3.4.2. Intra-landscape species traits

Diversity in quadrat scale

The species richness at quadrat scale is demonstrated in Table 3.4-1. Total, annual, perennial and woody plant-species richness per quadrat varied markedly among habitats. Verge meadows had substantially higher total species richness per quadrat (around 30 spp.), followed by levees (around 20) and paddy fields (less than 10). Paddy fields were primarily composed of annual species, whereas levees and verge meadows were primarily composed of perennial herbs, except for levees at Site A. Exotic species were relatively abundant in levees in the three study sites. In paddy fields and verge meadows ratio of the number of exotic species was less than 10 % to total species number (Table 3.4-2).

Diversity in each landscape element

The total species richness in each agricultural management unit is demonstrated in Table 3.4-2. Trends observed for species richness per quadrat are similar to those for species richness by management units. Species recorded in verge meadows were the most abundant, followed by levees and paddy fields.

The number of characteristic species and the number of common/unique species were shown in Table 3.4-3. Similar to the total recorded species number, verge meadows had the most abundant unique species in the three study sites. In paddy fields, although the number of unique species was not large, the ratio of unique species per all recorded species was similar to verge meadows. In levees, both unique species number and its ratio were low.

Table 3.4-1 Mean species richness per quadrat (± S.D.) for 3 landscape elements in three study sites.

		Paddy field	Levee	Verge meadow
Total	Site A	9.8 ± 3.6	20.6 ± 4.7	32.0 ± 7.0
	Site B	7.6 ± 2.0	22.6 ± 6.8	35.2 ± 7.2
	Site C	7.0 ± 3.3	24.1 ± 7.3	34.4 ± 5.9
Life history				
Annuals	Site A	7.6 ± 3.4	10.9 ± 3.4	7.2 ± 3.9
	Site B	6.6 ± 1.9	8.0 ± 4.2	4.4 ± 3.2
	Site C	4.9 ± 2.9	8.7 ± 3.5	3.5 ± 2.7
Perennials	Site A	2.2 ± 1.4	9.7 ± 2.7	19.5 ± 5.6
	Site B	1.0 ± 1.1	14.5 ± 4.4	22.8 ± 5.1
	Site C	2.2 ± 0.9	15.0 ± 4.9	23.7 ± 4.8
Woody species	Site A	0.0 ± 0.0	0.0 ± 0.1	5.2 ± 3.0
	Site B	0.0 ± 0.0	0.1 ± 0.3	8.0 ± 3.8
	Site C	0.0 ± 0.0	0.4 ± 0.8	7.0 ± 3.1
Exotic species	Site A	0.3 ± 0.5	3.5 ± 1.6	2.6 ± 2.1
	Site B	0.1 ± 0.3	2.8 ± 1.1	0.9 ± 0.8
	Site C	0.5 ± 0.8	1.6 ± 0.6	0.6 ± 0.7

Table 3.4-2 Mean species richness per agricultural management unit in three study sites.

		Paddy field	Levee	Verge meadow
Total	Site A	56	120	209
	Site B	43	112	233
	Site C	42	141	221
Life history				
Annuals	Site A	44	63	43
	Site B	29	36	43
	Site C	31	44	30
Perennials	Site A	12	56	124
	Site B	14	74	143
	Site C	11	86	132
Woody species	Site A	0	1	41
	Site B	0	1	46
	Site C	0	9	56
Exotic species	Site A	4	15	17
	Site B	3	9	11
	Site C	3	7	6

Table 3.4-3 Number of unique and common species in the three landscape elements.

(P, paddy field; L, levee; V, verge meadow).

		Unique species			Common species		
		P	L	V	P + L	L + V	Other combinations
Site	A	20	23	108	26	61	10
	B	17	19	103	12	68	14
	C	21	29	87	13	90	8

3.4.3. Inter-landscape species traits

The percentage similarity in each landscape element is shown in Table 3.4-4. Similarities among sites were not high. Hence potential habitat types in each management unit are shown in Figure 3.4-3. Dormancy form is shown in Figure 3.4-4. Disseminule form and plant height characteristics of recorded species are illustrated in Appendixes 1 and 2.

Paddy field

Species recorded in paddy fields were mainly species favouring wet conditions (W species) at the three study sites. Characteristic species of Oryzo-Echinochloion oryzoidis were commonly predominant compared to other characteristic species. Other characteristic species belonged to upland fields (Chenopodietea), wet-trampled footpaths (Artemisietalia principis) and riparian zoneS (Bidentetea tripartitae). In terms of life forms, therophyte (Th), low statue and anemochorous species, especially seeds dispersed by water, were commonly predominant.

The most abundant species was observed at Site A, which is due mostly to the number of annual species (Table 3.4-2). Most of unique species at the study area did not belong to typical paddy weeds (Kasahara, 1951), which corresponded to the abundance of common species in paddy fields and levees in the study area (Table 3.4-2).

Levee

In levees, the potential habitat of the occurring species was markedly different at the three sites. At Site A, the number of annual species exceeded perennials (Table 3.4-2). Potential habitat types of occurring species were mostly either upland field or roadside species (UR species) or W species. Characteristic species of Oryzo-Echinochloion oryzoidis,

Bidentetea tripartitae and Chenopodietea were frequently observed, compared to the other two study areas. However, at Site B grassland species (G species) were an added major component. Furthermore, at Site C, forest margin species (FM species) were an added major component. Correspondingly, the dormancy form of occurring species showed a higher number of therophyte at Site A, while a higher number of hemiphyte were observed at Site C. Characteristic species in Miscanthetea sinensis was frequently observed at Site B, while characteristic species in Rosetea multiflorae were observed at Site C, in addition to those in Miscanthetea sinensis.

Figure 3.4-5 shows the average species number of each potential habitat type at Site C according to the difference in slope length. G species and FM species were large in number at longer slope lengths, though UR species and W species were similar in number at any slope length. Correspondingly total number of occurred species was largest in longer slope length (> 2.0 m), whereas they are smallest in shorter slope length (< 0.5 m). Levees with 0.5 – 1.0 m slopes and 1.0 – 2.0 m slopes were similar in the number of each potential habitat type. Life history was observed to have similar trend. Levees with more than 2.0 m slope length had larger number of perennials and woody species. Each category of slope length had similarly approximately 1.5 spp. of exotic species per quadrat (data not shown).

Verge meadow

In verge meadows, G species and FM species were frequently observed compared with the other two management units in each study site. Hemicryptophyte was the major dormancy form in the habitat. The number of exiotic species was small, though *Solidago altissima* and *Erigeron philadelphicus* were frequently dominant.

Although 5 potential habitat types were observed, the number of each type was quite different in the three study sites. In UR species and G species, similar trend to levees were found in verge meadows. UR species were most abundantly observed at Site A, followed by Site B and Site C. Conversely, G species were most abundantly seen at Site C, followed by Site B and Site A. Especially the number of UR species at Site A was markedly high.

At Site B, a different trend was observed in terms of W species. At the site, W species were more abundantly observed in verge meadows than in paddy fields and levees, whereas at other sites, paddy fields were the major habitat for W species.

Distribution of unique species

Figure 3.4-6 shows the number of unique/common species in UR, W and G species. Three potential habitat types indicated substantially different trends. UR species were

composed of common species especially in levees and verge meadows. G species were, on the other hand, observed to have a larger number of unique species in verge meadows, except for Site C. With regard to W species, unique species in paddy fields were generally the largest. However, at Site B verge meadows had the most abundant unique species, indicating that the species composition of W species was different from paddy fields at Site B.

Comparison of all recorded species at the three study sites

A total of 279, 281 and 284 plant species were found in the three landscape elements in Sites A, B and C, respectively. If forest floor species (FF species) are excluded from the total species number because they are supposed to be in adjacent woodland, 248, 238 and 248 species were observed. Of the total of 435 plant species found at the three study sites, 362 species were those representative of the four habitat types without woodland. Similarly among 155 species occurring at all sites, 144 species were non-forest representative species.

47, 32 and 42 species were observed only at one study site, Sites A, B and C, respectively, indicating that more than 80 % of the species were observed at more than 2 study sites. Figure 3.4-7 shows the species recorded in one study site. G species were commonly unique species in verge meadows. W species, which were observed at one study site, were mostly composed of the unique species in paddy fields at Sites A and C, while they were mostly found in verge meadows at Site B.

Table 3.4-4 Percentage similarity of three study sites in each landscape element.

Paddy field	Site A	Site B	Site C
Site A		0.53	0.46
Site B			0.52
Site C			

Levee	Site A	Site B	Site C
Site A		0.51	0.42
Site B			0.54
Site C			

Verge meadow	Site A	Site B	Site C
Site A		0.57	0.54
Site B			0.57
Site C			

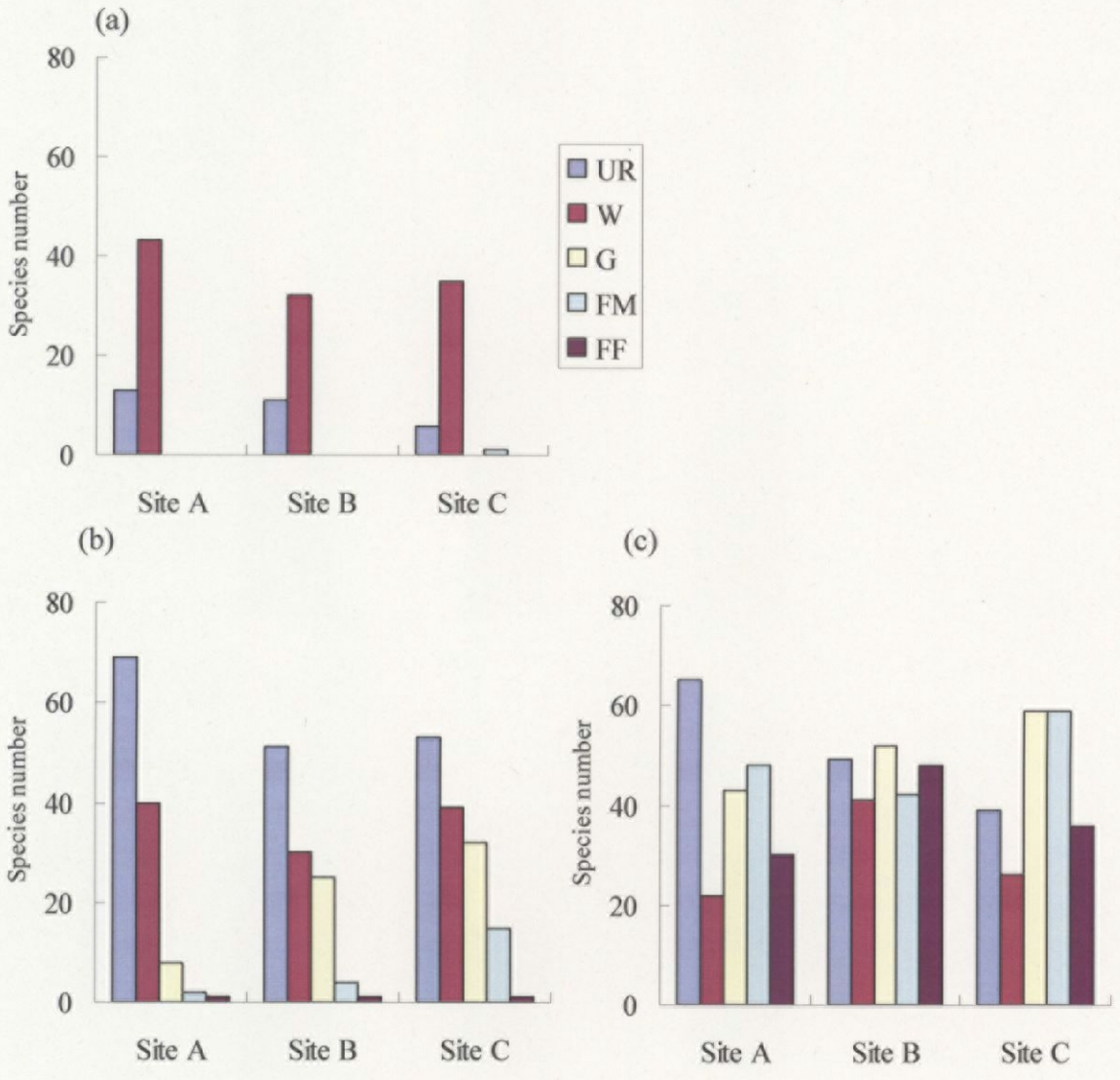


Figure 3.4-3 Potential habitat types of occurred species.

((a) Paddy field, (b) Levee, (c) Verge meadow; UR; upland field or road-side species, W; species favoring wet conditions, G; grassland species, FM; forest-margin species, FF; forest-floor species).

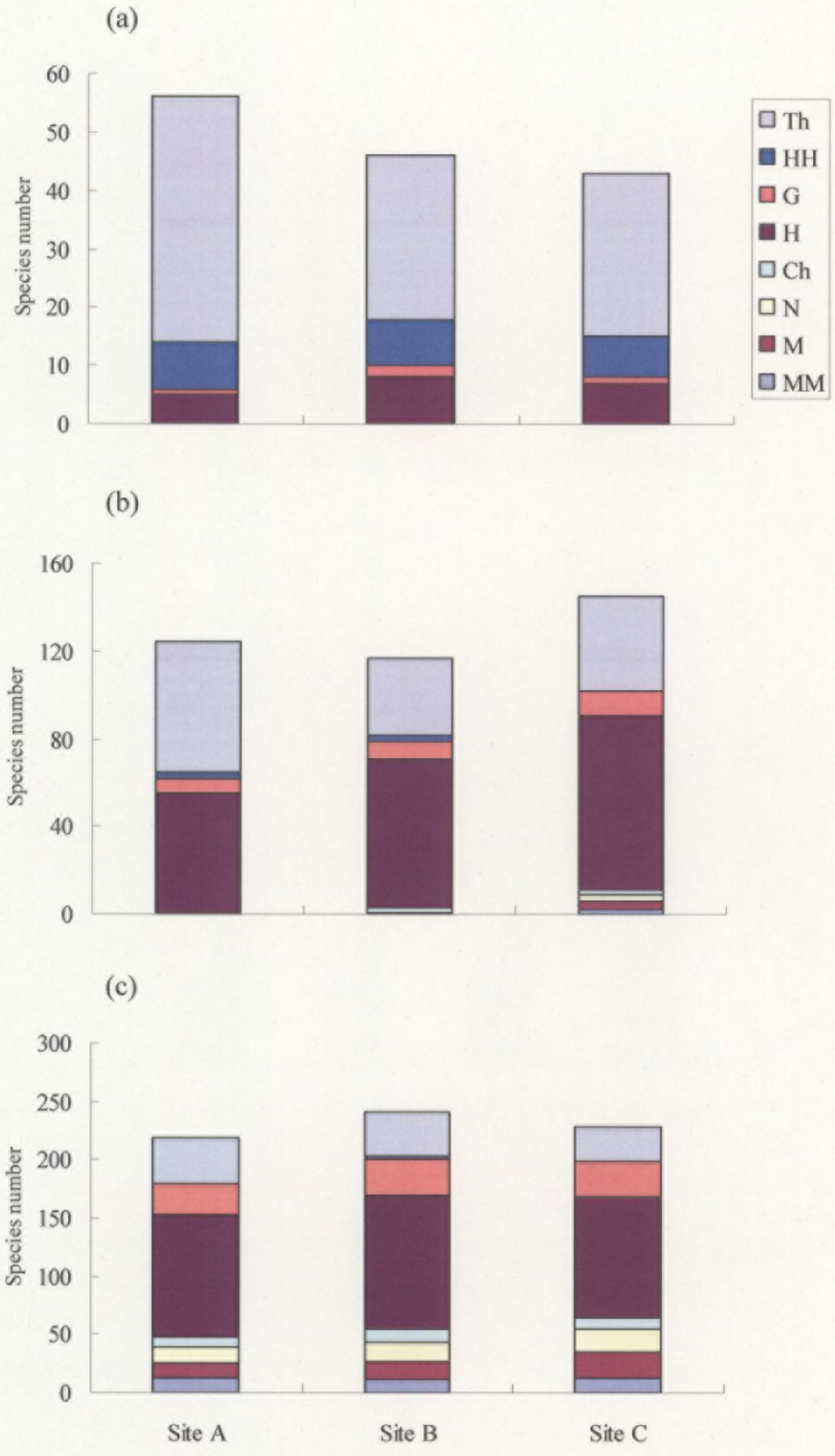
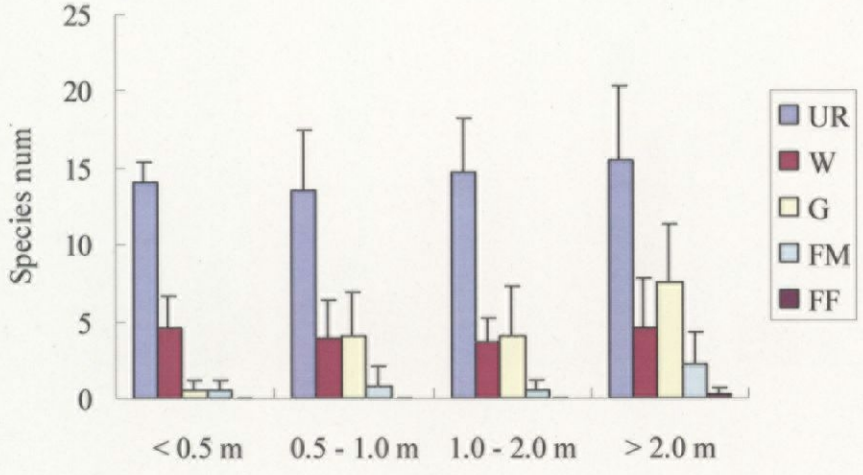


Figure 3.4-4 Dormancy forms of occurred species.

((a) Paddy field, (b) Levee, (c) Verge meadow; Th, therophyte, HH, hydrophyte or hygrophyte; G, geophyte; H, hemicryptophyte; Ch, chamaephyte; N, anophanerophyte; M, microphanerophyte; MM, mesophnerophyte and megaphanerophyte)

(a)



(b)

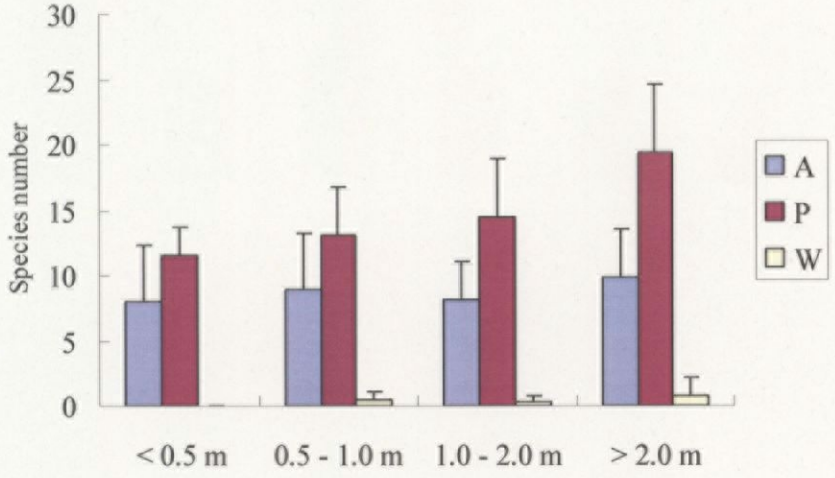


Figure 3.4-5 Mean species number (± S.D.) of each potential habitat type in Site C according to the difference in slope length.

((a) Potential habitat type, (b) Life history)

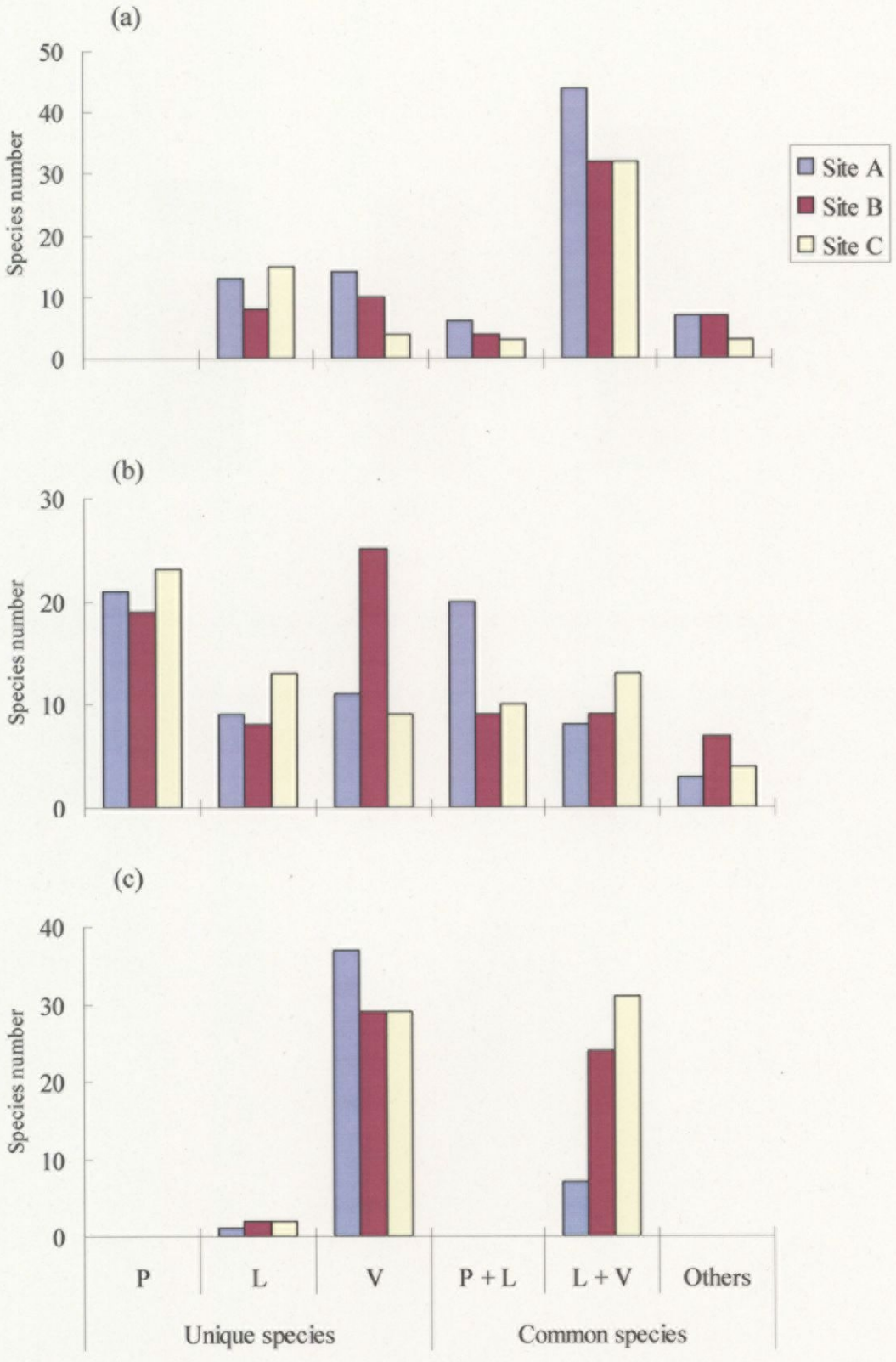


Figure 3.4-6 Common/unique species and recorded landscape element(s) of species in each potential habitat type.

(a) upland field or road-side species, (b) species favored of wet condition, (c) grassland species. (P, paddy field; L, levee; V, verge meadow).

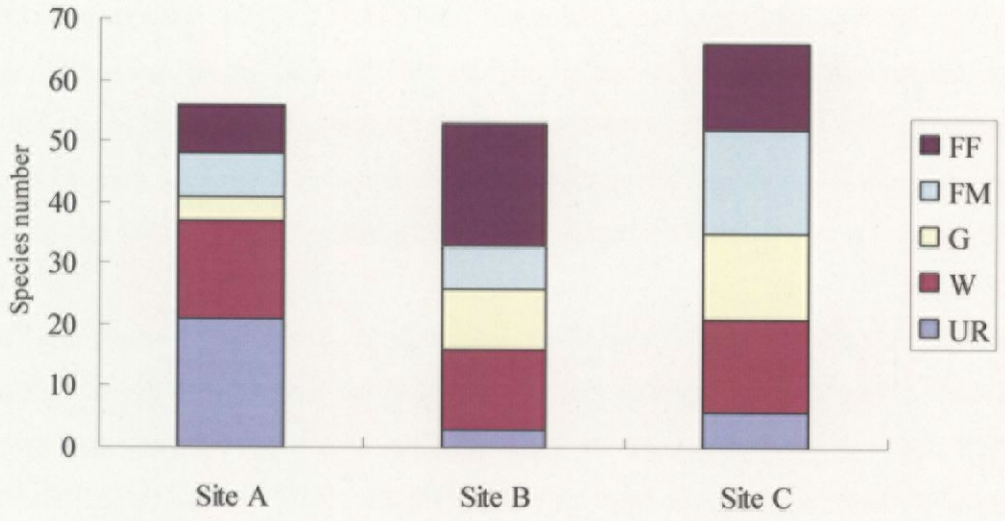


Figure 3.4-7 Potential habitat type of the unique species of inter-landscape scale.

(UR; upland field or road-side species, W; species favored of wet condition, G; grassland species, FM; forest-margin species, FF; forest-floor species)

3.5. Discussion

Field investigation into the 3 classified Yatsuda landscapes confirmed the differences in topography assumed on the basis of GIS analysis at the scale of the Kanto region. In levees, differences in composition in potential habitat types were observed in different geomorphic conditions (Figure 3.4-3 (b)). A similar trend was observed within Site C; longer levee slope is linked to the occurrence of grassland species (G species) and forest margin species (FM species).

The difference in floristic composition in levees was reported to correspond to geomorphic conditions. Characteristic species of Miscanthetea sinensis and Rosetea multiflorae were also seen in levees of paddy fields in mountains (Iiyama, *et al.*, 2002; Baba, *et al.*, 1991; Yamato, *et al.*, 1999). At Site A, levees were mostly composed of flat footpaths which were covered by soil from ditches in order to keep the height of footpaths. This soil addition, other than mowing, may prevent the persistence of perennial species in the study site. At Site C, soil addition was a rare event. Hence levees provided the habitat for perennials especially for hemicryptophyte.

Land consolidation in the 1990s might generally affect the floristic composition in the study site. Since number of exotic species in Site C was consistent according to slope length, one possibility is that land consolidation in Site A might enhance the invasion of these species. Arita & Kobayashi (2000) surveyed the difference in floristic composition between traditional Yatsuda paddy fields and consolidated paddy fields near the study site. Although some characteristic species in a traditional levee were not observed, dominant species and the ratio between annual species and perennials were similar to the present study.

Verge meadows were also substantially varied in the composition of potential habitat types. Although the differences were complicated, the habitat was characterized by abundant unique species. This suggests the high conservation value of verge meadows in Yatsuda landscapes, which corresponds with existing literatures (Kitazawa & Ohsawa, 2002; Okubo, et al., 2005; Kitagawa, et al., 2004).

Levees were, conversely, represented by a lower number of unique species. At Site C, although G species increased in number, few numbers of unique species were found in levees. This means less importance of conservation value than verge meadows unrelated to study sites.

Paddy fields were observed to have a higher ratio of unique species than levees, though the species number of unique species was similar to levees. These differences were assumed to derive from the differences in agricultural management regime. At Site A, rice was

harvested earlier than in the other two study areas. They unique species are abundantly recorded in the paddy fields after rice harvest. Repeated management regimes in paddy fields prevent the persistence of individual plant species. There is a relative abundance of places for various species to occur at Site A. Bare-soil after the rice-harvest provides an important habitat for weedy species especially in early season rice culture (Sakamoto, *et al.*, 1982). In fact, species occurred only in the Site A did not include winter annuals, of which the major growth period is spring. Moreover, in the study site, fallow paddy fields and paddy fields, which were soil-prepared but not cultivated for acreage reduction, were frequently observed compared to the other study sites. Seed representatives of paddy fields were dispersed via water (Appedix 3-1), hence the location of the seed source is likely to be another reason for the difference.