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EFFECT OF CUTTING PATTERN AND FERTILIZATION LEVEL ON SPECIES DIVERSITY AND EVALUATION OF GRASSLAND QUALITY

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Abstract

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The effects of fertilization level and cutting pattern on the species diversity and quality of a meadow stand were assessed in 2004–2012 in the small plot trial established in 2003 in Vatín, Vysočina Region, Czech Republic. Four levels of fertilization (none; $N_0 + P_{30} + K_{60}$ kg·ha^{-1}; $N_{90} + P_{30} + K_{60}$ kg·ha^{-1}; $N_{180} + P_{30} + K_{60}$ kg·ha^{-1}) were combined with four treatments of exploitation intensity (4 cuts per year, first cut on 15th May, every next after 45 days; 3 cuts per year, first cut on 30th May, every next after 60 days; 2 cuts per year, first cut on 15th June, next after 90 days; 2 cuts per year, first cut on 30th June, next after 90 days). Numbers of species, Simpson's diversity index and evaluation of grassland quality according to Novák (2004) were evaluated. Numbers of species and Simpson's diversity index were significantly affected by both fertilization level and cutting pattern. Species richness decreased along with increasing fertilization rates from 29.4 (no fertilization) to 27.8 (N180PK). When comparing cutting pattern treatments the highest species richness was found in four-cut swards (29.6 in average of fertilization levels) and it declines towards late double-cut regime (27.2). The Simpson's index generally increased from two-cut swards to four-cut and from fertilized treatments to control. Grassland quality was significantly affected by cutting pattern. Values increased from four-cut swards (38.1) to two-cut ones (43.8 and 44.0 in early and late harvest respectively).

Keywords: permanent meadow, Simpson's index, grassland nutrition, cutting frequency, species richness

INTRODUCTION

The distribution of grasslands and their floristic composition is related to the climate at the largest scale. Particular grassland is affected by bedrock, soil, water regime, altitude, nutrient status, local climate, disturbance etc (Gibson, 2009). As the most of grasslands in the Czech Republic are secondary communities developed as a result of human activities (Rychnovská *et al.*, 1985), their maintenance and composition depend also on system of cultivation and utilization (Klimeš, 1999; Klimek *et al.*, 2007). Grasslands provide not only production functions but also large scale of ecosystem services such as nutrient cycling, sequestration of carbon dioxide, prevention of soil loss and many others. Ability of grasslands to afford both production and ecosystem functions depends among others on the floristic composition (Chytrý, 2007). Semi-natural permanent meadows, as a result of the concurrence of many factors, represent a great reservoir of biodiversity. The aim of this contribution is to asses the effect of intensity of grassland management on its species diversity and fodder quality.

MATERIALS AND METHODS

A small plot trial was established in 2003 within the permanent meadow, which was set up in the 1990s. Site is located near Vatín, Vysočina Region, Czech Republic, in the floodplain of the Oslava River, at 535 m above sea level. Annual rainfall average is 618 mm; mean annual temperature is 6.9 °C. Soil is gleyic fluvisol on the quaternary fluvial deposits, bedrock is biotitic gneiss. The trial was designed in the form of split blocks with four replications. Area of the plot was 10 m^2. There were four treatments of nutrition level combined with four treatments of cutting intensity. Cutting pattern is described in Tab. I. Nutrition levels are described in Tab. II. Total amount of nitrogen was dosed in a ratio of 1:1:1:0, 1:1:1 and 1:1 in four-cut, three-cut and two-cut treatments respectively. Cover of each species was assessed by cover estimation method right before the first cut of the year. Average values from years 2004–2012 are presented in this paper. Results were processed through ANOVA in the STATISTICA software. To quantify species diversity Simpson's diversity index was used. It equals:

$$Sim = \frac{1}{\sum(p_i^2)},$$

where

p .... proportional cover of i-th species (Ricklefs and Miller, 1999).

Grassland quality was evaluated according to Novák (2004):

$$E_{GQ} = \frac{\sum(D_i \times FV_i)}{8},$$

where

E_{GQ} ... evaluation of grassland quality,
D ..... cover of i-th species,
FV .... forage value of i-th species.

RESULTS AND DISCUSSION

The effects of both fertilization level and cutting pattern on species richness were highly significant (Tab. III). When averaging cutting pattern treatments, the total number of species decreased along with increasing fertilization rates from 29.4

I: *Description of cutting pattern treatments*

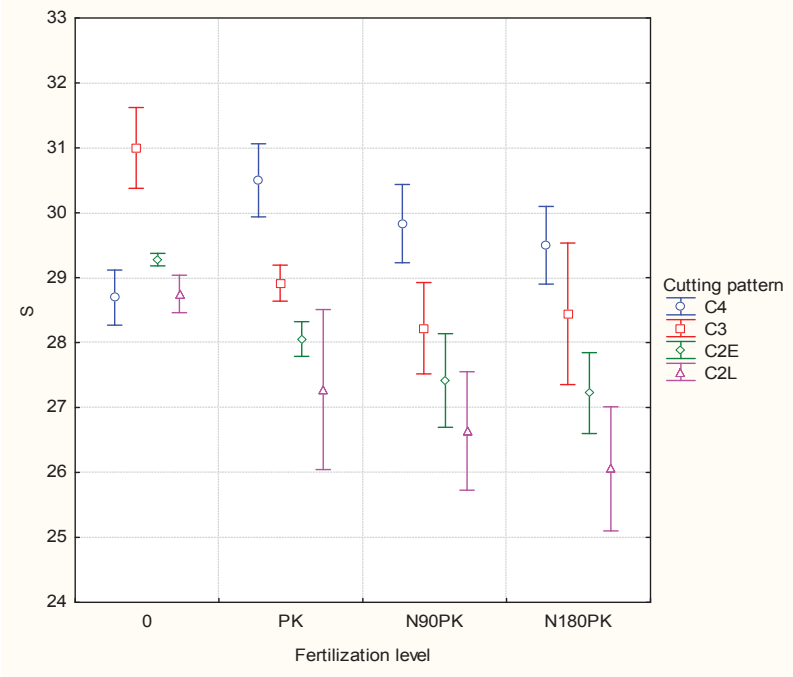
Cutting pattern	1st cut	2nd cut	3rd cut	4th cut
4 cuts (C4)	May 15	June 30	Aug. 15	Sept. 30
3 cuts (C3)	May 30	July 30	Sept. 30	-
2 cuts early (C2E)	June 15	Sept. 15	-	-
2 cuts late (C2L)	June 30	Sept. 30	-	-

II: *Description of fertilization level treatments*

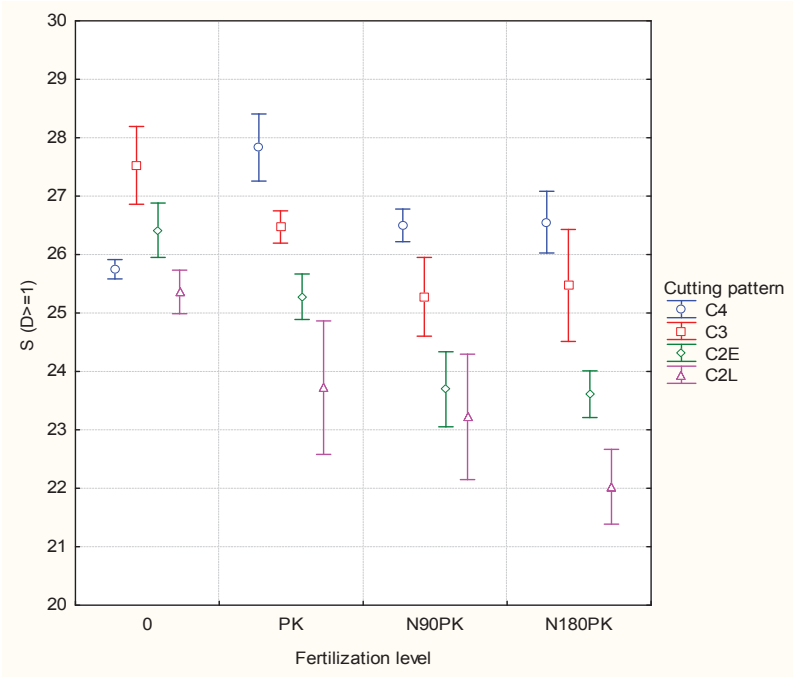
Fertilization level	kg.ha^{-1}.year^{-1}		
	Nitrogen	Phosphorus	Potassium
0	0	0	0
PK	0	30	60
N90PK	90	30	60
N180PK	180	30	60

III: *Mean values of evaluated parameters (s = number of species; S (D > = 1) = number of species with cover > = 1%; S (D > 1) = number of species with cover > 1%; Sim. = Simpson's diversity index; E_{GQ} = evaluation of grassland quality)*

Factor	Level	S	S (D > = 1)	S (D > 1)	Sim.	E_{GQ}
A – fertilization level	0	29.4	26.3	18.5	13.7	40.7
	PK	28.7	25.8	17.5	13.0	43.8
	N90PK	28.0	24.7	17.4	12.5	41.0
	N180PK	27.8	24.4	17.0	11.8	42.5
	p-value	**< 0.01**	**< 0.01**	**< 0.01**	**< 0.01**	0.15
B – cutting pattern	C4	29.6	26.7	18.6	13.8	38.1
	C3	29.1	26.2	17.9	13.5	42.2
	C2E	28.0	24.8	17.3	12.2	43.8
	C2L	27.2	23.6	16.7	11.5	44.0
	p-value	**< 0.01**	**< 0.01**	**< 0.01**	**< 0.01**	**< 0.01**
A × B	p-value	0.16	0.07	0.44	0.14	0.36

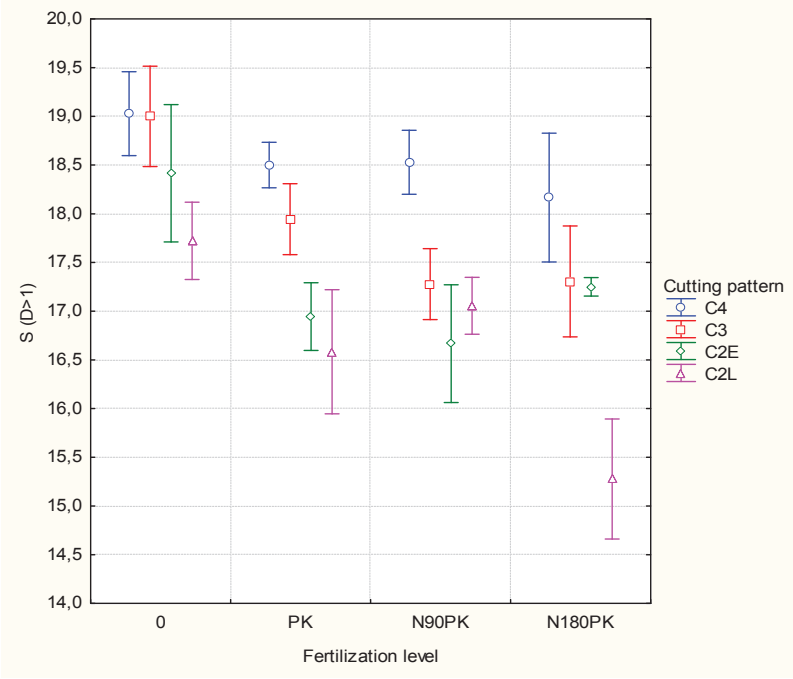


1: *Species richness (S) in relation to cutting pattern and fertilization level interaction (error bars represent standard error)*

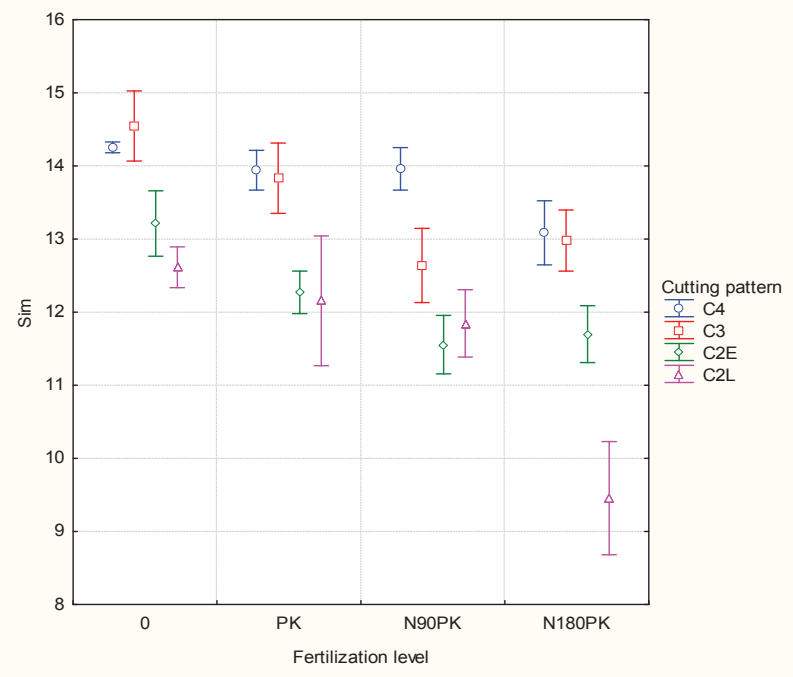


2: *Number of species S(D ≥ 1) in relation to cutting pattern and fertilization level interaction (error bars represent standard error)*

(no fertilization) to 27.8 (N180PK). As well numbers of species with cover of 1% and more – S (D ≥ 1) and S (D > 1) – showed this relation. When concerning the interaction, there were maximal counts detected in non-fertilized plots within each treatment of cutting pattern. Just one exception occurred: four-cut control swards had only 28.7 species, which is lower than any other fertilization level within this cutting pattern (Fig. 1). The absolutely highest species richness was observed in three-cut non-fertilized plots (31.0), whilst the lowest was in two-late-cut swards receiving highest fertilization rates (26.1). Trends in the group S (D ≥ 1) were very similar (Fig. 2). After separating accessory taxa, numbers

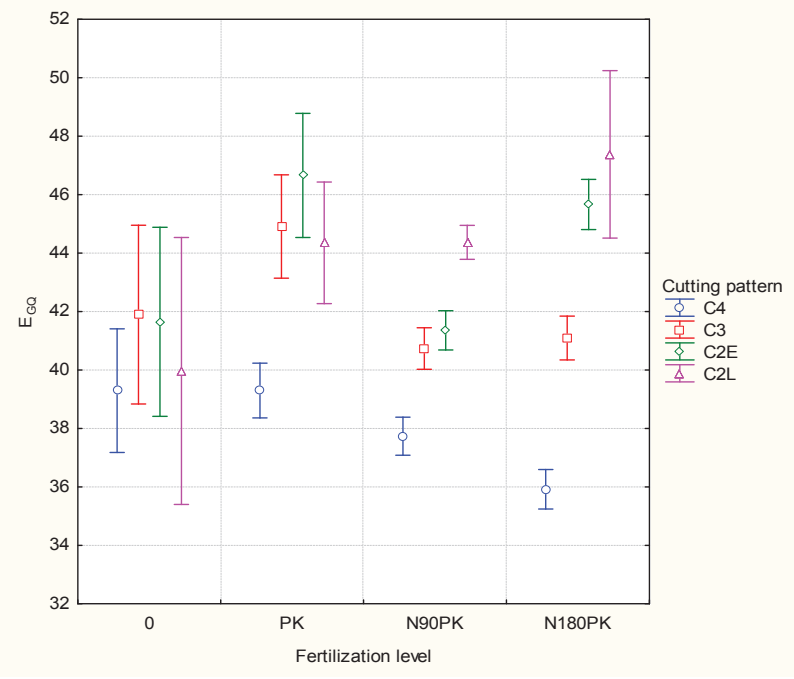


3: *Number of species S(D > 1) in relation to cutting pattern and fertilization level interaction (error bars represent standard error)*



4: *Simpson diversity index (Sim.) in relation to cutting pattern and fertilization level interaction (error bars represent standard error)*

of species were highest in control plots in every cutting pattern. Numbers of species reaching more than 1% of cover ranged from 15.3 in two-late-cut swards receiving N180PK to 19.0 in four-cut non-fertilized ones. Decrease of species richness due to the nitrogen fertilization was described by Mrkvička and Veselá (2002), yet the decrease was detected in accessory species, whereas the group S (D ≥ 1) was more or less equal across fertilization treatments. Socher *et al.* (2013) assumed that lower species richness on fertilized plots was possibly caused by a competitive advantage of tall grasses over smaller species. Also Hejcman *et al.* (2007) reported on higher species richness in swards



5: *Evaluation of grassland quality (E_{GQ}) in relation to cutting pattern and fertilization level interaction (error bars represent standard error)*

without nitrogen and phosphorus fertilization and pointed out that there was a clear trend towards a decrease of species richness with increased actual sward height. Data from the long-term Park Grass experiment clearly showed a negative effect of biomass yields on species richness (Silvertown *et al.*, 2006).

When comparing cutting pattern treatments, species richness increased together with harvest intensity from 27.2 species (C2L) to 29.6 (C4). Maximal numbers of species were always found in four-cut plots except the case mentioned above. Low numbers were detected within two-cut management, especially in late date of harvest in combination with high rates of fertilization. Species diversity expressed by Simpson's diversity index was significantly affected by the fertilization level as well as the cutting pattern (Tab. I). Generally, the index showed increasing trend of from two-cut levels towards four-cut levels of cutting management and the same trend was observed from fertilized to control conditions. Maximum and minimum of the index were 14.55 and 9.46 (Fig. 4). These values were obtained in the most and the least species-rich treatments, respectively. The grassland quality was significantly affected by cutting pattern, while the fertilization had no significant impact. Values increased from four-cut swards (38.1 on average throughout all fertilization levels) to two-cut ones (43.8 and 44.0). Quality of four-cut swards was evaluated as the worst here, what is in contradiction with outcomes of chemical analyses. Formerly published results of this trial (Hrabě and Knot, 2011) as well as parallel trial in Jevíčko (Nerušil *et al.*, 2008) reported better values of qualitative parameters (e. g. crude protein, fibre, NEL) of forage from four- and three-cut swards and summarized that number of cuts had a crucial effect on fodder quality. The explanation of this could be simple. Evaluation of grassland quality according to Novák (2004) is estimation based on fodder value of each species. Extensive harvest pattern supports the dominance of valuable species, yet at the same time the herbage is harvested too late in its inappropriate phenological phase. Raus *et al.* (2012) reported that higher number of mowings per year caused expansion of grasses at the expense of non-leguminous forbs which are generally found less valuable. There were also detected some shifts within the group of grasses. For example *Phleum pratense* which is considered to be one of the most valuable grass species tripled its abundance under C2L management compared to C4. At the same time the proportion of less valuable *Festuca rubra* retrieted. Skládanka and Hrabě (2008) stated that grassland quality according to Novák was lower at three-cut utilization compared to two-cut, especially because of enhancement of unvalued *Ranunculus* species and other forbs.

CONCLUSIONS

Cutting pattern significantly affected species diversity of the meadow stand. Numbers of species as well as values of Simpson index increased together with harvest intensity. On the contrary grassland quality was higher in double-cut swards compared to more intensive cutting patterns. It suggests that there were growing more valuable plants within double-cut swards. Fertilization level also caused

significant differences in both species richness and the Simpson index. The highest values of all diversity indices were detected in non-fertilized plots, while the lowest were in plots receiving N180PK. The significant impact of fertilization level on grassland quality was not proved.

SUMMARY

The effects of fertilization level and cutting pattern on the species diversity and quality of a meadow stand were assessed in years 2004–2012. The small plot trial was established in 2003 in Vatín, Vysočina Region, Czech Republic. Four treatments of nutrition level and four treatments of cutting pattern were combined. Cutting pattern: C4 – four cuts per year, first cut on 15th May, every next after 45 days; C3 – three cuts per year, first cut on 30th May, every next after 60 days; C2E – two cuts per year, first cut on 15th June, next after 90 days; C2L – two cuts per year, first cut on 30th June, next after 90 days. Nutrition levels: no fertilization; $N_0 + P_{30} + K_{60}$ kg·ha^{-1}; $N_{90} + P_{30} + K_{60}$ kg·ha^{-1}; $N_{180} + P_{30} + K_{60}$ kg·ha^{-1}. Numbers of species, Simpson's diversity index and grassland quality according to Novák were evaluated. Numbers of species and Simpson's diversity index were significantly affected by both fertilization level and cutting pattern. Species richness decreased along with increasing fertilization rates from 29.4 (no fertilization) to 27.8 (N180PK). Numbers of species after separating accessory taxa showed very similar trends. When comparing cutting pattern treatments the highest species richness was found in four-cut swards (29.6 on average of fertilization levels) and it declines towards late double-cut regime (27.2). Concerning the interaction, absolutely highest species richness was found in three-cut non-fertilized plots (31.0), whilst the lowest was in late double-cut swards receiving highest doses of fertilization (26.1). The Simpson's index generally increased from two-cut swards to four-cut and from fertilized treatments to control. Grassland quality was significantly affected by cutting pattern, while the fertilization had no significant effect. Values increased from four-cut swards (38.1 on average of fertilization levels) to two-cut ones (43.8 and 44.0 in early and late harvest respectively).

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REFERENCES

CHYTRÝ, M. (ed.). 2007. *Vegetace České republiky. 1. Travinná a keříčková vegetace*. Praha: Academia, 528 p.

GIBSON, D. J. 2009. *Grasses and Grassland Ecology*. New York: Oxford University Press.

HEJCMAN, M., KLAUDISOVÁ, M., SCHELLBERG, J., HONSOVÁ, D. 2007. The Rengen grassland experiment: plant species composition after 64 years of fertilizer application. *Agriculture, Ecosystems and Environment*, 122(2): 259–266.

HRABĚ, F., KNOT, P. 2011. The effect of trophism level and exploitation intensity on the production characteristics of grassland community dominated by *Festuca arundinacea* Schreb. *Plant, Soil and Environment*, 57(4): 160–165.

KLIMEK, S., RICHTER gen. KEMMERMANN, A., HOFMAN, M., ISSELSTEIN, J. 2007. Plant species richness and composition in managed grasslands: The relative importance of field management and environmental factors. *Biological conservation*, 134(4): 559–570.

KLIMEŠ, F. 1999. Phytocenologic relationships in pasture stands. *Rostlinná výroba*, 45(5): 205–211.

MRKVIČKA J., VESELÁ M., 2002: Influence of fertilization rates on species composition, quality and yields of the meadow fodder. *Rostlinná výroba*, 48(11): 494–498.

NERUŠIL, P., KOHOUTEK, A., KOMÁREK, P., ODSTRČILOVÁ, V. 2008. Effects of utilisation intensity and fertilization level on forage production and quality of permanent grassland on a fluvisoil. *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis*, 56(5): 153–162.

NOVÁK, J. 2004. Evaluation of grassland quality. *Ekológia*, 23(2): 127–143.

RAUS, J., KNOT, P., HRABĚ, F. 2012. Effect of fertilization and harvest frequency on floristic composition and yields of meadow stand. *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis*, 60(5): 181–186.

RICKLEFS, R. E., MILLER, G. L. 1999. *Ecology*. 4th edition, New York: W H. Freeman.

RYCHNOVSKÁ, M., BALÁTOVÁ-TULÁČKOVÁ, E., ÚLEHLOVÁ, B., PELIKÁN, J. 1985. *Ekologie lučních porostů*. Praha: Academia.

SILVERTOWN, J., POULTON, P., JOHNSTON, E., EDWARDS, G., HEARD, M., BISS, P. 2006. The Park Grass Experiment 1856–2006: its contribution to ecology. *Journal of Ecolgy*, 94(4): 801–814.

SKLÁDANKA, J., HRABĚ, F. 2008. Effect of fertilization and cutting frequency on botanical composition, diversity and grassland quality. *Agriculture (Poľnohospodárstvo)*, 54(1): 1–13.

SOCHER, S. A., PRATI, D., BOCH, S., MÜLLER, J., BAUMBACH, H., GOCKEL, S., HEMP, A., SCHÖNING, I., WELLS, K., BUSCOT, F., KALKO, E. K. V., LINSENMAIR, K. E., SCHULZE, E. D., WEISSER, W. W., FISCHER, M. 2013. Interacting effects of fertilization, mowing and grazing on plant species diversity of 1500 grasslands in Germany differ between regions. *Basic and Applied Ecology*, 14(2): 126–136.

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