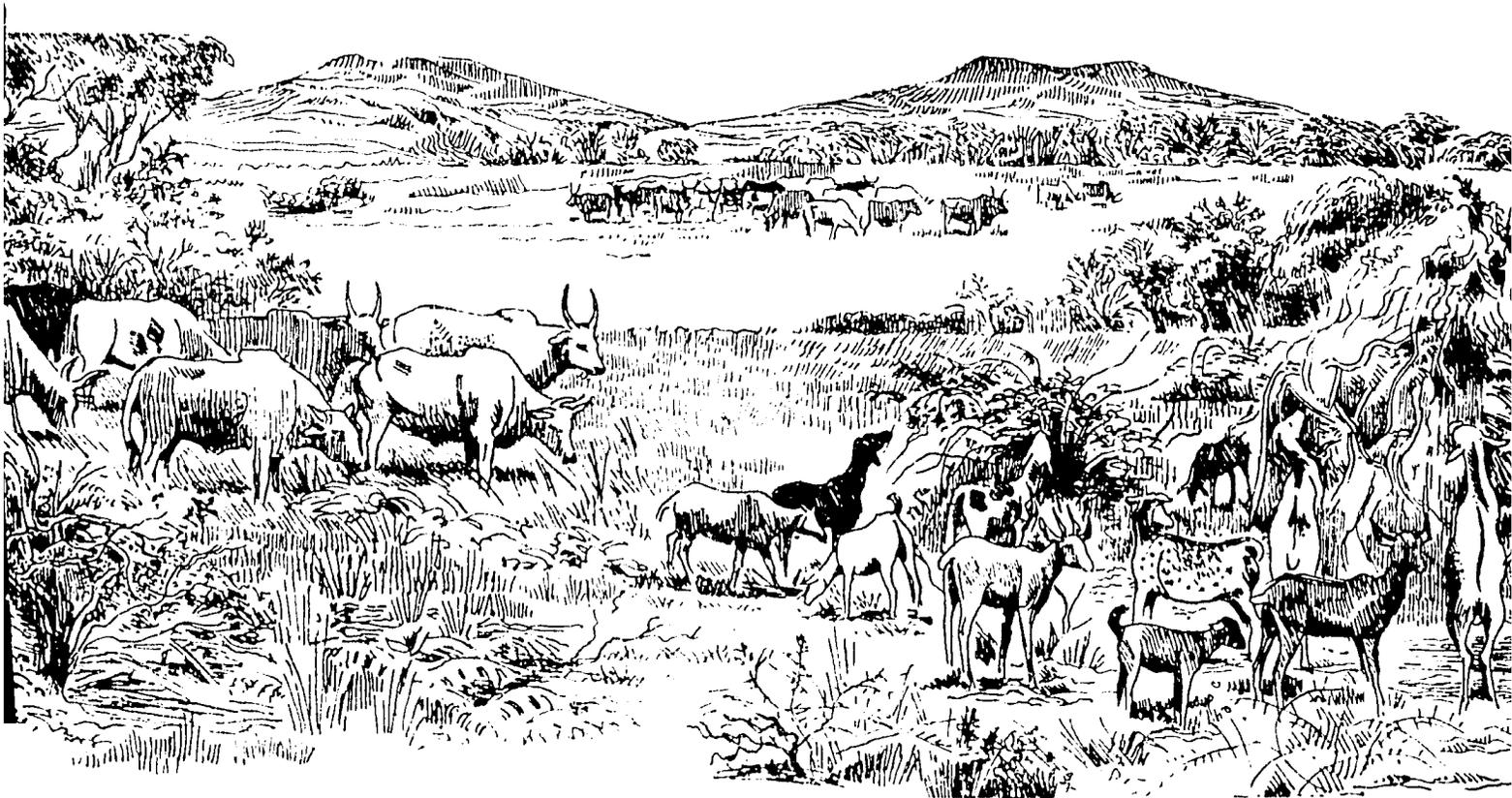


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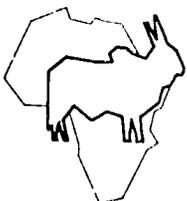


Land nationalisation and rural land tenure  
in southwest Nigeria

Herding practices and grazing behaviour  
of cattle in Nigeria's subhumid zone

Effects of legume hay supplements  
on sheep

Effects of N supplements on growing  
heifers



International Livestock Centre for Africa, P.O. Box 5689, Addis Ababa, Ethiopia

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The *ILCA Bulletin* is a quarterly publication of the International Livestock Centre for Africa. It provides an up-to-date account of aspects of the Centre's work. Contributions to the Bulletin are invited from other livestock researchers in Africa whose work is closely associated with that of ILCA. The *ILCA Bulletin* is distributed to 1500 researchers, policy makers, donors and extension agents throughout sub-Saharan Africa and elsewhere in the world.

ILCA is one of 13 international centres for agricultural research whose work is funded by the Consultative Group on International Agricultural Research (CGIAR). The 13 centres have been established by the CGIAR to provide long-term support for agricultural development in the Third World.

### PREFACE

This issue of the *ILCA Bulletin* includes an article on land nationalisation and rural land tenure in southwest Nigeria, a study of agropastoral herding practices and grazing behaviour of cattle in Nigeria's subhumid zone, and two articles on the effects of supplementing poor quality roughage diets for sheep and cattle.

The first article discusses the impact of the Nigerian Land Use Decree of 1978 on patterns of land holding and use in the cocoa belt of southwest Nigeria. The study showed that the system of land tenure prior to the Decree provided an equitable, stable and flexible means of regulating access to land, and that assertions about the shortcomings of traditional systems have been based on misconceptions of how such systems functioned. The general finding of the study was that the Decree has had little impact on land tenure and use, and has done nothing to rationalise the supposed defects of customary tenure systems.

The second article examines the herding practices of agropastoralists and the grazing behaviour of their cattle in the Nigerian subhumid zone. The present system of integrated cropping and livestock herding allows greater yields of food per unit area than either enterprise alone, but requires close control of grazing animals in order to avoid crop damage. As a result, herding periods are relatively short, which the author believes may be the cause of the low productivity of the cattle. The author states that development efforts should be aimed at maintaining the present integrated system while seeking to provide additional feed resources such as fodder banks.

The last two articles both deal with supplementing cereal crop residues. The first examines the effects of *Trifolium temense* hay on the voluntary intake and digestibility of maize stover and oat, wheat and teff (*Eragrostis tef*) straw by sheep. While only oat straw could support maintenance when fed alone, when supplemented with trifolium hay all four diets were eaten in sufficient quantities to permit moderate levels of production. The increases in nutritive value obtained by supplementing the cereal crop residues with trifolium hay were comparable to those expected from treating the crop residues with strong alkalis. However, supplementing diets with legumes is more appropriate to conditions on small mixed farms in Africa than is chemical treatment.

The last article examines the effects of supplementing wheat and teff straw with urea, noug (*Guizotia abyssinica*) and trifolium hay on the feed intake and liveweight gain of growing crossbred dairy heifers. While there were differences in the effects of the supplements on feed intake, all three increased the animals' liveweight gain, with diets supplemented with noug giving the highest rates of gain. This study indicates that cereal crop residues can support reasonable levels of production in growing cattle when supplemented with urea and a source of protein, either as a forage legume or as a locally available oil-seed cake.

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# Land nationalisation and rural land tenure in southwest Nigeria

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## SUMMARY

**T**HE NIGERIAN *Land Use Decree of 1978* nationalised all land in the country and notionally handed over its administration to committees constituted at state and local government level. One justification given for the Decree was the rationalisation of customary land tenure systems which were held to be a constraint on agricultural development. This paper considers the impact of the Decree on patterns of landholding and use in a community in the cocoa belt of southwest Nigeria. Analysis of the political conditions which govern the ownership and control of land indicates that the system of tenure as it existed prior to the Decree functioned as an equitable, stable and yet flexible means of regulating access to land. Suppositions about the defects of such customary tenure systems are shown to arise from fundamental misconceptions about the nature and operation of customary law. The Decree was ambiguous in key respects as to its implications for the continued validity of rural tenures, and introduced considerable confusion and uncertainty. In particular, tenancy became insecure with the deterioration of relationships between landowners and tenants as many tenants stopped paying ground rent. But for the most part, in the absence of effective structures for its administration, the impact of the Decree was slight. The legislation did nothing to 'rationalise' any of the supposed defects of customary tenure.

## INTRODUCTION

Customary land tenure is frequently considered to be an impediment to agricultural

development. The lack of secure and clearly defined rights is often held to lead to a disincentive or an inability to invest in agriculture, while the inflexibility of traditional systems is said to prevent the transfer of rights between groups and individuals and thus inhibit the mobility of factors of production. This paper, which is based on an analysis of the origins, intentions and effects of the Nigerian Land Use Decree of 1978 (Francis, 1984), questions two related assumptions: first that traditional tenure systems are a constraint on agricultural development and second that solutions to the 'problems' that such systems present are to be found in legislation at the national level.

The first section of this paper summarises the literature on the alleged defects of traditional systems of land tenure in Nigeria. The second section reviews the provisions of the Land Use Decree, which in 1978 nationalised all land in the country, and their implications for rural land tenure. Empirical evidence from the southwest Nigerian cocoa belt is used to show that arguments about the inappropriateness of traditional tenure institutions of the kind that legitimated the Decree are based on mistaken preconceptions about the nature and operation of customary law. This conclusion is confirmed by analysis of the actual effects of the Land Use Decree at the local level.

## LAND TENURE AS AN ECONOMIC CONSTRAINT

During Nigeria's colonial period a number of different phases may be distinguished in the debate about land. These phases are marked by the changing relationships be-

tween Africans, administrators and commercial interests. In the early colonial period the attitude of the administration was one of indifference. However, as the state and commercial interests began to seek and obtain interests in land, the issue took on increasing importance, becoming a preoccupation of Nigeria's colonial administrators. From this period, the 'land question' figures repeatedly in colonial correspondence, memoranda, reports and enquiries. The main concern of the colonialists was with political stability rather than agricultural development, their fear being that the extensive alienation of interests in land to national or expatriate commercial interests would lead to landlessness and discontent. In Northern Nigeria, the Land and Native Rights Ordinance of 1910 vested all lands in the governor of Northern Nigeria. Similar legislation was proposed in some quarters for the south of the country, but this was strenuously, and in the end successfully, resisted by indigenous interests.

With political independence and the opening of the global debate on economic development, economic arguments came to dominate the debate about land tenure in Nigeria. Elements of these arguments are found in the literature of the colonial period, but the debate was now cast in a new framework. While Lloyd had noted in 1962 (p.3) that his research on land tenure was occasioned 'by a realisation that ignorance of the law had been seriously handicapping the commercial development of Western Nigeria', only a few years later Adegboye (n.d., p.42) was arguing in a much more radical vein that 'any society seeking land reform must make a choice between economic efficiency

and retention of traditional ties and institutions'. From the late 1960s a number of Nigerian agricultural economists began to argue that customary forms of land tenure suffered from 'defects and inconsistencies' (Famoriyo, 1973a: 3) that militated against the most rational economic use of land. In the words of Oluwasanmi (1966: 23–55):

Social institutions may be so rigid as to constitute formidable barriers to agricultural production.... The traditional system of tenure may sometimes constitute a formidable obstacle to the enterprising farmer desirous of increasing the size of his farm business.

The literature on the shortcomings of customary forms of tenure is fairly large (see Adegboye, 1964; 1967; n.d.; Adeniyi, 1972a; 1972b; Fabiyi, 1974; Famoriyo, 1972; 1973a; 1973b; 1979; Ijaodola, 1970; Olatunbosun, 1975; Oluwasanmi, 1966; Osuntogun, 1976; Wells, 1974; Williams, 1978). The problems are generally given as relating to communal tenure, fragmentation, customary tenancy, and the use of land as collateral. A paper by Adegboye (1967), which enumerates most of the defects of customary tenure as found in the literature, is representative.

Adegboye (1967) identifies defects in land tenure, farm tenancy and the provision of agricultural credit as obstacles to increasing productivity per acre and per farmer. With regard to land tenure he states that: 'The present structure of land tenure makes it virtually impossible for enterprising young farmers to mobilise their labour and capital as freely as they would like to' (p.340). This is so, we are told, because sales of land are rare, and thus the cultivator and his descendants are confined to family land, and because the division of land upon inheritance leads to holdings becoming uneconomic in size and productivity. The defects of customary farm tenancy are enumerated as follows: the terms of leases are often verbal and indefinite; the amount of tribute paid is governed more by the tenant's relationship to his landlord than by the fertility or location of the land; sub-leasing is common in some areas; and the tenant is sometimes forbidden to plant permanent crops. Overall, the tenant's insecure position discourages him from making substantial investments of capital or labour in the land which he occupies. The principal problem with regard to agricultural credit is also held to stem from customary land

tenure: 'A piece of land which is communally owned cannot be used for collateral' and thus the commercial banks do not lend to farmers (Adegboye, 1967: 340).

The solution adduced by Adegboye to the inadequacies of traditional forms of tenure was to vest all land in the Government and administer it through a Lands Commission and subsidiary committees. A similar ideology – belief in the irrationality of local custom combined with unbounded faith in the potential of bureaucratic intervention – is found in the writing of Famoriyo (1972: 56–65):

The problems may be considered as institutional barriers to development and stem largely from the failure to intervene in order to direct and streamline the customary tenure system so that it could become more conducive to economic development. If there had been objective intervention the result could conceivably have been the existence today of a powerful, dynamic and flexible land tenure system making a positive contribution to Nigeria's agricultural development.... The complexity of the land tenure system in Nigeria shows that it is a single aspect of Nigeria's agrarian structure. It clearly requires an intervention at both state and local levels.... The policy should consolidate the existing social situation.... This is saying that the policy should give due regard to farmers as individuals whose willing participation will promote the integration of the rural community, thus mobilizing it for the achievement of set goals.

These assumptions became part of the conventional wisdom of development planning. Thus the second national development plan states: 'The prevailing land tenure system in the country sometimes hinders agricultural development.... If Nigeria's agriculture is then to develop very rapidly and have the desired impact on the standard of living, there must be reform in the system of land tenure' (Ministry of Economic Development, 1970). According to the third plan: 'The under-utilisation of agricultural land is itself a function of some institutional constraints, in particular, the land tenure system and seasonal labour shortages. The land tenure system is mainly responsible for fragmentation of holdings and the difficulties in mechanisation and modernisation of agricul-

tural production' (Federal Ministry of Economic Development, 1975). However, neither plan made any concrete proposals for reform.

## THE LAND USE DECREE

The Land Use Decree was promulgated on 29 March 1978 following the recommendations of a minority report of a panel appointed by the Federal Military Government of the time to advise on future land policy. With immediate effect, it vested all land in each state of the Federation in the governor of that state (Fed. Rep. of Nigeria, 1978).

The Decree distinguishes throughout between urban and non-urban (hereafter 'rural') land. In urban areas (to be so designated by the Governor of a state), land was to come under the control and management of the Governor, while in rural areas it was to fall under the appropriate local government. 'Land Use and Allocation Committees', appointed for each state by the Governor, were to advise on the administration of land in urban areas while 'Land Allocation Advisory Committees' were to exercise equivalent functions with regard to rural land. This paper is concerned principally with the provisions relating to rural land.

The Decree envisaged that 'rights of occupancy', which would appear to replace all previous forms of title, would form the basis upon which land was to be held. These rights were of two kinds: statutory and customary. Statutory rights of occupancy were to be granted by the Governor and related principally to urban areas. In contrast, a customary right of occupancy, according to the Decree, 'means the right of a person or community lawfully using or occupying land in accordance with customary law and includes a customary right of occupancy granted by Local Government under this Decree.' Local governments were empowered to grant customary rights of occupancy to any person or organisation for agricultural, residential and other purposes with the proviso that grants of land for agricultural or grazing purposes should not exceed 500 or 5000 hectares respectively without the consent of the State Governor. With the minor exception of land subject to Federal or State claims, the Decree also empowered the local government to 'enter upon, use and occupy for public purposes any land within the area of its

jurisdiction' and to revoke any customary right of occupancy on any such land. The approval of the local government was to be required for the holder of a customary right of occupancy to alienate that right.

Governors were empowered to revoke rights of occupancy for reasons of 'overriding public interest.' Such reasons included alienation by an occupier without requisite consent or approval; a breach of the conditions governing occupancy; or the requirement of the land by Federal, State, or local government for public purposes. Only in the last of these cases would any compensation be due to the holder, and then only for the value of 'unexhausted improvements' on the land and not for the land itself.

With regard to continued validity of customary forms of tenure, transfer and lease in the rural areas, the Decree left two key areas of ambiguity. The first was the question of the capacity of the holders of customary rights to land to alienate those rights. While the Decree defines customary rights of occupation to include 'the right of a person or community lawfully using or occupying land in accordance with customary law' and the transitional provisions of the Decree make the registration of such rights with local authorities optional, several other sections of the Decree either state or imply that the alienation of customary rights without the approval of the appropriate local government is illegal. The pronouncements of the executive on the purposes of the Decree were contradictory and did little to clarify the question.

The second key area of ambiguity with regard to rural land tenure was whether concurrent claims in rural land persisted after the enactment of the new law. No part of the Decree expressly abolished or outlawed the payment of rent in respect of customary tenures in land, but while the validity of mortgages and other encumbrances on urban land was explicitly preserved, this was not so for rural land. On the issue of collateral claims in rural land, however, the statements of the administration were consistent; there was no longer any obligation to pay ground rent in respect of rural lands after the Decree.

## THE IMPACT OF REFORM

Studies on the Land Use Decree have considered its impact in general or administrative terms (Fabiya, 1984; Uchendu, 1979;

Udo, 1985), or in terms of its implications for judicial decisions in the higher courts (Omotola, 1983; 1984). None of the literature considers the consequences of this legislation at the local or farm level, where it was presumably meant to have its impact on productivity. Here I consider the effects of the Decree in the area of Ibokun, a community in the Ijesha area of Oyo State situated just within the northern limits of the cocoa belt. Ibokun is a town of some 8000 people, most of whom are primarily dependant on agriculture, especially cocoa cultivation, for their living. Another 2500 or so people, almost exclusively migrant, cocoa-growing tenants renting land from indigenes, live in about 90 hamlets in the surrounding area. These immigrants have moved into the Ijesha area since the turn of the century from the Oyo culture area immediately to the north of Ibokun. They entered into agreements with local families and representatives of titled lineages for the use of land in exchange for the annual payment of several quarters of cocoa or its cash equivalent, a payment known locally as *isakole* and which was enforceable in the customary courts.

To what extent had the system of land tenure and distribution entailed by the history of settlement in the area been one whose inflexibility or inequity had inhibited the full economic use of land? A questionnaire administered to a random sample of 137 farmers in the Ibokun area in 1979 concerning their enterprises, and in particular their access to factors of production, included three questions that might have been answered by reference to land shortage ('Why did you not plant more cocoa than you did last year? Could you obtain more land for cocoa if you wanted? What are the main problems with your farming enterprise?'). The numbers of farmers who mentioned a shortage of land in response to any of these questions are given in Table 1 by their tenurial category.

This Table suggests that there is little difference between the categories of informants with regard to their perceptions of land shortage. This indicates that those kin-based groups with access to large areas of land have not been able to monopolise their interests to the disadvantage of other natives of Ibokun, nor even of tenants. With regard to natives of Ibokun, the tendency for land to have become distributed among them so that the effects of shortage

are felt fairly evenly throughout the farming population is due to genealogical, political and legal conditions of landholding which arise from two properties of the social and political system. The first of these properties is the relationship between personal choice, participation and lineage affiliation; the second that between political power and judicial decision-making.

Ibokun sees itself as a town of patrilineages, and access to land is held to be derived from membership of one of these groups. In practice, however, links which later become rationalised as agnatic are publicly established and maintained through exercise of the rights and acceptance of the obligations of lineage membership and through participation in the ceremonies, reciprocities and formalities which are the substance of communal life. These include the payment of bridewealth, the sponsoring of naming ceremonies, the exchange of gifts at funerals, the acts of succession and inheritance and the acceptance of liability for the debts of a deceased, and the contesting of lineage titles. In cases of dispute it is such concrete and public evidences of participation rather than any abstract issue of paternity which concern litigants and adjudicators alike. In practice, therefore, there is considerable flexibility and individual choice in the matter of lineage membership, which may be established from the basis of such links as matrilineal kinship, coresidence or cooperation in labour groups. This has meant, in turn, that those groups with the most to offer in terms of material, political and mystical resources have attracted the most members. Thus, about one-third of the town's population now trace their descent to one of the three major titles which are also the major controllers of land. (Excluding minor ones, there are over a hundred titles in Ibokun).

Competition and conflict both between and within these lineages often takes the form of disputes over the ownership and control of land. During the colonial period this tendency was exaggerated as control over land assumed increasing political importance. This was partly because of the emerging economic value of rights in land and partly because of colonial judicial conceptions, which accepted disputes over land (as opposed to, say, title disputes) as appropriate causes in the native courts. Within the lower courts, however, the establishment and maintenance of claims

Table 1. *Farmers' perception of land shortage by lineage membership.*

Lineage membership	Number suffering shortage	Sample size	Percentage suffering shortage
Three major titled lineages	11	25	44
Other titled lineages	12	25	48
Non-titled lineages	15	28	54
Tenants	33	59	56
All respondents	71	137	52

over land remained, as they always had been, largely a political affair. This was so not only because the flexibility of genealogical status and the multiplicity of the forms of evidence by which it was publicly established left ample room for manipulation, but also because of the political conditions of litigation.

In spite of the formal recognition given to some Ibokun chiefs through their integration into the colonial native court system, they remained unable or unwilling to interfere too directly in the affairs of other lineages or to attempt to impose judicial decisions that might prove unpopular. At the same time, norms governing landholding and inheritance, being themselves diffuse, flexible and multiple (except where tenants were involved); could be used to justify any of a number of outcomes to a particular dispute. A typical strategy on the part of native court judges in disputes between natives of Ibokun was to eschew norms of a decisive and quasi-legal nature and, exhorting the litigants to cooperation and compromise by stressing their kinship (no matter how distant or fictitious), to allow a solution to surface which was generally acceptable given the balance of power between the parties concerned. Thus, those whose influence enabled them to mobilise sufficient witnesses and supporters could make substantial gains from litigation.

Table 1 also indicates that such problems of land shortage as confront migrant tenants are little greater than those faced by natives of the Ibokun area. Thus lineages and households with excess land available have been willing to allow tenants to farm it even if this has resulted in recent years in some sections of those lineages themselves not having as much land at their disposal as they might have wished. This fairly equitable distribution of land between natives

and tenants also has its origins in the political conditions of litigation and the normative indeterminacy which characterises it, but for rather different, if not opposite, reasons from those outlined above. The flexibility inherent in the normative repertoire, in particular relating to the establishment of relationships construed as genealogical, has meant that indigenes, given sufficient support, may draw upon links such as matrilineality or coresidence in constructing their claims to land. But no such options have ever been open to tenants. Residing almost exclusively in hamlets and little involved in the political or social life of Ibokun, they maintain their primary affiliations with the town whence they or their ancestors originated. It is in those communities that they marry, build their houses, contest titles, spend their festivals and their retirement, and eventually are buried. Lacking manipulable connections such as marriage, kinship or coresidence and further distinguished by their dialect and facial scars, their status as immigrants is beyond repudiation in court. This is precisely why those with land available have allowed it to such immigrants, for as strangers they lack the means to construct claims to the ownership of land in competition with the grantor. The briefest acquaintance with local litigation confirms that should a landowner allow other natives the use of land he might eventually be unable to sustain his own claims to it. Tenants, on the other hand, are useful as witnesses in the event of a dispute, for the acts of granting land and receiving *isakole* are accepted in court as two of the strongest kinds of evidence for the ownership of land. Since early in the colonial period it has been the practice for many natives of Ibokun to spend the greater part of their working lives outside the community (typically engaged in trade) and thus the

granting of land to tenants was an effective way of securing and maintaining claims to land. Similarly, competition between communities has encouraged the granting of land to *isakole*-paying migrants in the attempt to consolidate contested territorial claims.

The above account of the sociopolitical factors conditioning the terms on which land is held in Ibokun demonstrates that the assertion that customary forms of tenure inhibit access to land in any simple sense is based upon fundamental misconceptions about the operation of customary legal rules. Given the political dynamic underlying the ownership and control of land, it is clearly invalid to speak of farmers being restricted in their farming enterprises by the defects and inconsistencies of an inflexible system of customary tenure. Rather, the opposite is the case: the various levels of normative indeterminacy in lineage recruitment and in litigation have allowed individuals a variety of means of asserting rights to land. Similarly, they have meant that lineages of declining strength and population could not sustain their claims to land against those of rising fortunes. These processes have led to land being distributed according to the needs and powers of its holders.

What of the other specific features of customary land tenure which have been regarded as the proper objects of reform? On the question of fragmentation, the survey referred to above found that on average each informant farmed only 2.1 plots. This would not seem to indicate a serious problem of fragmentation especially if it is borne in mind that it is a long established practice in the Yoruba culture area for cultivators to maintain one farm near their urban residence and another in the hamlets. In any case, the Land Use Decree explicitly states that succession to customary rights of occupancy is to be governed by local customary law, and would thus appear to have no effect on customary inheritance practices.

Adegboye (1966) asserts that the institution of customary tenancy is insecure, its terms being verbal and indefinite; that the rent paid is governed more by the landlord's relationship to his tenant than by the fertility and location of the land in question; that sub-leasing is common in some areas; and that the planting of permanent crops is sometimes forbidden. None of

these have force in the area under consideration. The verbal form which tenancy takes is not here due, as Adegboye asserts elsewhere (1966: 450), to 'illiteracy'. Written agreements, usually framed by public letter writers, are commonly entered into in other circumstances, for example when cocoa trees are rented out. However, such agreements are simply considered unnecessary for ordinary tenancies over vacant land. Tenants have not for a generation been precluded from planting permanent crops on the land allocated to them and have only occasionally been subject to eviction, and then almost always for strong reasons and with compensation for their crops. The massive investment in cocoa by tenants on Ibokun land bespeaks their sense of security.

Neither does Adegboye's assertion that the level of rents is determined by social rather than economic criteria hold here. According to the norms which regulated tenure and were enforced by customary courts prior to the enactment of the Decree, rates of *isakole* were explicitly related to the size and productivity of the land rented and the crops grown on it - i.e. economic rather than interpersonal factors determined the level of rents. In the event of a dispute about the level of rent to be paid, courts would often inspect the land in question and their decisions were related explicitly to the income to be expected from it. After the Decree, given the public statements of the administration that ground rent could no longer be demanded in respect of rural land, the customary courts (which received no other guidance on the Decree's interpretation) became unable to enforce the payment of *isakole*.

In the customary courts with jurisdiction over the Ibokun area, for a year after the enactment of the Decree all cases concerning interests in land were adjourned. In May 1979, several cases in which *isakole* was claimed were re-opened in the Grade B Court. The court ruled that it was unable to give judgement on the cases at present as they were 'connected with the Land Use Decree which prohibits the receiving of *isakole* from tenants'. (The judge added parenthetically but off the record that should the Decree be changed the following day the case would still be there.)

The reaction of tenants to the Decree was varied. Some refused outright to pay further *isakole*, some refused but were later

persuaded to change their minds, others paid a reduced amount or sought new agreements with landowners, while yet others paid the usual sum. The conditions of uncertainty created by the Decree made many tenants unwilling to discuss the question, but in 1979, of the 34 cases on which I believe my information to be reliable, 16 had continued to pay *isakole* after the enactment of the Decree and 18 had not.

Each tenant's decision as to whether or not to continue to pay *isakole* appears to have been made in the light of his assessment of the political situation of which he was a part at a particularly local level, the most important factor in which was his estimation of the potential disadvantage of alienating the landowner. Just as the tenants had done, the landowners reacted to the Decree in a variety of ways; some did not even make any request for *isakole* from their tenants while others not only demanded it, but sought to use the channels of traditional authority, and sometimes the police, in pressing their claims. Sometimes tenants found that they had misjudged the amount of pressure which a landowner could bring to bear and decided to pay up after an initial refusal.

Apart from the possibility of such direct pressure there were a number of other reasons for which tenants might be unwilling to incur the ill-will of the landowners. Many tenants had already planted all the land which they had been allocated with permanent crops and were dependent upon separate grants of land for the cultivation of food crops. Such grants were made for the cultivation of seasonal crops only and, more importantly, were always temporary, usually being made for one or 2 years only. Thus for many tenants, access to land for food crops was contingent upon the goodwill of landowners. It was also common for tenants to rent cocoa trees from landowners which the latter had planted themselves; the refusal to pay *isakole* would have jeopardised such arrangements.

Tenants were also hesitant to break with usual practice because of their uncertainty about the future of the Land Use Decree as well as the intentions towards it on the part of the enacting government and its successors (uncertainty which landowners exploited fully in their arguments). The prospect of a change in the administration in the near future and the cynicism about the

goals and effects of government policies, which earlier experiences had made general among farmers, led many to comply with custom to ensure their future security of tenure.

In subsequent years, with the Decree remaining on the statute books, fewer and fewer tenants continued to pay *isakole*. In February 1980 all of the customary courts in Oyo state, including the two serving the Ibokun area, were dissolved. Thus even the threat of pending court action was removed. By 1985, only the tenants of the most influential landowners were still paying *isakole*, and this apparently at a lower level than before the Decree. Towards the end of that year, however, a customary court was re-established in Ibokun, its bench consisting of three traditional rulers who were also major landowners. Although it was by no means clear that this court could adjudicate in cases involving *isakole*, its establishment encouraged Ibokun landowners to reassert their claims, and in the first months since the court's opening a number of tenants were sued for arrears of *isakole*. Most of these opted to settle out of court.

Thus the Decree, rather than introducing any economic rationalisation of rents in fact did the reverse. It made the payment of *isakole* a much more personal and political issue than it had been previously. In addition, the strained relationships which resulted between landowners and tenants made the position of the latter insecure, and many were told to leave the land which they were cultivating.

The third major feature of customary tenure that has been held to constitute an obstacle to agricultural development was that land could not be used as collateral. Here, too, some confusion was created, but certificates of occupancy issued under the Decree, even if obtained (which would have been both optional and tortuous), would appear to be less suitable as collateral than even the most tenuous claims to traditional tenure. For, legally, land no longer has a market value and its ownership is vested in the state. The prospective borrower is, of course, left with any improvements on the land. The mortgage of these however requires, according to the provisions of the Decree relating to rural land, the approval of the local government (for improvements on urban land the consent of the Governor would be needed). Further-

more, if on failure of the mortgagor to honour his debt a court ordered the sale of his property, the consent of the Governor would be required before it could proceed even if such property were on rural land. To both potential creditors and borrowers, the bureaucratic implications of such procedures would be discouraging. By customary arrangements, in contrast, the mortgaging of cocoa trees has long been a widespread and effective means of raising cash for capital or other expenditure.

## CONCLUSIONS

The effects of the Decree thus bear no relation (beyond being predominantly in the reverse direction) to the supposed objectives of rational intervention in customary tenure. In the Ibokun area, the main effect of the Decree was to change the relationship between landowners and tenants, introducing uncertainty, insecurity and conflict. Otherwise, the consequences of this potentially radical legislation were rather slight. Whatever the correct interpretation of the Decree's provisions on customary tenure, the allocation of land for houses continued as before, as did practices such as the division of land among segments of descent groups. The sale of land, although

it had never been very common in the area, also continued. (In urban areas, the conditions of dubious legality created by the Decree in fact led to a rise in the price of land). Thus if the Decree had any effect on the distribution of land, it was purely incidental.

Two sets of conclusions may be drawn from this case study. These relate respectively to customary tenure systems and to legislative intervention by the state. It has been shown that assertions about the shortcomings of traditional land tenure have been based upon misconceptions about how those systems functioned. In the area considered here (and this is an area where agricultural activity is intense), customary arrangements have functioned as equitable, stable and yet flexible means of regulating access to land. This is not to claim either that customary tenures are never a constraint on agricultural expansion, or that they are inherently just or egalitarian. However, assertions on the extent to which they inhibit production must be based firstly on a thorough understanding of the way in which rules governing access to land operate in practice and secondly on a clear idea of what alternative systems are administratively and politically viable.

Customary rules do not operate in an equivalent manner to laws, rather they are applied in the context of specific and concrete claims and actions. This gives customary tenure a flexibility which the interpretation of its rules as legal tenets disregards. Social scientists, if they are to participate in the formulation of appropriate land policies, must go beyond the simple stereotypes of depicting traditional tenures as 'communal', 'inflexible' or 'insecure', and examine in detail the actual operation of such systems and the political dynamics which underlie them. This implies intensive research at the local level.

On the question of legislated reform, the local effects of state law have been shown to be unpredictable. The intentions behind the Land Use Decree were, and have remained, obscure, and the somewhat arbitrary local effects of the law make it difficult to interpret its general significance. The massive notional powers over land given to government-appointed committees introduce a statism which operates beyond the rule of law. Nevertheless, the lack of administrative capacity on the part of the state has meant that the impact of the Decree has so far been slight, and it seems likely to remain a dead letter.

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# Agropastoral herding practices and grazing behaviour of cattle in the subhumid zone of Nigeria

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## SUMMARY

**S**TUDIES OF grazing behaviour of cattle kept by settled Fulani agropastoralists in central Nigeria revealed the use of a wide range of grazing resources, including crop residues, browse and various distinct types of natural range.

Herded cattle spent less time grazing than did free-ranging cattle. During the relatively short daily herding period, the cattle showed a high level of grazing activity with very little resting time. Use of diverse grazing resources in proximity to cropped land demands tight animal control which, together with competition for labour between herding and cropping, resulted in the short grazing time, particularly in the late wet season, and probably contributed to the low productivity of the cattle. Transhumant cattle kept in the study areas in the dry season were herded longer each day and were in better condition than the settled herds, which suggests that the transhumant herds are more productive.

Development efforts should concentrate on maintaining the present flexibility and diversity of grazing resource use. Small legume pastures for strategic use can be incorporated into both settled and transhumant pastoral systems. They can be used as an additional grazing resource and could also allow longer grazing periods, which might increase the productivity of the cattle.

## INTRODUCTION

Livestock development planners in tropical Africa often regard sedentarisation of pastoralists as a prerequisite for any form of improvement in animal production and of the welfare of the pastoralists (Swift, 1982), and tend to consider livestock husbandry in isolation from cropping. However, one of the great strengths of pastoral production systems in subhumid areas is that they permit spatial integration of cropping and livestock keeping, which, at a certain level of external inputs, allows more food to be produced per unit area than either enterprise alone (Bayer and Otchere, 1984).

Based on a study of herding practices and cattle grazing behaviour, this paper examines the consequences for cattle husbandry of livestock-crop integration as practised in an agropastoral production system in the subhumid zone of Nigeria, and discusses implications for livestock development. The study was a component of the research being conducted by the ILCA Subhumid Zone Programme into traditional livestock production systems with a view to developing innovations that build upon the existing systems.

## LOCATION AND METHODS OF INVESTIGATION

A study of the grazing activity of cattle kept by settled Fulani agropastoralists was carried out in Abet and Kurmin Biri, in central Nigeria. Both areas receive on average 1100 to 1300 mm of rainfall annually, of

which more than 95% falls between April and October. However, there are differences in land use between the two areas. In Abet, a farming area with higher human and cattle population densities, pastoralists have settled spontaneously amidst crop farmers and comprise approximately 10% of the agriculturally active population. In Kurmin Biri, designated as a grazing reserve, pastoral settlement is government assisted. In the reserve there are some enclaves of indigenous farmers and the pastoralists do some cropping themselves. Most of the pastoralists have settled close to the edge of the reserve and include neighbouring farming areas in their grazing orbits.

Both case study areas are in the Guinea savannah zone. The dominant grass species are *Andropogon*, *Hyperrhenia*, *Setaria* and annual *Pennisetum* on more fertile soils and *Loudetia* spp. and *Ctenium* spp. on poorer soils. The major indigenous woody species are *Terminalia*, *Combretum*, *Isobertinia* and *Ficus*.

In both study areas the resident cattle are kept almost exclusively by settled Fulani agropastoralists. Transhumant pastoralists who spend the wet season further north bring their herds into the study areas for dry-season grazing. Some characteristics of the intensive study areas and environs are given in Table 1.

The study was conducted in Kurmin Biri during 1980 and in Abet during 1980–81. Observations made by enumerators who followed the herds included the times at which each herd left and returned to the camp, and predominant herd activities dur-

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Table 1. Characteristics of case study areas in the Nigerian subhumid zone.

	Abet (9°40'N, 8°10'E) <sup>a</sup>		Kurmin Biri (10°5'N, 8°E)	
	Aerial survey area	Intensive case study area	Aerial survey area	Intensive case study area
People/km <sup>2</sup>	70	70	12	4
Cultivation density (%)	24	25	15	5
Fallow (%)	33	n.k. <sup>b</sup>	15	n.k.
Cattle density (head/km <sup>2</sup> )				
Wet season	22.7	25	4.2	5
Dry season	37.4	40	17.3	10
Mean herd size	47.8	49	51.4	53

<sup>a</sup> Coordinates refer to central points of intensive case study areas (60 km<sup>2</sup> each) within aerial survey areas (2500 km<sup>2</sup> each).

<sup>b</sup> Not known.

Sources: Milligan et al (1979); Waters-Bayer and Taylor-Powell (1984a).

ing the time out of the camp. These were classified into walking, resting, watering and grazing. Grazing was subdivided into grazing of natural range, browsing, and grazing on crop residues. During the course of the study it was decided to include grazing of burnt areas as an additional subdivision of grazing activities.

## RESULTS AND DISCUSSION

The agropastoralists' cattle in the study areas grazed a wide variety of feed resources (Table 2). Cattle in the farming area (Abet) spent twice as much time grazing crop residues as those in the reserve (Kurmin Biri), whereas the cattle in the reserve spent eight times as much time browsing as those in the farming area, reflecting the relative availability of crop residues and browse in the two areas. In this study, only sorghum and millet residues were considered, but subsequent more detailed work on crop residue utilisation in the farming area revealed that rice

and soya bean residues were also grazed to a considerable extent (Powell, 1984). The most important browse species were *Azizelia africana*, bamboo, *Khaya senegalensis*, *Adenolichos paniculatum* and *Mucuna* spp.

Both crop residue grazing and browsing were highly seasonal. Crop residue grazing was most intensive in December immediately after grain harvest, when it accounted for 65% of the total grazing time in the farming area and 50% in the grazing reserve. Browsing peaked in the late dry season, accounting for 30% of the grazing time in March in the reserve and 8% of the grazing time in April in the farming area (Figure 1).

Crop residues provided good quality forage during the early dry season (Powell, 1984). At the height of crop residue grazing in December, faecal nitrogen concentration of cattle in the farming area was 1.55%, whereas in the late dry season it had dropped to 0.6% (Powell, personal communication). If faecal nitrogen content falls below 1.3%, animals respond to non-

protein nitrogen supplements such as urea, indicating nitrogen deficiency in the diet (Winks and Laing, 1972). The peak in crop residue grazing coincided with a conception peak in the cattle (Ochere, 1984).

In both study areas, more than 80% of the total time spent grazing was spent on natural range (Table 2). During the second year of study, when regrowth on burnt areas was included as a distinct feed resource within the natural range, cattle spent 19.3% and 22% of total dry-season grazing time on regrowth after burning in the farming area and in the reserve, respectively. Regrowth after burning may contain more than 8% crude protein during the dry season, compared with only 1 to 2% in unburnt natural range vegetation (Blair Rains, 1978). However, it yields only 0.1 to 0.2 t/ha, compared with 1.5 to 2.5 t/ha from unburnt natural range (Mohamed-Saleem, 1984a).

## Herding and grazing time

Averaged over the whole year, the cattle were herded for about 8.5 hours per day in the farming area and slightly less than 9 hours per day in the grazing reserve (Table 3). Walking accounted for about one quarter of herding time, whereas resting and watering together represented only 5% of total time out of camp, with little difference between the two study areas. In both areas, actual grazing time accounted for approximately 75% of the time out of the camp (Table 3).

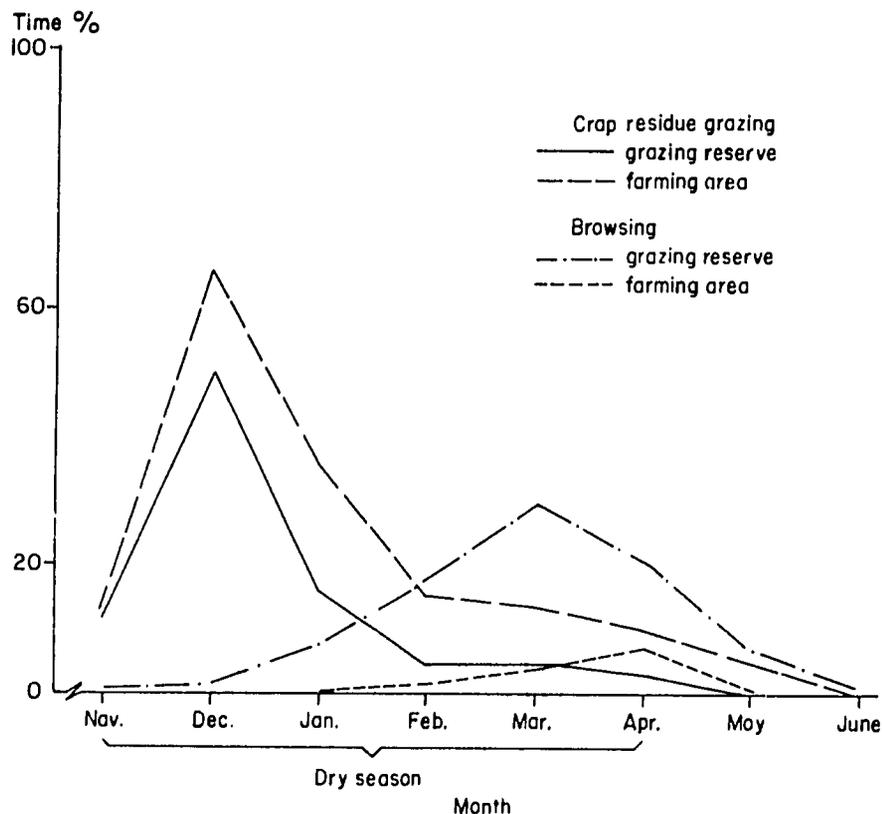
Herding and grazing times varied according to season. The longest herding time was recorded in April and the shortest in September (Figure 2). Actual grazing time was little more than 5 hours per day in the wet season, peaked at 8 hours per day in the late dry season and averaged only about 6 hours per day over the year as a whole. The general annual pattern of daily grazing time – longer in the dry than in the wet season, with a peak when the first scattered rains fall – agrees well with the pattern of free-ranging domestic ruminants in similar climates (Smith, 1959; Wilson, 1961). However, the absolute daily grazing times of the herded cattle were very short compared with those of free-ranging animals.

A review of more than 100 grazing studies in tropical and temperate areas (Arnold and Dudzinski, 1978) gave an average grazing time for beef cattle of 9.5 hours

Table 2. Contribution (%) of different grazing resources to total grazing time.

	Abet (farming area)	Kurmin Biri (grazing reserve)
Crop residues	12.6	6.6
Browse	1.4	11.2
Natural range	86.0	82.2
Average grazing time (h/day)	6.1	6.2

Figure 1. Crop residue grazing and browsing as percentage of total grazing time, November to June.



per day. Only 10% of the references indicated grazing periods of less than 7 hours per day, and only 2% gave a figure of less than 6 hours per day. Stobbs (1974) found grazing periods of up to 14 hours per day for grazing cattle in southern Queensland, Australia, and Smith (1959) found similarly long grazing periods for zebu cattle in Zimbabwe when pasture quality was low.

The impression that time spent grazing is restricted by the present herding practices is supported by the diurnal pattern of grazing activity. Free-ranging animals show a peak of grazing activity in the early morning, another in the late afternoon and substantial grazing activity during the night (Smith, 1959; Wilson, 1961; Arnold and

Dudzinski, 1978). The grazing periods are separated by resting and ruminating periods. Night grazing can account for up to 25% of total daily grazing time in free-ranging indigenous African cattle (Smith, 1959; Haggar, 1968). In contrast, the herded cattle studied maintained a high level of grazing activity throughout the herding day, and most of the non-grazing time was occupied by walking (Figure 3).

The present practices of the settled Fulani prevent grazing in the early morning and at night. As a result, the activity pattern during the herding period was one of more or less continuous grazing. This agrees with the findings of Smith (1961), who reported that animals that were allowed on

pasture for 7 hours per day grazed almost continuously and deferred resting and ruminating until they were confined at night. However, animals allowed on pasture for 11 hours (Smith, 1961) or 12 hours (Lewis, 1978) exhibited a normal grazing pattern.

The effects of restricted grazing time on animal productivity have not been extensively researched. In Zimbabwe, Smith (1961) compared liveweight gains of cattle allowed on pasture for 7, 11 and 24 hours per day. The animals in the 7-hour treatment gained less, or lost more, weight than those in the 11- and 24-hour treatments in the dry season, when pasture quality and quantity were low. Over the 16-month trial period, liveweight gains per animal in the 7-hour treatment were only half those in the 11- and 24-hour treatments (37 vs 73 kg). Over a 10-month trial period in Uganda, steers that were allowed to graze at night gained 13 kg (30%) more than those yarded overnight (Joplin, 1960). In Tanzania, heifers allowed to graze overnight were 25 to 110 kg heavier at 120 weeks of age than those allowed to graze only during the day (Kyomo *et al.*, 1972).

These findings suggest that the short grazing times observed in this study contribute to the low productivity of the cattle of settled pastoralists in the study areas, where calving rate was 49%, calves gained 0.2 to 0.3 kg liveweight per day and calf mortality up to 1 year of age was 30% (Otcere, 1984). It is unlikely that the herded cattle can eat their fill during the short grazing time (5 hours/day) in the wet season. Grazing time would probably be longer and feed intake higher if the animals were herded for a longer period at this time of year, as suggested by Haggar's (1968) findings that Fulani cattle allowed on pasture for 11 hours per day in the wet season grazed for 7.5 hours.

Some reasons given by pastoralists for short herding time were:

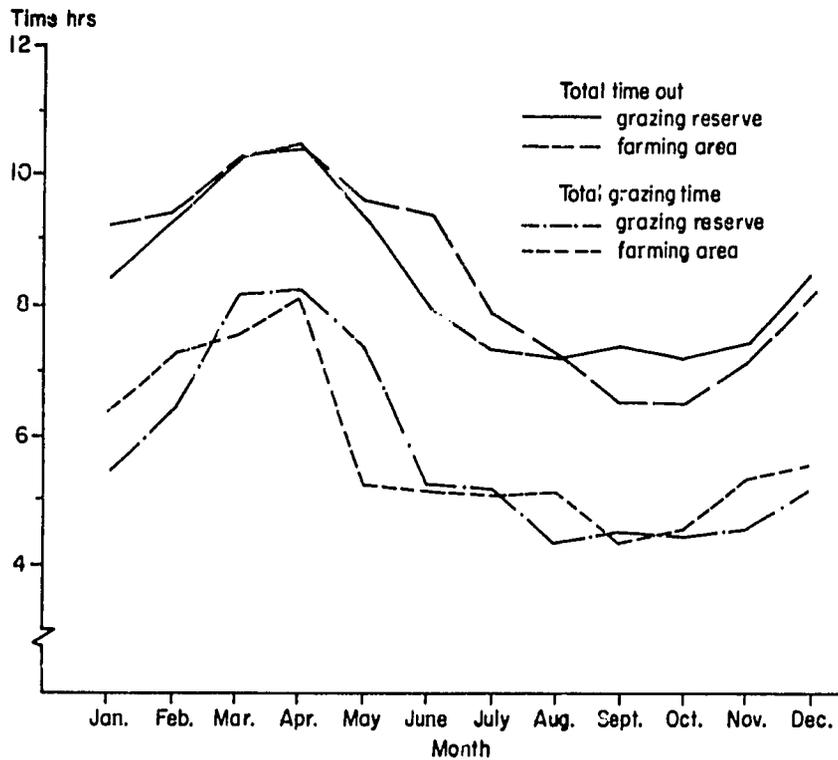
- Higher risk of worm infestation in the early morning during the wet season;
- Negative effect of wet-season dew on feed intake of cattle;
- Difficulty in controlling animals with satiated appetite; and
- Competition for labour between herding and cropping.

Night grazing was avoided for fear of predators and thieves.

Table 3. Herd activities as percentage of total annual time out of camp.

	Abet	Kurmin Biri
Walking	20.6	25.5
Resting	4.6	2.5
Watering	1.7	1.5
Grazing	73.1	70.5
Average time out of camp (h/day)	8.8	8.4

Figure 2. Herding time (total time out, and grazing time of cattle in Abet and Kurmin Biri.



## Herding and farming

Spatial integration of pastoral production and cropping permits more intensive use of land than cropping or livestock husbandry alone and also benefits both sectors. Crop residues and fallow lands offer better forage than natural range, and the open, park-like nature of cultivated land facilitates herding (Powell and Waters-Bayer, 1984). Furthermore, proximity to cultivators offers pastoralists relatively easy access to markets for purchasing consumer goods and for selling livestock products. The crop farmers benefit from the ready availability of meat and milk products, but the major advantage is the availability of manure for their fields.

The main disadvantage of integrating pastoral production and cropping for the pastoralists is that animals must be closely supervised to avoid crop damage. Thus, two of the reasons given for the short herding time deserve particular attention: the difficulty of controlling animals with satiated appetite and the competition for labour between herding and cropping.

Ethological studies show that towards the end of a grazing period some animals still feed while others begin to ruminate or wander idly (Arnold and Dudzinski, 1978).

A herd that ceases to behave uniformly becomes more difficult to handle. The practice of grazing fallow and uncultivated fields adjacent to unharvested fields demands tight herd control if crop damage is to be avoided. Cessation of herding before the animals' appetites are fully satiated, and hence before behaviour begins to diverge, reduces the difficulty of herding. Whereas young boys can handle the herds in the dry season, older youths or adult men must accompany the cattle when grazing control is critical during the wet season and early crop residue grazing period. However, these people are also needed for land preparation, weeding and harvesting of their own fields.

The present systems of livestock-crop integration in the subhumid zone are characterised by high labour requirements for animal control in order to make optimal use of land in farming areas. The short grazing time when pastoralism and cropping are spatially integrated may be a constraint on animal productivity, but is partly compensated for by the access to better quality feed on fallow and harvested land. Spatial segregation of cattle-keeping and cropping, as proposed in the original plans for grazing reserves in Nigeria, would sacrifice the better utilisation of land possible

within the present integrated systems and would lower the total combined yield of animal and crop products per unit area.

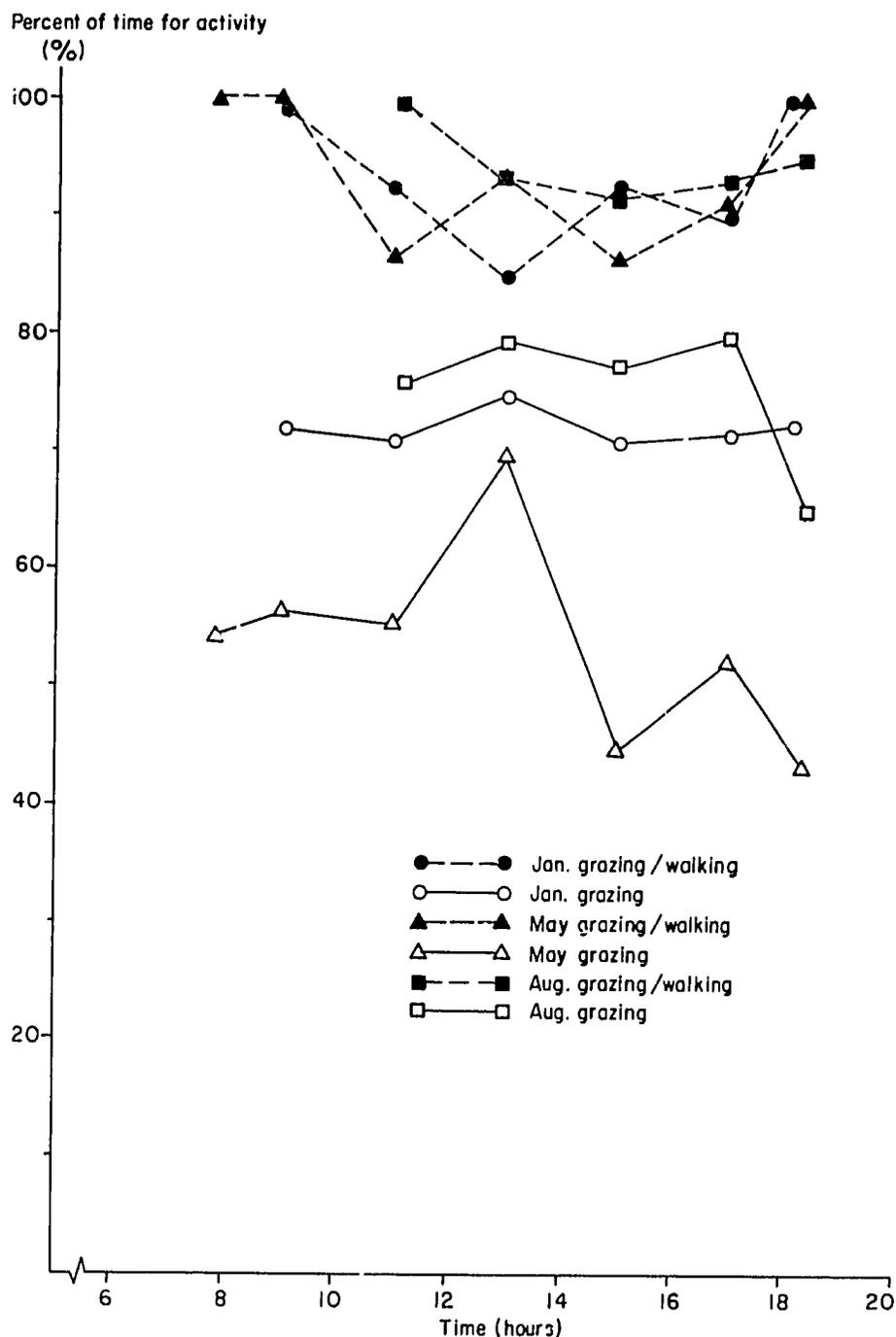
## Transhumant versus settled pastoralism

Transhumant herders who use the study areas in the dry season leave camp each morning 1.5 to 2 hours earlier than the settled Fulani and, subtracting a mid-morning break of half to 1 hour, herd their cattle for about 1 hour more per day. Those pastoralists who bring cattle into the study areas only during grain harvest herd their animals for up to 3 hours more per day than do the settled Fulani during that time. Reports from semi-arid savannah areas (e.g. Hopen, 1958; Barral, 1967) indicate that some transhumant pastoralists also allow their cattle to graze at night, but this was not observed in the study areas.

Few studies reported in the literature compare the productivity of different systems. Wilson and Clarke (1976) found in Sudan that productivity was higher in nomadic than in settled cattle herds, yet recent work in Mali (Wilson, 1982) showed no significant differences in productivity indices between a transhumant and a settled cattle keeping system. Van Raay and de Leeuw (1974) compared grazing strategies of nomadic and settled pastoralists in the semi-arid savannah of Nigeria, where human and cattle population densities are higher than in the subhumid savannah. The nomadic cattle were found to spend more time out of the camp and generally grazed longer, but walked up to 30 km per day, compared with a maximum of only 14 km for settled herds. The settled pastoralists were able to provide their cattle with a more varied and steady feed supply within more confined areas, i.e. requiring less energy expenditure by cattle and herders. By virtue of their closer association with cropping systems, the settled Fulani in the semi-arid zone appeared to have an advantage over nomads in terms of access to valuable grazing resources such as crop residues and *fadama* areas (low-lying seasonally inundated areas).

In the subhumid study areas, crop residues and *fadama* grazing are more abundant relative to cattle population than in the semi-arid zone, and transhumant herds appear to have easy access to these resources. Farmers in the zone welcome

Figure 3. Diurnal grazing activity pattern of agropastoral cattle herds.



Footnote: The beginning and end of each line indicates the beginning and end of the herding day

transhumant pastoralists camping and grazing their herds on farmland during the dry season, because they recognise the value of the manure and because the herds leave the area before any crop damage can occur. Thus, in contrast to the situation in the semi-arid zone, transhumant pastoralists who move seasonally into these subhumid farming areas are by no means disadvantaged and may even gain from their ability to

utilise a wider range of grazing resources than the settled Fulani.

Although the productivity of the transhumant cattle was not studied, they appeared to be in generally better condition than the resident cattle, which suggests that the transhumant herds may be more productive. The transhumant system of production is more likely to disadvantage people than animals, especially if the whole family moves

with the herd, since it limits accumulation of household goods, precludes permanent dwellings, and reduces access to health care, schooling and other social amenities. The hardship of movement on the pastoral family was a reason given by Fulani living in the study areas for their decision to settle (Waters-Bayer and Taylor-Powell, 1984b).

## IMPLICATIONS FOR LIVESTOCK DEVELOPMENT

Despite low productivity per animal, pastoralism can contribute to relatively high levels of food production per unit area, since it permits multiple use of land. Moreover, spatial integration of cattle-keeping and cropping benefits both the cattle, through crop-residue and fallow-land grazing, and the crops, through manure. The already high degree of flexibility and diversity of grazing resource use in the agropastoral production system in the study areas could be enhanced by the strategic use of an additional grazing resource. Small legume pastures (fodder banks), which are currently being tested by ILCA and some agropastoralists in the area, provide better quality feed in the late dry season than other grazing resources (Mohamed-Saleem, 1984b), and, being fenced, also permit the grazing day to be prolonged, and even allow night grazing, without requiring additional labour.

However, fencing represents a change from the communal grazing practised hitherto. Indigenous pastoralists have started to enclose land in other parts of tropical Africa (Behnke, 1985) and a small number of cases have also been observed by the ILCA research team in Nigeria, where the present system of land rights permits private use.

Estimated on the basis of literature values (Smith, 1961; Joplin, 1960; Kyomo et al, 1972) and preliminary results of grazing experiments in the Kurmin Biri reserve, grazing fodder banks at a stocking density of 4 to 5 head/ha for 2 to 4 hours/day in the late dry season, as a supplement to current feed resources, could increase liveweight gains by 25 to 30 kg/head per year in growing stock and also substantially increase cow and calf viability (Bayer, 1984). Fodder banks can be incorporated into both settled and transhumant pastoral systems, particularly if herd splitting is practised and a milking herd is kept close to the dry-season camp.

In the subhumid zone, settlement of pastoralists alone is unlikely to lead to increases in herd productivity. In fact, if pastoralists settle pasture development will probably be necessary to compensate for the loss of diversity in feed resources. Rather than concentrating on settling pastoralists, development efforts should aim at:

1. Maintaining the present crop-livestock integration and utilisation of di-

verse feed resources (crop residues, fallow land, *fadama*, browse and upland range, both burnt and unburnt);

2. Permitting seasonal use of different geographic regions, and providing marketing facilities and social services at wet- and dry-season grazing areas so as to improve the welfare of the transhumant pastoralists;

3. Increasing feed diversity and quality through promotion of small improved pastures for strategic use; and

4. Assisting pastoralists to obtain at least temporary rights to use small areas of land for such pasture improvement, ideally in combination with cropping.

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# The voluntary intake and digestibility of combinations of cereal crop residues and legume hay for sheep\*

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## SUMMARY

**T**RIFOLIUM TEMBENSE hay (TH) was fed to adult male castrate sheep in proportions of approximately 15, 30 and 45% with each of four cereal crop residues (CCRs) in four separate experiments. Each CCR was also fed alone. In a fifth experiment, TH was fed alone. The CCRs used were maize stover (MS), oat straw (OS), wheat straw (WS) and teff (*Eragrostis tef*) straw (TS). The sheep were housed in metabolism cages; five sheep were fed each diet. Voluntary dry matter (DM) intake, digestibility of various chemical components and nitrogen retention were measured.

The intake of OS was significantly higher than that of the other three CCRs. The apparent DM digestibilities of MS and OS were significantly higher than that of TS, and that of TS was significantly higher than that of WS. Higher digestibility was associated with higher metabolic loss. The addition of TH significantly reduced the consumption of each CCR but significantly increased total DM consumption. The extent to which this occurred differed among the CCRs and proportions of TH. TH also increased the apparent digestibilities of DM, crude protein (CP) and phosphorus (P) in each mixed diet, when compared with each CCR fed alone. The apparent digestibility of the cell wall fraction was increased in mixed diets based on MS and OS. The apparent digestibility of acid detergent fibre was also increased in OS-based diets. Nitrogen retention was in-

creased in all cases. The magnitude and significance of differences varied among levels of TH supplementation and among CCRs but the average increase in digestibility was 17% when the ration contained about 35% TH.

The increases in nutritive value obtained from supplementing CCRs with legume hay were comparable to those expected from treating CCRs with strong alkalis. Using legumes to supplement CCR-based diets is more appropriate to the conditions encountered on small mixed farms in Africa.

## INTRODUCTION

More than 340 million tonnes of fibrous crop residues are produced each year in Africa (Kossila, 1984), the great majority of which are from cereals. However, the utilisation of cereal crop residues (CCRs) is limited because they contain a large proportion of lignocellulosic compounds and little nitrogen. Substantial increases in the nutritive value of CCRs can be obtained by treating them with strong alkalis and ammonia, but these chemicals are expensive and not readily available in rural Africa.

Supplementing poor quality roughages, including CCRs, with legumes has been shown to increase digestibility (Devendra, 1982) or intake (Mosi and Butterworth, 1985) or both (Minson and Milford, 1967; Lane, 1982; Moran et al, 1983).

This study examined the effects of supplementing diets based on common Ethiopian crop residues (teff, wheat and oat straws and maize stover) with different proportions of hay made from a common local clover, *Trifolium tembense*.

## MATERIALS AND METHODS

Maize stover (MS), oat straw (OS), teff (*Eragrostis tef*) straw (TS) and wheat straw (WS) were obtained from the local market. *Trifolium (Trifolium tembense)* hay was made at the ILCA headquarters farm. Twenty adult male castrate sheep of the Ethiopian highland type were used in the experiments. The animals were kept in individual metabolism cages, which allowed all faeces and urine to be collected. The urine was collected in sulphuric acid.

Five experiments were carried out. In four, one CCR was fed alone or with one of three proportions of TH (15, 30 or 45%) to five sheep. In the fifth, TH was fed alone to 10 sheep. Although the rates of inclusion of TH were approximately 15, 30 and 45% of the total diet during the adjustment period, the final proportion of TH in the diet consumed (as opposed to that offered) differed from these percentages because the animals ate the CCR ad libitum. TH was provided as a separate meal that was consumed completely before the animals were offered the CCR.

Adjustment and intake periods of 10 and 7 days, respectively, were followed by a collection period of 7 days, a rest period of 4 days and a further collection period of 7 days, except in the case of WS, for which there was only one collection period. Feed offered and the unconsumed portion of the feed were weighed each day, and daily samples of feed offered, feed residues and faeces were analysed. Volume and nitrogen content of the urine were determined.

## RESULTS AND DISCUSSION

The chemical composition of the TH and the CCRs is given in Table 1. TH contained more CP and less neutral detergent fibre (NDF) and acid detergent fibre (ADF) than the CCRs.

The voluntary intake of DM and apparent digestibility coefficients of the various chemical components in mixtures of the CCRs and TH are given in Tables 2, 3, 4 and 5, and of TH fed alone in Table 6.

The chemical composition of the CCRs used in this series of experiments was similar to that described by Jackson (1977) and Hogan and Leche (1983), in that they contained a large proportion of lignocellulosic cell-wall constituents and had low CP contents. From this, one would expect both voluntary intake and digestibility of the feed to be low and that substantial increases in both would be required to support reasonable levels of production from these feeds.

The estimated intakes of metabolisable energy (ME = digestible energy x 0.81) for the crop residues fed alone were 2.9, 4.1,

Table 2. *Voluntary intake, digestibility and nitrogen retention of sheep on diets containing different proportions of trifolium hay and maize stover.*

Component	Trifolium (%)				SE (±)
	0	25	35	50	
<b>Intake of DM (g/kgW/day)</b>					
Maize stover	20 <sup>a</sup>	14 <sup>bc</sup>	15 <sup>b</sup>	12 <sup>c</sup>	0.9
Trifolium hay	0	5	8	12	0.7
Total	20 <sup>a</sup>	19 <sup>a</sup>	23 <sup>b</sup>	24 <sup>b</sup>	1.1
<b>Digestibility (%)</b>					
Dry matter	54 <sup>a</sup>	61 <sup>b</sup>	63 <sup>b</sup>	64 <sup>b</sup>	1.5
Organic matter	56 <sup>a</sup>	63 <sup>b</sup>	65 <sup>b</sup>	66 <sup>b</sup>	1.6
Crude protein	6 <sup>a</sup>	47 <sup>b</sup>	57 <sup>c</sup>	57 <sup>c</sup>	3.4
Neutral detergent fibre	59 <sup>a</sup>	65 <sup>b</sup>	66 <sup>b</sup>	66 <sup>b</sup>	1.9
Acid detergent fibre	64	67	68	67	1.7
Energy	54 <sup>a</sup>	62 <sup>b</sup>	63 <sup>b</sup>	64 <sup>b</sup>	1.8
Phosphorus	12 <sup>a</sup>	28 <sup>b</sup>	35 <sup>b</sup>	28 <sup>b</sup>	5.2
Nitrogen retention (g/day)	0.1 <sup>a</sup>	2.4 <sup>b</sup>	4.4 <sup>c</sup>	3.5 <sup>c</sup>	0.4
DDMI (g/kg/day)	10.8	11.6	14.5	15.4	

Values with different superscripts on the same line differ at  $P < 0.05$ .

3.0 and 2.8 MJ/day for MS, OS, TS and WS, respectively, compared with a maintenance requirement of 3.4 MJ/day for a 20 kg male castrate sheep (ARC, 1980). Thus, ME intake was sufficient for maintenance in the case of OS only. Successive increments of TH in the diet increased average ME intake to 3.8, 4.6 and 4.8 MJ/day across the four CCRs. These levels of ME intake would be sufficient to support modest levels of production.

The DM intakes and apparent DM digestibilities of the four CCRs when fed alone were compared by analysis of variance. The DM intake of OS was significantly higher than that of the other three CCRs. This was consistent with the observation that OS contained less NDF than

the other CCRs and with the hypothesis that the proportion of plant cell wall material in the feed is the primary determinant of feed intake (Mertens, 1973). The apparent digestibilities of MS and OS were significantly higher than that of TS, and that of TS was significantly higher than that of WS. Both lignin and silica content may have a negative relationship with digestibility (see, for example, van Soest, 1982), but in this series of trials there was no apparent relationship, except that WS had the highest lignin and silica contents and the lowest digestibility. There were, however, significant differences in metabolic loss among the CCRs. Values for the 'true digestibility' of DM (the sum of neutral detergent solubles and digestible NDF) were calculated for the various combinations, and metabolic loss was taken as the difference between true and apparent digestibility.

The negative values for the apparent absorption of P are in general agreement with the equation developed by Butterworth (1966) for tropical forages, which indicated that P absorption increases logarithmically with dietary P concentration, as was the case in this series of experiments. However, no explanation can be given for the high values observed in the case of WS.

In order to determine whether the CCRs had any associative effects on digestibility, which would give rise to values higher than would be expected from simple substitu-

Table 1. *Chemical composition of Trifolium lembense hay and cereal crop residues.*

Component	Content (% DM)				
	Tri- folium	Maize stover	Oat straw	Teff straw	Wheat straw
Organic matter	89.5	88.2	91.9	90.8	89.5
Crude protein	20.1	5.1	6.2	3.6	2.3
NDF <sup>1</sup>	44.4	75.5	71.2	77.5	76.1
ADF <sup>2</sup>	36.6	51.3	46.6	44.3	51.7
Lignin	4.8	4.8	6.6	5.1	6.4
Silica	—	5.2	3.6	3.4	6.9
Phosphorus	0.30	0.17	0.15	0.25	0.22
Gross energy (MJ/g)	19.0	16.7	17.9	17.6	18.8

<sup>1</sup> Neutral detergent fibre.

<sup>2</sup> Acid detergent fibre.

tion, the digestibility coefficients of TH and the CCRs when fed alone were used to calculate theoretical values for digestibility coefficients for combinations of the various CCRs and TH. While these calculations are somewhat hypothetical and may be subject to cumulative error, there was, however, a strong indication that consistent, small, positive associative effects occurred when MS and OS were supplemented with TH, amounting to 8 and 6% of calculated DM digestibility, respectively.

The addition of TH to each CCR caused a significant increase in nitrogen retention, which was sufficient to support production with MS, OS and WS. The low levels of both crude protein digestibility and nitrogen retention with TS alone or when supplemented with TH were in agreement with results reported by Mosi and Butterworth (1985).

Jayasuriya (1984) stated that treating roughages with sodium hydroxide can increase their digestibility by 10 to 20 percentage points and increase intake by 30 to 50%. Supplementing CCRs with legume hay at the higher levels used in this study gave similar increases over the unsupplemented CCRs. At the same time, nitrogen retention was increased to a level that would support modest levels of production.

Supplementing diets with legume hay is a more appropriate and cost-effective way of increasing animal production from CCRs in Africa than is the use of strong alkalis. Growing forage legumes on land that would otherwise be fallowed has the additional benefit of increasing the yield of subsequent crops through the nitrogen fixed by the legume. The use of the legume in supplementing the CCR diet also does not carry the risks to the environment that treatment with sodium hydroxide carries, in that it does not result in large quantities of sodium being excreted by the animals.

Animal production systems based on the use of legume hay and CCRs are being developed by ILCA for use in the Ethiopian highlands.

Table 3. *Voluntary intake, digestibility and nitrogen retention of sheep on diets containing different proportions of trifolium hay and oat straw.*

Component	Trifolium (%)				SE (±)
	0	14	23.9	35.7	
<b>Intake of DM (g/kgW/day)</b>					
Oat straw	27	23	23 <sup>b</sup>	19.1 <sup>c</sup>	0.9
Trifolium hay	0	4	7	11	0.2
Total	27 <sup>a</sup>	27 <sup>a</sup>	30 <sup>b</sup>	30 <sup>b</sup>	0.9
<b>Digestibility (%)</b>					
Dry matter	52 <sup>a</sup>	56 <sup>b</sup>	60 <sup>c</sup>	60 <sup>c</sup>	0.8
Organic matter	55 <sup>a</sup>	59 <sup>b</sup>	63 <sup>c</sup>	62 <sup>c</sup>	0.8
Crude protein	39 <sup>a</sup>	48 <sup>b</sup>	55 <sup>c</sup>	56 <sup>c</sup>	2.1
Neutral detergent fibre	55 <sup>a</sup>	58 <sup>b</sup>	61 <sup>c</sup>	58 <sup>b</sup>	1.1
Acid detergent fibre	53 <sup>a</sup>	55 <sup>a</sup>	58 <sup>b</sup>	57 <sup>ab</sup>	1.3
Energy	52 <sup>a</sup>	56 <sup>b</sup>	59 <sup>c</sup>	58 <sup>c</sup>	0.8
Phosphorus	-54 <sup>a</sup>	-41 <sup>b</sup>	-16 <sup>c</sup>	-8 <sup>d</sup>	5.2
Nitrogen retention (g/day)	2.8 <sup>a</sup>	3.0 <sup>a</sup>	5.5 <sup>b</sup>	6.0 <sup>b</sup>	0.4
DDMI (g/kg/day)	14.0	15.1	18.0	18.0	

Values with different superscripts on the same line differ at P<0.05.

Table 4. *Voluntary intake, digestibility and nitrogen retention of sheep on diets containing different proportions of trifolium hay and teff straw.*

Component	Trifolium (%)				SE (±)
	0	19	35	50	
<b>Intake of DM (g/kgW/day)</b>					
Teff straw	23 <sup>a</sup>	22 <sup>a</sup>	20 <sup>b</sup>	16 <sup>c</sup>	0.5
Trifolium hay	0	5	10	16	0.2
Total	23 <sup>a</sup>	28 <sup>b</sup>	30 <sup>c</sup>	32 <sup>d</sup>	0.5
<b>Digestibility (%)</b>					
Dry matter	45 <sup>a</sup>	48 <sup>a</sup>	52 <sup>ab</sup>	56 <sup>b</sup>	1.1
Organic matter	48 <sup>a</sup>	51 <sup>a</sup>	54 <sup>ab</sup>	58 <sup>b</sup>	1.19
Crude protein	-20 <sup>a</sup>	4 <sup>b</sup>	14 <sup>c</sup>	25 <sup>d</sup>	3.66
Neutral detergent fibre	53	54	56	58	1.87
Acid detergent fibre	56	55	56	59	1.2
Hemicellulose	50 <sup>a</sup>	56 <sup>ab</sup>	59 <sup>b</sup>	61 <sup>b</sup>	2.6
Cellulose	54 <sup>a</sup>	57.2 <sup>ab</sup>	60 <sup>bc</sup>	65 <sup>c</sup>	1.86
Energy	44 <sup>a</sup>	48.8 <sup>ab</sup>	53 <sup>b</sup>	56 <sup>b</sup>	1.8
Phosphorus	-51 <sup>a</sup>	-18 <sup>b</sup>	-9 <sup>c</sup>	-2 <sup>d</sup>	5.18
Nitrogen retention (g/day)	1.5 <sup>a</sup>	0 <sup>a</sup>	0.5 <sup>ab</sup>	1.7 <sup>b</sup>	0.3
DDMI (g/kg/day)	10.4	13.4	15.6	17.9	

Values with different superscripts on the same line differ at P<0.05.

Table 5. Voluntary intake, digestibility and nitrogen retention of sheep on diets containing different proportions of trifolium hay and wheat straw.

Component	Trifolium (%)				SE (±)
	0	19	34	44	
<b>Intake of DM (g/kgW/day)</b>					
Wheat straw	21 <sup>a</sup>	20 <sup>a</sup>	17 <sup>b</sup>	16 <sup>b</sup>	0.9
Trifolium hay	0	5	9	12	0.5
Total	21.2 <sup>a</sup>	24 <sup>ab</sup>	25 <sup>b</sup>	28 <sup>b</sup>	1.0
<b>Digestibility (%)</b>					
Dry matter	40 <sup>a</sup>	42 <sup>a</sup>	46 <sup>ab</sup>	48 <sup>b</sup>	2.2
Organic matter	47	48	51	53	2.1
Crude protein	-14 <sup>a</sup>	24 <sup>b</sup>	37 <sup>c</sup>	43 <sup>d</sup>	3.6
Neutral detergent fibre	47	47	50	50	2.2
Acid detergent fibre	52	49	52	53	2.4
Hemicellulose	42	43	44	42	3.5
Cellulose	58	57	60	60	2.0
Energy	42 <sup>a</sup>	47 <sup>ab</sup>	50 <sup>b</sup>	51 <sup>b</sup>	2.2
Phosphorus	65	64	61	60	2.5
Nitrogen retention (g/day)	-0.5 <sup>a</sup>	0.4 <sup>b</sup>	2.42 <sup>c</sup>	3.6 <sup>d</sup>	0.3
DDMI (g/kg/day)	8.5	10.1	11.5	13.4	

Values with different superscripts on the same line differ at  $P < 0.05$ .

Table 6. Voluntary intake and digestibility by sheep of Trifolium tembense hay when fed alone.

Component	Trifolium hay
Intake of DM (g/kgW/day)	39.3 ± 3.2
Digestibility (%)	
Dry matter	67 ± 2.5
Organic matter	66 ± 3.3
Crude protein	62 ± 3.5
Neutral detergent fibre	60 ± 3.5
Acid detergent fibre	61 ± 4.0
Energy	66 ± 3.8
Phosphorus	16 ± 7.5

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# The effect of supplementing cereal straws with urea, *Trifolium* hay and *noug* meal on feed intake and liveweight gain of growing crossbred heifers

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## SUMMARY

**D**IFFERENT COMBINATIONS of urea, *Trifolium* hay and *noug* meal were individually fed to growing crossbred heifers as supplements to diets based on teff or wheat straw. The rations given were isonitrogenous, and crushed maize was added to ensure that energy was not limiting. The aim of the experiment was to compare the supplements as sources of dietary nitrogen (N).

Total dry matter (DM) intake increased when *noug* was included in the rations and decreased when urea was fed. *Trifolium* hay increased the intake of rations based on wheat straw but did not have any effect on the intake of teff-based rations. Weight gains increased when *Trifolium* hay was included in the rations. The addition of urea to rations that did not contain *noug* increased the rate of weight gain, and this was further increased when *noug* was added. All differences were significant at  $P < 0.05$ .

The results of the study indicate that acceptable rates of weight gain can be obtained in growing dairy heifers by feeding rations based on cereal crop residues supplemented with small quantities of maize and urea, and protein from a legume or oilseed meal.

## INTRODUCTION

Grazing animals in the Ethiopian highlands are subject to widely varying levels of

nutrition, and during the dry season a large proportion of their diet is made up of cereal crop residues. These are high in lignocellulosic complexes and consequently of low digestibility, and as a result they are consumed in only limited quantities by ruminants. Cereal crop residues are often less than 50% digestible, and intake is usually 50 g/kg LW<sup>0.75</sup> or less (Mosi and Butterworth, 1985).

However, supplementation with protein or non-protein nitrogen (NPN) can increase both digestibility and intake of the complete diet. Clovers endemic to the Ethiopian highlands, such as *Trifolium tembense*, have been used in this way (Mosi and Butterworth, 1985), as has the residue of the oilseed *noug* (*Guizotia abyssinica*) after extraction (Butterworth and Mosi, 1985). Grown as an alternative to arable crops, clovers have the additional advantage of improving soil fertility through N fixation.

The objective of the work described in this article was to compare the effects of *noug* meal, *Trifolium tembense* hay and urea, fed in different combinations as supplements to wheat or teff straws, on feed intake and growth rate of crossbred heifers.

## MATERIALS AND METHODS

The study was carried out at ILCA headquarters in Shola, Addis Ababa, at an

altitude of 2380 m. Rainfall during the 4 years prior to the experiment averaged 900 mm per annum.

Thirty-six 1- to 2-year-old Holstein x Zebu heifers were used in the experiment. They had an average liveweight of 203 kg at the beginning of the experiment and were divided into 12 groups according to weight and age. The groups were randomly allocated one of 12 diets based on wheat or teff straw fed *ad libitum* and supplemented with different combinations of urea, *Trifolium* hay and *noug* meal. All rations were formulated so as to be isonitrogenous at 1.2% N. However, due to variations in the animals' consumption of the straw, which was offered *ad libitum*, the mean N content of supplemented rations was  $1.21 \pm 0.08\%$  N ( $7.55 \pm 0.52\%$  CP). Urea was sprinkled on the straw, which was then stored in polythene bags for approximately 16 hours before feeding. Supplements were given as a separate meal which was completely consumed before straw was offered *ad libitum*.

As the main aim of the experiment was to evaluate the supplements as sources of N, it was undesirable for energy to be limiting. Each ration was therefore supplemented with enough crushed maize grain to satisfy energy requirements for a daily weight gain of 250 g (Agricultural Research Council, 1980). Fresh water and a complete mineral lick were always available, and bone meal and anhydrous sodium sulphate were added to the feed daily.

The amounts of feed offered and refused were recorded daily, and samples were analysed using methods described in AOAC (1980) and Goering and van Soest (1970). Experimental animals were assigned at random to individual feeding pens. A standardisation period of 14 days was followed by an experimental period of 98 days. Animals were weighed every 14 days and rectal palpation was carried out to monitor ovarian activity.

## RESULTS AND DISCUSSION

The chemical composition of the various feeds used is given in Table 1. Except for *noug* meal, which was relatively low in N, the values shown are similar to those found by Mosi and Butterworth (1985) and Butterworth and Mosi (1985).

Daily consumption of individual feed components in the different rations is given in Tables 2 and 3. Although there were substantial differences in the intake of straw among the different diets, they were not significant. This was to be expected in view of the similarity in the NDF content of the two straws (Mertens, 1973).

Table 4 gives the total consumption of dry matter. Analysis of variance of the pooled data showed that the intake of rations containing urea was significantly lower than that of rations without urea or with *noug* meal supplements. This may have been due to the fact that urea was fed at one time rather than throughout the day. The importance of efficient allocation of feed supplies over the 24-hour period has recently been emphasised by Sniffen and Robinson (1984), and it is evident that feeding strategy is particularly important

Table 2. Daily consumption of individual dietary constituents of teff-based diets.

	T	T+U	T+NM	T+Trif.	T+Trif.+U	T+Trif.+NM	SD
Teff straw (kg)	3.79	3.31	4.26	3.35	3.39	3.85	±1.04
Maize grain (g)	498	515	337	337	351	353	± 36
Trifolium hay (g)	-	-	-	500	501	452	± 117
Noug meal (g)	-	-	412	-	-	434	± 140
Urea (g)	-	21.4	-	-	9.2	-	± 2.5

T = teff straw; U = urea; NM = *noug* meal; Trif. = *Trifolium* hay.

Table 3. Daily consumption of individual dietary constituents of wheat-based diets.

	W	W+U	W+NM	W+Trif.	W+Trif.+U	W+Trif.+NM	SD ±
Wheat straw (kg)	3.00	2.69	3.79	3.30	2.84	3.74	1.12
Maize grain (g)	648	652	394	351	381	307	131
Trifolium hay (g)	-	-	-	629	496	428	66
Noug meal (g)	-	-	382	-	-	347	27
Urea (g)	-	24.5	-	-	9.2	-	2.2

W = wheat straw; for U, NM and Trif. see Table 2.

when considering the supplementation of diets based on crop residues.

There was a significant interaction between *Trifolium* hay and the straw fed. When no *Trifolium* hay was fed total DM intake was higher on teff-based diets than on wheat-based diets, but when *Trifolium* hay was included there were no significant differences in intake between the straws.

The increased DM intake associated with *noug* meal was consistent with the results obtained by Butterworth and Mosi (1985), which showed that supplementing cereal crop residues with *noug* meal in-

creased both intake and digestibility of the diet when fed to sheep.

Pooled results for weight gains (g/day) are given in Table 5; no significant differences in growth rate could be attributed to straw type. The inclusion of *Trifolium* hay in the rations significantly ( $P<0.05$ ) increased the daily rate of gain. This finding is consistent with the results obtained by Mosi and Butterworth (1985). Animals fed urea gained more weight than those fed rations containing straw and *Trifolium* hay only; the weight gain of animals fed *noug* meal was greater than that of those fed

Table 1. Composition of feeds expressed as percentage of dry matter.

	Tef straw	Wheat straw	Trifolium hay	Noug meal	Maize grain	Urea
Organic matter	92.1	93.2	89.5	89.5	98.1	-
Nitrogen	0.86	0.74	2.5	4.5	1.7	45
NDF	73.5	72.2	44.4	31.1	15.9	-
Hemicellulose	29.3	17.9	7.8	5.7	11.3	-
ADF	44.2	54.3	36.6	25.4	4.6	-
Cellulose	40.0	48.4	31.8	20.1	3.6	-
Lignin	4.2	5.9	4.8	5.3	1.0	-
Ash	7.9	6.8	10.5	10.5	1.9	-

Table 4. Pooled mean values of total DM intake (g/kg LW<sup>0.75</sup>) by animals fed different combinations of cereal crop residues, *Trifolium* hay, urea and *noug* meal.

	-Trif.	+Trif.	SE
Wheat straw	71.5 a	79.5 b	± 1.75
Teff straw	81.5 b	81.8 b	± 1.75
No urea or no noug	Urea	Noug	SE
72.2 a	71.7 a	86.8 b	± 1.51

Note: For each sub-table, means followed by the same letter are not significantly different ( $P<0.05$ ).

straw and *Trifolium* hay with or without urea ( $P < 0.05$ ).

Table 6 shows that the marked effect of *Trifolium* was not matched by any increase in ruminal ammonia concentration. Both urea and *noug* caused marked increases in ruminal ammonia levels, from 6–8 mg/100 ml to 10–12 mg/100 ml. Only in the case of *noug* was this associated with higher intake; weight gains of animals fed *noug*-supplemented diets were much higher than those of animals fed urea-supplemented diets.

These results indicate that addition of either urea or *noug* meal increased the weight gain of animals fed straw with or without *Trifolium*. The increased DM intake associated with *Trifolium* hay and *noug* meal might be due either to their providing bypass protein or to their increasing the availability of amino acids, peptides or branched-chain fatty acids in the rumen, which in turn would increase the yield of rumen microbial protein (van Soest, 1982). No significant treatment effects on ovarian function were observed.

## CONCLUSIONS

Satisfactory growth rates were obtained in crossbred dairy heifers by feeding cereal crop residues supplemented with small amounts of maize and urea and additional protein. The protein could be supplied in the form of either legumes grown in an alley-farming system or on fallow land, or locally available oilseed meals or similar protein concentrates.

Table 5. Pooled mean values of weight gain (g/day) by animals fed different combinations of cereal crop residues, *Trifolium* hay, urea and *noug* meal.

-Trif.	+ Trif.	SE	No urea or <i>noug</i>	Urea	<i>Noug</i>	SE
133 a	227 b	± 25.2	72 a	179 b	289 c	± 30.8

Note: Means followed by the same letter are not significantly different ( $P < 0.05$ ).

Table 6. Effect of diet on ruminal ammonia concentration (mg/100 ml).

Basal component <sup>1</sup>	Alone	With urea	With <i>noug</i>
Teff straw	8.5 <sup>2</sup>	11.0	10.2
Teff straw + <i>Trifolium</i>	7.0	11.6	11.2
Wheat straw	5.5	12.3	10.6
Wheat straw + <i>Trifolium</i>	8.1	9.3	10.6

<sup>1</sup> All diets contained about 10% crushed maize.

<sup>2</sup> Each entry is a mean of three sampling times.

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## LIST OF ABBREVIATIONS

ADF acid detergent fibre  
 CCR cereal crop residue  
 CP crude protein  
 DM dry matter  
 LW liveweight  
 ME metabolisable energy  
 MJ megajoules  
 MS maize stover

N nitrogen  
 NDF neutral detergent fibre  
 NPN non-protein nitrogen  
 OS oat straw  
 SD standard deviation  
 SE standard error  
 TS teff straw  
 WS wheat straw