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Socio-Economic and Ecological Analyses of the Use of Controlled Fires in Pastoralism: Cases of two Agro-Ecological Zones of Benin

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Abstract

The studies of social acceptability, technical feasibility, economical profitability and ecological effects of the controlled fires use were conducted in two agro-ecological zones of Benin. Objectives were: (i) to test the effects of various controlled fires on the grasslands productivity and quality; (ii) to make a comparative socio-economic analysis of the controlled fires use and the establishment and utilisation of artificial pastures. Socio-economic data were collected through surveys with small breeders, farmers, and managers of pilots' ranches of the "Projet de Développement de l'Elevage au Bénin". Three types of vegetation fires (early fires, late fires and out-of-season fires) were tested. The use of Phytosociological and linear relevés results in the typology and determination of pastures pastoral values. Phytomass was harvested inside and outside protected plots.

Pastures respond differently to various types of fires. Early fires significantly improve productivity with a coefficient of improvement of 18.2% in Sudano-Guinean zone and 24.4 to 24% in Guineo-Sudanian zone. Pasture productivities were low in response to both late and out-of-season fires in both guineo-sudanian and sudano-guinean zones. The coefficient of productivity reduction ranged from 10 to 20.1% for the late fire and 26.2 to 50.3% for the out-of-season fire. Both early and late fires improve the pastoral values in the two zones. The average values were 51.2% and 50.7% respectively for early and late fires. Conversely, the out-of-season fires decreased this value in the magnitude of 9 %.

Fires are used in Benin for economic, ritual and hygienic reasons. Their application on natural pastures is relatively more profitable than producing artificial pastures. Establishing and maintaining 1 hectare of artificial pasture requires 306.76 $US/ha/year while managing a natural pasture by fire costs 11.43 $US/ha in the first year and approximately 4.82 $US the four last years. Globally, managing a natural pasture by fire is more profitable than producing an artificial pasture which requires investments that small breeders and farmers cannot afford to do with their small resources. Controlled fires might improve the natural pastures productivity and could be recommended in the current degradation context of natural pastures in Benin.

Keywords: Agro-ecological zone, analyze, Benin, controlled fires, ecological, socio-economic

Introduction

The demand in livestock products should double near the year 2020 with the increasing demography in developing countries (Delgado *et al.* 1998). Consequently, increased productivities, environmental preservation and natural resources management are needed. How to supply human needs in balancing pastoral resources conservation is woefully urgent. Bush fires have proven to affect ecosystems dynamics (Meurer *et al.* 1994), are used as tool for building and managing grazed ecosystems (Sinsin & Saïdou 1998), controlling grasslands invasiveness (Cesar 1992), and improving fodder quality (Geny *et al.* 1992). However, the use of bush fires should be convenient with pasture types and specific phytogeographical sites. In this context, do the uses of controlled fires influence economy and customs of stockbreeders in Benin? What are the ecological impacts of bush fires in Benin? The present work was undertaken in the ranches of the Projet de Développement de l'Elevage (PDE III). The overall aims were: (i) to test the effects of various controlled fires on the grasslands productivity and quality; (ii) to make a comparative socio-economic analysis of the controlled fires use and the establishment and utilisation of artificial pastures.

Study area

Two ranches were studies in Benin (Fig. 1):
a) The ranch of Okpara (FEO) is located in the north within the sudanian area, at 2°40'-2°55'E and 9°06'-9°21'N. The rainfall averaged 1200 mm from April to October;

b) The ranch of Samiondji (FES) is located in the centre within the guineo-sudanian area, at 2°22'-2°25'E and 7°25'- 7°30'N. The rainfall averaged 1100 mm in March-July and September-November.

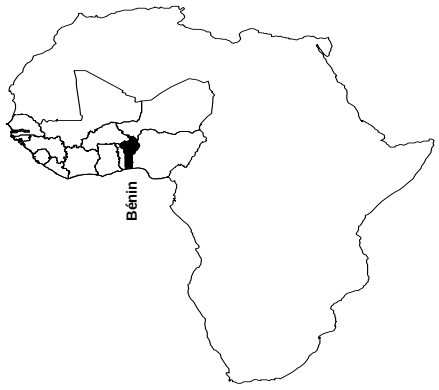

Fig. 1 : Benin in Africa

Methodology

A) The **socio-economic** data were collected by interviewing stockbreeders, farmers and staffs of the PDE III project. The impacts of the various fires (early, late and out-of-season fires) were appreciated throughout: (i) Types of pastures and floristic composition from 622 phytosociological relevés using the method of Braun-Blanquet (1932); (ii) species frequencies from 738 linear relevés using the method of aligned point-quadrats (Daget & Poissonnet 1990); (iii) relative frequency, specific contact contribution of species, pastoral values and shrub percentages using linear relevés; (iv) phytomass measurement inside and outside protected plots (Sinsin 1993). **B)** The **experimental design** globally results in the early fire application (to access the hemicryptophytes abundance) one month after the last rain of rainy season and the out-of-season fire in the full rainy season from July to August. **C)** The **ecological parameters** were**:** (1) Fires impact index (Coefficient of improvement or reduction for the estimation of grassland productivities) calculated as follow: $Ip=(P_{treatment}-Pp_{control})/P_{treatment}x100$; Ip=Fire impact index ; Ptreatment=treated productivity; Ppcontrol=initial productivity. Ip>0: improved productivity; Ip<0: decreased productivity. (2) Specific contact contribution CSCi per species i, $CSCi=FSi/\sum FSi$: FSi=specific frequency of species i; $\sum FSi$=arithmetic sum of grouping specific frequencies. (3) Fire impact index on specific hemicryptophytes contribution: $Ir=(CSCH_{treatment}-CSC_{control})/CSCHtreatment \times 100$; Ir=Fire impact index on specific part; $CSCH_{treatment}$=specific contact contribution of hemicryptophytes after treatment; $CSCH_{control}$=specific contact contribution of hemicryptophytes in controlled treatments. Ir>0: increased recruitment; Ir<0:

stressed recruitment. (4) Shrub percentage Te; $Te=CSC_{rejected}/CSCtotal \times 100$. (5) Pastoral value $Vp=0.25\ Rv \times \sum CSCi \times ISi$; Rv=soil recovery rate; ISi= index of species quality i appreciated in the scale of 0 to 4. **D) Data analyses** were performed using Analysis of variances at 5 % and post hoc test of Newman & Keuls with Statistica 7.0.

Results and discussion

1) Sociology of vegetative fires in Benin

Three types of vegetative fires existed in Benin: mythological and ritual fires, agricultural and hygienic fires. (A) Mythological and ritual fires are used during ceremonies for fighting bad spirits sheltered by a bush and having good harvest in northern Benin. (B) agricultural fires are used to: (i) clean and prepare fields in the traditional farming system; (ii) facilitate fruits harvests (shea tree nut, néré: *Parkia biglobosa*); (iii) to facilitate wild animals visioning tourism and collective hunting; (iv) support pastures regeneration; (C) Hygienic fires of dwellings, enclosure and animal parking against snakes, scorpions, ticks, small rodent and tse tse flies. Rural tracks as well as "pare-feu" were also cleaned. The fire management integrated some manners, habits and customs, and was widely acceptable in grassland management in Benin.

2) Economic analysis of pasture management using fires

Comparative economical analysis of prairie establishment and grasslands management using controlled fires reported approximately a total of 1159.38 $US/ha for establishment and 72.54 $US/ha for maintenance. Costs and inputs for the establishment and maintenance of one hectare of fodder cropping include followings: Clearing and shifting (by bulldozer), ploughing and pulverizing (by tractor), sowing (13 man-days/ha), maintenance (5 man-days/ha), manures (50 kg NPK and 50 kg Urea; 1 man-day/ha), closure plots (research stake, dung, barbed wire; 24 man-days/ha), opening of "pare-feu" (4 man-days/ha). (2) 11.41 $US8/ha/year for natural grasslands management by fire which required spatial zoning, assembling grasslands and watchtowers preparation (1 person on watchtower and 2 persons supervising 500 ha using bicycles). Details of costs by operation were not reported in this communication. Establishment of one hectare of prairie costs 1159.38 $US/ha/year. On a basis that a prairie might be used for five years and annually maintained for 72.54 $US/ha, a fodder prairie establishing cost [(1159.38/5) + 72.54=300.42] $US/ha/year. Managing natural grasslands by fire cost 11.43 $US/ha in the 1st year and about 4.82 $US during the fourth following years (table 1). Globally, using fires in managing grasslands appeared to be 26 times more economic than establishing fodder prairie with high implementations generally unavailable to stockbreeders.

Table 1: Comparative costs ($ US/ha) of grassland establishment and management using fires

Type of management	Funding Year 1	Maintenance Year 2	Maintenance Year 3	Maintenance Year 4	Maintenance Year 5
Fodder plot	1168.3	73.1	73.1	73.1	73.1
Management using fires	11.50	4.82	4.82	4.94	4.94

3) Effect of fires on grasslands productivity

Six types of pastures were studied, which were respectively dominated by *Andropogon gayanus*, *Andropogon schirensis*, *Andropogon tectorum*, *Brachiaria falcifera*, *Heteropogon contortus* and *Hyparrhenia smithiana.* Fire effects on grassland productivities were appreciated using index of fire impact. Fig. 2 highlighted averaged values of index during 2001 and 2002. Early fires slightly improved productivities in rates of 18.2% and 24.0% respectively for FEO and FES. The coefficient of productivity reduction ranged from 10 to 20.1% for the late fire and 26.2 to 50.3% for the out-of-season fire. Pastures significantly responded differently and their productivity

depend on farms (p=0.0443). The early fire increased soil covering as the late fire increasing naked beaches. The out of season fire provides tender, palatable straw in dry season, but does not ensure an optimal soil covering. Grasses which were grown 3 months after OSF application still remained small and the lower biovolum might be related to the lower productivity. While early fire improves pastures productivities, both late and out-of-season fires decreased productivities values.

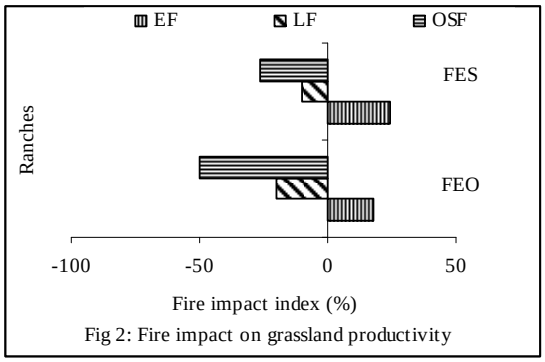

Fig 2: Fire impact on grassland productivity

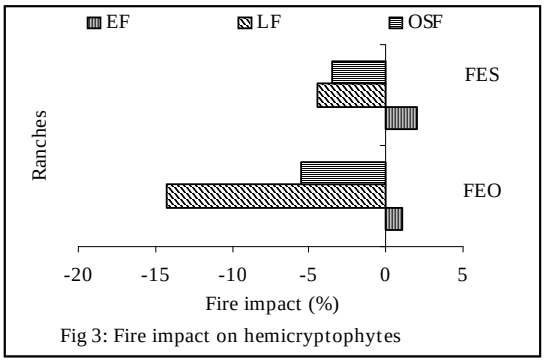

Fig 3: Fire impact on hemicryptophytes

FEO: Okpara's ranch; FES: Samiondji's ranch; EF: early fire; LF: late fire; OSF: Out of season fire.

4) Effects of fires on linear frequency of hemicryptophytes

The impact of fires on the linear frequency of hemicryptophytes was appreciated through analysis of fire impacts index on the contact specific contributions of the years 2001 and 2002 (Fig. 3). Early fire improved the hemicryptophytes' abundance in contrast to the late fire. Impact index differ significantly with fires (p=0.0473). Coefficients of stimulation of the hemicryptophytes recruitments averaged 8.6 % and 5.4% for FEO and FES respectively. The important water stock of soil at the early fire application reduces the fire vigour, and stimulates the hemicryptophytes recruitments. The coefficients of inhibition of the hemicryptophytes recruitments were -13.2% and -2.9% for FEO and FES respectively. The late fire compromises hemicryptophytes recruitments (CIR= -11.9 % and -5.0% from 2001 to 2002 after the fire application on the hemicryptophytes linear frequency). Results were not significant with the out-of-season fire.

5) Effects of fires on shrub percentage and pastoral value of natural grasslands

Fig. 4 and 5 respectively highlighted variation in shrub percentage and pastoral values in the years 2001 and 2002 after fires application on to the Okpara and Samiondji pastures. The shrub percentage significantly respond differently to fire (p=0.0017) with the higher values in controlled plots (Te=0.13) and the lower with the late fire (Te=0.06). Otherwise, the shrub percentage response to various types of fire was not significant from a farm to another (p=0.1532) in regard with the type of fires.

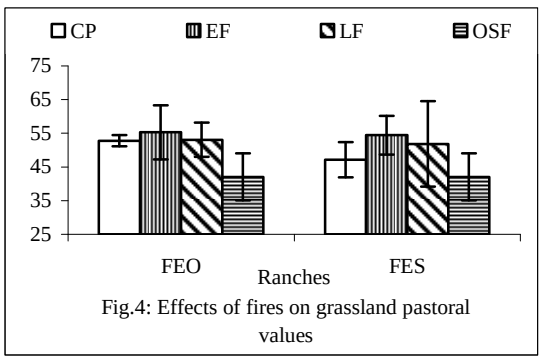

Fig.4: Effects of fires on grassland pastoral values

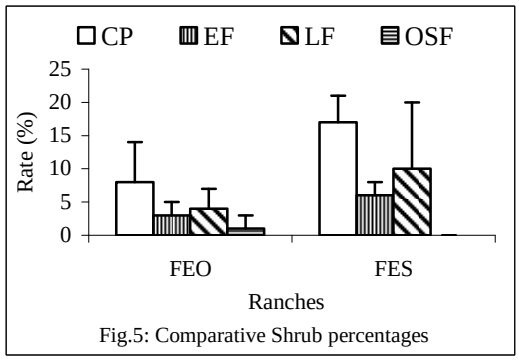

Fig.5: Comparative Shrub percentages

CP: Control treatment

The late fire compromised the regeneration of chamephytes that are lowly grazed by animals. This result is in accordance with the hypothesis that controlled fires can help in well controlling natural pasture invasiveness (Sabitti & Wien 1991). The EF and LF improved grasslands pastoral values of both ranches while the OSF decreased its (fig. 5). Average values were respectively 51.2% and 50.7% for early and late fires. Out-of-season fires reduce values from 46.2 % (control plots) to 42.0 %. The pastoral values were significantly different (p=0.0303). Indexes of impact were 51.2%, 50.7%, 46.2% and 42.1% respectively for EF, LF, CP and OSF.

Conclusion

The use of fires in managing natural pastures integrates well the local communities' customs in Benin. Specifically, using the early, late and out-of-season fires in establishing natural pastures appeared to be economically profitable and ecologically sustainable in the sense that: (A) the early fire stimulates the hemicryptophytes recruitments, improved notably the potential production and optimal soil covering; (b) the late fire burnt in the dry season disturbs the grasses recruitments development and decreases pasture invasiveness. The naked beaches were accelerated and the carrying capacity was limited; (c) the out-of-season fire improved tender and palatable straw in the dry season. These fires can be well useful technologies for improving pastoral productivity and nutritive values of grasslands. These good tools are still well required for managing the pastoral resources in sub-Saharan zones.

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