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Seasonal growth of forage production in relation to altitude in rangelands of western Crete and its implication to sustained animal production

S.D. Kyriakakis* and V.P. Papanastasis**
*Mediterranean Agronomic Institute, 73100 Chania, Crete, Greece
**Aristotle University of Thessaloniki, 54006 Thessaloniki, Greece

SUMMARY - Forage production of three phryganic rangelands located at the low (25 m), middle (675 m) and high (1200 m) ecological zones respectively of western Crete was studied at the end of each of the four seasons (autumn, winter, spring and summer) of the year. It was found that on the low and middle zones forage production peaked at the end of spring, while on the high zone at the end of summer reaching 378, 534 and 367 g DM m^2 respectively. The bulk of these yields was contributed by the phryganic species (90%) at the first two zones while at the high zone the proportion was much lower (66%) as compared to herbaceous plants. *Sarcopoterium spinosum* was the dominant species at the low zone, *Cistus incanus* and *C. salviaefolius* at the middle zone and *Ononis spinosa* at the high zone. By considering a proper use factor 50% for the herbaceous plants, 60% for the palatable *Ononis spinosa* and 30% for the other phryganic species as well as the crude protein contents of forage over the seasons, it was concluded that combining the low and high zones will ensure a 10-month long grazing period for sustained animal production.

Key words: Forage, seasonal growth, altitude, phryganic rangelands, sustained production, Crete.

RESUME - *"Production fourragère saisonnière* en fonction de l'altitude dans des parcours de Crète occidentale et son implication pour une production animale soutenue". La production fourragère dans trois parcours phryganiques situés en Crète occidentale dans les zones écologiques basses (25m), moyennes (675m) et hautes (1200m) respectivement, à été étudiés à la fin de chacune des quatre saisons (automne, hiver, printemps et été). On a trouvé que dans les zones basses et moyennes la production fourragère a atteint un maximum à la fin du printemps, tandis que dans la zone haute à la fin de l'été elle a atteint 378, 534 et 367 g MS m^{-2} respectivement. La majorité de cette production provenait de l'espèce phryganique (90%) dans les deux premières zones tandis que dans la zone haute la proportion était très inférieure (66%) comparée aux plantes herbacées. Sarcopoterium spinosum *était l'espèce dominante dans la zone basse,* Cistus incanus *et* C. salviaefolius *dans la zone moyenne et* Ononis spinosa *dans la zone haute. En considérant un facteur d'usage adéquat de 50% pour les plantes herbacées, de 60% pour les Ononis spinosa palatables et de 30% pour l'autre espèce phryganique, ainsi que la teneur en protéine brute du fourrage pendant les saisons, on a conclu que la combinaison des zones basses et hautes assurera une période de 10 mois de pâturage pour une production animale soutenue.*

Mots-clés *: Fourrage, croissance saisonnière, altitude, parcours phryganique, production soutenue, Crète.*

Introduction

Crete is a mountainous island with an area of about 8300 km^2. The dominant type of land use are rangelands grazed by small ruminants. About 60% of these rangelands belong to the phryganic type of vegetation extending from sea level up to almost 2500 m altitude.

Phrygana are predominantly composed of seasonally dimorphic dwarf shrubs while grasses and forbs grow between them.

In the Mediterranean region, forage availability fluctuates throughout the seasons and in the various ecological zones (Papanastasis, 1982; Kyriakakis and Papanastasis, 1993). Similarly, forage quality undergoes sharp changes during the period of growth within each ecological zone and along the altitudinal gradient (Kyriakakis and Papanastasis, 1997). For a better utilisation of rangeland production, grazing should be adjusted to match forage availability and nutritional value with animal requirements. The objective of the present study was to investigate the seasonal changes in forage quantity of the dominant species and their implications to sustained animal production.

Materials and methods

Three study sites were established on the north slopes of the White Mountains at altitudes of 25 m, 675 m and 1200 m, representing the low, middle and high ecological zones, respectively. Rainfall and temperatures varied accordingly. Soil depth and slope inclination were the same at the three zones, 30 cm and 15% respectively. Phrygana was the common type of vegetation, although species composition was similar only in the low and middle zones, while the high zone was substantially different (Kyriakakis and Papanastasis, 1993).

In each zone an area of about 200 m^2 was fenced in the summer of 1987, prior to the sampling period. The most homogeneous part was divided into 40 quadrats, 1 m^2 each. Ten quadrats were sampled at the end of each season starting from autumn. Sampling involved clipping of biomass at the ground surface. The vegetation harvested from each quadrat was separated into its herbaceous and phryganic components. The latter was further sorted into its main sub-components, namely *Sarcopoterium spinosum, Cistus* spp., and other phryganic species in the low and middle zones, while in the high zone no separation was carried out because *Ononis spinosa* was the only phryganic species.

The oven-dry weight of each component of biomass was determined in the laboratory and expressed in g m^{-2}; it included the old and the current year's (live) biomass. Biomass measurements were subjected to analysis of variance; if significant differences were detected, the Duncan's multiple range test was applied. Only the live part which represents the annual growth is reported in this paper.

Results and discussion

Seasonal growth of dominant species

Figure 1 shows the live biomass of the dominant species over the four seasons of the three ecological zones. It is clear that the peak growth of all phryganic species was attained in the spring at the low and middle zones and in the summer in the high zone. Middle zone had the highest total live biomass while the other two zones did not differ much between each other. Individual species or groups of species however showed different trends. *Sarcopoterium* was much more important at the low than at the middle zone while it was not recorded at the high zone. *Cistus* species, namely *incanus* and *salviaefolius*, were not recorded either at the high zone but they were much more important in the middle than in the low zone. Other phryganic species were more important in the middle than in the low zone. *Ononis,* the only species present at the high zone, did not produce any biomass in the autumn and winter due to its leaf shedding. Herbaceous species finally were very important in the high zone, where they made up almost half of the total biomass, while at the other two zones their contribution was negligible.

Sustained animal production

The seasonal growth of forage production in any of the three rangelands studied raises the question whether two or more ecological zones can be combined so that sustained animal production is ensured. To answer this question we calculated the grazeable portion of forage production in the three rangelands separately for the herbaceous and phryganic species. For herbs, we established the proper use factor to 50% of the maximum growth everywhere; for phrygana, we estimated that no more than 30% of the maximum growth can be grazed by animals due to their morphological (ex. spines) and nutritional limitations in the low and middle zones, but for the palatable *Ononis* of the high zone we set a factor equal to 60% of the maximum growth. The amounts of grazeable dry matter received were 16, 30 and 100 g m^{-2} for herbs and 104, 143 and 144 g m^{-2} for phrygana respectively for the low, middle and high ecological zones. Figure 2 shows the periods during which these amounts are available to animals and therefore the respective grazing periods.

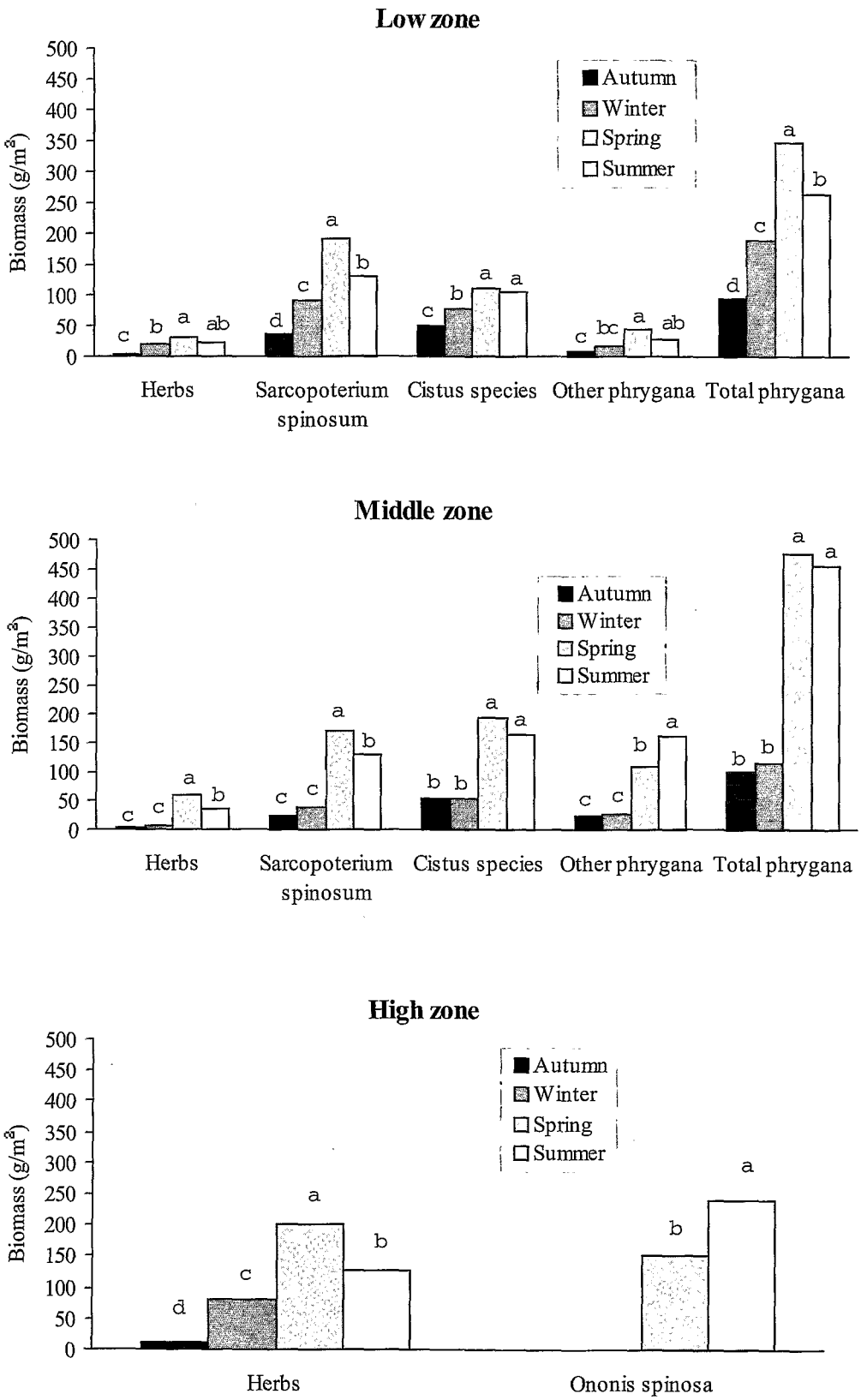

Fig. 1. Live biomass (g m^{-2}) of the dominant species at the three study zones over the four seasons of the year. a, b, c, d: bars with different letters are significantly different at $p \leq 0.05$.

Forage however should be not only of sufficient quantity but also of acceptable quality in order to be beneficial to animals for their various physiological functions. According to literature (reviewed by Papanastasis, 1982), rangeland forage must contain at least 6.5%, 8.6% and 9.7% of crude protein so that animals maintain their weight, become pregnant and lactate respectively. From the chemical analysis of the two groups of plants at the end of each season (Kyriakakis and Papanastasis, 1997) it comes out that forage is of low nutritional value to animals, even for maintenance, for most of the grazing period when sufficient amount is available (Fig. 2).

It may be concluded that to extend the grazing period when both sufficient quantity and acceptable quality are available it is necessary to combine two or all the three zones. Figure 2 shows that the best combination is between the low and high zones; grazing can start on December 10 and continue until April 10 in the low zone, then move the animals to the high zone and stay there until the beginning of October. This combination will make a total of about 10-month grazing period thus leaving only 2 months (October and November) to be supplemented with other feed resources. Such a scheme corresponds with the traditional system of transhumance.

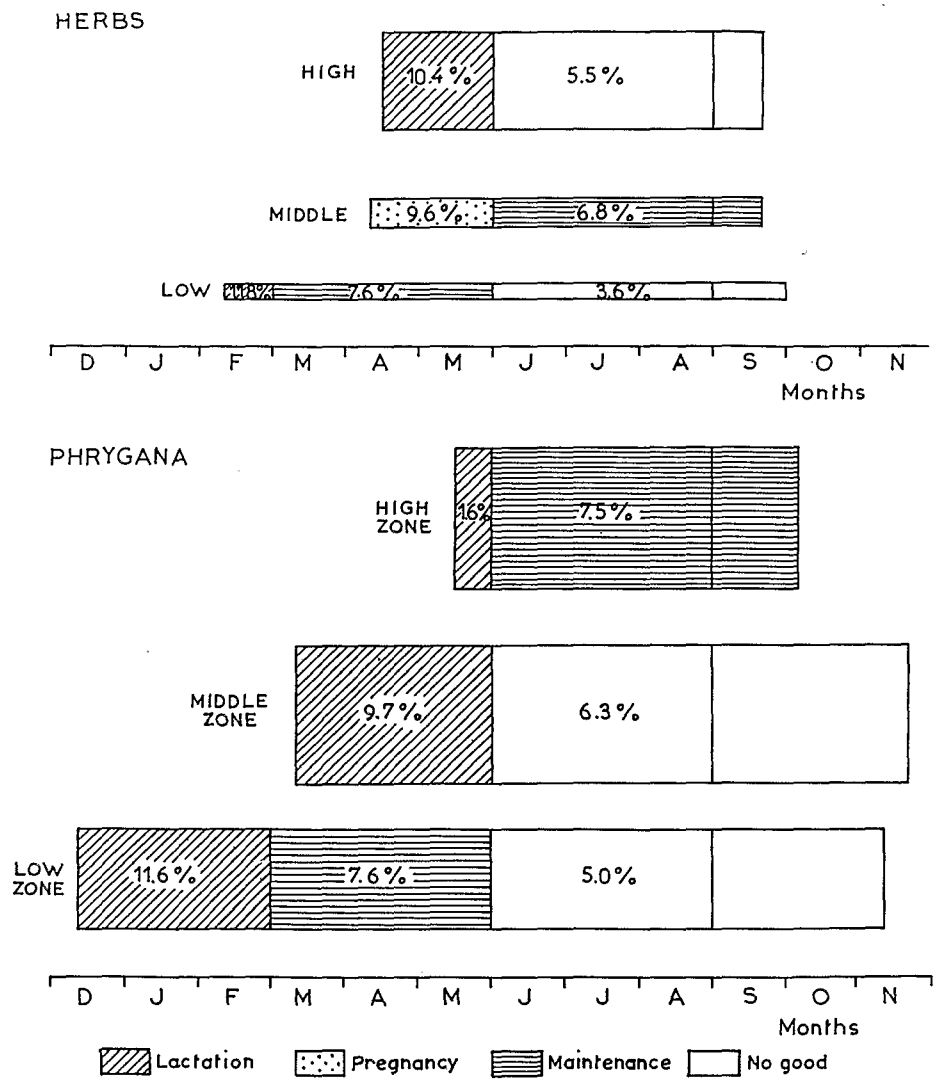

Figure 2. Altitudinal distribution of grazeable dry matter (g m^{-2}, scale 1mm=5g m^{-2}) over the growing season in phryganic rangelands of western Crete. (Percentages indicate CP content at the end of each season; for the autumn season, the CP values are the same as for summer since effective rains did not start before the end of October.)

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