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THE PRIMARY PRODUCERS IN THE ALPINE MEADOW ECOSYSTEM

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The alpine meadow dominated by *Kobresia* plants belongs to one of the typical zonal vegetation on Qinghai-Xizang plateau. It is adapted to the severe alpine climate and its special structure and function are part of an alpine meadow ecosystem. It is the major nutrition source and productive base for the development of animal husbandry on the plateau.

I'd like to present an outline on the study of the primary production at the Haibei Research Station of Alpine Meadow Ecosystem carried out from 1976 to 1985.

There are about 300 spermatophyte species at Haibei Research Station of Alpine Meadow Ecosystem, among which there are 49 families and 164 genera. The main families are *Cyperaceae, Compositae, Gramineae, Leguminosea, Ranunculaceae* etc. There are over 20 dominant species which have the characteristics of coldresistance and belong to mesophytic, perennial herbaceous plants. The dominant species of alpine shrubland are *Dasiphora fruticosa* and *Salix oritrepha* which along with *Sibiraea angustata* belong to endemic species on Qinghai-Xizang Plateau. The dominant species of alpine meadows are perennial herbaceous plants of genus *Kobresia*, such as *Kobresia tibetica*, also species endemic on Qinghai-Xizang Plateau, which is a dominant in swamp meadows. *Kobresia pygmaea, K. capilifolia* and *K. humilis* which represent the floral elements of central Asia or Sino-Himalaya, are the dominant species of alpine meadows. Most of the companion species, the floral element of Sino-Himalaya or arctic-alpine, such as *Lancea tibetica, Polygonum viviparum, Thalictrum alpinum. Stipa aliena* and *Koeleria cristata*, which are warm steppe elements, also play an important role in alpine meadows.

1. The Composition of the Principal Vegetation Types

(1) *Dasiphora frudticosa* alpine shrubland

Dasiphora fruticosa shrubland is widespread in the study area. This type is found on flat ground, alluvial fans in the foothill, river terraces, and north facing hill slopes, usually at elevations 3150—3800 m asl. The soil is alpine shrubland meadow soil. The dominant species, *Dasiphora fruticosa* is about 30—40 cm high; the cover of the community is 60—70%. There are usually 15—25 species per m^2. Within the shrubland often occur mixtures of species which predominate on flats such as *Hippophae thibetana* and on north facing hill slopes such as *Salix oritrepha, Spiraea alpina,* and *Caragana jubata*. The accompanying herbaceous plants are *Polygonum viviparum* and *Festuca rubra*.

(2) *Kobresia humilis* alpine meadow

Kobresia humilis is also a widespread alpine meadow type in the study area. This meadow type is mainly found on flat ground, foothill, and partly sunny, partly north slopes.

The soil is alpine meadow soil. The cover of the community is 60—90%, and 20—30 species can be found in 1 m^2. The dominant species is *Kobresia humilis,* and the companions are *Stipa aliena, Koeleria cristata, Elymus nutans,* and many forbs. *Kobresia* has a soft texture and a high nutritional value. This type of pasture is often degraded by overgrazing and by the rodent disturbances.

(3) *Elymus nutans* meadow

The type is widely distributed on flat ground. It is a secondary succession vegetation type which develops after a disturbance to the primary vegetation. The specific species composition and structure depend on the degree of damage and the succession stage.

(4) *Blysmus sinocompressus* or *Kobresia tibetica* swamp meadow

This luxuriant type can be found in marshy lowlands near lakes and river. The soil is swamp meadow soil. The specific composition of this vegetation type is simple; most of plants are hygro to mesophytes.

Other vegetation types include a *Kobresia pygmaea* meadow and a *Kobresia capilifolia* meadow.

2. The Primary Production of the Main Vegetation Types

We measured the primary production of the main vegetation type dominated by *Dasiphora fruticosa, Kobresia humilis,* and *Elymus nutans,* and of an artificial grassland dominated by *Elymus nutans*. The biomass was measured by periodic harvests in plots undisturbed by grazing (grazing exclosures).

The result showed that the aboveground biomass of all four vegetation type increased with the ground moisture and temperature during the growing season and with the continuing growth and development of plants. The time of the peak biomass values was different in different vegetation types. After the peak, biomass gradually decreased with plant senescence. The belowground biomass of roots was the highest after the withering of the aboveground parts.

Listed below are these standing crop values. *Dasiphora fruticosa* shrubland was the highest (1692.1 g/m^2.yr., dry weight), aritificial grassland of *Elymus nutans* was lower (831.4) along with *Elymus nutans* (600.8) and *Kobresia humilis* madow was the lowest (772.9). Only aboveground net production can be used by the domestic animals. The net aboveground production values were the following: The maximum occurred in the ariticifial grassland of *Elymus nutans* (515.0), the *Elymus nutans* meadow was 258.2, the *Kobresia humilis* meadow was 190.3, and the minimum occurred in the *Dasiphora fruticosa* shrubland (176.1).

We have also been studying the annual and seasonal biomass dynamic in *Kobresia humilis* meadow which was not affected by grazing, in an enclosure. The results showed an obvious seasonal dynamic of both above and belowground biomass. The three groups of herbage (grasses, sedges, and forbs) differed in their growth rate and water content percentage of the total biomass; these differences were related to the differences in their eco-biological features. The minimum of the aboveground production was 296.66 g/m^2.yr. in 1980 and the maximum was 403.0 in 1984.

The seasonal dynamics of aboveground biomass was related to the seasonal dynamic temperature. The annual fluctuation was related to the moisture and temperature differences between years. The belowground biomass of roots was the lowest during the flowering period in July and the highest before the withering in September. This was related to the high utilization of the plant organic matter recerves by the flowering and intense growth. After the peak growth, the nutrient material was transported to the roots. The belowground biomass of the root system was different in different soil layers. 90.7% of the root system was concentrated in the upper 0—10 cm soil layer. This was correlated with the more favorable moisture, temperature, and next to the surface aeration. The ratio of live and dead roots varied during the growth and development. The maximum proportion of live roots occurred during the flowering period, and the minimum before the withering period. The net production of the root system was the lowest (525.26 g/m^2.yr.) in 1982 and the highest (796.0 g/m^2.yr.) in 1983. The net belowground production was 1.37—1.98 times higher than net aboveground production. The above and belowground standing crop ratio was 1:5—8.

These results reflect the adaptation of alpine plants to the severe conditions of their environment.

The biomass of standing dead gradully decreased after long cold winter; its minimum (158.0 g/m^2.yr.) occured in mid-March. Most of the standing dead was consumed by the domestic animals. The biomass of litter was the lowest during the period of initial growth.

3. The Plant Caloric Content and the Utilization Rate of Solar Energy

In formation for the model of energy flow, we have measured the caloric content of the main plants, vegetarion types, and of the main plant groups at different pheological stages in the alpine *Kobresia humilis* meadow. We determined the caloric values of 69 species. The caloric value of shrubs (4950.0 cal/g, ash-free) was higher than the value of herbaceous plants. The evergreen shrub (5345.85) had values higher than the deciduous shrub (4950.0). Sedges were (4643.84) higher than grasses (4555.37) Edible forbs (4542.77), occasionally edible, and non-deible forbs (4549.23), and poisonous and other otherwise harmful plants (4561.33) had slighly higher values than the average value for grasses and forbs. The high plant caloric content in alpine meadow is correlated with the strong solar radiation at the high elevations of the plateau, caloric content of the main vegetation types was the following: *Kobresia humilis* meadow (4780.9) was higher than *Dasiphora fruticosa* shrubland (4672.20); the *Elymus nutans* meadow (4644.60) and the *Blysmus sinocompressus* swamp meadow (4575.50) were the lowest.

The study of the caloric content of the main plant groups at different phenological stages of the *Kobresia humilis* meadow showed that:

The caloric content was higher during the flowering period for all three groups (grasses, sedges, and forbs), during this period, the plants were growing at the most vigorous rate and were accumulating most organic matter.

The rate of the aboveground utilization of solar energy in the *Kobresia humilis* meadow was only 0.094%, which was only 0.1—0.5% lower than the average for terrestrial plants.

4. Anatomical Characteristics of C_3 and C_4 Plants in Alpine Meadows

We have studied the anatomical characteristics of the leaves of 51 species. According to Kranz structure and other characteristics, we tentatively classified seven species of *Gramineae* as C_4 plants: *Agropyron cristata, Aneurolepidium dasystachys, Roegneria kokonorica, Roegneria grandiglumis, Helictotrichon tibeticum, Elymus nutans* and *Achantherum chingii*. The other 42 species are C_3 plants, for *Saussurea nigrecens* and *Adonis coerule* which are intermediate. The seven C_4 species show greater adaptability, quicker growth, and higher yield. They are good forage plants for artificial grassland on the plateau. These results provide a scientific basis for the future forage acclimation and breeding.

5. The daptations of Plants to Their Alpine Environment

Among alpine habitats the common characteristics are: high elevation, low air temperature, significant diurnal fluctutions of temperature, intensive solar radiation and strong wind. The plant adaptation to this severe environment include the growth form low or prostrate shrub, dwarf rosette or cushion, the high frequency of vegetative reproduction and apomixis, and the development of insulating structures. The physiological adaptations include: the limited respiration related to low nightly temperature, increased chlorophyll content. All these adaptations produce an increase in the accumulation of organic matter and the content of proteins and fats. The strong ultraviolet light in the alpine enivironment is contributed to the short stature of alpine plants.

6. Scientific and Rational Management of Alpine Pastures for Raising their Productivity

Kobresia humilis meadows are often degraded by overgrazing and by rodents; the quality of the forage deteriorates and the yield declines.

The experimental aritificial improvement of the pastures and the control of grazing showed that degraded pastures can be improved through protection and application of manure as nitrogen and phosphorus, planting of highly productive forages and making a full use of the summer and autumn pastures to develop seasonal animal husbandry. The carrying capacity and the productivity of the pastures can be raised only through application of these forceful measures.

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高寒草甸生态系统中的初级生产

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摘　　要

初级生产者是生态系统研究的中心环节，十年来，我们从事以下6个方面的研究工作：

1. 高寒草甸主要植物群落类型及其结构特征：定位站地区的植被类型主要为高寒灌丛和高寒草甸，其结构简单，种类组成以中亚、中国-喜马拉雅和北极-高山植物区系为主。在高寒气候影响下，它们具有多种生态适应特征和极强的抗寒能力。高寒灌丛以金露梅（*Dasiphora fruticosa*）灌丛为主。主要分布在潮湿的滩地、山麓洪积扇、河流两岸阶地、山地阴坡，海拔3150—3800米。高寒草甸以矮嵩草（*Kobresia humilis*）草甸为主，广布于滩地、坡麓和山地半阴半阳坡。

2. 主要植被类型的初级生产量：用收割法定期测定了金露梅灌丛、矮嵩草草甸、垂穗披碱草（*Elymus nutans*）草甸和垂穗披碱草人工草地的地上生物量。重点研究了矮嵩草地上和地下生物量的季节动态，年间动态和立枯物的变化规律。地上生物量季节动态同气温变化有关，年间变化同不同年间的温度和湿度波动有关。而地下生物量以7月份植物旺盛生长时期最低，9月份植物枯黄前最高。

3. 植物热值含量和光能利用率：主要测定了高寒草甸主要植物种群以及混合牧草不同物候期的热值含量。结果证明，植物在生长盛期，热值较高。矮嵩草草甸地上部分光能利用率仅为0.094%。

4. 高寒草甸 C_3 和 C_4 植物解剖特征：依据植物叶片有无花环状结构特征，确定了定位站51种植物中7种为 C_4 植物、42种为 C_3 植物，2种为中间类型。

5. 植物对环境的适应性：植物长期适应高原特殊的生境条件，塑造了一系列形态、生理-生态特性。形态上表现为植株低矮、呈莲座状、垫状，多数植物行营养生殖或无融合生殖，植株被毛或具有厚的角质层等；夜间低温提高了植物可溶性糖的含量；强烈的紫外线辐射，对作物高产形成和营养成分的增加有明显影响。

6. 科学和合理经营管理，将提高草场生产力：多年来，我们进行了天然草场改良和放牧强度等多项研究，为合理利用草地资源和科学管理牧场提供科学依据。