近縁な人里植物2種，オオバコとセイヨウオオバコの生態分布とニッチの違い

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Kazuhito MATSUO*: Ecological Distribution and Niche Separation in Two Closely Related Ruderal Plantain Species, *Plantago asiatica* and *P. major*

松尾和人*：近縁な人里植物2種，オオバコとセイヨウオオバコの生態分布とニッチの違い

Abstract

Plantago asiatica and *P. major* are very similar in microhabitat preference (both inhabiting parking sites, gardens, lawns, and roadsides), but they exhibit rather conspicuous habitat segregation. With the exception of small overlapping zones in urban areas, *P. asiatica* is predominant in rural areas, while *P. major* monopolizes urban areas. Association analysis in an overlapping zone, however, suggested that they do not directly compete with each other by mutual shading or allelopathy. A preliminary study on the environmental factors indicated that *P. major* tends to become predominant in sparse and short plant communities that develop on bare ground, while *P. asiatica* is a member of more closed communities.

Key Words: Competition—Habitat preference—Introduced species—*Plantago*

Plantago major, a weed of European origin, has been spread all over the world, probably through global trade, and now is well known as a cosmopolitan species, even in Asia which is dominated by another native ruderal species, *P. asiatica*. *P. major* is expanding its distribution especially in dairy regions and urban areas (SAGER and HARPER. 1975). In Japan, too, the occurrence of this species has been confirmed in Sapporo, Hokkaido (FUJIWARA, 1957), Yokohama and Fujisawa, Kanagawa Prefecture (ASAI, after OSADA, 1976) and Tokyo (OSADA, 1976). Nevertheless, this species has been considered minor compared with the native ruderal plantain species, *P. asiatica*, which is expanding its distribution range even into subalpine zones ca. 2500m in altitude after extensive human disturbance (e. g. road construction) in central Honshu (KAWANO and MATSUO, 1983).

However, in Sapporo and its vicinity, the populations of *P. major* are expanding as rapidly as and, in some sites, even faster than *P. asiatica* (ITO, 1984). As part of the comparative ecological studies on Japanese *Plantago* species, I hereby report on the ecological distribution and niche partitioning of these two species in Sapporo and its vicinity.

Methods

Surveys were conducted in the seed-maturing season (late August to early November) each year from 1984 to 1987, since *P. major* and *P. asiatica* can easily be identified by the morphological difference in their seeds (Matsuo, 1989).

Macro-distribution

At each of 143 sites haphazardly chosen in Sapporo and its vicinity, about 30 *Plantago* individuals were collected. In addition, the same sampling method was used for the survey at 31 sites situated along a ca. 20km long road through Mt. Teine, along which the degree of human impact gradually increases from natural woodlands to urban communities, forming a gradient.

Micro-distribution

In single-species populations of *P. asiatica* (Nopporo Forest Park) and *P. major* (Hokkaido University), a 50-cm-wide belt-transect was established across a weedy path. In each belt a vegetation survey was made, and, at 50cm intervals, soil hardness was measured by a Yamanaka System Hardness Tester DIK-610 Type. At another site where these two species coexist, the

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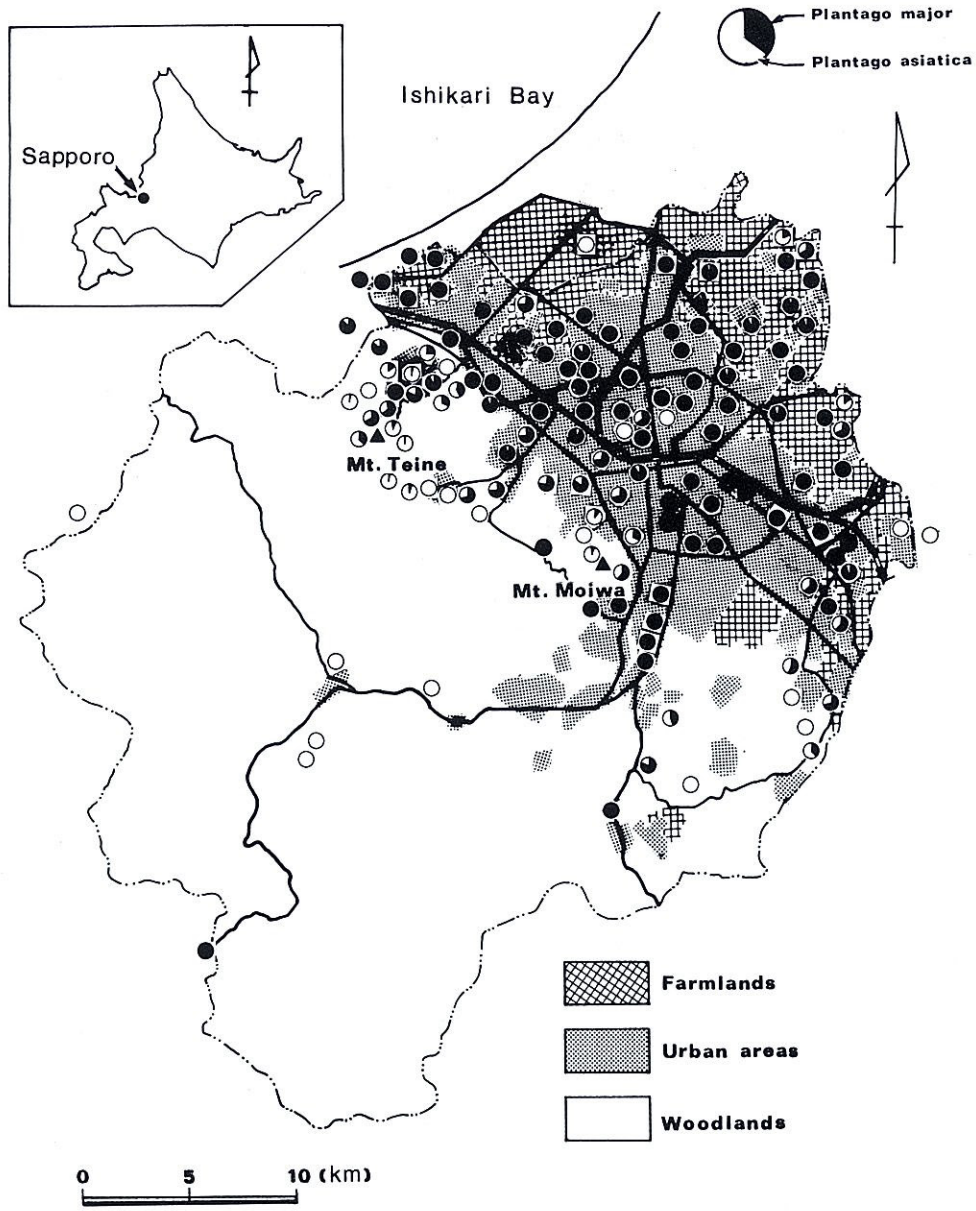

Fig. 1. Distribution of *P. major* and *P. asiatica* surveyed at 135 stands in Sapporo and its vicinity.

mapping of seeded *Plantago* plants was undertaken within a 4m×4m quadrat to analyze the association of these two species by using the following methods of KERSHAW (1960):

When the quadrat is divided into N grids, and species A and B are not independent of each other,

$$\mathrm{Var.(A+B)=Var.A+Var.B+2Cov.AB}$$

or $$V_{A+B}=V_A+V_B+2C_{AB}$$

$$C_{AB}=(V_{A+B}-V_A-V_B)/2.$$

Now correlation coefficient $r=\sqrt{C_{AB}/V_AV_B}$

i. e., $r=(V_{A+B}-V_A-V_B)/2\sqrt{V_AV_B}$

Its significance can be tested by t-test:

$t=\sqrt{r^2(N-2)/(1-r^2)}$, with $N-2$ degrees of freedom.

Environmental factors

As a preliminary study on the elements controlling the separate distribution of the two species, the following factors were measured at 103 1m×1m quadrats randomly chosen in

Table 1. Association analysis of *P. major* and *P. asiatica* by the covariance method of KERSHAW (1960). A 4m×4m quadrat was set up at stand 19 (Fig. 2) where the two species were coexisting.

	Grid size			
	$(0.25m)^2$	$(0.5m)^2$	$(1.00m)^2$	$(2.00m)^2$
No. of grids	256	64	16	4
Variance of				
P. asiatica	0.59	4.43	206.2	90
P. major	1.95	12.52	28.73	308.3
Covariance	0.14	1.94	−56.12	−159
t	2.05	2.12	3.99	4.53
	$p<0.05$	$p<0.05$	$p<0.001$	$p<0.05$

Table 2. Environmental conditions at 103 1m×1m stands. Mean±SD and, in parentheses, numbers of stands concerned are given.

Environmental factors	Stands inhabited by *P. asiatica*	both species	*P. major*
Coverage (%)	75.1±27.1 (24)	88.8±17.6 (34)	45.8±29.8 (39)
Vegetation height (cm)	17.4±10.2 (24)	10.7±6.2 (34)	5.4±7.5 (39)
Relative light intensity (%)	57.1±26.0 (24)	72.3±14.4 (34)	78.6±10.3 (39)
Soil hardness (kg/cm^3)	10.9±18.8 (21)	12.2±5.0 (27)	21.4±31.6 (39)

Sapporo and its vicinity: plant coverage and vegetation height (VH), i. e., the mean height of dominant plant species; relative light intensity (RLI), using a Topcon Illuminance Meter IM-3; and soil hardness (SH).

Results

Macro-distribution

Of 143 sites examined, 62 were dominated by *P. major*, 26 by *P. asiatica* and 55 shared by these two plantain species. As shown in Fig. 1, the urban areas and farmlands were predominantly covered by *P. major*, while the open spaces of woodlands were monopolized by *P. asiatica*, both species inhabiting roadsides, parking sites, gardens, turf, and other open spots. The stands shared by these two species were mainly on the border between woodlands and housing lots. This pattern of distribution was also observed along the 20-km road (Fig. 2), *P. major* predominantly growing in more developed areas and *P. asiatica* predominating in woodland areas. Such recreation facilities as ski grounds, amusement parks and some relay stations has been constructed in the woodland areas of Mt. Teine (Stands 9 to 12); however, *P. major* constituted 22 to 67% of the *Plantago* populations there. These facilities were located ca. 1000m above sea level, indicating that neither low temperature nor snowfall prevents the expansion of this introduced species.

Micro-distribution

Figure 3 shows the results of a belt-transect survey in the single-species populations of *P. major* and *P. asiatica* which were accompanied by typical openland weeds such as *Poa annua, Taraxacum officinale, Trifolium repens,* etc. Both *Plantago* species were confined to the central parts of the paths, due to intensive competition with tall and dense populations of *Dactylis glomerata, Festuca elatior* and *Artemisia montana.* Soil hardness ranged from 2 to $86kg/cm^3$ on the path, and *Plantago* species were more dominant on moderately hard grounds of SH=12-36kg/cm^3. Table 1 gives the association of the two *Plantago* species cohabiting within a 4m×4m quadrat chosen at Site 19 in Fig. 2. A total of 76 *P. asiatica* and 275 *P. major* seeded plants grew here. When this quadrat was divided into small grids of $(0.25m)^2$ or $(0.50m)^2$, they showed a positive association which was statistically significant. However, in the case of large grids of $(1m)^2$ or $(2m)^2$, the association was significantly negative. Thus, there seems to be no or little direct competition between these two *Plantago* species growing side by side, but some factors unknown at present are weakly controlling them to be distributed separately.

Environmental factors

The environmental conditions at 103 sites are summarized in Table 2. *P. major* is evidently a species of sparser and shorter plant communities developed on harder ground than *P. asiatica,* which prefers relatively closed communities. The stands shared by those two species showed intermediate values of VH, RLI and SH. Although the coverage was the highest in the coexisting stands, the value (88.8±17.6%) was significantly higher than that in *P. asiatica* stands (75.1±27.1%) ($t=2.1716$, $p<0.05$).

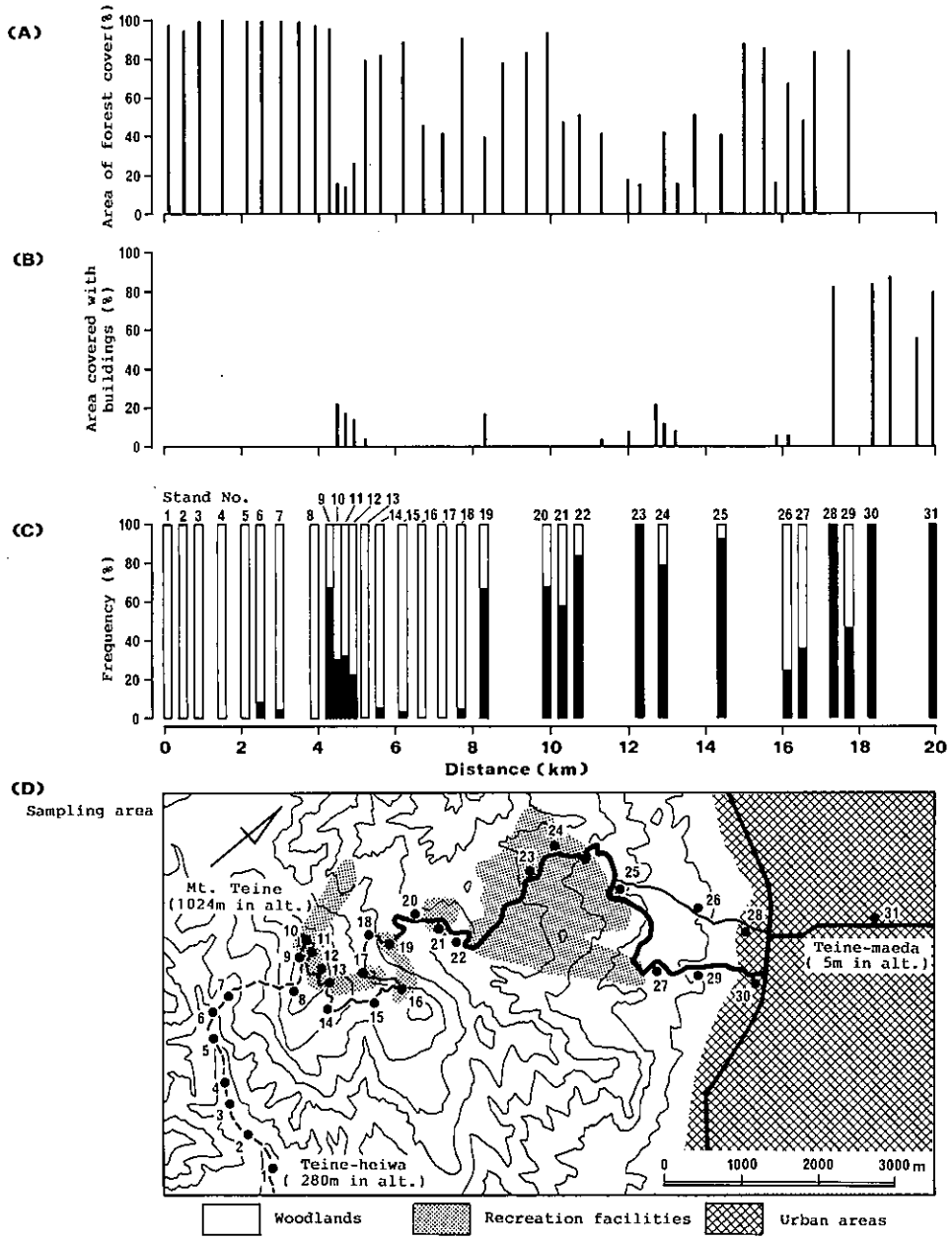

Fig. 2. Percentage of forest cover per 160m×160m (ca. 2.6ha) around the sampling stand and its neighborhood, (A); in an area covered with buildings, (B). Occurrence frequency of two *Plantago* species (*P. asiatica*; open bars, *P. major*: filled bars) along a road passing through Mt. Teine (C). About 30 *Plantago* individuals were collected at each stand. Figures in Fig. 2-D show the stand numbers; (thick lines, thin lines and dashed lines indicate more than 5.5m road width, 2.5-5.5m road width and less than 2.5m road width, respectively.

Discussion

The segregated distribution of *P. major* from its related native species *P. rugelii* was observed in Canada (HAWTHORN, 1974). HAWTHORN and CAVERS (1978, 1982) revealed that more resources are allocated to reproductive organs such as scapes, flowers, capsules and seeds in *P. major*, but to the root system in *P. rugelii*, suggesting that *P. major* is more competitive in urban areas, because seed recruitment rate is critical for population recovery when habitats are frequently disturbed by human activities. In *P. major* of

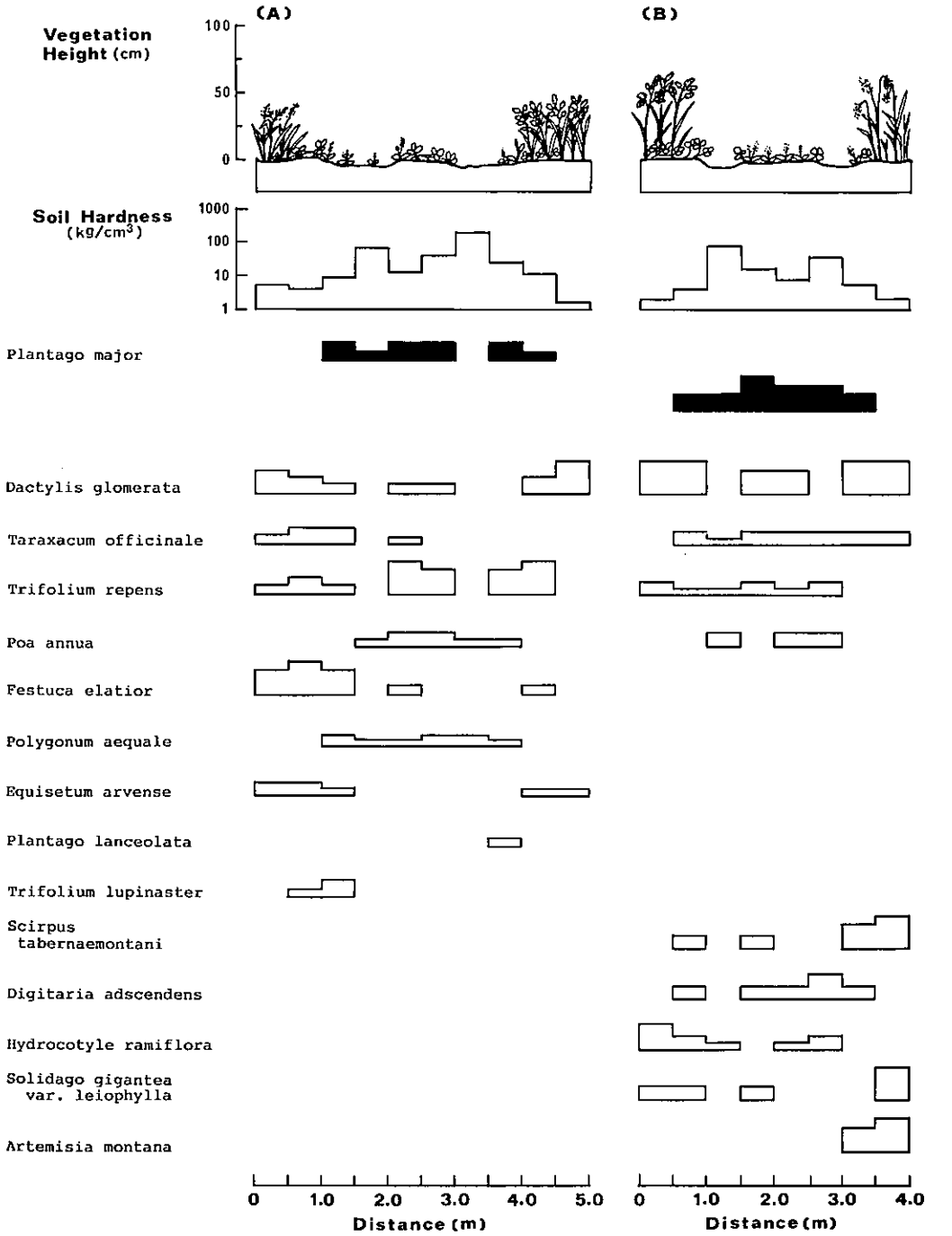

Fig. 3. Micro-distribution of *P. major* (A) and *P. asiatica* (B) in single-species populations, with main cohabitants. In each population, a 50cm wide belt was set up across a weedy path.

England, a form with erect leaves is more competitive in wild grasslands than another form with prostrate leaves that usually dominates gardens and lawns (WARWICK, 1980). However, *P. major* and *P. asiatica* do not show sharply segregated distribution when they coexist within a small microsite. This fact suggests that segregated distribution of these two species may not be due to direct competition through shading or allelopathy but be due to more complicated

mechanisms, probably including the seed recruitment rate and tolerance to various other environmental factors.

In addition to *Plantago* species here reported, somewhat similar cases of habitat segregation between closely related plant species have been known in *Taraxacum* (*T. officinale* and native species such as *T. japonicum, T. platycarpum* and *T. hondoense*: NAITO, 1975; HOTTA, 1978; SAWADA *et al.*, 1982; OGAWA and MOTOTANI, 1985) and *Artemisia* (*A. rubripes* and *A. montana*: NAKAYAMA, 1985) in Japan. In particular, *T. officinale* has rapidly been expanding its range all over Japan, taking over all possible habitats (HOTTA, 1978). SAWADA (1982) demonstrated that *T. officinale* extends its leaves more quickly than related natives species, suggesting that *T. officinale* is more competitive because it shades the natives. However, according to OGAWA and MOTOTANI (1985), such direct competition is unlikely, and *T. officinale* outcompetes when they coexist with related natives. The mechanisms by which the introduced plant species frequently can dominate the related natives could be clarified by more detailed comprehensive studies on the physiological and ecological aspects of these species.

I thank Prof. Koji ITO for his comments on ruderal vegetation, and Drs. Hiromi FUKUDA and Masahiro HARUKI for their encouragement throughout the present study. Cordial thanks are also due to Dr. Seigo HIGASHI and Prof. Shoichi KAWANO for critical reading of the manuscript and valuable suggestions on the ecology of *Plantago species*.

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摘 要

札幌市とその近郊においてオオバコ（*Plantago asiatica* L.）個体群セイヨウオオバコ（*P. major* L.）個体群の分布とその生育地環境の比較を行った。両種とも札幌市のほぼ全域に分布するが人為的影響が大きい市街地や農地の区域ではセイヨウオオバコ個体群のほうがオオバコ個体群と比べて優勢に分布する傾向が見られる。一方，森林内の比較的明るい遊歩道や林道には，セイヨウオオバコの侵入は非常に少なく，オオバコが優勢に分布・生育している。両種ともスズメノカタビラ，セイヨウタンポポ，シロツメクサなど共通した草本種と共に群落を形成するが，セイヨウオオバコを含む群落は群落被度が小さく，群落高も低い傾向が見られる。また，そのような群落が形成される生育地の光環境は良好である。それに対し，オオバコは被度や高さがより大きく密な群落内へも侵入し，セイヨウオオバコが生育できないような光環境下でも個体群を形成することが出来る。市街地と森林が接する所では，両種の混成群落が多くみられる。このような区域で両種の個体が含まれるように4 m×4 mの方形区を設置しAssociation analysis (KERSHAW, 1960)を行った結果，比較的小さい方形枠サイズで解析すると両種の個体は，しばしば隣接して生育することもあり，生態分布の相違を明瞭に把握することはできないが，枠サイズを大きくするにしたがってこれら両種が異なった生態的立地に分離して生育する状態が鮮明になってする。以上のことより，オオバコとセイヨウオオバコの生態分布の違いはアレロパシーや競争などの直接的な相互作用より，むしろ生育地の微環境要因によって制御されていると考えられる。

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○ 堀田満ほか（編） **世界有用植物事典** 平凡社。1989年8月25日発行。四六倍判，総ページ1505，モノクロ図1,300点。定価24,000円（税込）。

日本語で書かれた有用植物事典は，いくつかの園芸植物事典はあるものの，有用植物百般にわたるものはほとんどない。この本は，かつての北隆館の資源植物事典（1949）以来，実に40年ぶりに出た本格的な有用植物事典である。本辞典は，編集委員代表の堀田さんはじめ6名の先生方を編集委員に，各分野の専門家14名を編集専門委員に配し，339名の執筆者を動員して15年の歳月をかけてつくられたという。内容は，植物編（1-1126頁），事項編（1127～1438頁）および索引（欧文・中国名・事項，1439～1499頁）の3部構成である。植物編では一貫して「植物の属」を大項目としてとり上げ，まず属の所属や分布を簡明に記し，その下に種名（学名と和名）を小項目にとって，それぞれに生態・形態・利用の解説をおこなうという体裁になっている。全項目数約3,500，収録植物ほぼ8,500程である。次の事項編では，麻・油・油脂といった順序で一般項目を138個にまとめて，文化史や利用面をとり扱っている。こうして，植物編をいわば縦の解説とすれば，事項編は横の解説であり，縦と横の糸で織りなされた本事典は，他に類例をみない誠に強靱なものとなった。記事そのものは，一部平凡社の最新版世界大百科辞典から援用されたものもあるが，編集陣の努力で一貫した方式にまとめ上げられた。随所に入れられた1,300点余の精緻な植物図や分布図などのモノクロ図も嬉しい。最近のビジュアル主義の出版界にあって，カラー写真やモノクロ写真が一枚も使われていないというのも本書の大きな特徴である。

もう何年も以前から畏友の堀田さんが事あるごとにコンピュータにせっせと有用植物の情報をつめ込んでいる姿をみかけていたが，そうした長年にわたるたゆまぬ努力がここに見事に開花したのである。堀田さんはじめ編集委員各位に心からおめでとうといいたい。（清水建美）

○ 嘉弥真国男 **緑が丘学園の植物図鑑** 昭和63年2月発行。B5判，前文22頁＋図鑑160頁。非売品。

本書は，表題に示すとおり，緑が丘学園内に自生ならびに栽培されている植物の写真（白黒とカラー）を，1頁に2枚づつ計294種，収録した植物図鑑であるが，著者は，沖縄少年院矯正専門職にあって，ここに収容されている少年の矯正教育に，緑が如何に彼等の精神安定効果に役立つかを知り，本書を編集したようである。

アンケート調査によると，学園に収容された少年は，一般児童に比し，植物の緑に対する意識は低いようで，非行少年たちのほとんどが，木や草花に対して関心が少い。この無関心さが，情操の乏しさや心の貧しさに結びついているようで，青少年の健全育成の一つとして，植物に関心を持たせることの必要性を強く感じていると言われる。前文の“学園内植物を教材としての活用について”は，このような問題に関心を持たれる方には，参考になることであろう。（里見信生）