Biochemical composition and nutritional value of *Leymus chinensis* (Trin.) Tzvel. in eastern Transbaikalia

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Abstract. The article objective is to define the biochemical composition of *Leymus chinensis* (Trin.) Tzvel., its nutritional and energy value in the southern steppe zone of eastern Transbaikalia, growing in different soil and environmental conditions due to the lack of such data. The authors use standard biochemical methods to determine nutrients calculated by assessing the nutritional value and energy of plant forage. Statistical data processing is carried out in Microsoft Excel. The paper examines content of crude protein, sugars, crude fat, crude cellulose, nitrogen-free extractives, feed units and metabolizable energy in dry matter of *Leymus chinensis* for the first time. The study ascertains a definite relation of the nutrient accumulation, and soil and environmental conditions, growing season duration, plant development phase, and the species adaptation to prolonged aridization, which causes its vegetative reproduction due to a decrease in generative reproduction. It reveals protein ratios as an indicator of forage digestibility. The research found that the amount of both digestible nutrients, and the content of energy and metabolic energy in the forage varied in a rather narrow range, which is associated with the short growing season of *Leymus chinensis* development under the harsh continental climate of the steppe zone in eastern Transbaikalia.

1. Introduction
Grassy ecosystems are widespread in all natural and climatic zones, characterized by a wide floristic variety, projective cover, and soil and environmental conditions of growing, which causes significant variability in their productivity, mineral and biochemical composition, and nutritional value. The grassy ecosystem production is determined and limited by many drivers: species composition, water regime, their supply with nutrients, growing season duration [1–4].

Genus *Leymus Hochst.* (Kolosnyak) includes about 50 species, half of which are spreading at the territory of Asian Russia, including Transbaikalia. Many *Leymus* species are of great importance as food introducers [5–6], and potential donors of beneficial traits to improve cereals. *Leymus chinensis* (Trin.) Tzvel. is an economically valuable hay and fattening pasture plant widespread in steppe biocenoses of Transbaikalia, northern Mongolia and northern China [7–9], where it forms almost monospecific communities. It is of great importance as a component of productive pastures and hayfields, used to restore degraded lands and fasten disturbed areas. *Leymus* coenosis grow mainly on riverine hills, higher central floodplain parts, near-terrace stripes, alluvial fans, as well as lower parts of gentle slopes.
The floristic composition of coenoses, peculiarities of species vegetation, natural-climatic and soil-environmental conditions largely determine the quality of grass forage due to great variations in chemical composition of plant individual families and species, their grazing, and other parameters. Nutritional value based on the content of crude protein, sugars, crude fat, crude cellulose, nitrogen-free extractives decreases in plants of various families in the following series: Cruciferae, Fabaceae, Gramineae, Cyperaceae, Chenopodiaceae, Compositae. However, this series will be presented as follows according to plant grazing by animals: Fabaceae, Gramineae, Cruciferae, Cyperaceae, Compositae and Chenopodiaceae. Decreasing or raising the content of certain plant species (valuable or low valued in terms of forage, poorly eaten or uneatable, harmful or poisonous) in the herbage significantly affects the quality of green fodder [10]. Each plant species is characterized both by certain morphological features, and biochemical process direction and intensity. The latter effect the synthesis and accumulation of individual organic compounds in plants, which amount determines the nutritional value of a species or whole plant community [11]. There are studies on nutritional value of Leymus chinensis only for western Transbaikalia and northern China [12–13], where the climatic conditions of this species growing differ those of eastern Transbaikalia. Therefore, the research objective is to study the biochemical composition and nutritional value of the species Leymus chinensis in the southern steppe zone of eastern Transbaikalia

2. Materials and methods
The research was carried out in 2019 in the steppe zone of the Transbaikal Region. The study object was monodominant leymus communities (Leymus Chinensis), growing on different soil types (table 1).

| Number of descriptions, soil | Geographic coordinates | Total projective cover, % | Leymus projective cover, % | Number of species | Co-dominants |
|-----------------------------|------------------------|--------------------------|---------------------------|------------------|-------------|
| 1, typical saline           | N50.93630° E115.41905° | 80                       | 55                        | 19               | Artemisia anetifolia Web. ex Stechm. |
| 2, lithosol light-humus     | N50.86464° E115.46143° | 90                       | 70                        | 16               | Carex duriuscula C.A. Meyer |
| 3, lithosol light-humus     | N50.86435° E115.46164° | 95                       | 80                        | 24               | Thesium longifolium Turcz. ex Ledeb. |
| 4, alluvial light-color-humus quasi-gley | N50.86311° E115.46511° | 85                       | 70                        | 20               | Equisetum arvense L. |
| 5, alluvial light-color-humus quasi-gley | N51.04865° E114.37504° | 65                       | 40                        | 17               | Carex duriuscula |
| 6, alluvial humus stratified | N50.47533° E114.02410° | 55                       | 40                        | 9                | Potentilla bifurca L., Carex duriuscula |

Table 1. Leymus coenoses of eastern Transbaikalia.
The selection of study areas resulted from vast areas of grassy ecosystems: hayfields make up 98,973 hectares, pastures – 247,608 hectares in the Olovyannin District; and 55,746 and 326,467 hectares respectively in the Agin District. Average multiyear precipitation at the studied areas is 325 mm, and 306 mm for the growing season. The total precipitation for May-September at the period under consideration was 309 mm. It should be noted the extremely uneven precipitation in southern Transbaikal Region due to the arid climate of the territory.

Soil availability of nitrate nitrogen is low and very low; mobile phosphorus – average, except for community 4; exchange potassium – predominant low. The soils differ in pH, granulometric composition, cation exchange capacity, and humus content.

Plant sampling of aboveground green phytomass for biochemical analysis was carried out in the 3rd decade of July at 50 × 50 cm plots in 5 replicates, of which a mixed sample was formed for each coenosis. To assess the reserves of the underground mass in the coenosis, sampling was carried out by the method of monoliths, followed by washing on soil sieves. The soil monoliths were taken at three 25×25 cm plots layer-by-layer every 10 cm to a depth of 20 cm in 3 replicates for each community. The aboveground mass and washed roots were dried to an air-dry state and weighed. At sampling time, the quantitative characteristics of *Leymus* in the communities were unlike (table 2) due to the different soil and environmental conditions of its growth. For example, vegetative shoots exceeded generative ones 18.7 and 13.3 times, in Coenoses 1 and 6, respectively; 5.6–6.8 times in Coenoses 2, 3, and 5; and only 2.2 times in Coenosis 4.

**Table 2.** Quantitative characteristics of *Leymus chinensis* in conenoses.

| Number of descriptions | Amount of stems, pcs/m² | Height of stems, cm | Length of ears, cm |
|------------------------|-------------------------|--------------------|-------------------|
|                        | vegetative | generative | vegetative | generative |                        |
| 1                      | 896        | 48        | 33.1±1.1  | 54.2±1.4  | 8.3±0.3               |
| 2                      | 832        | 128       | 45.2±2.5  | 56.7±2.1  | 10.2±0.4              |
| 3                      | 720        | 128       | 43.2±1.3  | 60.3±2.2  | 10.7±0.5              |
| 4                      | 608        | 272       | 43.7±1.8  | 64.1±2.4  | 9.9±0.7               |
| 5                      | 768        | 112       | 27.1±1.4  | 48.7±2.7  | 7.4±0.5               |
| 6                      | 640        | 48        | 28.6±2.0  | 45.9±2.8  | 9.3±0.6               |

Plant samples were examined for dry matter determined according to V. G. Mineev et al. [14]; raw ash (RA) – by GOST 31640-2012 [15]; crude cellulose (CC) – followed to M. Kurschner and N. Haneck’s technique modified by A.B. Peterburgsky [16]; crude fat (CF) – by F. Soxhlet [17]; sugar – using G.E. Bertrand’s method; crude protein (CP), digestible protein (DP), nitrogen-free extractives (NFE). Feed units (FU), metabolizable energy (ME), total digestible nutrients (TDN), sugar-protein (SPR) and protein (PR) ratios were calculated according to GOST 13496.4-93 and Methodological guidelines [18–19]. Statistical data analysis of the productivity was performed in Microsoft Excel.

### 3. Results and Discussion

The total amount of nitrogenous substances, expressed by the content of crude protein, in meadow grass in the stem phase is usually 10–20 % of dry weight, before flowering – 5–15 %. The effect of external conditions (light, heat, moisture, etc.) on the synthesis of nitrogenous substances and carbohydrates in leaves of food grasses is the same as on other plants. The biosynthetic processes of the nitrogenous substance synthesis are activated at more intense illumination, it results in raising the concentration of proteins and amino acids in the vegetative mass of plants. The amount of nitrogenous substances in grasses also increases at elevated temperatures (25–35°C). The accumulation of carbohydrates and, first of all, their
labile forms (sugars, starch, fructosides) grows in plant leaves at lower temperatures [20]. The effect of light and air temperature changes can modify the content of crude protein in herbs 1.5–2.0 times, concentration of water-soluble carbohydrates – 2–3 times. It should be taken into account that raising light intensity and air temperature is always accompanied by a decrease in the plant moisture supply under natural conditions. The study reveals that the concentration of easily digestible carbohydrates decreases, and the content of proteins increases under conditions of moist deficit in the vegetative mass.

The dry matter of *Leymus chinensis* in the coenoses of eastern Transbaikalia is characterized by relatively high content of crude protein (table 3), which is related to the presence of a large number of vegetative shoots. The sugar content in grasses is usually 4–7 %. However, different soil and environmental conditions under the leymus coenoses (the degree of moisture supply) caused significant variability in sugar concentrations. Normally, the sugar-protein ratio should be 0.8–1.0, but in practice, it is 0.3–0.4 as a rule. This indicator does not correspond to the norm in Leymus for Descriptions 1 and 5.

To characterize the quality of feed, lipids including both fats, and other lipid groups, are commonly called "crude fat". Much more crude fat is in the phytomass of leguminous plants (2–5 % of dry weight), and less in meadow grass (1.5–3.0 %). During the growing season, the lipid content in forage grasses decreases, especially during the reproductive period of development. At their oxidation, more water is released than in other accumulated (reserved) substances, which can be critical to survive a plant organism under water stress. Slightly increased content of crude fat is, possibly, due to the vegetative form of reproduction predominantly. Although it has corresponded to the zootechnical feeding standards, it is significantly lower in absolute values than in *Leymus chinensis* growing in western Transbaikalia [21]. The content of crude protein and crude fat in dry matter of leymus in western and eastern Transbaikalia at present compared to their values in leymus communities before the drought [22] is 7.02–10.8 % and 1.31–1.96 %, respectively, prompt the conclusion that this is due to adaptation of this species to the prolonged drought, which start was noted since 2000. Perhaps for the same reason, it was observed the leymus vegetative reproduction by decreasing generative one, i.e. increased nutrient reserves cause the energy of vegetative growth and reproduction.

The crude cellulose content in dry matter of *Leymus chinensis* is increased due to both the presence of generative shoots and spikelets in the phytomass (table 3), and plant adaptation the harsh continental climate of Transbaikalia.

**Table 3.** Biochemical composition and feeding value of *Leymus chinensis*.

| Number of descriptions | Crude protein % | Sugars % | Crude fat % | Crude cellulose | NFE | Feed units per 1 kg | Metabolizable energy, MJ/kg |
|------------------------|----------------|----------|-------------|-----------------|-----|-------------------|----------------------------|
| 1                      | 9.37±1.15      | 1.15     | 3.31±0.16   | 39.02±0.46      | 42.33 | 0.34±0.01         | 7.96±0.20                  |
| 2                      | 9.06±0.98      | 3.32     | 3.34±0.31   | 35.81±0.65      | 45.94 | 0.43±0.02         | 7.99±0.15                  |
| 3                      | 7.86±0.70      | 5.17     | 3.33±0.10   | 35.10±0.78      | 48.27 | 0.45±0.02         | 7.81±0.13                  |
| 4                      | 6.69±0.69      | 1.70     | 3.28±0.12   | 37.74±0.55      | 46.58 | 0.38±0.01         | 7.54±0.12                  |
| 5                      | 9.56±0.91      | 0.83     | 3.72±0.14   | 39.26±0.56      | 42.53 | 0.34±0.01         | 7.99±0.15                  |
| 6                      | 9.69±1.25      | 3.44     | 3.78±0.08   | 34.17±0.82      | 47.19 | 0.48±0.03         | 8.16±0.23                  |
| Concentration norms in |                |          |             |                 |      |                   |                            |
| vegetable food         | 10–11          | –        | –           | 22–30           | –    | 0.64–0.70         | 8.4–8.9                    |

The usual concentration of NFE in grasses is 50–60 %. According to the obtained results, the content of these organic compounds in *Leymus* is 1.2–1.4 times less. The nutritional and energy value of dry matter of *Leymus chinensis* is lower than the standard one. Maybe, all parameters of the plant biochemical
composition, nutritional and energy value are related to change in precipitation spread in the growing season, including previous years, due to the increased aridity in southeastern Transbaikalia.

Protein ratio is an indicator of nutrient digestibility. With its value <1:6 it is narrow, with 1:6–8 – medium, >1:8 – wide. Growing animals better digest feed and absorb nutrients at a narrow protein ratio, adults – at a normal one (1:8–10). Under a wider ratio, the feed digestibility deteriorates. It should be noted that this indicator for eastern Transbaikalia is characterized by a stable wide ratio (table 4), and corresponds mainly to feeding adult animals, in contrast to the value of the protein ratio in dry matter of *Leymus chinensis* in western Transbaikalia.

**Table 4.** Content of digestible nutrients, sugar-protein and protein ratios.

| Number of descriptions | Crude protein g/kg | Crude cellulose g/kg | Crude fat g/kg | NFE g/kg | TDN g/kg | Sugar-protein ratio | Protein ratio |
|------------------------|--------------------|----------------------|----------------|----------|----------|---------------------|--------------|
| 1                      | 53.4               | 230.2                | 38.0           | 270.9    | 592.5    | 0.2                 | 1:10         |
| 2                      | 51.6               | 211.3                | 38.2           | 294.0    | 595.1    | 0.6                 | 1:10.5       |
| 3                      | 44.8               | 207.1                | 38.2           | 308.9    | 599.0    | 1.2                 | 1:12         |
| 4                      | 38.1               | 222.7                | 37.6           | 298.1    | 596.5    | 0.4                 | 1:15         |
| 5                      | 54.5               | 231.6                | 42.7           | 272.2    | 601.0    | 0.2                 | 1:10         |
| 6                      | 55.2               | 201.6                | 43.4           | 30.2     | 602.2    | 0.6                 | 1:9.9        |

An important indicator of the nutritional value of forage grasses is the total digestible nutrients (TDN). It is known that 1 g of the total digestible nutrients corresponds to 18.46 kJ of metabolizable energy [23]. According to our data (table 4), TDN varied in a rather narrow range, as well as the content of energy and metabolizable energy in the food, 10937.6–11116.6 kJ and 9187.6–9337.9 kJ, respectively, that may be related to a short growing season of *Leymus chinensis* development in harsh continental climate of the steppe zone in eastern Transbaikalia.

4. Conclusion

The paper has examined the biochemical composition of *Leymus chinensis*, its nutritional and energy value in the steppe zone of eastern Transbaikalia under different soil and environmental conditions of growing. For the first time, the content of crude protein, sugars, crude fat, crude cellulose, nitrogen-free extractives, feed units and metabolizable energy in dry matter of *Leymus chinensis* has been studied. Our study has revealed a definite dependence of the nutrient accumulation on soil-ecological conditions, the duration of the growing season and phase of plant development, this species adaptation (increased content of protein and crude fat) to prolonged aridization, which causes its vegetative reproduction due to decreasing generative one. Protein ratios have been determined as an indicator of feed digestibility. Despite the different quantitative parameters of biochemical substances and their digestibility, it has found that the total digestible nutrients, content of energy and metabolizable energy in the feed changed in a fairy narrow interval, which is associated with the short growing season of *Leymus chinensis* development in the harsh continental climate of the steppe zone in eastern Transbaikalia.

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