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ORIGINAL ARTICLE

Nutritional and pastoral evaluation of steppe rangelands in Khenchela region, Algeria

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The steppe plant species play an important role in ruminant feeding systems. It becomes necessary to put precise methods to evaluate the fodder quality of these pastures. The purpose of this study was to evaluate the pastoral productivity (PP) expressed in UF/ha and the pastoral value (PV) expressed in the form of a note or score then to fix the load per hectare to avoid the regressive synergy of the steppe ecosystem, providing proteins to satisfy the basic needs of the Algerian human economy. The research was carried out on Touchent pastures, located in Khenchela Wilaya in North-Est of Algeria. Which was undertaken during two seasons (Autumn, Spring) over 4 campaigns. The study area was dominated by *Stipa tenacissima*, *Artemisia herba alba*, *Thymus algeriensis* and *Genista quadriflora.* The linear surveys in 5 selected stations of 100 m^2, Pastoral productivity (PP) and the pastoral value (VP) were been calculated. The obtained results, showed that the nutrient composition of species during both seasons were very close. Generally, there was a slight difference between species during the same season, there was a difference in chemical composition between perennial species and annual species during Spring (Annual plants have the heist values). We note from this study that the pastoral value depends on the duration of the protection, the degree of degradation and the rainfall. The measures of pastoral productivity (PP) and pastoral values (PV) present a highly significant correlation between them. Indeed, the determination of the load per hectare contributes to the preservation, rational exploitation and sustainability of natural steppe rangelands.

Keywords: Rangeland, Load per hectare, Pastoral productivity, Pastoral value, Steppe.

Introduction

In Algeria, the steppe rangelands occupy a vast zone of terrestrial ecosystems, with more than 20 million hectares (Nedjimi et Guit, 2012). These rangelands are facing several degradation factors such as, climatic irregularity, demographic increase and inadequate use of natural resources (Boussaada and Benabdelli, 2018), the overall reduction of plant cover under the effect of overgrazing (Boukerker et al., 2021, Bahlouli et al., 2018, Slimani et al., 2010).

East of Algeria has important animal and pastoral resources where natural rangelands play a fundamental role in the agricultural production system with a great diversity of habitats occupied by an important floristic richness (Chalane et al., 2019).

Algerian natural rangelands present an immense floristic sources host of a predator, that important in number and varies in race. The sheep, which is supplier of red meat, covers 50% of the needs of the country (Yabrir et al., 2015, Senoussi et al., 2011). These rangelands are characterized by spontaneous vegetation and exploited extensively (Benrebiha and Bouabdellah, 1992), for the feeding of an ovine head estimated at more than 18 million head in 2009 (Yabrir et al., 2015).This Rangeland area undergoing

overgrazing (Mallem et al., 2017, Yerou and Benabdelli 2013, Le Houerou 1995) must be studied as part of its safeguarding and protection. One of the measures of this last action must be accompanied by a control of the load per hectare to be respected to avoid a new regressive synergy of the rangeland ecosystem. The determination of the nutritional value of the courses in Autumn and Spring will allow us to situate this value by season.

The objective of our research is to put:

- In results a food value by season in our case it is for the Autumn and the Spring for this grouping.
- In particular, a method of evaluating Rangelands developed by (Ghamri, 2015) which is correlative between the pastoral value (VP) and the pastoral productivity (PP) in order to preserve the ecosystem of the rangelands as part of the fixation of the charge per hectare to be respected.

This objective will highlight:

a) The food value of the course per season.
b) The year n, pastoral productivity (PP) expressed in energy value per season through the obligatory passage to the laboratory.
c) Another value, namely the pastoral value, will be calculated in situ at year n and will be correlated to the PP in order to make a regression line that determines the PP at the year n+1 hectare so as not to alter the equilibrium ecosystem of the course.

Hence, the question is how farmers adapt their feeding system to preserve this rangeland undergoing overgrazing and what is the style of pasture in order to safeguarding and protection of this rangeland. This study aims at answering these questions in the context of the east rangeland of Algeria.

Materiels and Methods

The description of the study area

The study area is located in the east of Algeria, and more specifically in the Wilaya of Khenchela, Touchent's region in the South East of Constantinois and at the opposite of the Mount of Aurès between 34°6'36"and 35°41'21"latitude North, between 6°4'12" and 7°35 '56"east longitud (Fig. 1), it extends over an area of 9715.6 km^2, It occupies a geographical position between the Atlas chain and the highlands, which gives it a character of agro-pastoral area. Touchent is part of the high plains of eastern Algeria, it is located in the north of the Wilaya of Khenchela. The climate of this forest massif is characterized by a long, dry and hot summer season and an increasing number of years with less rainfall. Rainfall is generally low and irregular (Hani et al., 2020).The experimental site is a defensive space since 2015and has made it possible to express the nutritive value, the pastoral productivity (PP) and the pastoral value (VP) per season.

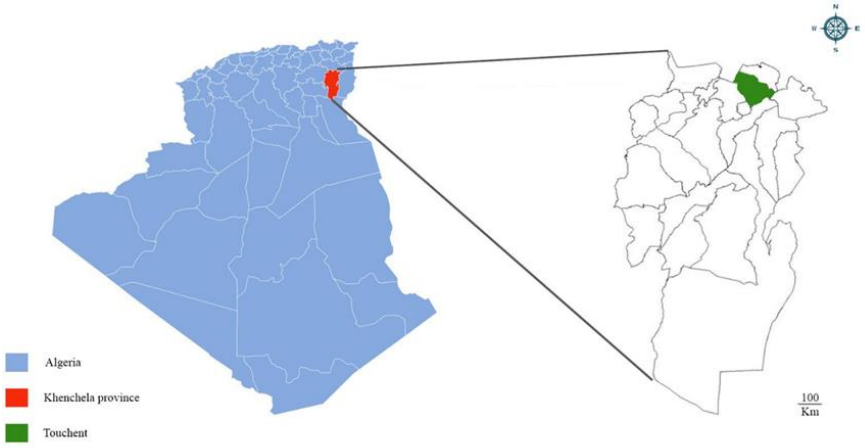

Fig. 1. Map of study area.

Sampling and measure vegetation methods

The study area is characterized by steppe vegetation dominated by *Stipa tenacissima*, *Artemisia herba alba*, *Thymus algeriensis* and *Genista quadriflora* (Fig. 2).

Field data collection was carried out on a course of 200 ha put in defense in the wilaya of Khenchela region of Touchnet, during two seasons (Autumn, Spring) over 4 campaigns (2019, 2020, 2021, 2022) corresponding to the growth peak of most steppe species. We carried out linear surveys in 5 selected stations of 100 m^2 (Daget et al., 2010). This linear survey is based on the techniques cited by (Daget and Poissonnet, 1971, Gonot, 1960).The choice of stations was based on the homogeneity of the physiognomy of the vegetation, on the one hand; on the other hand, it was based on the representativeness of the sampled stations. Five experimental stations was placed in this area; the distance between them was 500 m. After a description of the vegetation, a sheet for each floristic statement was drawn up, and finally to refine the results, a summary table is drawn up using the stations data. A line of 100 points spaced 10 cm apart, the starting point and direction of which have been chosen randomly, then a reading is taken along this line of the vegetation points. The samples was collected and placed in coded bags.

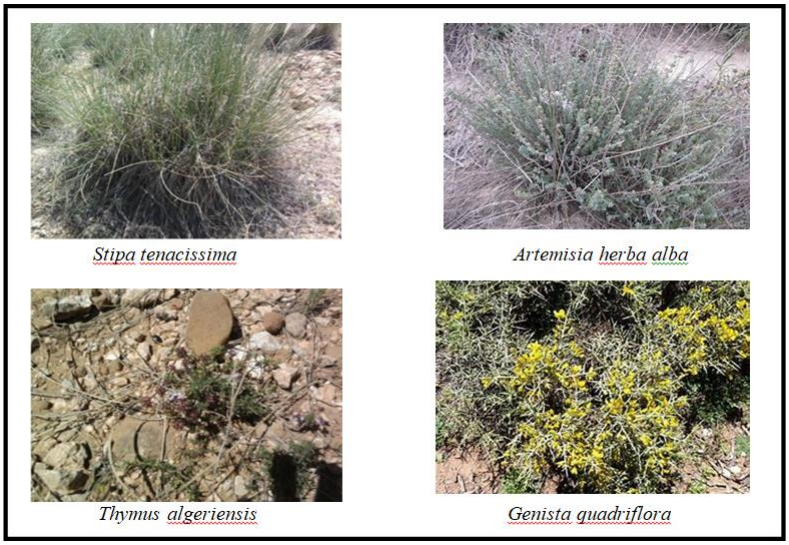

Fig. 2. The study perennial plants.

In the study of plant species, the measurement of the phytomass consists in cutting the vegetation at the level of the first 10 centimeters of the consumable biomass (secondary biomasse) parts consumable by the animal on a determined surface, 100 m^2 for perennial species and 1 m^2 for annual species for each station.

The perennials (the four species studied) were weighed on site; the annuals taken are also weighed, then dried in an oven (105°C) for 5 hours to determine the dry matter of these plants. Each station sampled, has a number n of species presenting with a given abundance that can be expressed either by density and frequency, the frequency was recorded by point reading along a line (Rekik et al., 2014).

The first approach is to make a statement of the nutritive value weighted by the consumable biomass per season (Autumn-Spring) to express the value that represents the (PP). The second is to relate the pastoral productivity (PP) expressed in energy value (UFL, UFV), protein values (PDIN, PDIE) and the pastoral value (VP).The study station was guided mainly by the writings and recommendation from (Chessel et al., 1975). Expressed from 0 to 100.

Methods for calculating the pastoral productivity of the group

Pastoral productivity (PP) production per hectare and per season has been calculated using the following formula: (I)

$$PP = \sum_{i=1}^{i=n} Rie.Vei \quad (I)$$

Rie=net secondary productivity expressing the yield of species I in kg of dry matter (DM)/ha/season. Vei=Nutritional value in UFL, UFV, PDIN and PDIE. At the point of programming (the UFV value is the one that was taken to determine the PP because always the UFV<UFL).

PP=Pastoral productivity of the group expressed in UFV, PDIN and PDIE/ha/season.

The main sources of the equations used to estimate the PP of each species i with a chemical composition determined in the laboratory was guided according to the methods of (AOAC, 1990), (Jarrige et al., 1978, Jarrige et al., 1988). The organic matter digestibility was calculated according to the method of (Aufrère, 1982).

Methods of calculating pastoral value

The pastoral value (VP) developed by (Ghamri, 2015) on steppe course which can take a value from 0 to 100 and developed in the formula below:

$$VP = \sum_{i=1}^{i=n} Csi.\frac{1}{Sei} \text{ (II)}$$

Or Sei is expressed in decimeter (stratum …) and $Csi = \frac{Fsi}{\sum_{i=1}^{i=n} Fsi}$

With $Fsi = \frac{Fsi}{\sum F} \times 100$

Fsi: number of the frequencies of the species i encountered on a line of 100 points.

∑Fsi: sum of the frequencies of the species i encountered on a line of 100 points.

Csi: specific contribution of the steppe plants.

Sei: is expressed in decimetre (stratum 1=1dm, stratum 2=2dm, stratum 3=3dm and stratum 4=4dm).

Chemical analysis

Plant material Sampling is performed in the course of Touchnet (Khenchela Province) during the period of Autumn and Spring of each year for the four years. The identification of plants was made with the help of the work of (Quézel and Santa, 1962, Ozenda, 1991). The chemical analysis of plants was performed according to the methods of the Association of Official Analytical Chemists (AOAC, 1990). The dry matter (DM) content of plants was determined by drying to constant weight at 105°C for 4 hours and Ash after heating at 550°C until a constant weight has been reached. Nitrogen (N) content was measured by the Khjeldal method (AOAC, 1990). Cured protein (CP) was calculated as N × 6.25. Ether extractive (EE) were defined with diethyl ether extraction in a Soxhlet apparatus. Crude fiber (CF) was determined according to (Van Soest and Wine, 1967).

Results and Discussion

The chemical composition of the group

The chemical composition of plant species encountered in the region is reported in Table 1.

Table 1. The chemical composition of the plant species per season.

Season	Speaces	DM	Ash	OM	CF	EE	CP
		g/kg	g/kg DM	g/kg DM	g/kg DM	g/kg DM	g/kg DM
Autumn	*Stipa tenacissima*	871.3	42	958	490	28	47.5
	Artemisia herba alba	826.7	56	944	500	28	66.7
	Genista quadriflora	782.2	30	970	498.3	44	69.9
	Thymus algeriensis	720.4	59	941	410	16	67.0
	Annuel plantes	/	/	/	/	/	/
Spring	*Stipa tenacissima*	854	40	960	470	18	44.8
	Artemisia herba alba	750	70	930	416.6	20	71.1
	Genista quadriflora	760	36.7	969.3	454.4	48	72.2
	Thymus algeriensis	740	62	938	411.1	12	70.8

Annuel plantes	548	127.4	872.6	275.5	48	132.3

DM: dry matter content (g/kg); Ash: Mineral content (g/kg DM); OM: Organic matter content (g/kg DM); CF: Cured fiber (g/kg DM); CP: Cured protein (g/kg DM); EE: Ether extractive (g/kg DM).

Forage dry matter was 871.3, 826.7, 782.2 and 720.4 g/kg for *Stipa tenacissima, Artemisia herba alba, Genista quadriflora and Thymus algeriensis* respectively during Autumn, whilein Spring DM ranged between 854 g/kg in *Stipa tenacissima* and 548 g/kg in annuel plants. In Autumn the highest OM content was recorded for *Genista quadriflora* (970 g/kg) while *Thymus algeriensis* recorded the least value (941 g/kg MS), although in Spring the highest OM content was recorded for *Genista quadriflora* and the less value recorded for annuel plants (872 g/kg DM). CF values fluctuate around 500 g/kg DM in Autumn, but in the Spring the CF values decrease, less value recorded for 275 g/kg DM.

The obtained results showed that the dry matter content of shrubs (Table 1) was within of those reported by other authors (Chehma and Youcef 2009, Boufennara et al., 2012, Mayouf and Arbouche, 2015, Medila et al., 2015). This could be due to the ecological conditions, these plants grow under similar conditions in arid and semi-arid Algerian areas. However, dry matter content of annual plants was lower than those reported by authors cited previously. The CF value of the studied browse shrubs was compared to those reported by (Bouallala et al., 2011, Chehma et al., 2010) for perennial plants of Algerian arid areas. The CP content was lower to those obtained by (Heli et al., 2009) in India and (Arab et al., 2009) in Algeria. While it is well known that the CF of annual plants was less than those of shrubs but CP was higher than these latter. This could be explained by plants harvest stage.

The nutrient contents of the studied species were compared with study carried out by other workers in species like *Atriplex canesscen s*and *Anabasis articulate* (Amrani, 2021), *Fraxinus oxyphylla* (Bencherchali et al., 2019). *Albizia lebbeck, Leucaena leucocephala, Morinda lucida, Senna siamea* (Mboko et al., 2017).

The differences among shrub species in terms of these properties have been reported by (Akanmu et al, 2020, Ertekin et al., 2019). This difference in content of elements likely to be related to the species stage of maturity during sampling.

The nutritional value of the group

The nutritional value of floristic species encountered in the region is reported in Table 2.

Table 2. Nutritional value of the plant species studied per season.

Season	Speaces	DOM g/kg DM	UFL	UFV	PDIN g/kg DM	PDIE g/kg DM
	Stipa tenacissima	546	0.62	0.52	101	55
	Artemisia herba alba	538	0.63	0.53	142	60
	Genista quadriflora	552.9	0.58	0.27	164	64
Autumn	*Thymus algeriensis*	536	0.57	0.48	142	59
	Annuel plantes	/	/	/	/	/
	Stipa tenacissima	528	0.60	0.53	95	52
	Artemisia herba alba	520.8	0.61	0.54	152	59
	Genista quadriflora	610.65	0.72	0.67	149	66
Spring	*Thymus algeriensis*	497.4	0.57	0.49	151	58
	Annuel plantes	636	81	0.78	283	86

DOM:digestible organic matter; UFL: Net forage unit expressed in forage unit milk; UFV: Net fodder unit expressed in forage unit meat; PDIN: PDIA+microbial protein digestible in the intestine corresponding to the nitrogen of the degraded food in the rumen in grams; PDIE: PDIA+microbial protein digestible in the intestine corresponding to the energy of the degraded food in the rumen; PDIA: Protein digestible in the alimentary gut.

The OMD (Table 2), varied between species and seasons. During the Autumn, OMD varied from 536 g/kg DM in *Thymus algeriensis* to 552 g/kg DM in *Genista quadriflora*. During Spring OMD ranged between 497 g/kg DM in *Thymus algeriensis and* 636 g/kg DM in Annual plants.

OMD results are with findings of (Ertekin et al., 2019) but lower then findings of (Arbouche et al., 2014). This could be due to the study area wetland chosen by (Maamri et al., 2015). Results shows that OMD tends to decrease depending on the maturity of the plant species.

The nutritional value of the species has been well estimated according to the chemical composition and their digestibility, they are in the norms of expression of energy and nitrogen (UFL>UFV) and nitrogenous matter of species rich in proteins such as *Artemisia herba alba*, Thymus and annuals. This assessment is more pronounced in Spring than in Autumn.

The energy value (Table 2) expressed in UFL is slightly higher than that expressed in UFV. The energy values of studied plants are similar to those of certain forage plants such as *Dactylis glomerata, Festuca arundinacea and Phalaris aquatic* (Nabi et al., 2020) and *Calycotum spinosa, Myrtus communis, Pistacia lentiscus,* (Mebirouk-Boudechiche et al., 2014). These results demonstrated that the plants of the Algerian steppes have almost the same energy level while their nitrogen level is intermediate. During Autumn, the nitrogen values PDIN are between 101 and 164 g/kg DM respectively for *Stipa tenacissima* and *Genista quadriflora*, while during Spring the values are between 95 and 283 g/kg DM respectively for *Stipa tenacissima* and Annual plants. For PDIE, during Autumn the values are between 55 and 64 g/kg DM and correspond respectively to *Stipa tenacissima* and *Genista quadriflora* during Spring PDIE values ranged betwen 52 and 86 g/kg DM for *Stipa tenacissima* and Annual plants. Overall, the studied species gave values comparable to the value recorded by (Mebirouk-Boudechiche et al., 2014, Nabi et al., 2020).

Values of DMO, UFL, UFV, PDIN and PDIE were within the range reported by (Arab et al., 2009) formain fodder of arid and semi-arid zone in Algeria according to (Arbouche et al., 2008) for forest pastures of Algeria. However our results are higher than the values reported by (Rekik et al., 2014) for steppe dominated by *Salsola vermiculata L* in Algéria. Results of this study suggest that the nutritional characteristics of studied shrubs have potential as a good forage for ruminant.

The Pastoral Productivity (PP) of the group

Table 3 reports both yield (Rei), density per hectare and season. These values will allow us to highlight the (PP) expressed in UFV, PDIN and PDIE at the same time.

During the Autumn the yield of the species is oscillating between 6 kg DM/ha for *Genista quadriflora* and 795 kg DM/ha for *Stipa tenacissima*, *Artemisia herba alba* and *Thymus algeriensis* recorded a yield of 44 and 141 kg DM/ha respectively. In Spring *Artemisia herba alba* recorded a very high yield compared to Autumn. Annual plants gave a considerable yield of 300 kg DM/ha. (Moulay, 2011) put forward an average annual production between 115 and 721 kg DM/ha for *Stipa tenacissima*. (Rekik et al., 2014) mentioned an average yield of 758 kg DM/ha during Spring. (Yerou et al., 2022) found an average yield of 3120.4 kg DM/ha in protected rangelands against 490.3 kg DM/ha for open rangeland. (Yousfi et al., 2017) mentioned for the wilayate with an agro-pastoral vocation the contribution of rangelands and pastures represents less than 50% of energy fodder resources. The case of the wilaya of Khenchela, also with agro-pastoral vocation, forms the exception for reasons of a very important fodder supply in the pastures and rangelands. Salem (kour et al., 2013), reported that the above ground biomass in *Stipa tenacissima* rangelands increases with their cover and the size of the dominant species.

(Houbib, 2013), reported that in the region of khenchela the summer rains are generally stormy, becoming more pronounced from May to September, with a maximum in August. These rains require the increase in the yield of some species in Autumn such as *Stipa tenacissima.*

For the pastoral productivity, we recorded pastoral productivity values in Autumn between 3.5UFV/ha for *Genista quadriflora* and 413 UF/ha for *Stipa tenacissima*. In Spring *Artemisia herba alba* recorded the highest pastoral productivity 382 UFV/ha, while *Genista quadriflora* recorded the lowest value 37.5 UFV/ha (Table 2). The results of (Rekik et al., 2014) recording an average PP of the order of 100 FU/ha are close to our results. Daget et Poissonet, 1972 found a pastoral productivity value of 4 UFV/ha for *Antboxa ntumodoramm* and 2.8 UFV/ha for *Brizemedia* species. (Aidoud et al., 2006) mentioned that in an average year (P=200 mm), pastoral production varies from 10 to 50 UF/ha.

Table 3. Pastoral Productivity (PP) of the grouping per season.

Season	Speaces	Rei Kg DM/ha	Density/ha	PP UFV	PP PDIN (kg/ha)	PP PDIE (kg/ha)
Autumn	*Stipa tenacissima*	795	6630	413	80	43
	Artemisia herba alba	44	4430	27.7	6	2.6
	Genista quadriflora	6	1130	3.5	1	0.3
	Thymus algeriensis	141	1175	86	20	8.4
	Annuel plantes	/	/	/	/	/
	Total	/	/	530.2	107	54.3
Spring	*Stipa tenacissima*	464	6630	246	44	43
	Artemisia herba alba	708	4430	382	107	2.6
	Genista quadriflora	56	1130	37.5	8.3	0.3
	Thymus algeriensis	49	1175	80	2.5	8.4
	Annuel plantes	300	**/**	234	263	108
	Total	**/**	**/**	979.5	424.8	162.3

Rei: yield of species i in kg DM per hectare; Annual plants: It is a floristic procession: plantago albicans, Schismus barbatus, Arnebia decumbens.

If aewe is monitored with 1.1 lambing per year, a 3-12 month old calf and a 3-4 month old mustard requires 900 UFV and 120 kg PDIN annually (including 0.01 rupees per ewe followed).

Therefore, without altering the ecosystem of this group or without altering primary productivity, one (1) hectare can feed 1/2 ewe followed or two hectares ewe monitored according to the energy supply of the Autumn flora. For the same nutritive energy value of the courses in the Spring one hectare can feed a sheep followed.

The pastoral value of the group

Table 4 shows the pastoral value (VP), whose bromatological quality of the specific index developed by (Daget et al., 1972) has been replaced by the stratification index (Ghamri, 2015).

According to the Table 4 There are significant variations in pastoral value between species. In Autumn the highest value was recorded in *Stipa tenacissima*, while the low value was recorded in *Thymus algeriensis*. In Spring *Artemisia herba* alba and *Stipa tenacissima* recorded the highest values 14.2 and 8.6 respectively, followed by annual plants with 5.6.

Our results recorded for *Artemisia herba alba* and *Stipa tenacissima* are superior to those obtained by (Rekik et al.,2014), but results recorded for *Genista quadriflora* and *Thymus algeriensis* are lower. (Yerou et al., 2022) mentioned a value 5.4 for unprotected rangeland.

This difference is justified by the contribution of species with great pastoral interest and also by the low rate of vegetation cover, by the low richness of the flora.

Table 4. Pastoral value of the group.

Season	Speaces	Stratum	Fis	Csi	VP
	Stipa tenacissima	4.0	25.5	75.3	18.8
	Artemisia herba alba	3.5	4.3	12.9	3.7

Autumn	*Genista quadriflora*	2.6	2.5	7.3	2.8
	Thymus algeriensis	2.8	1.2	3.4	1.2
	Annuel plantes	/	/	/	/
	Total	/	/	/	26.5
Spring	*Stipa tenacissima*	4.1	18	35.3	8.6
	Artemisia herba alba	3.4	25.5	50	14.2
	Genista quadriflora	2.9	4.0	7.8	2.7
	Thymus algeriensis	2.3	1.2	2.3	1.0
	Annuel plantes	1	2.8	5.6	5.6
	Total	/	/	/	32.1

Stratum: Level of plant heights; Fis: specific frequency of steppe plants; Cis: specific contribution of steppe plants; VP: Pastoral value of steppe plants.

Results of correlation between pastoral value PV and pastoral productivity PP

Table 5 highlights the correlation results between PP expressed in UFV and VP.

Table 5. Correlation Results between PP (n) and VP (n).

Season	**PP UFV**	**Obs**
Autumn	0.979	P=0.004
Spring	0.991	P=0.000

PP UFV: Pastoral productivity in UFV. Obs. Observation

The results are interesting in order to predict PP_{n+1} in UFV following an in-situ biometric measurement to determine the VP_{n+1} in a frame work of preservation of the group following a setting of defenses.

The setting in defense will be valorized by the fixing of the charge per hectare of the main predator (the sheep) for a possible grazing and this operation will thus maintain the pastoral potentialities of this course or in other term this operation will preserve the primary productivity of the pathway involving consumable biomass or secondary productivity. In this same observation when a fall is rainy, this group can feed 0.5 ewes and a climatically favorable Spring also a ewe followed and this per hectare.

The following year after a biometric in-situ measurement to fix the VP, it is possible to calculate a PP in order to fix a charge per hectare to be respected and this thanks to the regression equations quoted above.

We have tried to make the method of evaluating pastoral routes simpler and faster, knowing that this technique loses in terms of precision, but on the contrary gains in terms of time and cost, two major factors for the exploitation rational of a course.

Conclusion

The variation between seasons and between species in the nutrient composition was well revealed by our results which give total PP values oscillating between 54.3 and 162.3 kg DM/ha and corresponding to pastoral values of order 26.5 and 32 during the Autumn and Spring respectively in courses in the Touchent region.

The above mentioned correlation between PP and VP was very significant and moreover, the estimate of PV in situ the following year can be used to estimate the PP which will be able to predict a value of the load per hectare that it must be respected so as not to alter primary productivity or consume more than the productivity allowed by the consumable biomass.

The other reflection is that the current northern region of Khenchela called Touchent presents a pastoral resource of a *Stipa tenacissima* and *Artemisia herba alba* group and annual plants which has the potential of one hectare of which it can feed 1/2 ewes

followed in Autumn and a sheep followed in the Spring. This load per hectare expressed in sheep zootechnical unit will maintain the ecosystem of this group in stable synergy.

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