THE ANALYSIS AND DIAGNOSIS OF SOWN PASTURE VEGETATION
2. GROUPING AND CHARACTERIZATION THE SOWN AND WEED SPECIES BY MEANS OF PRINCIPAL COMPONENT ANALYSIS

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Summary

Analysis of the characteristics and the grouping of the species of sown and weeds in artificial pastures was studied applying the principal component analysis method. Presency and coverage of six sown species and fifteen weed species which occurred in pastures of under-grazing and optimum-grazing were subject to analysis. From field survey, species were divided into three groups: the group A included five species such as *Festuca arundinacea, Lolium perenne* and *Dactylis glomerata*, etc., the group B included eleven species such as *Polygonum longisetum, Agrostis alba* and *Rumex obtusifolius*, etc., and the group C included five species such as *Miscanthus sinensis, Rubus palmatus* and *Artemisia princeps*, etc. The group A species corresponded to good pasture conditions and management. On the contrary, the group C species occurred in poor pasture conditions with inadequate management. The group B species corresponded to intermediate pasture conditions and management. Interrelated pair species co-existing and species non-co-existing were discovered. Factor loading as negative for the group A species, positive for the group C species and positive but lower than the group C species for the group B species. From these results it is concluded that the principal component analysis seems to one of the useful tools for the analysis of characteristics of species and the diagnosis of sown pasture vegetation, although further studies are required to get more general information about species characteristics.

(**Key Words**: Characterization of Pasture Species, Diagnosis of Pasture Condition, Grouping Species in Pasture, Principal Component Analysis)

Introduction

In order to diagnose pasture conditions the characteristics of species which constitute the vegetation or indicator species should be known in the first place. Since weeds are useful indicators, they are tools to identify pasture conditions and serial stages (Okuda et al., 1985). However, in some pastures where there are only a few weed species, diagnosis requires the analysis of not only weed species but also the major component species, the sown species. To identify species characteristics and the indicator species involved, informations accumlated by numerous field observations have been used. But if the characterization of species is possible by means of the principal component analysis, it would be great help for diagnosis. The principal component analysis is a statistical method to summerize synthetically a large number of variables to a small number of characteristic variables. For vegetation study in which a large number of measurements should be processed the principal component analysis is helpfull in the task to reducing the number of data needed to describe a phenomenon through grouping the species as well as classifying the surveyed sites. Adoption of the principal component analysis was examined in fairly good pastures in the previous study (Kawanabe and Mukaiyama, 1990). Species groups such as the *Lolium perenne* group and the *Dactylis glomerata* group, etc. have been distinguished by values of correlation matrix. Five pasture types have been classified by the species with maximum value of frequency. Some connections between these pasture types and utilization of pasture, number of annual and perennial weed species and years after establishment have been found. The present study examines the principal component analysis in pastures showing both of good and degraded conditions in which a good deal

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of weeds are present.

Materials and Methods

The pasture on a Chichibu public livestock farm in Saitama prefecture, in the central part of Japan, were surveyed. The farm located in mountainous region. Pastures which have been established 12 years ago distributed on top and adjacent slope of the hill. Area of a paddock is 4.3 hectors in average and about 25 heads of holstein-friesian heifers have been grazed rotationally during April to November. The carrying capacity is about 240 cowdays per hector.

Seven paddocks out of 29 paddocks of the farm and two sites of each paddock, one near from the gate (about 0-50 m) and one far from the gate (about 100-250 m), were selected for survey. Most of the latter sites (B) were separated not only by distance but by topography from the former sites (A). The site A and the site B were received the same management except for grazing intensity. The sites B was nuder-grazed compared to the site A owing to obstructions to the movement of grazing animals. Quadrats of 1 × 1 m divided into nine subplots (33 × 33 cm) were used with 3-4 replications. The presency was measured with subplots of 33 × 33 cm, the coverage with a 1 × 1 m quadrat and plant height was measured with ten plants of each species. Data of the presency and the coverage were only processed for grouping and the principal component analysis. Representative weed species were treated but not all for analysis. For analyze the principal component a personal computor and the soft of the multivariate analysis were used. Values of mean, standard deviation, correlation matrix of the presency and the coverage of species, and factor loading of the first principal component were used for analysis. Meaning of the principal component was interpreted with factor loading of species, which is correlation between the principal component and original variable, together with general scientific informations of pasture management.

Results and Discussion

I. The difference of vegetation between the sites near and far from the gate.

The mean number of annuals and prennial weeds (except woody) and woody species appeared in the vegetation near the gate (site A) were 3.0, 1.9 and 0.1, respectively. Similarly, the number of these species appearing in the vegetation far from the gate (site B) were 3.7, 7.7 and 3.4, respectively. It is clear that vegetation in the site B has more weed species of perennial and woody than that in the site A.

The first, the second and the third species of summed dominant ratio (SDR) in the site A were *Dactylis glomerata* (Og), *Lolium perenne* (Pg) and *Festuca arundinacea* (Tf), respectively. Simlarly, these species of SDR in the site B were Og, *Agrostis alba* (Rt) and *Trifolium repense* (Wc), respectively.

The mean values in seven paddocks of the presency and the coverage are shown in table 1. The vegetation in the site A where there is no obstruction to the grazing behavior of cattle and which received grazing of proper intensity, displays favorable vegetation with abundant sown species and few weed species. On the contrary, the vegetation in the site B which received grazing of lax intensity shows a degenerated vegetation with more weed species and a few sown species. The vegetation in the site A had a significantly higher percentage of the presency and the coverage in Pg and Tf but other sown species such as Og, Rt, *Poa pratensis* (Kb) and Wc had not significant difference compared to that of the site B. This seems to indicate that Pg and Tf respond to better management and also that under better conditions but Og, Rt, Kb, and Wc respond to rather poor management.

The site B had more weed species than the site A such as *Miscanthus sinensis* (Ms), a dominant species in semi-natural hay fields, *Duchesnea chrysantha* (Dc) and *Rubus palmatus* (Rp), a woody weed. This seems to show that Ms, Dc and Rp respond to very poor pasture management and that their presence indicates very poor conditions in sown pasture.

The mean values of the presence and the coverage of species in the site A and B is shown in figure 1. The vegetation in the site A had a higher mean percentage of Pg, Tf, Og, *Digiteria adscendens* (Da) and *Plantago asiatica* (Pa); they were designated as group A species. The weeds which occurred in the vegetation of the site B but not in that of the site A were Ms, Rp, *Macleya cordata* (Mc), *Duchesnea chrysantha*

TABLE 1. PRESENCY AND COVERAGE OF VEGETATION IN THE SITES NEAR AND FAR FROM GATE (%, MEAN ± STANDARD DEVIATION)

Species	Presency Sites Near	Presency Sites Far (Sig.[c])	Coverage Sites Near	Coverage Sites Far (Sig.[c])
Dactylis glomerata[a]	66.0 ± 23.2	57.9 ± 31.2	33.6 ± 16.5	18.9 ± 10.5
Lolium perennea[a]	64.1 ± 35.4	15.7 ± 22.8**	32.4 ± 21.6	2.3 ± 5.6**
Agrostis alba[a]	42.1 ± 36.2	38.6 ± 38.3	21.4 ± 23.0	23.7 ± 25.4
Festuca arundinacea[a]	39.7 ± 14.6	0.8 ± 2.3**	21.6 ± 11.7	0.3 ± 0.8*
Trifolium repense[a]	37.0 ± 24.5	44.9 ± 21.3	6.3 ± 5.6	9.0 ± 7.9
Poa pratensis[a]	18.6 ± 25.5	27.0 ± 38.7	3.3 ± 4.5	10.1 ± 21.4
Erigeron annuus[b]	20.0 ± 13.6	24.7 ± 24.0	1.4 ± 1.4	1.7 ± 1.1
Pleioblastus Chino	12.9 ± 22.2	33.8 ± 43.6	3.4 ± 6.5	5.0 ± 9.2
Plantago asiatica	8.4 ± 11.4	1.7 ± 2.1	0.7 ± 0.9	0.3 ± 0.8
Polygonum longisetum[b]	7.3 ± 12.0	8.6 ± 11.2	0.7 ± 1.5	2.1 ± 3.4
Stellaria media[b]	4.4 ± 6.0	15.0 ± 34.5	0.4 ± 0.8	2.1 + 4.5
Digiteria adscendens[b]	4.4 ± 11.7	0 ± 0	1.0 ± 2.6	0 ± 0
Taraxacum officinale	3.1 ± 7.1	6.3 ± 6.4	0.4 ± 1.1	1.4 ± 2.7
Rumex obtusifolius	0.6 ± 1.5	0.4 ± 1.1	0 ± 0	1.1 + 3.0
Artemisia princeps	0 ± 0	7.3 ± 10.0	0 ± 0	1.9 ± 2.2
Duchesnea chrysantha	0 ± 0	7.0 ± 7.4*	0 ± 0	0.3 ± 0.8
Macleya cordata	0 ± 0	2.1 ± 3.1	0 ± 0	4.4 ± 6.4
Miscanthus sinensis	0 ± 0	17.7 ± 20.6*	0 ± 0	4.1 ± 6.6
Rubus palmatus	0 ± 0	13.3 ± 11.9*	0 ± 0	6.6 ± 8.6*
Stellaria aquatica[b]	0 ± 0	5.4 ± 9.3	0 ± 0	0 + 0
others	– ± –	± –	0.3 ± 0.5	14.2 ± 10.6**

Note; [a] Sown species.
[b] Annual weed.
[c] Statistical significance between site near and far from gate;
** $p < 0.01$, * $p < 0.05$.

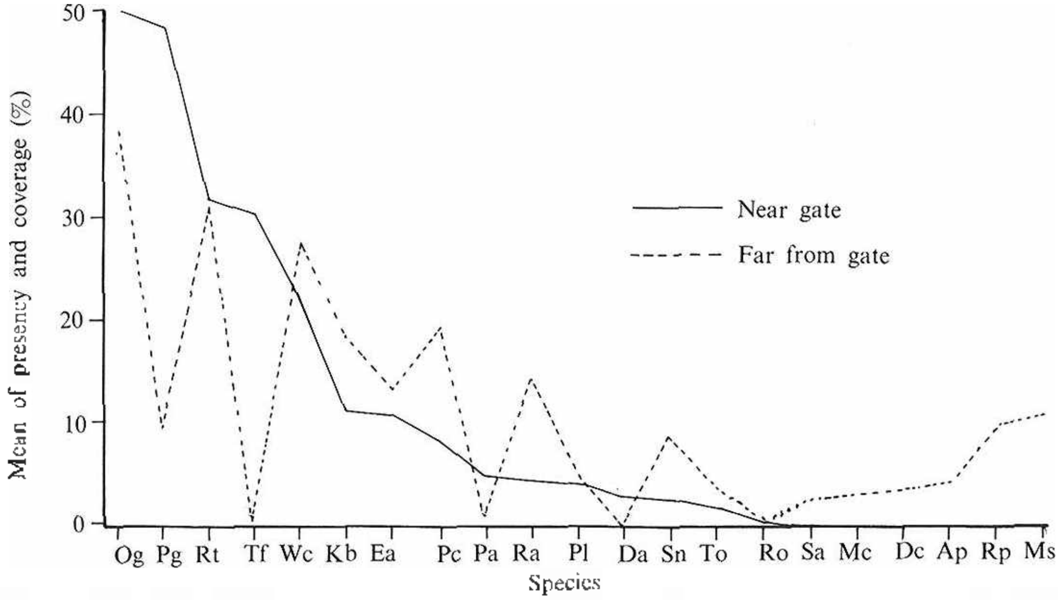

Figure 1. The mean values of presency and coverage of vegetations in sites near and far from gate (%)

(Dc), *Stellaria aquatica* (Sa) and *Artemisia princeps* (Ap); they were called group C species. These species which occurred in the vegetation of both sites were *Agrostis alba* (Rt), *Rumex obtusifolius* (Ro), *Polygonum longisetum* (Pl), *Trifolium repense* (Wc), *Poa pratensis* (Kb), *Erigeron annuus* (Ea), *Pleioblastus Chino* (PC), *Rumex acetosella* (Ra), *Stellaria media* (Sm), and *Taraxacum Officinale* (To); they designated as group B species. Especially large differences in the two sites were shown in Pg and Tf, indicating these species responded very sharply to the adequacy of management. It is considered that vegetation in the site B shows the physiognomy of abandoned pastures and is situated at a more advanced serial stage than that of the site A.

2. Correlation coefficient of species in presency and coverage.

The correlation coefficients of species which have values more than ± 0.4 are shown in table 2. There were high positive correlations between Tf and Pg, and Rp and Ap. However, there was a negative correlation among Tf, Pg and Rp, Ap.

The species which have a high positive correlation coefficient are considered generally to co-exist in definite environments and are species used in making combinations. On the other hand,

TABLE 2. CORRELATION COEFFICIENT OF PRESENCY AND COVERAGE[1]

Group	Species	0.5	0.5～0.4	−0.4～−0.5	< −0.5
A	Pg	Da, ***Pa***[2]	***Da***, ***Tf***, ***Wc***	Rp, ***Rt***	***Ap***, ***Dc***[3] ***Kb***
	Tf	Pg, Og, Da		Ap, ***Mc***, ***Ms***, ***Ms***, ***Rp***	***Ap***, ***Dc***
	Pa	***Pg***, ***Da***	Da, ***Ro***, Sn		
	Da	Tf, ***Pg***, ***Pa***	Pc, Pg	Ea	
	Og	Tf			Ms, ***Ms***
B	Sn	Pc, ***Pc***	Pa		
	Pl	Ra, Mc, ***Pc***, ***Sa***	Ro, ***Wc***		
	Ro	To, ***Ra***	***Ms***, ***Pa***, Pl		
	Ra	Pl, Mc, ***Ro***	***Ap***, ***Tf***		
	To	***Dc***, Ro		***Og***	
	Ea	***Ap***, ***Dc***		Pa	
	Pc	Sn, ***Sn***, Wc, ***Wc***, Sa, ***Sa***, ***Pl***	Ms, Pc		
	Wc	Sa, ***Sa***, ***Pc***, Pg, Ms	***Pl***	Pg	
	Rt		***Kb***, Sa	Pa, ***Pg***, ***Wc***	
	Kb		***Rt***, Sa	***Og***	***Pg***, Wc
	Sa	Pc, ***Pc***, ***Pl***, Wc, Ap, Rp, Ms, ***Ms***	Kb, Rt, Wc		
C	Dc	***Ap***, ***Ms***, ***To***			***Pg***, ***Tf***
	Mc	***Ap***, Pl, Ra, ***Rp***		***Tf***	
	Ap	***Dc***, ***Mc***, ***Rp***, Rp	***Ra***	Tf	***Pg***, ***Tf***
	Rp	***Ap***, Ap, Dc, ***Mc***		Pg, ***Tf***	
	Ms	***Dc***, ***Sa***, Wc	Pc, ***Pl***	***Og***, Tf	Og

Abbreviations of species;

Ap; *Artemisai princeps*, Da; *Digiteria adscendens*, Dc; *Duchesnea chrysantha*, Ea; *Erigeron annuus*, Kb; *Poa pratensis*, Mc; *Macleya cordata*, Ms; *Miscanthus sinensis*, Og; *Dactylis glomerata*, Pa; *Plantago asiatica*, Pg; *Lolium perenne*, Pc; *Pleioblastus Chino*, Pl; *Polygonum longisetum*, Ra; *Rumex acetosella*, Ro; *Rumex obtusifolius*, Rp; *Rubus palmatus*, Rt; *Agrostis alba*, Sa; *Stellaria aquatica*, Sm; *Stellaria media*, Tf; *Festuca arundinacea*, To; *Taraxacum officinale*, Wc; *Trifolium repense*.

1) Italic letters; Presency, Normal letters; Coverage.

2) Underline; Group A species.

3) Underline; Group C species.

those which have a negative correlation are considered generally to occur in the distinct environments and do not make combinations. These relationships of correlation and species combination may be useful in analyzing the characteristics of species and in diagnosing the conditions.

Tf and Pg occurred together abundantly in the site A, so it is estimated that this combination indicates fairly good pasture conditions receiving proper grazing pressure and good management. Similarly, Rp and Ap occurred together only in the site B, so it is estimated that this combination indicates very poor conditions receiving inadequate pasture management. Since the combinations of Tf and Pg, and of Rp and Ap have a negative correlation, it is estimated the both combinations occur in distinct environments.

These species which have a positive correlation with Tf and/or Pg in either or both the presency and the coverage are Pa, Da, Ro and Og. The character of these species seems close to that of Tf and Pg. These species agree with those species of the group A except Ro.

Similarly, these species have a positive correlation with either Rp and/or Ap, which may possess similar characteristics with Rp and Ap are Mc, Ms and Dc. These species agree with those species of the group C.

3. **Factor loading.**

Factor loading of the first principal component are shown in figure 2. These species of low values were Tf, Pg, Da, Pa and Og, which occurred abundantly in the site A but not much in the site B. These species belonged to group A. The species of high values were Ms, Rp, Ap, Mo and Dc; they occurred in the site B but not at all in the site A. These species belonged to group C. The species of intermediate value were Pl, To, Rt, Pc and Wc, etc. which occurred in the both sites including the species more abundant in the site B than in the site A. These species belonged to group C.

The sequence of factor loading of species seems roughly to correspond to the species occurring in the serial stage; the low values correspond to the initial stage and high values to the advanced stage. It is reported that Da, Pl, Ro and Sm are weed indicators of fertile pasture conditions; Rt, and Ra are indicators of infertile conditions and Ms is an indicator of very infertile conditions (Igarashi et al., 1983; Sakai, 1978; Sakai and Kawanabe, 1982). It should be pointed out that species in figure 2 in which species are arranged according to the value of factor loading, agree generally with indicator species in the sequence going from fertile to infertile.

Referring the species of the group A, B and C of this study to species of group classified to the initial, the optimum and the degenerated stages (Okuda et al., 1985), species group A correspond to the initial and the optimum stage; species group B to the optimum stage mostly

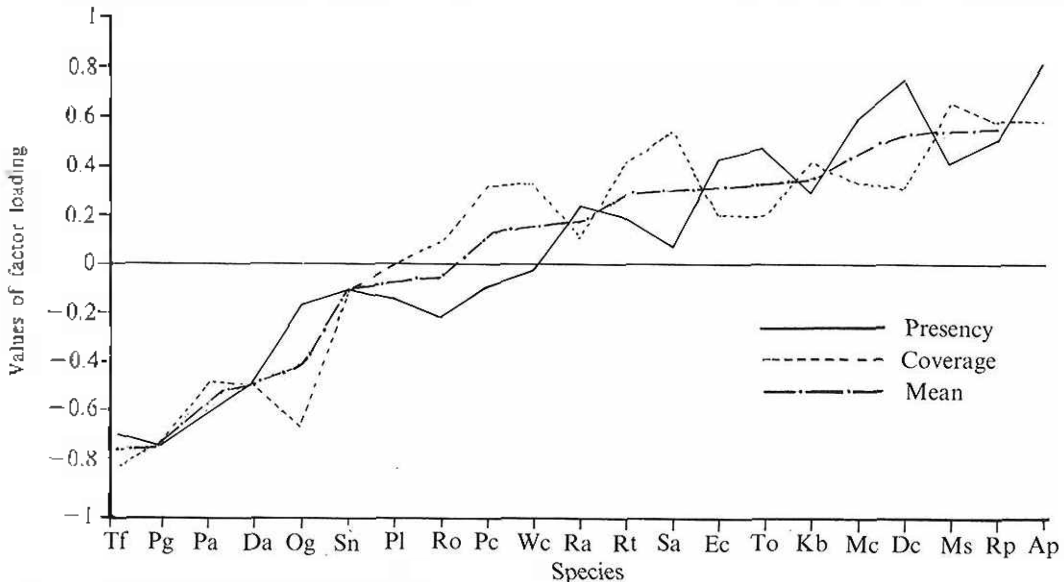

Figure 2. The factor loading of presency and coverage

and species group C to the degenerated and to the optimum stages. Although the grouping in this study and Okuda's grouping which was based on the serial stage of community is slightly different, these are likely no basic contradiction.

From these results, it is concluded that factor loading represent characteristics of species occurring in the vegetation in the sites near and far from the gate, and that the principal component analysis precisely evaluated the characteristics of species. However, since pasture vegetations are so delicate and heterogenous, further studies should be carried out to get more general information on the characteristics of each species.

In the present study, the serial change of species along with successional change in the extremely different vegetations is successfully analysed by means of the principal component analysis. But there will be cases in which factor loading do not correspond to the species occurring in successional sequence. However, the correlation matrix of each species may be useful even in such case to analyze interrelations and the grouping of the species.

The site B displayed the degenerated vegetation caused by under-grazing. It will be pointed out that in a humid temperate climate such as in Japan where plants grow luxuriously, under-grazing is more harmful for the maintainence healthy pasture conditions and production than over-grazing which tends to occur more frequently in arid climates.

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