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A BRIEF INTRODUCTION TO THE FUNDAMENTAL CHARACTERISTICS AND THE WORK IN HAIBEI RESEARCH STATION OF ALPINE MEADOW ECOSYSTEM

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Alpine Meadow distributes itself widely on Qinghai-Xizang (Tibetan) Plateau and its vast areas spread extensively in the east of the plateau and on high mountainous ranges. Amounting to 16 million ha, it covers 40% of the area of grasslands of various kinds in Qinghai Province itself. It is, therefore, necessary to make systematic and long-term studies of it, and in 1976, Haibei Research Station of Alpine Meadow Ecosystem was set up. Primary investigations about the basic situation there were carried out from May 26 of that year and in the meantime, preparations for the construction of houses were started. Systematic observations began after 1977, including studies of the primary production, and the energy flow of secondary producers. Attentions were also paid to the changes of soil fertility and material cycling. In 1980, studies on decomposer microbes started. During the course of studies, the mathematical model was designed and put to use.Up till now, the construction and calculation of the biomass dynamic model of subsystem consumers have been brought to completion. During this time the capital construction was gradually increased, more houses were built, and electricity, heating and telephone line were installed, road had been paved and the laboratory replenished, and by 1985, construction of the station was largely completed.

NATURAL CONDITIONS

The alpine meadow ecosystem research station is located at Menyuan Stud Ranch of Menyuan Hui Autonomous County, Haibei Tibetan Autonomous Prefecture, Qinghai Province, with Lat. 37°29′—37°45′N and Long. 101°12′—101°33′E. The station lies at the foothill on the south slope of Mt. Lenglongling in the east part of Qilian Mountains, and at the northwest valley of the Datong River. Lenglongling streching from the northwest to the southeast forms a natural line of demarcation between Qinghai and Gansu Provinces. The highest peak of the Lenglongling mountain range has an altitude of 5076 metres, covered with snow all the year round, the snow line of which is about 4200 metres. Lowest lands on the south side range between 3200 and 3400 m. in alt. forming a natural pasture where the station is situated. The Datong River valley does not vary much in topography and has an altitude of 2800—3000 metres. In some places, the culture of plant has been developed, with rape (*Brassica campestris*) as the main crop.

On the south side of the Datong River lies Daban Mountain, whose altitude is 4000 metres above sea-level, with undulating hills. Swamplands and wateraccumulated lake-Luan-Hai

Zi are formed. All these factors exercise different influences on their economic utilization.

Climate

Characterized by the alpine continental climate, the place does not have a real summer. Only the cold and warm seasons can be recognized. In other words, there is half a year of winter and half a year of summer.

Temperature: The annual mean temperature at the research stationis −2°C and the mean temperature in January is −18°C and the lowest temperature goes down to −35.0°C. In July, the average temperature is about 10°C and the highest temperature reaches 27.5°C. There is no absolute frost-free period. If the critical point is set at the temperature of 5°C when herbage can grow, the grass growing period is 130—140 days; the temperature accumulated of ⩾5.0°C turns out to be 1042°C, while the temperature accumulated of ⩾10°C is only 269°C.

Precipitation: Annual precipitation is 530 mm at the station being a place with a precipitation above the average in Qinghai. The precipitation mainly occurs in the half a year of summer and the precipitation from June-Aug. amounts to 55% of the total of the whole year, whereas the precipitation in the half a year of winter (from Nov. to April, next year) only makes up 10.5%, and consequently, snow coverage is practically absent during winter. In summer, however, rainfall and heat come simultaneously and this is beneficial to the growth of herbage.

Solar radiation: The annual radiation is 140—160 kilocalorie/sq. cm in all abundant, indeed. The total sunshine of a year is 2670 hours. Both radiation and the total sunshine are far more higher than those on the plain areas, and this fact provides advantages for the photosynthesis of herbage.

Wind: Winds in the half a year of winter is principally WNW and WNN. Wind speed is 1.7 m/s. on the average and the maximum wind velocity is 17 m/s. Wind scaling above eight occurs 27 times within a year. Wind erosion is serious.

Vegetation

There are 11 vegetation formations, according to Zhou (1982), in the region of Haibei Research Station, of which the most important three are as follows:

Dasiphora fruticosa shrub: The dominant plant, *Dasiphora fruticosa* is short, with a height not over 30—40 cm and an accompanying plant, *Salix oritrepha,* often appear at the north slope. There is *Hippophae thibetana* on the swamplands. In the lower layer, *Kobresia capillifolia* grows in abundance in warm areas, while in higher and colder places exist *Polygonum viviparum* and *Festuca rubra* dominantly.

Kobresia humilis meadow: *Kobresia humilis* meadow is most widespread in the area of the research station and is regarded as the best natural pasture. It is distributed on beachland, slopes, half south and half north of the hills. The dominant species is *Kobresia humilis* and subdominant species are *Elymus nutans, Festuca ovina, Stipa aliena* etc., varing with the grazing intensities.

Blysmus sinocompressus and *Carex moorcroftii* swamp meadow: Distributes around the water-accumulating lakes and the low and wet lands on the sides of the river where the soil contains more water. The dominant species are *Blysmus sinocompressus* and *Carex moorcroftii,* with the appearance of *Kobresia tibetica* etc.. All these plants are good for the grazing of yaks.

Soil

There exist alpine meadow soil, alpine scrubby meadow soil and bog soil.

Alpine meadow soil: This is the soil spreading most extensively in the areas of the research station and has grass epipedon or soddy layer, and humus layer. containing plenty of organic matter. It can be divided into two types: One is alpine meadow soil and the other, carbonate alpine meadow soil. Alpine meadow soil formation has significant grass growth process and its leaching founction is comparatively stronger, without lime reaction through the whole profile. Carbonate alpine meadow soil possesses strong grass epipedon and the layer of accumulated calcium carbonate.

Alpine scrubby meadow soil: Its vegetation is alpine shrub under which are strata of thick moss and litter. The soft sod appears wherever shrubs are sparse, under which humus layer may reach 30 cm in thichness and is followed by basement rock underneath. The leaching action is strong. There is no lime reaction generally.

Bog soil: This kind of soil occurs around Luan-Hai-Zi and the low and wet places on the beach of rivers. Some small sedge dunes known as 'pagoda-head' appear on the surface of earth, under which is the peat layer which is followed by gleization layer.

pH values of soil types mentioned above are over 7 and soil forming process is young. The content of organic matter is rich but slow in decomposition.

Animals

As to domestic animals, there are horses, yaks and sheep but there is little horse tending around the research station. As a matter of fact, Fengxia-kou, a residential area of Tibetans is mainly a grazing land for yaks and sheep.

Rodents are dominant animals, especially the plateau pika, *Ochotona curzoniae*, the plateau zokor, *Myospalax baileyi*, inhabiting mostly in the *Kobresia humilis* meadow in great quantity, they are very harmful. In the *Dasiphora fruticosa* shrubs live the Kansu pika, *O. cansa* and the root vole, *Microtus oeconomus*. The small carnivores, *Mustela altaica* and *M. eversmanni* are common but the large carnivores such as *Vulpes vulpes*, *V. ferrilatus* and *Canis lupus* are rarely found.

The commonest small birds are larks, *Fremophila alpestris* and *Alauda gulgula*. Carnivorous birds are *Falco cherrug* and *F. tinnunculus*.

Many kinds of insects occur in the region of the research station. According to the preliminary statistics, there are 11 orders, 126 families and 374 species all together, of which the steppe caterpila (*Gynaephora qinhaiensis*), though recorded for being in outbreak and very harmful, it has been kept low in quantity for the recent ten years.

Microorganisms

The microorganism acting as decomposers, has a slow effect on material transformation, due to the low temperature, and consequently the organic matter accumulated becomes greater than the matter decomposed, and the speed of turnover of material is rather low.

One characteristic of microorganisms is the absence of aerobic nitrogenfixing bacteria. Therefore, nitrogen fixation is realized by anaerobic nitrogen-fixing bacteria

ECONOMIC CONDITIONS

The general economic condition of the Sud Ranch is made up of two parts-animal husbandry and agriculture. It has a population of 2,458, including 720 regular professional workers. As to animal husbandry, the area of grassland is 25,962 ha., of which 43.82% is more or less in the state of degeneration. There are 532.22 ha of artificial grassland from which

the grass obtained is used for supplementary feeding in winter. And this represents the direction of modernization of the Stud Farm in animal husbandary.

According to the statistics at the end of 1984, the numbers of livestock are as follows:

Tab. 1 Livestock of Menyuan Stud Ranch

Number (indiv.)	Stocking capacity (indiv./ha.)
Horse 2,482	0.96×10^{-1}
Yak 4,762	1.83×10^{-1}
Sheep 22,163	8.54×10^{-1}

(Tab. 1). Suppositing that horses and yaks could be converted into sheep units (one horse=6 sheep, one yak=4 sheep), it would have 56,103 units and the stocking capacity would be 2.16 sheep units/ha.. In Qinghai, this is comparatively high.

Originally, the Stud Ranch relied heavily on horse raising, and now stress has been laid on yaks and sheep, for horse raising sustains losses in business. In recent years, sheep have been greatly developed. In 1978 the total number of sheep in the Stud Ranch was only 12400, while in 1984 the number reached 22163. Land used for agriculture is 1833.34 ha.. In 1984, 1366.67 ha. were planted with rape and 266.67 ha. with highland barley, 200.00 ha. with oats. The sales of rape seeds have an income of 741707 yuan, of highland barley 81007 yuan, of oats 33200 yuan of green dried hay 98985 yuan, totalling 954899 yuan. Sales in animal husbandry have been calculated as follows: 331398 yuan for horses, 82128 yuan for yaks, 118126 yuan for sheep, 176855 yuan for wool, 16240 yuan for milk, 1054 yuan for pigs. The total income of animal husbandry amounts to 725801 yuan, less than that of agriculture by 24.0%, i.e. 229098 yuan.

As to the division of labour, 325 hands are engaged in animal husbandry, 165 in agriculture. Labour forces put into animal husbandry are 1.97 times as many as that into agriculture. Actually, animal husbandry has been invested much more funds, but it suffers losses while agriculture production makes profits. It's certainly not appropriate for a ranch to compensate for the losses in animal husbandry with the surplus in agriculture production. If feeding crops is taken as the dominant production in agriculture and their seeds or straw are used for surplementary feeding or fattening of animals, the animal products may be increased. This is something worth while further studying.

RESEARCH WORK

To design the arrangement of researches, on the basis of the clues of energy flow and matter flow in the ecosystem, our study is still confined to grassland, and over-all studies on agriculture have not yet begun. What has already been taken into consideration is but its economic benefit. A diagram of the structure of alpine meadow ecosystem (Fig. 1) has been drawn and the research work in every compartment done at the station is presented.

1) As to light energy, its utilization rate of grass has been studied; the content of nitrogen and phosphorus in atmospheric precipitation has been measured.

2) For the aboveground part of plants, the following work has been done; The structure of grass communities, the measurement of net primary production, the observations on the herbage regeneration, the phenology of grass, and the distributing pattern of some species.

3) For the underground part of plants, the net production of the underground part of plants and the ratio of living and dead root biomass have been studied.

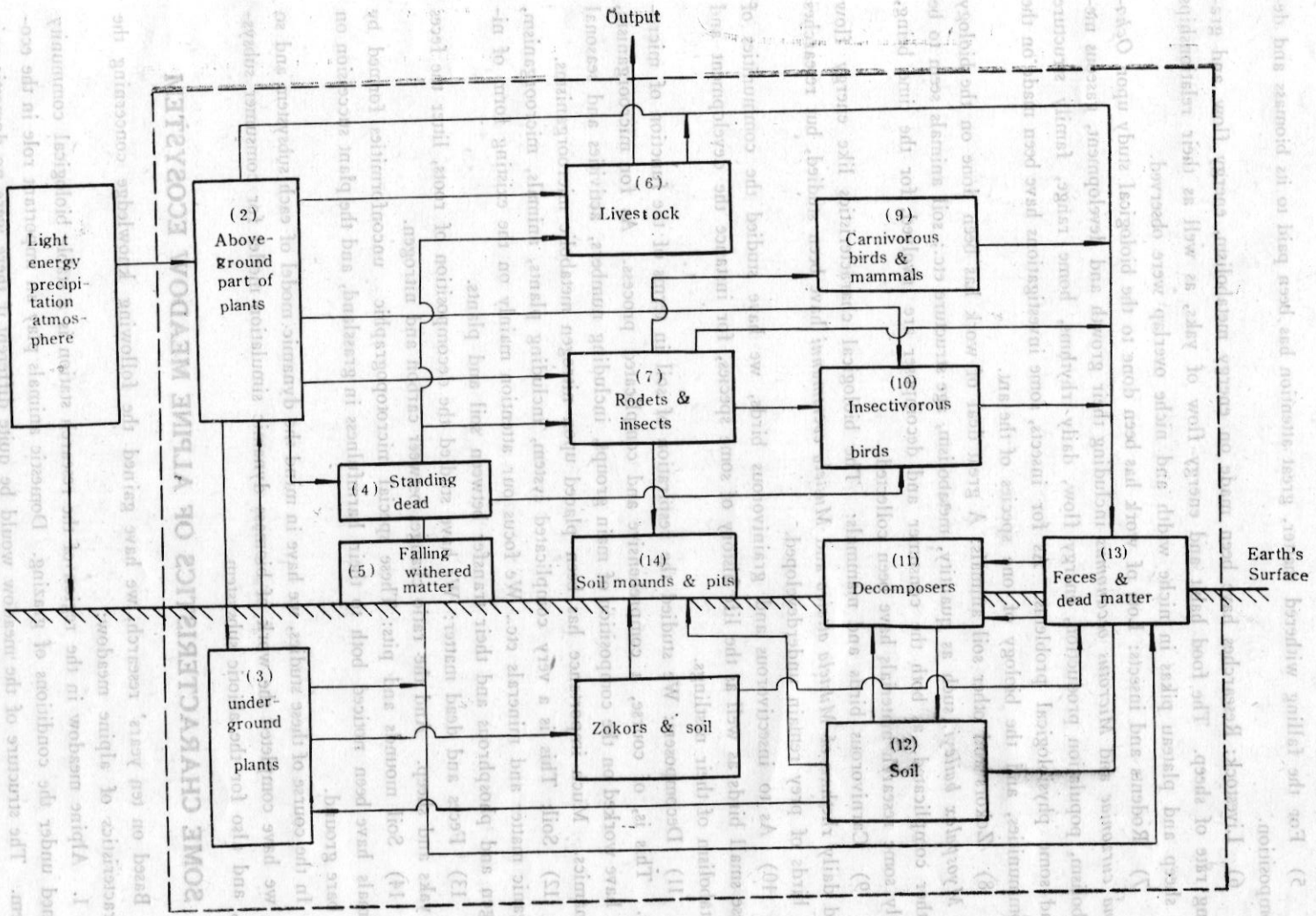

Fig. 1 Diagram of compartment in the alpine meadow ecosystem

4) For the standing dead, it serves as the basic forages in winter. Its seasonal changes have been studied.

5) For the falling withered matter, great attention has been paid to its biomass and decomposition.

6) Livestock: Researches have been made on energy metabolism, energy flow and grazing rate of sheep. The food habit and energy flow of yaks, as well as their relationships to sheep and plateau pikas in niche width and niche overlap were observed.

7) Rodents and insects: Lots of work has been done to the biological study upon *Ochotona curzoniae* and *Microtus oeconomus* including their growth and development, gaseous metabolism, population production, energy flow, daily rhythms, home range, family structure and some physiological problems. As for insects, some investigations have been made on the communities, and the biology of one species of the ant.

8) Zokors and other soil animals: A great deal of work has been done on the biology of *Myospalax baileyi,* such as quantity, metabolism, age structure etc.; soil animals seem to be rather complicated, as both the consumer and decomposer are involved, for the time being, only some research materials have been collected.

9) Carnivorous birds and mammals: The biological characteristics like energy flow and daily rhethms of *Mustela altaica* and *Musiela eversmanni* have been studied, but researches on birds of prey remain underdeveloped.

10) As to insectivorous and grainivorous birds, we have studied the communities of these small birds as well as the life history of some species, for instance the development and metabolism of their nestlings.

11) Decomposers: We studied the respiration of soil in terms of the function of microbes. This is, of course, a comprehensive and complicated process. As for microorganism, we have worked on the composition of main groups, including numbers, activities and seasonal dynamics. Much importance has been placed upon nitrogen metabolic microorganisms.

12) Soil: This is a very complicated system, including plants, animals, microorganism, organic matter and minerals etc.. We focus our attention mainly on the existing form of nitrogen and phosphrous and their transfer between soil and plants.

13) Feces and dead matter: We have studied the decomposition of roots, litter the feces by yaks and sheep. And the ratio changes betweer carbon and nitrogen.

14) Soil mounds and pits: These special microtopographic unconformities formed by animals have been noticed both to their harmfulness in grassland, and the plant succession on the bare ground.

In the course of these studies, we have in mind the dynamic model of each subsystem and so far, we have completed the work of biomass dynamic simulation model for comsumer subsystem, and also for the abiotic subsystem.

SOME CHARACTERISTICS OF ALPINE MEADOW ECOSYSTEM

Based on ten years' research, we have gained the following knowledge concerning the characteristics of alpine meadow:

1. Alpine meadow in the region of the research station is a stable biological community formed under the conditions of grazing. Domestic animals play an important role in the ecosystem. The structure of the meadow would be quite different if there were no domestic animals. In the grassland fenced for three years, greet changes have taken place, due to the fact that there were no grazing done by animals. As a result, the vegetation structure of two layers

was formed instead of the original one layer, with Gramineae grasses being the upper layer and sedges of *Kobresia* being the lower layer. But the grazed district presented a single layer constructed mainly by *Kobresia*. With the changes in grass community, changes in small animals accompanied——the invasion and increase of root voles.

The stability of biological communities can be explained in terms of pedology, as nutritional matter reserved in soil is very large in quantity, but the matter used each year is very little. The organic matter content in the soil is over 10%. If it is calculated by NH_4-N and NO_3-N, the availability of nitrogen is no more than 0.5%. Besides, there is less than 2% of the total N is discharged in nitrogen mineralization potential. Since the amount is more reserved in the mineral stock and drawn is very little, it is certainly stable.

2. Wind erosion of soil occurs easily but water erosion of soil seldom happens. The meadow is covered with a thick layer of solid sod which is endurable for grazing and treading by livestock, so that the meadow can not be destroyed. Sod and soft humus soil layers possess a strong capacity of water conservation, the soil will not be washed away even if rainstorm happens. It's very valuable in the mountainous area, with steep slopes, failling and rising all the time. The river water here is clear and of very good quality.

However, wind erosion merits attention, in cultivated land, no matter what it is used for, either for agricuture or grass planting, if the soil is turned up, a lot of dust will be produced and blown up into the air, when wind blows over and consequently losses of soil will be caused. So we should consider to use the method of non-tillage, i.e. caltivation without turning over soil.

Erosion might not occour if there were no harms done to the soil by rodent pests, as the grassland is covered with sod. The sod is damaged when the alpine pika burrows and soil pits of varied sizes are formed, sometimes, a pit over one sq. m can be made with several openings around it. All the soil dug out and the top soil of the pits will be blown away by wind. Even if the pit is abandoned, the recovery of vegetation is very slow. Countless mounds made by plateau zokers aggravate the damage to the vegetation. The wind erosion would be very serious before revegetation. In addition, the aggravation of vegetation will be accompanied by the increasing of the number of the two pest rodents, and the result of which will cause further degeneration in vegetation. As the vicious circulation occur, the strong erosion will finally give rise to the formation of a secondary naked area——"black earth land". It's rather difficult for the vegetation to recover from such land, for the most part, artificial transformation must be done to this kind of area.

3. Primary production and energy flow. On the whole, the primary production of alpine meadow is low. In our country, most of grasslands degenerate to a certain degree due to reasons like grazing. The primary productivity of alpine meadow is higher as compared with the other places. The comparison between the materials obtained from Haibei Research Station and that from Pasture Land Research Station of Inner Mongolia in the typical steppe has been made and shown below (Tab. 2).

It may be seen that the primary productivity in the area of alpine meadow is much higher than that of the typical temperate steppe. Grasses on steppe are tall but sparse, grasses on alpine meadow are short but dense, therefore the total biomass is higher as compared with the biomass of the former.

The primary productivity is bound up with photosysthesis. The sunshine on the plateau is intense and hours of sunshine are longer so it is favourable to photosynthesis. If the temperature is too low, however, it will be unfavourable; while the temperature is too high, it may

Tab. 2 Comparison Between Net Primary Productivity of Different Grasslands

(Dry weight)

Places	Type of grassland	Aboveground productivity (g/m^2/year)	Underground productivity (g/m^2/year)	Under ground/ Above ground
Xilin River Valley, Inner Mongolia	*Aneurolepidium chinese* steppe	142.0 (1979)	616.1	4.34
	Stipa grandis steppe	125.5 (1979)	345.8	2.76
Haibei	*Kobresia humilis* meadow	190.3 (1978) 296.7 (1980) 403.2 (1984)	582.6	3.06
	Dasiphora fruticosa Shrub*	176.1(1978)	1516.0	8.60

* Only twigs and leaves are calculated for shrubs.

cause the photosynthesis to cease. Hence, in the area of low elevation, most of plants cease photosynthesis due to very high temperature at noon and this phenomenon is called "nap" of plants. However, this does not occur on plateau and it may be one of the reasons for relatively high primary production. Another reason for fairly high primary production is the daily range of temperatures on the plateau varies greatly Consequently consumption at night becomes very low.

How about the situations of primary production flowing to consumers? Take sheep, for example, based on the statistics by Pi Nan-lin (1978), the density of sheep is 0.35 indiv/ha. The energy intake from summer grassland amounts to 6.52% of the total primary productivity. As mentioned above, the stocking capacity in the region of the Stud Ranch is 2.16 sheep unit/ha, and thus the grass intake is 40.24% of the primary production. Such efficiency is fairly high but the primary productivity here does not include the calculation of the yield of regenerated grasses. Repeatedly grazing by livestock and continued growth of grass as well as the relations of the restriction and promotion to each other should be studied.

Wang Zuwang, et al, has been studying the energy intake of the alpine pika and they have learnt that, the intake rate is about 1 kcal/g./day and the daily energy intake is 125 kcal/indiv/day when the body weight of each pika is set to be 125 g.. The animal lives for 153 days in summer pasture, if the density counted by 100 indiv/ha, the energy intake is 1.91×10 kcal/ha, amounting to 20.60% of the primary production, which is considerably high. If it is calculated by the year (365 days), the amount will be larger, nevertheless, the density of these small animals decreases greatly in winter.

In a word, the energy flow to small animals is remarkable, and some adjustment should be made.

4. Characteristics of the turnover of domestic animals. Domestic animals, being the main output of the ecosystem, play a very important part in ecosystem. They live on herbage, which varies greatly with seasons, thus the livestock raising must be adapted to it accordingly. In

the warm season, May-Sept., when the pasture develops from phases of green up and exuberance to the withering phase, food is plenty and of good quality with high protein content is provided for yaks and sheep. As a result, body-weight of livestock increase, and domestic animals are fat and strong. During the cold season lasting for more than 7 months, livestock lives mainly on standing dead grasses, which suffer from great natural losses, even without being grazed on. The loss rate of body weight from Nov. to April amounts to 52.37%. Specific data are shown in Tab. 3.

Tab. 3 Loss of Standing Dead Grasses

Month	Nov.	Dec.	Jan.	Feb.	Mar.	April	Loss%
Grass available (kg/m^2)	193.08	158.14	136.27	106.69	97.60	92.00	52.37

The content of crude protein in grasses in Sept. is 7.581% and then decreases to 5.581% in April, dropping by 26.38%. Compared with the amount of 12.344% in June, it drops by 54.79%. Livestock has to graze on the standing dead whose biomass descreases daily and nutritional value drops thereby, the area for grazing of winter pasture is insufficient, livestock is in the state of hunger. The energy intake can not be balanced with the energy consumption so that the energy reserved in body is consumed and this gives rise to the decrease in body-weight. Taking the adult wether of strong viability for example, its body-weight decreases from 59.29 kg in Nov. to 37.81 kg in April next year. The total decrease is 21.48 kg, amounting to 36.23%; if young ewes are weighed, the decrease in body-weight is from 35.88 kg to 19.75 kg, dropping 16.13 kg, amounting to 44.96%. The ratio of bone to meat for the sheep slaughtered in autumn is one to two point eight (1:2.8); while for those slaughted in spring the ratio is one to one. The loss is obvious. The domestic animal repeats itself in an endless cycle in such a model, which shows that the livestock is replete in summer, fat in autumn, thin in winter, and dies easily in spring—— this is to maintain the energy balance both in population and in individual.

In order to reduce the losses and make rational use of the grassland, more sheep should be slaughtered in winter and hence the turnover of the population can be rationalized. Judging from the consumption of energy, all the yearling wethers should be slaughtered; and the ewes degenerated in production should also be slaughtered. By so doing, the pressure of winter grassland may be reduced, the body-weight of the livestock be maintained at a high level and the mortality in spring be reduced.

海北高寒草甸生态系统定位站的基本特点及研究工作简介

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摘 要

高寒草甸广泛分布于青藏高原，为最重要的植被类型，面积很大，仅在青海省即占各

类草场面积的49%，约有1600万公顷，很有必要对它进行比较系统的长期研究，因此于1976年建立了海北高寒草甸生态系统定位站。除进行基础情况的调查外，逐年开展初级生产力及次级生产者能流的研究，同时注意土壤肥力变化及物质循环以及微生物的分解作用等。在自然条件方面，研究了气候、植被、土壤、动物和微生物等，在经济条件方面，研究了人口、牲畜及农业生产等。

该站的研究工作以生态系统中能流和物质流为线索(图1)，安排各个环节的工作，目前还只限于草地这部分，农业部分尚未开展研究工作，只是初步注意到农业的经济效益问题。现依图上各个环节介绍我站所进行的研究工作。

1. 光能利用上作过牧草的光能利用率，大气降水作过氮、磷等含量的测定。

2. 植物地上部分作过草群结构初级净生产量的测定等。

3. 植物地下部分作过净生产量和活根死根生物量等。

4. 立枯物的季节变化。

5. 凋谢物的生物量及分解。

6. 家畜，做了绵羊的能量代谢、能流，放牧强度以及牦牛与绵羊与高原鼠兔的生态龛宽度与重叠。

7. 鼠类进行了高原鼠兔和根田鼠大量的生物学研究。昆虫作过一些群落调查和一种蚂蚁的生物学。

8. 鼢鼠及土壤动物：对高原鼢鼠的生物学进行了不少工作。

9. 食肉鸟兽；对艾虎及香鼬作过一些生物学研究如能流、昼夜活动等。

10. 食虫鸟与食谷鸟等小形鸟类作过群落的生活史和代谢等研究。

11. 分解者：从功能角度研究过土壤的呼吸，微生物的主要类群的组成、数量、活性及季节性动态

12. 土壤是一个非常复杂的系统，研究过动物、植物、微生物、有机质和矿物质等等。

13. 粪便、死亡物：研究了植物的根、枯枝落叶、牛粪、羊粪的分解作用及其碳氮比的变化等。

14. 土丘、土坑：由动物所形成的。注意到它们对草场的危害，及其上的植被演替。

工作中初步完成了消费者亚系统的生物量动态模拟模型和非生物环境方面的模拟。

工作中对高寒草甸生态系统的一些特点有些初步认识：

1. 定位站一带的高寒草甸为在放牧条件下形成的稳定的生物群落。家畜在这个生态系统中占有重要位置。土壤的营养物质的库存大，而每年的动用量很低。

2. 水土不易流失但易风蚀。

3. 初级生产力总的看来，是低的，但仍高于内蒙古的典型草原(表2)。高原上有一些有利于光合作用的因素，如光照强，昼夜温差大等。

初级生产流入到消费者中的情况曾研究过绵羊和鼠兔。绵羊的摄入占初级生产的40.24%，鼠兔则为20.60%，摄入率很高，而且二者比例应予调整。

4. 家畜周转在本生态系统中，占有重要位置，夏季牧草丰富，营养价值高，牲畜膘肥体壮；冬季，枯草不足且自然损失很大，营养价值低，牲畜消瘦，乃至死亡。为此应秋季多屠杀，调整种群结构，使种群周转合理。以减轻冬季草场的压力，使牲畜的体重维持在稍高的水平，减轻春季的死亡。