Bull. Tohoku Natl. Agric. Exp. Stn., **58**: 97–209. (in Japanese with English summary).

PIANKA, E. R. 1978: Evolutionary ecology. The 2nd edition. Harper & Row, Publishers, 397 pp.

SNEATH, P. H. A. and R. R. SOKAL, 1971: Numerical taxonomy. The principles and practice of numerical classification. Freeman, San Francisco. 573 pp.

SOUTHWOOD, T. R. E. 1962: Migration of terrestrial arthropods in relation to habitat. Biol. Rev., **37**: 171–214

WHITTAKER, R. H. 1952: A study of summer foliage insect communities in the Great Smoky Mountains. Ecol. Monograph, **22**: 1–44.

YOSHIDA, K. 1980: Seasonal fluctuation of a moth community in Tomakomai Experiment Forest of Hokkaido University. Res. Bull. Coll. Exper. Forests, Hokkaido Univ., **37** (3): 675–685.

YOSHIDA, K. 1983: Heterogeneous environmental structure in a moth community of Tomakomai Experiment Forest, Hokkaido University. Jap. J. Ecol., **33**: 445–451.

要　約

1979年，1980年の6月上旬から10月下旬の間，北海道大学苫小牧演習林の二次林およびオープンランドと苫小牧市の市街地においてガ類相の調査を行ない，13科304種7,891個体を採集した。森林ではシャクガ科が優占したのに対し，オープンランドや都市ではヤガ科が優占した。環境選好性の類似度合から28優占種は森林性種，広場所性種，オープンランド性種の三つの種グループに分けられた。特に，森林性種とオープンランド性種とは生活史においていくつかの点で異なり，これらの適応的意義について論議された。