EKOLOGIA POLSKA (Ekol. pol.)	22	3/4	527–534	1974

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ANALYSIS OF A SHEEP PASTURE ECOSYSTEM IN THE PIENINY MOUNTAINS (THE CARPATHIANS)

V. HERBIVORES AND THEIR EFFECT ON PLANT PRODUCTION*

ABSTRACT: Moderate grazing of a mountain pasture resulted in greater plant production. In comparison with the production of a non-fertilized pasture the production increase on an intensively fertilized pasture (sheep-folds) was much higher (by 471 g/m^2/season) than on a pasture fertilized only when driving sheep (by 143 g/m^2/season). The sheep consume about 90% of above-ground plant production. There are very few phytophagous insects on above-ground parts of plants and their consumption is probably of little significance in pasture production.

1. INTRODUCTION

This paper presents part of the work of a research team studying the functioning of a mountain pasture ecosystem. The aim of this paper is (1) to determine the composition and density of phytophagous animals on the pasture and (2) to analyse their effect on primary production. The studies were conducted in 1971.

2. INVESTIGATED AREA

The pasture examined is in the Małe Pieniny range near Jaworki, and runs along the Potok Skalski (the Skalski Stream) at an altitude 700 m above sea-level. The pasture is

*Praca wykonana w ramach problemu węzłowego nr 09.1.7 (grupa tematyczna „Produktywność ekosystemów trawiastych").

covered by a plant association *Lolio-Cynosuretum* R. Tx. 1937, belonging to the class *Molinio-Arrhenatheretea* R. Tx. 1937, (T r a c z y k and K o c h e v 1974) which has replaced former associations.

The vast pasture, covering about 100 ha of differentiated relief and vegetational cover, is being grazed by sheep. The sheep graze while they are being driven through the pasture. At night and during milking the sheep are locked in small fenced areas, the so-called sheep-folds, 25 × 50 m (1250 m^2) in area. The sheep-folds are systematically shifted every 2 or 3 days according to the rainfall.

The grass on the piece of pasture with a sheep-fold is trodden by sheep and is covered by a thick layer of faeces. In rainy periods the grass is more damaged and the faeces are trampled and mixed with the washed away soil covering the entire sheep-fold with a uniform crust. In conditions of such high organic fertilization the place where the sheep-fold has been becomes covered with lush grass within a few weeks, but the sheep being at first reluctant to consume this. Only after 2–3 months can the pasture be used for sheep grazing.

The places of former sheep-folds differ basically from other parts of the pasture in the amount and dosage of organic fertilization, and thus in vegetational cover.

Two stations *P* and *PF* have been chosen in order to analyse the effect of phytophagous animals on the pasture vegetation.

P – the pasture called Sheep Way (Owcza Droga), where from May to October the sheep were driven about three to four times a day and the sheep grazing there left behind a certain amount of faeces. According to the data of O l e c h o w i c z (1974) the amount of faeces left on the pasture during the season was 360 mg/m^2.

PF – (sheep-fold) – part of pasture where once a year there is a sheep-fold. The amount of faeces produced there during 2–3 days was about 510 g/m^2 (O l e c h o w i c z 1974). The sheep-fold was usually put up early in spring (end of April, beginning of May) or in autumn just before the sheep leave the pasture. At the time the studies began the sheep-fold had not been there for six months.

3. METHODS

The composition and density of phytophagous insects were analysed from samples taken by a biocenometer, i.e. the insects were caught on a pasture surface 30 × 30 cm covered with a cuboidal net. On each site 20 samples were taken once a month. A sucking apparatus was used to take the insects out from under the net.

The effect of sheep on the pasture production and the amount of grass consumed by them on the pasture were analysed by protecting small surfaces against grazing. Fifteen wooden frames, 0.5 × 1.0 m, protected from above with metal netting were placed on the pasture. The frames remained in the same places for about 5 weeks, and then were shifted to surface grazed by sheep. Just before shifting the frames samples of plants were taken on the pasture and under the frames. The botanical samples were taken using a method already described by T r a c z y k (1968). The plants were cut close to the ground from circles of a diameter 33 cm. Series of 15 samples were taken once on the pasture and from under the frames.

Before the grazing took place, on both sites, a fence made of poles was placed on a surface 1 × 3 m in order to protect this surface from grazing during the season. It was therefore possible to calculate the production of above-ground pasture vegetation using the "maximal yield" method (T r a c z y k 1971). The production was the sum of samples taken in the period of the maximal biomass of the above-ground parts of the plants (August) and of samples collected at the beginning of October.

All plant samples were divided into green and dead parts, but no division into species was made. After oven-drying, the plants were weighed and the biomass was calculated per square metre of pasture surface.

The subject of this study is the determination of plant production, expressed as dry weight per square metre under different conditions of fertilization and utilisation of the pasture.

4. RESULTS

4.1. Biomass of above-ground parts of plants

Due to constant grazing of the plants by sheep on the pasture the changes in biomass are not great, and especially considering the height of the plant cover. This is mainly true in the case of a site with a small supply of organic fertilizer – Sheep Way. During the season the biomass levels range from 24.5 to 102.4 g/m^2. The weight of green plant parts is smallest in the autumn, when the sheep are leaving the pasture, and is highest at the end of June (Tab. I).

Tab. I. Biomass of green and dead parts of plants on pasture with low fertilization (*P*) in g d.wt./m^2 (1971)

	28 IV	25 V	27 VI	5 VII	2 IX	14 X
Green plant parts	63.3	75.7	102.4	50.5	55.1	24.5
Dead plant parts	93.9	84.8	51.1	39.2	44.5	30.9

The biomass of green plant parts on pasture supplied with a great amount of organic fertilizer (sheep-fold) is similar, although much more variable. The lowest biomass is 36.1 g/m^2, and the highest – over 189 g/m^2 (Tab. II).

Tab. II. Biomass of green and dead parts of plants on pasture with high fertilization (*PF*) in g d.wt./m^2 (1971)

	13 V	16 VI	4 VII	6 VIII	28 VIII	2 X
Green plant parts	44.3	159.4	189.7	156.1	74.1	36.1
Dead plant parts	20.0	36.8	62.9	118.9	100.2	95.4

As has been already mentioned the height of pasture sward does not change much, i.e. the part of plant production left by the sheep. Therefore, the changes in plant biomass during the season are mainly the result of increasing plant density and their strong tillering (P l e w c z y ń s k a - K u r a ś 1974) – the reaction of plants to intensive grazing and treading by sheep.

4.2. P h y t o p h a g a n s

The main consumers of the production of green plant parts on the pasture are sheep. A flock of about 700 sheep has been driven about 4 times a day across the examined site.

The most abundant phytophagous insects on the above-ground plant parts of the pasture belong to the *Homoptera* (suborders: *Auchenorrhyncha* and *Aphidodea*).

The leafhoppers (*Auchenorrhyncha*) are found in small numbers during the entire vegetation season, but are slightly more abundant on a more fertilized pasture (*PF*), about 3 ind./m^2, and on site *P* 1.5 ind./m^2. Analogously, the numbers of *Auchenorrhyncha* hatched during the vegetation season are higher on *PF*, 28 ind./m^2, than on *P*, 12 ind./m^2.

The aphids (*Aphidodea*) appear at the end of June and at the beginning of July, attaining a relatively high density on strongly fertilized areas. The maximal density on *PF* early in July is 30.2 ind./m^2, and 6.7 ind./m^2 on *P*. The aphids come from the neighbouring environments, especially from places overgrown with nettles. Such a high abundance of aphids does not last long. During a week their abundanc' is reduced to about 0.1 ind./m^2.

The *Diptera*, although abundant, are for the most part saprophagous (98%). Within the remaining 2% there are phytophagous, and predatory ones (O l e c h o w i c z 1974).

Sporadically, single specimens of the grasshoppers (*Orthoptera*) appear on the pasture. They are more numerous on the areas adjoining the pasture and those not used for grazing. There, and on the pasture itself, but in places not trodden by sheep (rubble overgrown with stinging nettles, heaps of cut juniper), are colonies of field-voles. Their home ranges undoubtedly extend onto the pasture and in periods of their great abundance, field-voles may participate considerably in the utilization of plant production on the pasture. However, this has not been estimated here.

4.3. C o n s u m p t i o n b y p h y t o p h a g a n s

The production of above-ground parts of plants on the pasture was calculated from the difference in biomass between the areas protected against sheep grazing and of the pasture. Then the biomass of plant growth obtained for periods of several weeks was summed for the whole period of sheep grazing on the pasture, i.e. from May to October, which is the equivalent of the vegetation season. Thus calculated, the production of the above-ground plant parts was 554.2 on *P* and 957.2 g dry plant weight/m^2 on *PF* (Figs. 1, 2).

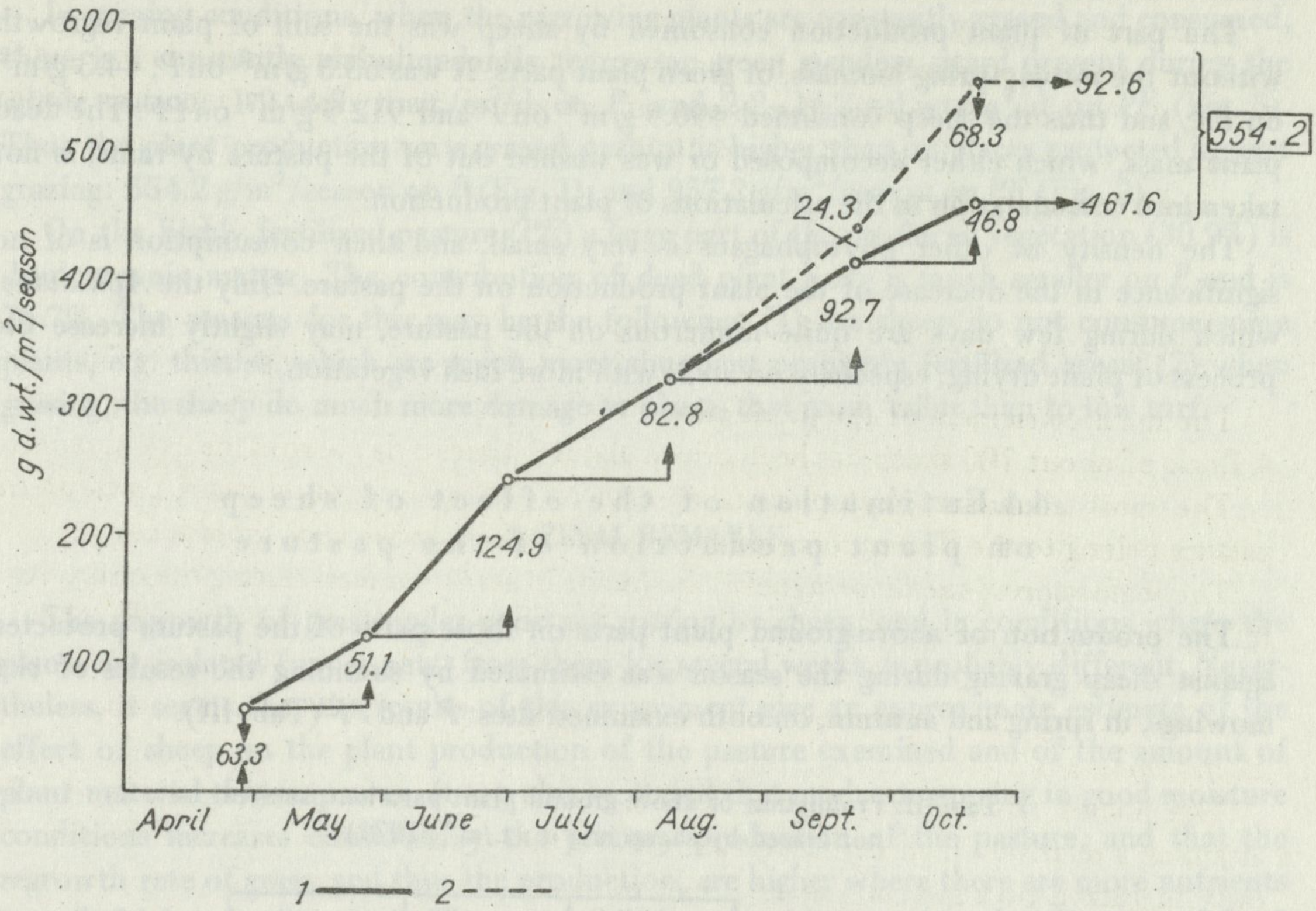

Fig. 1. Production of above-ground plant parts on Sheep Way (*P*) grazed by sheep

1 – green plant parts, *2* – dead plant parts

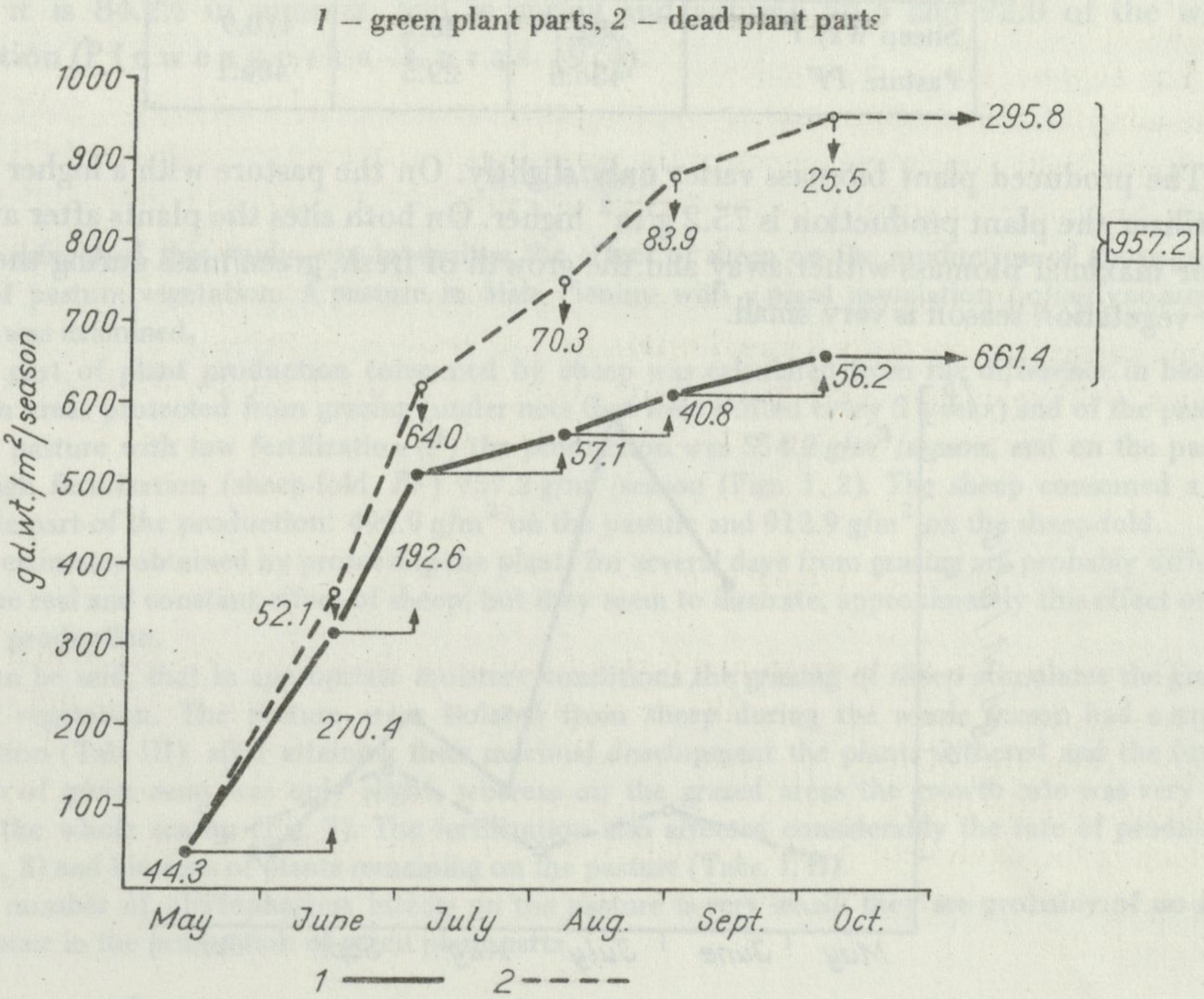

Fig. 2. Production of above-ground plant parts on a sheep-fold (*PF*) grazed by sheep

1 – green plant parts, *2* – dead plant parts

The part of plant production consumed by sheep was the sum of plant regrowth without the initial, spring biomass, of green plant parts. It was 63.3 g/m^2 on *P*, 44.3 g/m^2 on *PF*; and thus the sheep consumed 490.9 g/m^2 on *P* and 912.9 g/m^2 on *PF*. The dead plant mass, which either decomposed or was washed out of the pasture by rains, is not taken into consideration in the calculations of plant production.

The density of other phytophagans is very small, and their consumption is of no significance in the decrease of the plant production on the pasture. Only the *Aphididae*, which during few days are quite numerous on the pasture, may slightly increase the process of plant drying, especially on areas with more lush vegetation.

4.4. Estimation of the effect of sheep on plant production of the pasture

The production of above-ground plant parts on those parts of the pasture protected against sheep grazing during the season was estimated by summing the results of two mowings, in spring and autumn, on both examined sites: *P* and *PF* (Tab. III).

Tab. III. Production of above-ground plant parts on pastures not grazed by sheep in g d.wt./m^2 (1971)

	Summer mowing	Autumn mowing	Sum
Sheep Way *P*	382.7	28.2	410.9
Pasture *PF*	456.6	29.5	486.1

The produced plant biomass varies only slightly. On the pasture with a higher dose of fertilizer the plant production is 75.2 g/m^2 higher. On both sites the plants after attaining their maximal biomass wither away and the growth of fresh, green mass during the rest of the vegetation season is very small.

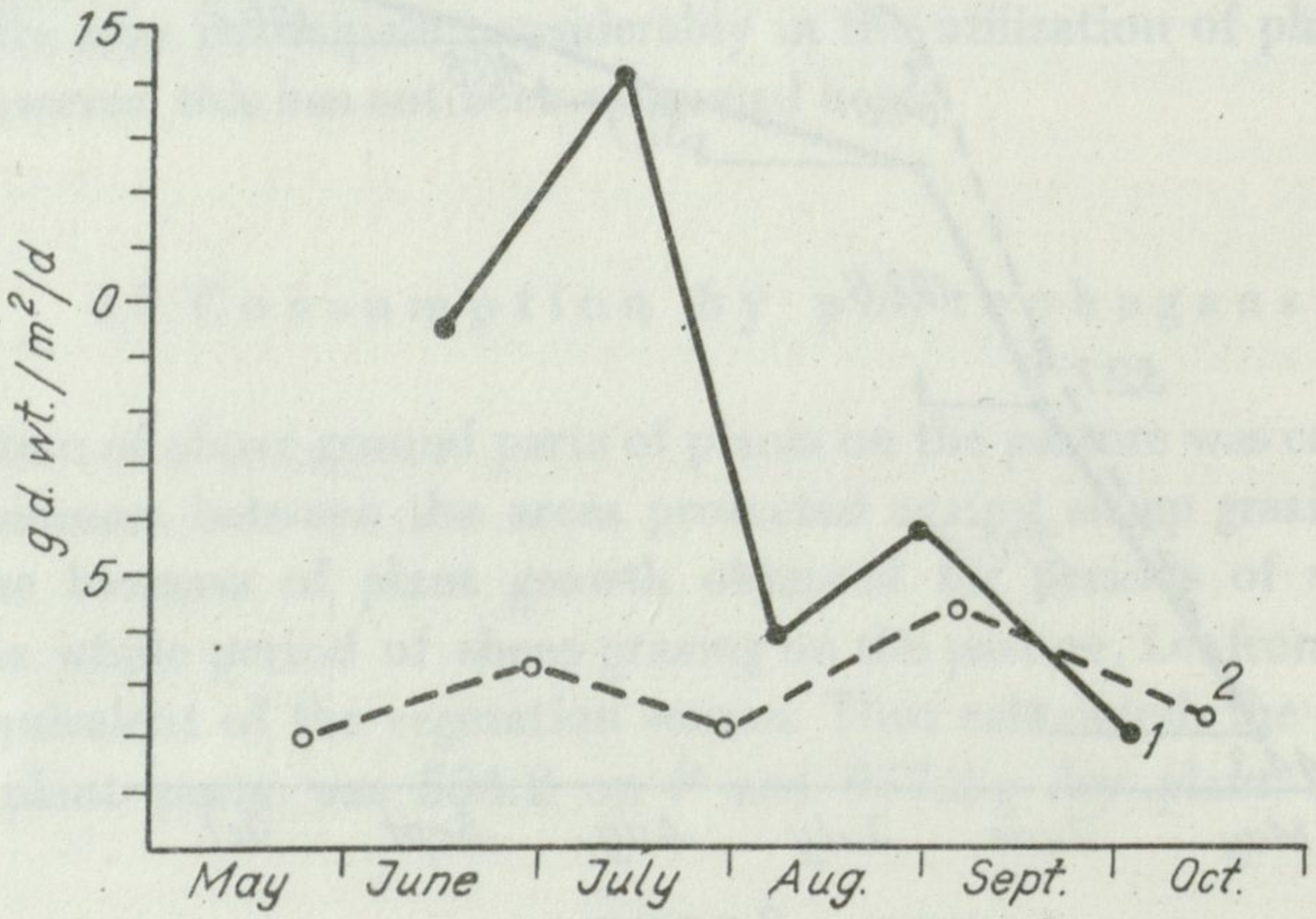

Fig. 3. Plant growth rate on pastures *PF (1)* and *P (2)* in g d.wt./m^2/d

In grazing conditions, when the regrowing plants are constantly grazed and consumed, there is a constantly and abundantly regrowing green meadow sward present during the whole season: 1.9–4.3 g d.wt./m^2/d on *P*, and 2.2–14.2 g d.wt./m^2/d on *PF* (Fig. 3). Thus the plant production on a grazed pasture is higher than on places protected against grazing: 554.2 g/m^2/season on *P* (Fig. 1), and 957.2 g/m^2/season on *PF* (Fig. 2).

On the highly fertilized pasture (*PF*) a large part of the produced vegetation (30.9%) is dead organic matter. The contribution of dead plant parts is much smaller on *P* and is 16.7%. The reasons for this may be the following: (1) the sheep do not consume some plants, e.g. thistles, which are much more abundant on highly fertilized areas: (2) when grazing, the sheep do much more damage to plants that grow taller than to low turf.

5. FINAL REMARKS

The regrowth of grass under constant grazing by sheep, and in conditions where the plants are isolated (under nets) from them for several weeks, is probably different. Nevertheless, it seems that the results of this experiment give an approximate estimate of the effect of sheep on the plant production of the pasture examined and of the amount of plant material they consume. It can also be stated that moderate grazing in good moisture conditions increases considerably the primary production of the pasture, and that the regrowth rate of grass, and thus the production, are higher where there are more nutrients in soil (higher fertilization). These possibilities of quick growth and utilization of food resources in the soil by the plants on the pasture are due to the relatively big root system. On *P* it is 84.2% in summer, and in spring and autumn 96.4 and 92.0 of the whole vegetation (P l e w c z y ń s k a - K u r a ś 1974).

6. SUMMARY

The subject of this study was to analyse the effect of sheep on the production of above-ground parts of pasture vegetation. A pasture in Małe Pieniny with a plant association *Lolio-Cynosuretum cristati* was examined.

The part of plant production consumed by sheep was calculated from the difference in biomass between areas protected from grazing (under nets that were shifted every 5 weeks) and of the pasture. On the pasture with low fertilization (*P*) the production was 554.2 g/m^2/season, and on the pasture with high fertilization (sheep-fold, *PF*) 957.2 g/m^2/season (Figs. 1, 2). The sheep consumed a considerable part of the production: 490.9 g/m^2 on the pasture and 912.9 g/m^2 on the sheep-fold.

The estimates obtained by protecting the plants for several days from grazing are probably different from the real and constant effect of sheep, but they seem to ilustrate, approximately this effect on the pasture production.

It can be said, that in appropriate moisture conditions the grazing of sheep stimulates the growth rate of vegetation. The pasture areas isolated from sheep during the whole season had a smaller production (Tab. III), after attaining their maximal development the plants withered and the further increase of green mass was only slight, whereas on the grazed areas the growth rate was very high during the whole season (Fig. 3). The fertilization also affected considerably the rate of production (Figs. 1, 2) and biomass of plants remaining on the pasture (Tabs. I, II).

The number of phytophagous insects on the pasture is very small; they are probably of no great significance in the production of green plant parts.

7. POLISH SUMMARY (STRESZCZENIE)

Celem badań było oszacowanie wpływu owiec na produkcję nadziemnych części roślin pastwiska. Badane było pastwisko w Małych Pieninach należące do zespołu *Lolio-Cynosuretum cristati*.

Część produkcji roślinnej zabieranej przez owce wyliczono z różnic biomas między powierzchniami chronionymi od wypasu (siatkami przestawianymi co 5 tygodni) i pastwiskiem. Na pastwisku słabo nawożonym (*P*) produkcja wynosiła 554,2 g/m^2/sezon; przy obfitym nawożeniu (koszarowanie owiec, *PF*) – 957,2 g/m^2/sezon (fig. 1, 2). Owce zjadały bardzo znaczną część produkcji – 490,9 g/m^2 na pastwisku i 912,9 g/m^2 na koszarze.

Oceny otrzymane przez kilkudniowe izolowanie roślin od wypasu nie są prawdopodobnie identyczne z rzeczywistym stałym wpływem owiec na produkcję pastwiska, dają jednak obraz przybliżony.

Można stwierdzić, że przy odpowiednich warunkach wilgotnościowych wypas owiec wywiera stymulujący wpływ na tempo wzrostu roślinności. Płaty pastwiska izolowane od owiec na przeciąg całego sezonu wykazywały niższą produkcję (tab. III), rośliny po osiągnięciu maksymalnego rozwoju obsychały i dalszy przyrost zielonej masy był już niewielki. W warunkach wypasu natomiast przez cały sezon utrzymywało się wysokie tempo przyrostu (fig. 3). Stwierdzono też duży wpływ nawożenia na wielkość produkcji (fig. 1, 2) i wielkość biomasy roślin pozostających na pastwisku (tab. I, II).

Stwierdzono, że stosunkowo bardzo mała jest liczebność owadów roślinożernych na pastwisku; prawdopodobnie nie wywierają one znaczniejszego wpływu na produkcję zielonych części roślin.

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