IAEA-TECDOC-708

Improving the productivity of indigenous African livestock

Results of FAO/IAEA/DGIS Co-ordinated Research Programmes organized by the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture

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FOREWORD

In 1987, a Co-ordinated Research Programme entitled "Improving the Productivity of Indigenous African Livestock using Radioimmunoassay and Related Techniques" was initiated by the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture through funding provided by the Netherlands Directorate General of Development Co-operation (DGIS). The aim of this Programme was to support the national agricultural research systems (the NARS) of African countries in their efforts to find ways of improving the productivity of indigenous ruminant animals (cattle, sheep and goats). Work under the NARS network which was established through this Programme was extended for a further three years in 1990 when DGIS agreed to fund a follow-up Co-ordinated Research Programme entitled "Improving the Productivity of Indigenous African Livestock through Integrated Studies on Smallholder Farms".

Through these Programmes and with additional support provided by the IAEA Department of Technical Co-operation and the Joint FAO/IAEA Division, baseline parameters of livestock productivity and reproductive efficiency were obtained for a variety of local breeds of ruminant animals kept by smallholder farmers and/or on NARS field stations or farms. Attempts were also made to improve productivity by introducing simple low-cost changes in feeding and/or reproductive management.

This publication contains the results presented by the NARS scientists who participated in the final Research Co-ordination meeting of the Programmes which was held in Accra, Ghana, from 21-25 September 1992. Details are also given of the technical and other inputs provided to assist manpower and infrastructure development within the NARS which participated in these Programmes. It is hoped that this publication will help to stimulate further research into ways of improving the efficiency and sustainability of livestock production in Africa.

The research for this publication was co-financed by the Research and Technology Programme of the Netherlands Minister for Development Co-operation, who also shares copyright.

The FAO and IAEA wish to acknowledge the generous support to these Programmes provided by the Government of the Netherlands. They would also like to record the enthusiastic collaboration of all who assisted in the Programmes, and in particular the great personal commitment of Drs M. Thibier (France) and A.H. Willemse (Netherlands) in their capacity as Research Agreement holders.

EDITORIAL NOTE

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1. AFRICAN AGRICULTURE AND THE CONTRIBUTION OF RUMINANT LIVESTOCK

Africa's population is growing faster (3% per annum) than that of any other region of the world and sub-Saharan Africa alone, with a present population of 500 million, will have a population of 1300 million by the year 2025 if present trends continue [1]. This rate of population growth is posing severe problems for African agriculture. On the one hand, the steady increases in agricultural output achieved over the past 25 years have in fact resulted in severe reductions in *per capita* cereal, crop, meat and milk production [2]; on the other, the rapid rural-urban migration which has taken place over the last decade (7% per annum), has focused government attention on politically more influential city populations which demand value-added food products. In many countries this demand has been met by the importation of food which can be purchased for less than the price that local farmers can produce it. Whilst this appears to be a cheap solution it is having serious economic consequences. Firstly, more and more foreign exchange is being used to finance food imports which depresses local production because less foreign exchange is available to buy the inputs needed to boost production. Secondly, local markets are becoming flooded by cheap food which depresses the price that farmers can charge for their products and reduces further any incentive they have to improve productivity over that required to meet local or subsistence needs. And finally, imported food reduces the number of people employed in agriculture.

Apart from these economic factors, African farmers face many other problems, most notably poor soils and unpredictable climates. Nevertheless, overcropping of soils has been a consistent feature of African agriculture for several decades and increases in livestock numbers have put grazing land under intense pressure. What in effect is happening in many parts of Africa is that food from both crops and livestock is progressively being produced at the expense of the environment or the natural resource base and is therefore not sustainable over the long-term from the economic and/or environmental standpoints. Whilst the need for increased production is obvious and urgent, agriculture must be put on a more sustainable basis so that the adverse effects of production and exploitation of the resource base are balanced by conservation measures which minimize waste and maximize nutrient recycling as well as production per unit of resource (i.e. productivity).

The livestock sector in Africa is a good case in point. Livestock are an important and integral part of most farming systems in Africa, and indeed are one of the region's major assets. According to FAO [3] sub-Saharan Africa alone has around 162 million cattle (14% of the world's total), 127 million sheep (17% of world total) and 147 million goats (31% of world total). Seventy percent of the world's camel population are also found in this region along with substantial numbers of equines (around 11 million), pigs (11 million) and poultry (630 million). Unlike the specialized and intensive systems in the developed world, ruminant

animals like cattle, sheep and goats provide more than simply the meat, milk, wool and hides which constitute 25% (or US $ 12 billion) of the total agricultural output in sub-Saharan countries [4]. They provide draught power and manure which partially substitute for the fossil fuel-driven tractors and fertilizers used in developed countries - contributions which have been estimated to increase the value of livestock to 35% of total agricultural production in sub-Saharan Africa [5]. Livestock also provide income on a regular basis and serve as a "walking savings bank" which can be used when required, e.g. to purchase seeds, medicines, etc. But most importantly, they provide a means of converting surplus crops, crop residues and by-products to high value commodities which increase income and enhance the economic viability of farming systems. These products (particularly meat and milk) are significant sources of food for the majority of African people, providing about 17% of the dietary protein [6]), but the animals themselves are also often a primary source of cash that farmers use for buying food grains, and therefore they play an important role in food security at the rural level.

Nevertheless, the productivity of livestock in Africa is low when compared with other parts of the world - at least when measured in terms of the parameters used in industrialized countries [7]. For example, the average milk yield of cows in developed regions is 3605 kg per lactation; in Africa it is 200 - 700 kg. Similarly, the annual red meat off-take from cattle in developed countries is 25% and average carcass weights are 250 kg; in Africa, the annual off-take is only around 10% and average carcass weights are 135 kg. These figures, coupled with the demand increase associated with population growth have produced a situation whereby Africa is now a net importer of both milk and meat. In sub-Saharan Africa, these imports now represent 3% and 11% respectively of total consumption and cost US $ 900 million annually [8]. If present livestock production trends continue, milk output in 2025 will be about 32 million tons and red meat output 12 million tons, representing only 65% and 75% respectively of demand requirements. Hence, even allowing for the additional value of livestock as providers of draught power and fuel, unless productivity is increased in an environmentally and economically sustainable fashion by improving the resource base with minimal or no external inputs and/or the efficiency with which this base is used for producing animal by-products, African governments will be faced with import bills totalling well in excess of US $ 25 billion to meet the demand for livestock products. This level of imports is beyond the realm of economic feasibility.

To meet the escalating demand will require an annual increase of 4% in supplies of livestock products [9]. At this rate of increase, milk production in sub-Saharan Africa would reach 43 million tons by 2025 and meat production 19 million tons - sufficient to feed the growing population, improve nutrition and eliminate food imports. In its recent study entitled "Assessment of Animal Agriculture in Sub-Saharan Africa", Winrock International analyzed the current status and past trends of animal agriculture and estimated future livestock inventories, productivity levels and feed requirements by agroecological zones [9]. The study suggested that increases in the order of 3-4% per annum in milk and meat production could be achieved through moderate increases in livestock numbers (1.3%) coupled with increases of 4% and 2% respectively in milk and red meat animal productivity. Whilst the study concluded that such growth coefficients were extremely ambitious, they were nevertheless achievable provided improved technologies were introduced and an economic and institutional environment favourable to agricultural development was created.

2. CONSTRAINTS TO AND OPPORTUNITIES FOR INCREASED RUMINANT LIVESTOCK PRODUCTION AND PRODUCTIVITY

The factors limiting livestock production in Africa can essentially be grouped under 4 categories, i.e. technical, land resources, policy and institutional, with the importance of each varying enormously from country to country and between agroecological zones within a country [9]. Throughout the region, quantitative and qualitative deficiencies in the feed resource base mean that the feed requirements for existing levels of production, let alone for any increase, cannot be met. Nor are there significant opportunities for improving this situation in the arid zone (0-500mm. rainfall annually), which accounts for around 7.5 million km^2 of sub-Saharan Africa and is mostly used by pastoralists keeping sheep, goats and camels. The potential for improving animal off-take and productivity in this zone is therefore low and strategies for development should focus on preserving rangeland productivity and controlling cultivation in areas unsuited for sustained crop production.

Likewise, in the highlands areas (about 1 million km^2 with average daily temperatures of less than 20°C), feed resources are again almost completely utilized, but here there are good opportunities for stimulating meat and milk production from cattle, sheep and goats by increased use of technology and inputs - provided appropriate incentives are provided for both crop and livestock development. In most of the highland zone, agricultural production systems already involve a high degree of crop-livestock interaction and stimulating this further coupled with the provision of improved infrastructure would catalyze intensification, and improvements in productivity and sustainability.

However, it is in the semi-arid and subhumid zones with average annual rainfalls of between 500-1000 mm and 1000-1500 mm respectively, and which together constitute about 9 million km^2 of sub-Saharan Africa, that the major potential exists for stimulating animal and crop production - by improving soil fertility through the greater use of leguminous crops and by encouraging improved pastures and cultivated forages, and a better exploitation of grain, root crops and oil seeds. With these steps, crop-livestock systems would be more widely adopted and the process of intensification stimulated.

A second technical impediment to livestock development in Africa is diseases (particularly viral, parasitic and those such as trypanosomiasis, theileriosis and dermatophilosis which are transmitted by fly or tick vectors), and associated with these, the inability of many African countries to maintain effective disease surveillance and control measures. Significant opportunities do however exist to ameliorate the effects of animal diseases and these should be exploited.

Two further technical factors - poor animal genetic resources and insufficient knowledge on the dynamics of the different types of farming systems existing in Africa are also serious constraints. There is scope to upgrade indigenous animals through cross-breeding or the introduction of stock with better genetic potential for growth and/or milk production in high potential zones (e.g. highland areas), and there is an urgent need to understand the dynamics of the crop-livestock farming systems upon which most of African agriculture is based. This would be particularly relevant for the subhumid zone where crop-livestock farming is at an embryonic stage of development but could be of major importance in the future.

Aside from these technical issues, the livestock sector in Africa has been subjected to a wide variety of government policies hardly conducive to the development of efficient industries, and most of these have been mentioned earlier. In addition, chronic institutional constraints have hampered research and extension and the development of producer, marketing and financing organizations. All of these will require substantial

overhaul and/or strengthening if the strategies needed to improve livestock production in the region are to succeed.

3. STRATEGIES FOR RESEARCH

Stimulating agricultural output and productivity in Africa will require, amongst others, research to generate basic knowledge on crop and animal production and interactions between these in different agroecological zones, and to generate appropriate technological and management packages and transfer these to producers [9-11].

Research must also address the sustainability of production systems in both economic and environmental terms, as well as questions like satisfying food and social needs. Research to improve animal production must be based on the premise that animal agriculture is indeed a necessary and positive component of long-term sustainable agriculture, and that technologies and approaches derived from research which enhance animal productivity will also stimulate sustainable agricultural development, and that this in turn will benefit rural and national economic development. There are a number of striking examples in Africa to demonstrate that this thesis holds - most notably smallholder dairy development in East Africa, and the widespread introduction of animal traction and expansion of smallholder systems of fattening in parts of West Africa. Equally, there have been many disappointments, e.g. efforts to increase the productivity of rangelands and the off-take of animals in pastoral systems, and to introduce artificial insemination or exotic breeds in areas which for one reason or another were inappropriate. Lessons from both the successful and the unsuccessful efforts coupled with better understanding of livestock production systems in the region should allow future efforts to be better targeted and more successful.

In its report, Winrock International [9] identified the necessity of adopting a farm systems approach in developing and implementing the research strategies needed to help Africa meet its agricultural production targets. It also stated that: "the quality and effectiveness of the institutions that conduct the research, education and extension in Africa more than any other process will determine how well this region feeds its people".

The agricultural research system in Africa consists of national public, parastatal and non-profit institutions like universities, and is commonly referred to as the NARS. The NARS are the focal point of the system, responsible for identifying researchable problems and conducting research, and they are the main link to extension services and other national organizations as well as to regional and international bodies such as the international agricultural research centres of the CGIAR and FAO. They are mandated to work with farmers, farmer organizations, industry and extension officers to identify constraints and develop interventions to resolve these constraints, to identify, and evaluate and exploit potentials, and to seek alternatives within production systems that will be technically practical, economically feasible and socially acceptable.

Unfortunately, and for many reasons, the NARS are invariably not generating sufficient technology to fuel agricultural development in Africa and they require substantial strengthening in terms of manpower, infrastructural development and organization. For example, the universities (which in developed countries conduct most agricultural research), have many scientists with post-graduate qualifications, but many of them are not engaged in research which contributes creatively to national development priorities. This is one reason why agricultural and rural development in Africa are not keeping pace with needs. Too many programmes reflect specialized interests developed through often inappropriate and narrow training in

developed countries, and there is often little contact with farmers and even commercial enterprises which are the major stakeholders in agriculture. Furthermore, the number of African scientists educated to a level sufficient to conduct the modern animal research required to meet the critical food needs of the region is totally inadequate, and the funding of animal agricultural research is chronically short. Poor communication and isolation amongst scientists is also a major problem in Africa, because few NARS have funds to enable staff to attend scientific meetings; to interact with each other and to establish collaborative links with scientists in other countries or those belonging to relevant international agricultural research organizations; and to maintain adequate scientific libraries and access to scientific information. These problems have to be addressed to improve the effectiveness of the NARS.

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CO-ORDINATED RESEARCH PROGRAMMES ON IMPROVING THE PRODUCTIVITY OF INDIGENOUS AFRICAN LIVESTOCK

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1. BACKGROUND

The Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture is part of FAO's Department of Agriculture and of the IAEA's Department of Research and Isotopes, and its activities are funded by both organizations. These activities are essentially carried out through the operation of Co-ordinated Research Programmes and Technical Co-operation projects, both of which aim to stimulate and improve the capacity of NARS to identify and resolve problems connected with agricultural development in their Member States. Co-ordinated Research Programmes are developed around a research topic on which 10-15 NARS collaborate - the topic itself being defined through consultation with the NARS, staff of international agricultural research centres and organisations such as FAO and IAEA, and with staff of national agricultural research institutions in developed countries. The role of the Joint FAO/IAEA Division is then to ensure that efforts under these Programmes are properly co-ordinated, that the required inputs are made in timely and appropriate manner, and that the results are published and made available to relevant government and other organisations.

The financial and technical resources made available through the Research Contract and Technical Co-operation Programmes aim to strengthen the NARS through provision of capital equipment and disposables; through training of staff abroad by awarding fellowships and in their own institutes by arranging short-term visits by FAO/IAEA staff and technical experts; and through the alleviation of isolation by promoting collaborative links between NARS and experts from other countries, and by providing relevant literature and computerised data bases. Further support to Programmes in the form of ready-made kits, technical manuals and protocols and quality assurance are provided from the FAO/IAEA Agricultural Laboratory at Seibersdorf near Vienna. Funding of these activities comes from the Regular Budgets and Technical Co-operation funds of FAO and IAEA, and from extra-budgetary contributions from Member States.

It was in November 1986 that agreement was reached between the Government of the Netherlands and the IAEA to fund a 3-year Co-ordinated Research Programme on "Immunoassay Techniques to Improve the Reproductive Efficiency and Health Status of Indigenous African Livestock". In March 1990, the Dutch Government agreed to continue the programme for a further 3 years but with some modifications to the objectives and title. This second Programme was entitled "Improving the Productivity of Indigenous African Livestock Through Integrated Studies on Smallholder Farms, and the Use of Improved Methods for Diagnosing and Controlling Trypanosomiasis". The Dutch Government provided funds totalling approximately US $ 2 million over a period of 6 years for these activities of which around US $ 1 million were made

available to support the work on animal production described in this report. Work on animal disease diagnostics forms the basis of a separate technical report [1].

In addition to these extra-budgetary contributions, funds totalling US $ 1.6 million were made available through the IAEA's Department of Technical Co-operation and the Joint FAO/IAEA Division in support of the animal production component of the Co-ordinated Research Programmes. Essentially, funds from the Netherlands were utilised for Research Contracts and Co-ordination Meetings, for laboratory support services, and for the salaries and some of the travel of FAO/IAEA staff members assigned to the Programmes. FAO and IAEA provided complementary support in the form of equipment and reagents, training through fellowships and courses, and visits by FAO/IAEA staff and outside consultants.

2. OBJECTIVES OF THE PROGRAMMES

The great differences in livestock productivity between African and developed countries were described earlier, as were some of the technical and other constraints to achieving both higher levels of off-take from existing resource bases and at the same time, promoting sustainability and rural development. These differences are due largely to differences in how the animals are managed, particularly from the standpoint of feeding, breeding and disease control, and probably also to the genotypes of animals kept [2]. In developed countries, the husbandry, animal genotypes and types of management are fairly stereotyped whereas in Africa they vary enormously within and between countries and agroecological zones. These diversities in livestock species and types, in the resources available to feed them, and in the environmental and managerial conditions under which they are kept make it difficult to develop strategies for improvement which are of widespread applicability. Nevertheless, in attempting to meet the demand of their growing urban populations for milk, meat and other animal products, even some of the least developed African countries have imported technological packages consisting of high yielding stock and compound rations to feed them, together with semen for artificial insemination and vaccines and drugs for disease control. The mistakes that have been made through this approach have shown that, except in special circumstances, it is not what is required. Certainly for the many smallholder farmers in Africa who overwhelmingly form the food production base it is largely irrelevant. For these farmers and for the countries as a whole, the greatest need is to improve the sustainability of their own livestock-crop systems, making the best possible use of the indigenous animals and of the feeds and other resources which are locally available. However, and as emphasised earlier and by recent reports from Winrock International and others [2,3], constraints within the NARS have meant that little research has been undertaken to determine existing and potential levels of productivity within different farming systems so that this information can be used to find approaches which can bridge the gap between these and which could then be incorporated into such systems.

It was against this background and with the general aims of promoting on-farm research into existing levels of animal productivity and ways of improving these through simple low-cost changes in management practices, that the Co-ordinated Research Programmes funded by the Government of the Netherlands were initiated. It was recognised at the outset that key factors in addressing these aims would be strengthening of the NARS in terms of technical and infrastructural capability, and ensuring that the research conducted addressed the perceived needs of farmers by promoting close interaction and feedback between the NARS and the farming communities they are mandated to assist. It was further recognised that existing barriers to inter-disciplinary team effort (e.g. between animal nutritionists and reproduction specialists) within the NARS

would need to be broken down to ensure that the critical masses of scientists with relevant technical knowledge interacted amongst themselves and with farmers.

During the first Programme emphasis was placed on obtaining basic information on the productive and reproductive parameters of a variety of indigenous breeds of ruminant livestock kept under different production systems, e.g. bodyweights and growth, age at puberty and first parturition; pregnancy and parturition and culling rates, calving intervals and number of offspring born. Within the context of this work, studies were also initiated on the effects of seasonal, management and breed factors on these parameters and measurements of the hormone progesterone by radioimmunoassay (RIA) were introduced to complement other methods (e.g. rectal palpation/record keeping) for monitoring ovarian activity and the factors which influence this. In all cases, the focus was on smallholder farming systems and traditional breeds of cattle, sheep and goats. In a number of instances comparisons were also made with animals kept under more controlled conditions (e.g. institute farms) since this would help to obtain information on potential as well as realised productivity and thereby provide an insight into increases in productivity which were potentially possible by improved management practices.

Full details of the work conducted and of the results achieved by each of the NARS participating in this Programme and of the technical and financial support provided were described in Activity Reports submitted to the Government of the Netherlands between 1987 and 1989. The Programme was also evaluated by an independent review team at the request of the Dutch Government, and the results of this review published by the IAEA in 1989 [4].

The evaluation team concluded that this Co-ordinated Research Programme had great potential for improving livestock productivity in participating countries, but needed to be continued so that the NARS could broaden the base of their work by incorporating in addition to reproduction, studies of nutritional and other constraints on the production systems being examined. In March 1990, the Government of the Netherlands agreed to fund a second phase of the Programme in which emphasis would be given to strengthening on-farm studies and the collection of data on animal nutrition as well as reproduction.

To gain a better understanding of the role of nutrition, one aspect of this Programme was to develop simple colorimetric methods for measuring the levels of certain metabolites which, in conjunction with data on e.g. bodyweight and milk yield changes, could then be used as indicators of the nutritional status of the animals under study. The aim of this work was to determine whether, by measuring one or a number of key metabolites within the animal itself rather than in the feedstuffs with which it is provided, it was possible to develop early indicators of nutritional stress or the success or otherwise of a particular feed supplementation strategy. This in turn would not only enable a better understanding of the role of nutrition in influencing key reproductive events and thereby reproductive efficiency and productivity, but could also be an approach to avoiding expensive and time-consuming feed analyses in attempting to formulate diets and develop feeding strategies.

A further thrust in this second Programme was to strengthen the capabilities of the participating NARS with respect to data recording, statistical analysis and presentation. This was considered essential in view of the large amount of (often unanalyzed) data collected during the first Programme and that likely to arise from the second, and it was envisaged that this aim would be achieved by the supply of personal computers and the development and use of suitable computer programmes. The development and validation of the colorimetric tests and computer data base programmes were carried out in collaboration with the Agricultural University, Wageningen, and the State University of Utrecht, Netherlands. The activities

conducted under this Programme were described in Activity Reports submitted to the Government of the Netherlands in 1991 and 1992.

The information given below summarises the technical inputs made to the NARS which participated in the Co-ordinated Research Programmes funded by the Government of the Netherlands between 1987 and 1993, the technical and other achievements of these Programmes and the constraints which operated. Full details are then provided of the work conducted by each of the NARS and of the developmental and validation work provided by Dutch and other institutes in support of the Programmes.

3. IMPLEMENTATION OF THE PROGRAMMES

3.1. Research Contracts and Agreements

Subsequent to obtaining the funds from the Netherlands Government, a research network was established consisting of 16 institutes in African countries (NARS) with national mandates for conducting research in animal production and two institutes with a similar mandate in Europe. Each African institute was awarded a Research Contract providing US $ 5000 - US $ 9000 per annum for the purchase of equipment and various other disposable items, while the European institutes were awarded no-cost Research Agreements. This network was subsequently reduced to 12 research contracts since the remainder could not provide the required counterpart contribution (usually because staff left the institute without transferring their research responsibilities). The geographical distribution of the research contracts in operation during 1992 is illustrated in Figure 1.

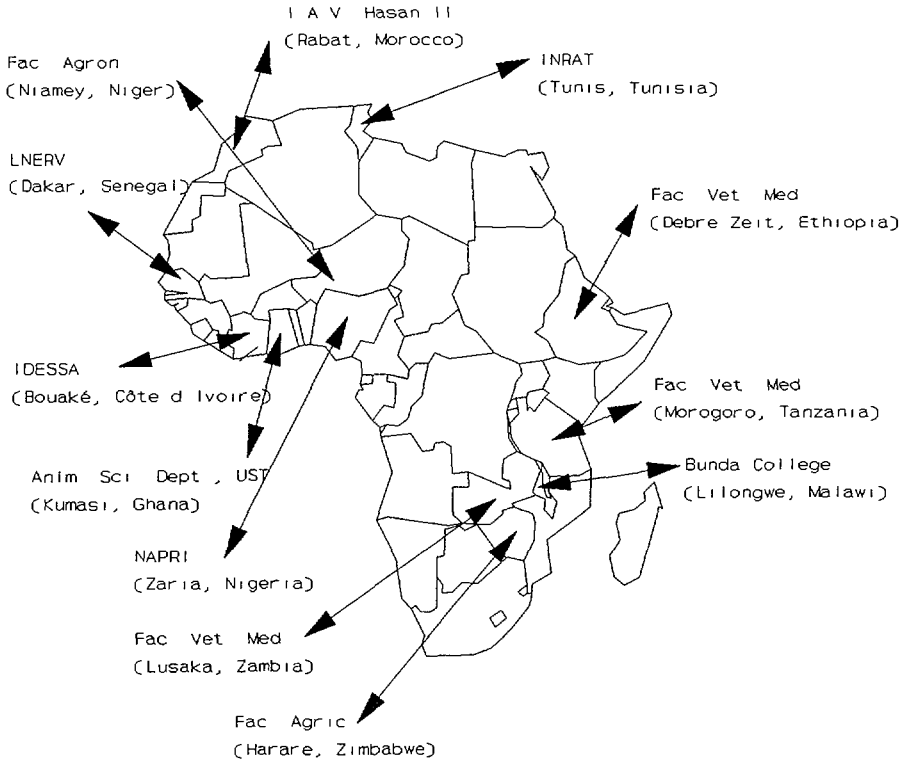

Fig. 1. Research Contracts of FAO/IAEA Co-ordinated Research Programme "Improving the Productivity of Indigenous African Livestock using Radioimmunoassay and Related Techniques".

Research Agreements were concluded with the Faculty of Veterinary Medicine, University of Utrecht, the Netherlands, and with the Union of Cooperatives of Artificial Insemination (UNCEIA) in Maisons Alfort, France, to assist in planning and monitoring the work conducted under the Research Contracts.

3.2. Research Co-ordination Meetings

Four Research Co-ordination Meetings (RCMs) were held. The first was in March 1988 at the headquarters of the International Livestock Centre for Africa (ILCA), Addis Ababa, Ethiopia. At this meeting the initial work plans for the Research Contract holders were formulated. The meeting was followed by a training workshop on approaches to livestock management and on RIA and EIA methodology for measuring progesterone levels in blood and milk.

The second RCM was held in September 1989 at the Faculty of Veterinary Medicine, University of Zimbabwe, Harare, Zimbabwe. The results presented at this meeting showed that many of the Research Contract holders were still collecting baseline data on productivity, reproductive performance, management and health. However, some of the participants had already identified reasons for low livestock productivity and had embarked on introducing low-cost management changes on farms to improve animal performance.

In May 1991 the third RCM was held at Abidjan, Côte d'Ivoire. The collection of baseline data on productivity and reproductive performance had been completed by nearly all the participants, and undernutrition and poor management were identified as the major constraints responsible for poor productivity. The work plans formulated at this meeting therefore focused on enhancing livestock productivity by improving nutrition and management.

The final RCM was held at Accra, Ghana in September 1992. This RCM was attended by the Research Contract and Agreement holders, two consultants, and as during previous RCMs, by participants in a related UNDP/FAO programme on "The Promotion of Trypanotolerant Livestock in West and Central Africa". At this meeting the Research Contract holders presented their final reports which are included later in this technical document.

3.3. Training Activities

Just prior to the initiation of the Programmes (in November 1986) the Joint FAO/IAEA Division organized a 4-week training course on "Immunoassay Techniques in Animal Production and Health" at the University of Nairobi, Kenya. This course covered basic lectures on animal reproduction and practicals dealing with RIA and EIA methods for measuring reproductive hormones.

A further training course on "Immunoassay and Related Techniques in the Study of Livestock Production in the Tropics" was held during September/October 1991 at the IAEA Agricultural Laboratory in Seibersdorf. During this course training was provided in the use of RIA and metabolic kits, on body condition scoring as well as on statistics and scientific writing.

The Joint FAO/IAEA Division then organized a training course entitled "Analysis of Animal Production Data using Personal Computers" at ILCA in March 1992. During this course the participants were assisted in analyzing their data and given additional training on scientific writing, statistics and the use of personal computers.

In addition, counterpart staff received training in RIA of progesterone and other techniques used for monitoring livestock productivity, and on the use of personal computers and statistical analysis of research data by visiting FAO/IAEA experts and technical officers.

A summary of the training provided to NARS staff is given in Table I.

TABLE I. SUMMARY OF TRAINING PROVIDED TO NARS COUNTERPARTS

Course	Countries participating	
FAO/IAEA Course on: "Immunoassay Techniques in Animal Production and Health", Nairobi, Kenya, November 1986	Ethiopia Malawi Tanzania	Ghana Senegal Nigeria
FAO/IAEA Course on: Immunoassay and Related Techniques in the Study of Livestock Production in the Tropics, Seibersdorf, Austria, Sept. - Oct. 1991	Nigeria Tanzania	
FAO/IAEA Course on: "The Analysis of Animal Production Data using Personal Computers", Addis Ababa, Ethiopia, March 1992	Côte d'Ivoire Ethiopia Ghana Malawi Morocco Niger	Nigeria Senegal Tanzania Tunisia Zambia Zimbabwe
Individual training at FAO/IAEA Agricultural Laboratory in Seibersdorf	Ethiopia Ghana Tanzania	Zambia Zimbabwe
Individual training at other laboratories	Senegal Tunisia	

3.4. Technical Contracts

3.4.1. Institute for Animal Production "IVO Schoonoord", Zeist, Netherlands

Programme participants were supplied with FAO/IAEA radioimmunoassay (RIA) kits for progesterone determination. However, in some developed countries enzymeimmunoassay (EIA) tests are used as an alternative to the conventional RIA for measurement of hormones and the serodiagnosis of diseases. Such tests have the advantage over RIA of not requiring a radioisotopic marker, and they are presently used extensively in the animal health programme of the Joint FAO/IAEA Division. It was considered that EIA of progesterone might also prove to be preferable to the RIA in the FAO/IAEA programmes on animal production. A Technical Contract was therefore awarded to the Institute for Animal Production "IVO Schoonoord", Zeist, Netherlands, to develop an EIA kit for the measurement of progesterone in blood plasma and skim milk, and to assist the Joint FAO/IAEA Division in the validation of this kit. Development of this EIA kit was completed in 1988, and it was then validated at IVO "Schoonoord" , the FAO/IAEA Agricultural Laboratory in Seibersdorf, and 10 institutes in both developed and developing countries.

The main conclusion of this validation was that the EIA kit was less robust than the FAO/IAEA RIA kit, as enzymes are more sensitive to changes in water pH and quality, ambient temperature, and exposure to light. Thus while the EIA kit performed well under the standardized conditions of laboratories

in developed countries, in developing country laboratories with poorer facilities to standardize the assay it did not perform satisfactorily. The RIA kit, on the other hand, performed well in all the laboratories participating in the validation, and it was therefore decided to provide Programme participants with FAO/IAEA RIA kits for the measurement of progesterone. A full report on the validation is given in Appendix II.

3.4.2. Faculty of Veterinary Medicine, University of Utrecht, Netherlands

At the RCM in Harare (September 1989) it was concluded that research on nutrition-reproduction interactions was essential for the identification and alleviation of constraints responsible for low livestock productivity, and that simple tests to assess the nutritional status of indigenous livestock would assist this research. A Technical Contract for the development of these tests was therefore concluded with the Faculty of Veterinary Medicine at the State University of Utrecht. Through this Technical Contract, staff of the Animal Production Unit at the FAO/IAEA Agricultural Laboratory received training in Utrecht and kits for the measurement of certain blood metabolites were developed and validated, i.e. blood urea nitrogen (BUN), albumin, total protein and beta-hydroxy-butyrate, and some minerals, e.g. inorganic phosphorus. These kits are colorimetric, require relatively little equipment and training, and are very user friendly. The Faculty of Veterinary Medicine in Utrecht is also currently providing an External Quality Control Service for these measurements.

Protocols for the use of these kits and a field validation on their performance in laboratories in developing and developed countries have been completed and the kits will be routinely supplied to the NARS in 1993 through a new Co-ordinated Research Programme on "Development of Supplementation Strategies for Milk-producing Animals in Tropical and Sub-tropical Environments". This programme will provide detailed information on the value of metabolite measurements as indicators of nutritional status.

3.4.3. Department of Tropical Animal Husbandry, Agricultural University, Wageningen, Netherlands

It was recognised at an early stage that most Research Contract holders required assistance in analyzing research data, and that the provision of personal computers and appropriate software would be of great benefit. Computers were therefore provided to counterpart institutes, and a Technical Contract awarded to the Department of Animal Husbandry of the Agricultural University in Wageningen for the development of an appropriate software package for data analysis. A draft version of this package was demonstrated to network participants during the RCM in Côte d'Ivoire (May 1991) and introduced at the Department of Animal Science, University of Zimbabwe, for testing, since experience in the use of similar software packages was already available at this department.

The development of the software package was completed, and the final version distributed to network participants. It consists of a database system for recording and processing of data on animal production and reproduction (3 Way), and a program for statistical analysis (DBstat). Both programs operate independently.

Research Contract holders received training on the use of both packages at the FAO/IAEA Training Course on "The Analysis of Animal Production Data using Personal Computers", held at ILCA in 1992 and much of the statistical analyses reported in this technical document was carried out using DBstat.

3.5. Equipment and Technical Backstopping

The equipment and other materials provided to the participating NARS consisted mainly of manual gamma counters, centrifuges, refrigerators and computers; and materials for blood sampling and animal identification; chemicals, computer software packages and RIA kits. In addition funds were provided for local purchases, e.g. fuel, drugs etc.

All participants measured progesterone (P_4) in skim milk and/or blood plasma to monitor the reproductive performance of female livestock. To facilitate these measurements standardized RIA kits were provided and an external quality control service (EQCS) to monitor the performance of the kits was organized by the Animal Production Unit of the FAO/IAEA Agricultural Laboratory, Seibersdorf. The major objective for the development of the FAO/IAEA RIA kit was to provide counterparts with a standardized technique for the quantitative measurement of progesterone in biological fluids that was robust, user-friendly and simple, requiring a minimum of equipment, training and safety precautions. This kit was validated at Seibersdorf and several other laboratories in both developed and developing countries prior to the initiation of the present programmes (see Appendices I and II).

Experts provided on-site training of counterpart staff on RIA of progesterone and other techniques for monitoring livestock productivity, and assisted them in the formulation and updating of work plans, in the analysis of research data and in the preparation of scientific publications. In addition the FAO/IAEA Technical Officer visited the NARS on a regular basis and undertook duty travels for around 3 months each year.

A summary of the consultancy services provided to the participating NARS through IAEA Technical Co-operation funds is given in Table II.

4. CONCLUSIONS AND RECOMMENDATIONS

As stated earlier, four Research Co-ordination Meetings were held during the course of these Programmes and these provided opportunities for discussion of work plans and results achieved by individual Research Contract holders. Equally important, however, were the discussions which took place between Programme participants on the"broader picture" of the Programmes ie. the purposes for which the RIA and other tests provided were used; the difficulties encountered with the tests and how these might be resolved; what the Programmes had done to assist the participating scientists, institutes and countries; and the interactions between Contract and Agreement holders and the Joint FAO/IAEA Division.

The outcome of these discussions on the Programmes is given below under 3 headings, i.e. achievements, constraints and future activities.

4.1. Achievements of the Programmes

(a) **By providing quantitative data on the performance of indigenous animals, identifying constraints to productivity and demonstrating interventions to alleviate constraints, these Co-ordinated Research Programmes have contributed significantly to increasing the awareness of the scope that exists for improving the performance of African livestock kept under traditional systems of management.**

TABLE II. EXPERT SERVICES PROVIDED TO THE PROGRAMME THROUGH IAEA TECHNICAL CO-OPERATION SUPPORT

Country	Expert	Period
Côte d'Ivoire	M.J. Bryant (United Kingdom)	December 1991
Ethiopia	S. Wahab (Malaysia)	December 1987
	M. Jainudeen (Malaysia)	November 1989
	J. Wilkinson (United Kingdom)	November 1988 Febr./March 1990 November 1990
	E. Owen (United Kingdom)	April 1989
	C. Galina (Mexico)	December 1991
	G. King (United Kingdom)	March 1992
	L. Williams (United Kingdom)	March 1992
	M.N. Jayasuriya (Sri Lanka)	September 1992
Ghana	R. Eley (Kenya)	September 1987 December 1987 April 1989
	E. Owen (United Kingdom)	December 1987 August 1988
	M. Bryant (United Kingdom)	December 1990 December 1991 September 1992
	L. Williams (United Kingdom)	September 1992
Niger	W. Thatcher (USA)	February 1988
	J. Mariana (France)	February 1990
Nigeria	A. Madej (Poland)	November 1987
	W. MacKelvey (United Kingdom)	December 1989
Senegal	A. Lahlou-Kassi (Morocco)	November 1988
	P. Glatzel (Germany)	March 1989
Tanzania	P. Glatzel (Germany)	March 1987
	G. King (Canada)	August 1989 August 1990
	I. McMillan (Canada)	January 1992
Tunisia	R. Stupnicki (Poland)	November 1987
	J. Thimonier (France)	April 1990
	W. Thatcher (USA)	October 1990
	E. Orskov (United Kingdom)	December 1991
	D. Keisler (USA)	February 1992
Zimbabwe	H. Meyer (Germany)	April 1990
	M. Bryant (United Kingdom)	May 1991

One of the most striking features of the data collected was the large within-breed variations recorded on individual farms or in institutional herds with respect to the parameters measured; these parameters also varied enormously in animals of the same genotype kept on different farms. For example at some locations and with some breeds of cattle, puberty was recorded as early as 9 months of age, while in other animals it was attained only after as long as 4 years. Likewise, intervals between calving and the beginning of ovarian activity varied between 1.5 months and about 2 years, and calving intervals could be as short as 1 year, but as long as 2.5 years. Variations in the reproductive performance of indigenous sheep and goats were of a similar order. Such dramatic differences in reproductive efficiency not only demonstrate the enormous scope for improving overall productivity, but confirm that Africa has animal genetic resources which can be productive even under conditions of sub-optimal management. These Programmes have therefore also confirmed that the major thrust for improving productivity lies in these indigenous breeds and not in imported exotic livestock.

(b) **An RIA technique for measurement of progesterone was successfully transferred to all the counterpart NARS and its role as a tool for monitoring reproductive events and determining the factors (environment, management, nutrition) which influence these events was confirmed.**

Reproductive performance is a key determinant of the efficiency of livestock production and in the course of these Programmes a substantial amount of basic information was assembled on the reproductive characteristics of indigenous species. To assist the NARS in these studies, radioimmunoassay (RIA) laboratories were established for the purpose of measuring progesterone levels in blood plasma and skim milk, and standardized RIA kits were provided at regular intervals from the FAO/IAEA Agricultural Laboratory, Seibersdorf. The performance of the RIA in the counterpart laboratories was also monitored through an External Quality Control Service (EQCS) organized by the FAO/IAEA Agricultural Laboratory. The EQCS showed that the kits performed well in the NARS laboratories, and where problems were encountered the EQCS assisted in the identification and subsequent resolution of these problems. Clearly therefore, the RIA technique was transferred successfully to the NARS and there is every reason to believe that it will continue to be used in the future.

Measurement of progesterone in blood plasma or skim milk is a direct and accurate indicator of the presence or absence of a progesterone-secreting corpus luteum. This information is valuable for avoiding the mistakes which occur if record keeping and oestrus detection are used in isolation. Failures to detect signs of heat are very common, and dates of parturition only provide retrospective information on conception, but not on onset or resumption of ovarian cyclicity. In these Programmes progesterone measurements proved to be a powerful tool to monitor and study aspects such as the onset of puberty, post-partum ovarian activity, the efficiency of oestrus detection and conception, and to carry out early diagnosis of non-pregnancy. These measurements were used to complement information obtained from record keeping, heat detection, rectal palpation and in some cases endoscopy or ultrasonography. Initially they were used to obtain baseline parameter and to identify factors responsible for poor reproductive performance. Once interventions had been made for the alleviation of these factors, e.g. improved nutrition, management or parasite control, progesterone measurements helped in studying the effects of the interventions on reproductive events.

(c) **Through these Programmes, the overriding importance of feed availability and quality in determining reproductive efficiency and productivity was clearly demonstrated.**

The importance of nutrition was mainly demonstrated by the strong correlations recorded at a number of locations between season and such factors as onset of puberty, duration of post-partum acyclicity, conception rates, generation intervals and the number of surviving offspring. This suggests that particularly in situations where there are limited possibilities to make nutritional interventions, more disciplined management of livestock breeding would significantly improve individual animal and herd performance.

In the course of these Programmes, a number of studies were initiated to examine further the role of nutrition in determining levels of animal productivity. This was attempted by providing supplements consisting of locally-available agricultural by-products such as maize bran (Tanzania and Zambia), rice bran (Niger), maize stover and cotton seed hulls (Senegal), brewers grain (Ghana), groundnut tops (Senegal); locally produced concentrates (Nigeria and Tunisia); and locally grown legumes, e.g. *Dolichos lablab* (Zimbabwe). Whilst it was clearly demonstrated that a number of these products were useful for supplementary feeding, the gains in productivity could not be fully quantified due to the time-scale of the work involved and the need to complement on-farm studies with data from research stations with larger animal populations.

This work should be strengthened so that strategic supplementation can be examined not only in relation to the production system and season, but also to the physiological status of the animals concerned. An essential pre-requisite for this process is obtaining more quantitative information on potential feed resources prior to embarking on studies to examine how these resources or modifications to them could benefit these systems. Also, for nutritional strategies to be more effective, more information is needed to quantify relationships between basal feeds and the common supplements such as cereal brans, oil seed cakes and leaves.

Work under the Programmes clearly showed the difficulty in predicting animal performance (largely due to inability to predict roughage intake with any precision), and protein and energy status, and efforts should therefore be made to strengthen the capacity of the NARS to incorporate into their repertoire of technologies, measurement of feed degradation characteristics and some of the blood and urine markers of protein and energy status developed through these Programmes (see below).

(d) **The Programmes have stimulated the NARS to establish or strengthen their interactions with local farming communities.**

Most of the participating NARS have built up good collaboration with farmers, and as a result are therefore now much more aware of local farming systems, of the technical and other problems faced in studying and improving these systems, and thereby of how they might creatively contribute to solving these problems. The stimulus given to on-farm research by the Programmes has encouraged farmers to request advice from the NARS and the NARS themselves to organize staff into multi-disciplinary groups consisting of nutritionists, reproduction specialists and veterinarians so that they can respond more comprehensively to local farming needs. These are significant and positive developments, since many counterpart staff had little contact with farmers and most were focusing on their own specialisation (usually through on-station

research) during the early stages. These are therefore strong grounds for optimism that by maintaining this approach, research at the NARS will be driven more by actual rather than by perceived needs and that the approach itself and the results arising from it will be passed down through the formal educational and extension structures for the wider benefit of agricultural communities.

(e) **The Programmes have contributed substantially to "institution building", through improvement of infrastructure and relevant training of professional and technical staff.**

Through these Programmes, substantial amounts of equipment and materials were provided to establish or strengthen the capacity of participating NARS for doing research and also for teaching. Many of these institutes could not have worked effectively without this assistance. However, and perhaps even more important from the standpoint of sustainability of the research, has been the training provided at all levels through the courses, fellowships, and contact with animal production and reproduction specialists. This training covered many subjects, ranging from the relatively simple such as measuring bodyweight and body condition scores through to the somewhat more complicated, e.g. radioimmunoassay of hormones, proximate analysis of feeds, and colorimetric measurements of metabolites. A substantial amount of training was also given on experimental design, statistical interpretation of animal production data, the use of personal computers and scientific writing.

In the vast majority of cases, it is already clear that the equipment, training and other inputs provided succeeded in transferring these technologies and that they played an invaluable and complementary role in the development of the research, teaching and/or extension carried out at the counterpart NARS.

(f) **The Programmes have successfully promoted Regional collaboration and exchange of ideas and information between African institutes and institutes in Europe and North America.**

The organization of the Programmes as a network of NARS provided one of the few opportunities available for African scientists dealing with similar problems to interact and collaborate with each other and with scientists of the same and other disciplines in developed countries. There is no doubt that this approach not only improved the direction and focus of the work conducted and the knowledge and experience of all involved, but it also served to motivate and encourage the NARS staff involved who now feel much less isolated and indeed, a part of the international scientific community.

(g) **These Programmes promoted self-reliance and accountability among the staff of participating NARS.**

Funding organizations must recognize that agricultural research is a long-term investment requiring continuity of support and inputs over a protracted period. This is true in all countries whether they be developed or developing, but it is particularly important in developing countries and even more so in Africa because of the complexity of the problems requiring resolution. As mentioned earlier, and emphasised yet again by Winrock International in its comprehensive report on sub-Saharan agriculture [5], the key to the problem is rehabilitating and organizing the NARS. Several aid organisations which fund agricultural research in Africa through the NARS provide the services of foreign experts on a long-term basis, whose salaries and allowances often consume a substantial, if not the major part of the total package. In fact, during the period 1981-1985, approximately 30% of research workers in sub-Saharan Africa were expatriates [6]. This approach

is not sustainable and for the most part, experience has shown that it actually discourages self-reliance and accountability of local staff.

It is the belief of this organization that agricultural development in Africa will only be successful and sustainable if the proper machinery is put in place to encourage African scientists, policy makers, etc. to identify and solve their own problems "from within". While it is recognised that the inputs through these Programmes were limited, one of the key outputs through the approach adopted was that NARS staff had developed the confidence to work with a far greater degree of independence from foreign inputs than at the outset of the Programmes.

(h) **The Technical Contracts awarded under the Programmes to institutes in the Netherlands resulted in the development of relevant technologies and packages (e.g. EIA and metabolic kits, and computer databases) for use in developing countries.**

These were successfully transferred to the NARS and which are now being used within the framework of Research Contract programmes, Technical Co-operation projects and training courses organized by the Joint FAO/IAEA Division in Africa and other developing regions of the world.

4.2. Constraints to Programme Implementation

In 1985 (i.e. about 2 years before these Programmes were initiated), the Joint FAO/IAEA Division sent out 3 teams to Africa consisting of staff members and outside consultants to evaluate at first hand the potential of some 180 departments or sections in 58 NARS in 14 countries to carry out applied and problem-oriented research in animal production and health.

In the course of these visits, the mission became all too aware of the generally run-down state of African animal and veterinary research institutes and university departments. Dirty and dust-covered laboratories often without regular water or electricity supplies, broken down or malfunctioning equipment and even good equipment never used, chronic shortages of simple glassware, chemicals and reagents were common sights. Equally common was staff who were either plain idle, lacking in creative ideas, or completely demoralized by the situation in which they found themselves. These were by and large the facts of African scientific life at the time of the mission.

On the other hand, the mission also visited institutes which despite all the underlying economic and other problems facing them were functioning, and within the limited resources available to them, were functioning well. In virtually every case, these institutes (or departments within them), had motivated and enthusiastic directors or senior staff who knew what they were trying to do, and how they were going to do it. It was not difficult therefore for the mission to distinguish between those who were doing or trying to do something, from those who were doing nothing and never would do anything, even if provided with substantial outside support. Indeed, and perhaps surprisingly in view of their very different disciplinary backgrounds, there was complete unanimity within each of the three teams groups as to the actual and potential work ethic of the scientists met and the value and degree of problem-orientation of the projects being undertaken within the institutes evaluated. This mission was therefore able to build up a comprehensive picture of what was and what was not going on, and its recommendations were duly considered in deciding upon the NARS which participated in the Programmes described in this document.

Despite this selection process several constraints to Programme implementation were encountered. These included:

(a) Limited availability of support funds within the NARS.

The research budget of many of the NARS participating in the Programme was as expected very limited. This led to transport difficulties due to lack of vehicles and fuel, and problems with obtaining feedstuffs, drugs, travel allowances etc. These constraints became particularly apparent during the on-farm interventions, as these studies required frequent field visits and local purchases. Through the Research Contracts some funds were made available for local purchases, but these funds were insufficient to provide all local requirements. Consequently, the size of many experiments had to be reduced, with the number of animals and farms involved often being smaller than required to enable highly significant differences to be demonstrated between treatment groups on-farm.

An additional problem was that the very low salaries and the limited local research budgets did not encourage the counterpart staff to conduct research. Many counterpart staff therefore had additional occupations, and several found employment outside of the NARS during the course of the Programmes and had to be replaced by other, often less-qualified staff. This turnover of local staff obviously adversely affected the continuity and quality of work conducted.

(b) Difficulties in the collaboration with farmers.

Although many farmers initially showed great interest in the research projects, this interest decreased when they did not see any immediate benefit from it. Counterpart staff were therefore advised to provide some incentives to the participating farms e.g. drugs, feedstuffs and veterinary care. An additional problem was that farmers were occasionally reluctant to provide information to counterpart staff due to fear of being taxed.

The control over on-farm experiments also proved to be difficult and on several occasions farmers sold experimental animals, or did not adhere to the experimental protocol.

These difficulties may have been resolved or lessened by the involvement of staff with local knowledge of socioeconomic and risk constraints on animal productivity. In industrialised countries, material wealth is generally perceived as the barometer of success and increasing this is invariably the prime motivation of human endeavour. In the rural areas of the countries represented in these Programmes, this is often not the case, and therefore in the planning and the conduct of the technical/biological studies reported here, efforts to understand these values and aspirations of the overall "community cultures" of the participating client smallholder farmers would surely have improved the focus and relevance of the work performed. On the other hand, given the limited budget available and the biological and infrastructural constraints of the systems being studied and the institutes involved, much was achieved in catalysing farmer - NARS interaction.

(c) Difficulties in servicing and repairing equipment.

The servicing and repair of equipment provided to NARS was difficult as in most countries local expertise was not available. Frequently even the smallest repairs could not be carried out locally, and equipment had to be sent back to Vienna, or replaced. This involved costs and resulted in delays in the project implementation. FAO/IAEA tried to alleviate this constraint by providing only equipment that had been tested for its "robustness", and providing training on maintenance of equipment. Minor repairs were also carried out be the Technical Officer during his visits.

The electricity supply to many of the counterparts laboratories was very irregular with frequent power surges. This made carrying out assays and storing samples difficult. These constraints were partially overcome by the provision of battery-operated gamma counters and power stabilizers. Counterpart staff were also advised to assay blood plasma and skim milk samples as soon as possible after collection.

(d) Insufficient communication between donor agencies.

It was noted that recipients of FAO/IAEA Research Contracts were also in receipt of funds from other donor agencies and international organizations involved in supporting research, e.g. ILCA, IFS, EEC, and National Governments. Communication between these organizations is clearly almost non-existent and while the resulting lack of a composite funding cannot be regarded as a major constraint, the effectiveness of the support could be increased significantly by a more coordinated approach by donors to funding research on improving animal productivity in Africa. For example, it would reduce the amount of time counterpart staff spent abroad attending meetings and training programmes supported by different donor organizations.

(e) Dependency on expatriate staff.

All Research Contract holders were local scientists. However, in several projects large contributions were made by expatriate staff. All of these expatriates have since left the NARS concerned. In some cases this led to a considerable disruption to the research conducted by these institutes. One Research Contract had to be terminated for this reason.

(f) Delays in clearance of equipment and materials.

In most countries, customs clearance of equipment and materials took considerable time, which in many situations slowed down the realization of work plans. This constraint was partially overcome by the assistance of the local offices of the United Nations Development Programme (UNDP). The customs clearance of the RIA kit created special problems due to the short half-life of the radioisotope. However, after a courier service was used for the dispatch of the kits, these problems were largely overcome.

(g) Poor communication between FAO/IAEA and the NARS.

Communication between FAO/IAEA and the NARS sometimes proved to be difficult. The delivery of mail was slow, and telephone, telefax and telex connections were unreliable. The UNDP offices also assisted in communication and in providing counterparts staff with air tickets to attend meetings etc.; indeed, assistance of the UNDP proved to be essential for the implementation of the Programmes.

(h) Dependency on FAO/IAEA RIA kits.

All project counterparts obtained FAO/IAEA RIA kits for the measurement of progesterone. It was considered necessary and beneficial that all the NARS received the same standardized kits, and would not try to develop their own assays. However, this created a dependency on the FAO/IAEA RIA kits. FAO/IAEA is now reducing this dependency by developing a self-coating RIA kit. This will allow counterpart staff to be more independent, since users of such a kit will be provided with antibody cost-free and can therefore obtain other kit components relatively cheaply.

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COUNTRY REPORTS

FACTORS AFFECTING THE REPRODUCTIVE PERFORMANCE OF BUNAJI CATTLE UNDER DIFFERENT PASTORAL MANAGEMENT SYSTEMS IN THE GUINEA SAVANNA ZONE OF NIGERIA

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Abstract–Résumé

FACTORS AFFECTING THE REPRODUCTIVE PERFORMANCE OF BUNAJI CATTLE UNDER DIFFERENT PASTORAL MANAGEMENT SYSTEMS IN THE GUINEA SAVANNA ZONE OF NIGERIA

The effects of management on the productivity of Bunaji cattle were investigated on 6 farms using 38 post-partum cows and 8 heifers General information obtained on management of the farms indicated differences in management practices between farms The screening of the animals in the various farms for blood and endo-parasites showed that some of the farms had problems of helminthiasis and fasciolıasis Uterine involution was complete within 25 days of calving in all post-partum cows Intervals from calving to ovulation and conception were different between farms The conception rates for all farms over a period of 730 days ranged from 60 to 100% A higher percentage of heifers on farm A reached puberty at an earlier age than those in farm B It was concluded that management affects reproductive performance and thus productivity of Bunaji cattle, with nutrition and disease being the major contributing factors

FACTEURS INFLUANT SUR LA PERFORMANCE DE REPRODUCTION DES BOVINS BUNAJI DANS DIFFERENTS SYSTEMES DE CONDUITE PASTORAUX DE LA ZONE DE SAVANE A HERBE DE GUINEE DU NIGERIA

Les incidences du type de conduite sur la productivité des troupeaux Bunaji ont été étudiées sur 38 vaches en période post-partum et huit génisses, appartenant a six exploitations Les renseignements généraux obtenus sur la gestion des exploitations ont fait apparaître des différences dans leurs pratiques de conduite Le dépistage des parasites du sang et des endo- parasites dans les troupeaux des differentes exploitations a montre que certains presentaient des problèmes d'helminthose et de fasciolose L'involution utérine était terminee 25 jours apres le vêlage chez toutes les vaches en période post-partum La durée des intervalles séparant le vêlage de l'ovulation et de la conception variait selon les exploitations Dans toutes les exploitations, les taux de conception sur une periode de 730 jours se situaient entre 60 et 100% Dans l'exploitation A, un pourcentage plus important de génisses a atteint la puberté a un âge plus precoce que dans l'exploitation B En conclusion, on peut dire que le type de conduite influe sur la performance de reproduction et donc sur la productivite des bovins Bunaji, les principaux facteurs etant l'alimentation et l'etat de santé du betail

1 INTRODUCTION

The cattle industry plays a significant role in the economy of Nigeria with beef cattle being the largest livestock enterprise in the agricultural sector However, over 90% of the herds of cattle in the country belong to the traditional pastoral farmers In order to improve the productivity of these animals their reproductive performance must be improved

There are indications that the reproductive performance of Bunaji (White Fulani) cattle, the most common breed of cattle in the country, differ under different management conditions. For example, it has been observed that when these animals are reared under institutional conditions they attain puberty earlier and have shorter calving intervals than when reared under the traditional system [1, 2]. Thus, to improve the reproductive performance of these animals, a good knowledge of their performance under the varying management systems and factors affecting it is desirable Therefore the long term aims of this investigation are to identify factors militating against efficient reproduction of these animals under the different management systems

Reproductive activities during the post-partum period are good determinants of the overall reproductive and productive performance of an animal, and cows must conceive within the first 90 days post-partum to have a calf per year. This study was thus focused on the post-partum period and with the following specific objectives:

(i) To investigate the post-partum reproductive activities of Bunaji cows under different management systems;

(ii) To determine the age and weight at onset of puberty in their female offspring.

2. MATERIALS AND METHODS

2.1. Environment

The farms used in this study are located within the Northern guinea savanna zone of Nigeria. The two major seasons of the year are the rainy (April to September) and the dry (October to March) season. Within the dry season there is a period (November to March) of very dry, windy and cold weather, known as the harmattan.

The climatological data for the study area are presented in Table I.

TABLE I. LONG TERM CLIMATOLOGICAL DATA FOR THE STUDY AREA

Seasons	Rainy	Dry warm	Dry cold
	(April-Sept.)	(Oct.-Nov.)	(Dec.-March)
Air temperature (°C)	25.6	24.1	22.7
Relative humidity (Am-Pm %)	69.9-54.6	43.5-32.1	20.0-14.2
Sunshine (h/d)	7.1	8.8	8.6
Rainfall (mm)	1018.2	38.3	1.8
Days of rain (d)	78.1	3.9	1.1

2.2. Animals

A total of 38 postpartum Bunaji cows in 6 farms, A, B, C, D, E, F, and 8 heifers in 2 farms (A and B) were used in the study.

2.3. Study procedure

The study was conducted over a period of 730 days. Following farm identification, information on herd structure and management were recorded for all farms. Blood samples were collected from all the animals on all the farms, for screening for blood parasites and brucellosis, while prepucial washings of the bulls in the farms were used to test for Campylobacter infections. Random faecal samples were taken from the animals in each farm and examined for gastrointestinal parasites. Weekly milk sampling for progesterone (P_4) measurement, to monitor ovulation and conception, and rectal palpation to monitor ovarian structures and uterine involution, were undertaken beginning from calving. Monthly body condition score using the ILCA 1-9 scoring table [3] and heart girth measurement or weight were also recorded for the animals.

Screening for blood parasites was done by examining Giemsa stained blood smears under a light microscope, while that for brucellosis was done by the Serum Agglutination Test method. Half a ml of antigen diluted in phenol saline was added to serially diluted sera, incubated at 30°C for 24 h and examined for agglutination. The culture method was used to test for campylobacteriosis while P_4 measurement was by radioimmunoassay (RIA) technique using the FAO/IAEA RIA kit.

Intervals from calving to ovulation and conception were determined for all animals using the P_4 concentration and rectal palpation findings. A P_4 concentration above 1.59 nmol/l [4] was taken as indicative of ovulation. Intervals from calving to complete clinical uterine involution was also determined for each cow.

Monthly weight or heart girth measurements and blood samples for P_4 determination were also taken from 5 and 3 heifers on farms A and B respectively, beginning from nine months of age to the end of the study, to determine age and weight at puberty. Ovulation, as indicated by a P_4 concentration of 1.59 nmol/l, was taken as indicative of attainment of puberty.

A one-way analysis of variance was used to compare weight and body condition changes for animals between farms. The non-parametric equivalent of analysis of variance (Kruskal-Wallis test) was used to compare calving to ovulation and conception intervals between farms.

3. RESULTS

3.1. Farm management

The extensive system of management was adopted with calves suckling their dams throughout the study period in all the farms.

3.1.1. Farm A

Animals grazed for at least 7 h/day on sown pasture during the rainy season and were occasionally supplemented with stylosanthes hay during the dry season. The animals sometimes had access to mineral salt licks, especially during the dry season. Water was adequately provided. Routine deworming, vaccination and general veterinary care were available to these animals.

3.1.2. Farm B

Animals on this farm grazed on natural pasture during the rainy season and received crop residue supplemented with poultry droppings during the dry season. Ponds were the main sources of water for these animals. Veterinary care was given when needed. Sheep were reared with cattle.

3.1.3. Farm C

Apart from grazing natural pasture, the animals in this farm were given wet brewers' grains and milked once daily. Water was adequately provided for these animals while veterinary care was given as needed.

3.1.4. Farm D

The animals in this farm were hand-milked every morning before going out for grazing on natural pasture. During the rainy (planting) season the grazing area for these animals was very limited. The animals grazed crop residues supplemented with locally conserved fodder (*Dolichos lab* and groundnut haulms) during the dry season. The sources of water were a hand-dug well and ponds. 'Kanwa', a local mineral

supplement was occasionally provided to the animals. Veterinary treatment was provided occasionally. Goats were also kept in this farm. A heifer introduced into this farm tested positive for brucellosis and was culled.

3.1.5. Farms E and F

The management of these two farms is similar. Animals grazed limited natural pasture during the rainy season and crop residues during the dry season. Daily milking of the animals was also undertaken. Water supply was a very serious problem as the ponds dried up during the dry season. 'Kanwa' was also occasionally used as a source of minerals. Veterinary treatment was rare. Sheep and goats were reared with cattle on these farms.

3.2. Effects of management on postpartum reproductive activities

Two to five animals in farms A, B ,C and D and 14 in farm E had a few Theileria mutans parasites in their blood. Only one case of positive brucellosis (farm D) was observed. Farms D, E and F had problems of helminthiasis and fascioliasis.

Tables II and III show the intervals from calving to ovulation and conception for all cows in all the farms while Tables IV and V show the comparison of the intervals between farms. The intervals from calving to ovulation were different ($P < 0.001$) between farms with farms A and F having the shortest and longest intervals, respectively. While all the cows studied in farms A, B and C ovulated, only 3 of 6 cows in farms D, 4 of 7 cows on farm E and 1 of 3 cows in farm F ovulated during the study period.

TABLE II. INTERVALS (DAYS) FROM CALVING TO FIRST OVULATION

Animals	Farm					
	A	B	C	D*	E	F
1	21	28	77	68	350	634
2	14	34	63	65	267	No
3	24	45	102	40	180	No
4	24	203	69	No	55	
5	6	214	90	No	No	
6	20	457	100	No	No	
7	25				No	
8	21					
9	30					
10	15					

* Farm D was only studied 207 days.
No = No ovulation.

Intervals from calving to conception were also different ($P < 0.001$) between farms. While the mean intervals to conception were within 90 days post-partum in farms A and C the interval for farm B was well over 400 days. Only one animal conceived in farm F with an interval of over 600 days. Effect of season of calving on the intervals from calving to ovulation and conception was not tested as most calvings in all farms occurred within the same season.

TABLE III. INTERVALS (DAYS) FROM CALVING TO FIRST CONCEPTION

Animals	Farm					
	A	B	C	D	E	F
1	81	49	77	Nc	Nc	634
2	46	685	63	Nc	Nc	Nc
3	72	691	110	Nc	Nc	Nc
4	80	405	69	Nc	Nc	
5	90	Nc	90	Nc	Nc	
6	85	Nc	120	Nc	Nc	
7	60					
8	51					
9	60					
10	70					

Nc = No conception.

TABLE IV. KRUSKAL-WALLIS TEST COMPARING POST-PARTUM INTERVALS TO OVULATION BETWEEN FARMS

Farm	N	Median
A	10	21
B	6	124
C	6	83
D	6	354
E	6	495

TABLE V. KRUSKAL-WALLIS TEST COMPARING POST-PARTUM INTERVALS TO CONCEPTION BETWEEN FARMS

Farm	N	Median
A	10	71
B	6	321
C	6	83

Table VI shows mean days open and conception rates for all farms. The cows in Farm F were open longer than those of the other farms. Farm F also had the lowest conception rate among all farms. None of the cows in Farms D and E conceived before they dropped out of the study after 207 and 511 days, respectively. There was no clear influence of body weight, or heart girth or condition score on conception within farm. Clinical uterine involution was complete within 25 days of calving in all post-partum cows.

3.3. Effect of management on attainment of puberty

Data on attainment of puberty for heifers in farms A and B are presented in Table VII. A seemingly higher proportion of animals in farm A (3 out of 5) attained puberty and at an earlier age as indicated by ovulation, than those in farm B (1 out of 3). Average weight at ovulation was lower for farm A than farm B animals. It should, however, be noted that weight was determined for farm B animals by estimation from the heart girth measurement, as against actual measurement for farm A animals. Two of the 3 animals that ovulated in farm A conceived; one at the first ovulation and the other 10 months after the first ovulation.

The remaining two heifers had yet to ovulate at an average age and weight of 724 days and 165 kg, respectively. On the other hand 2 of the 3 heifers in farm B had yet to ovulate at an average age and weight of 1171 days and 131 kg, respectively.

TABLE VI. DAYS OPEN FOR ANIMALS THAT CALVED IN EACH FARM AND CONCEPTION RATE FOR ALL ANIMALS IN EACH FARM OVER A PERIOD OF 730 DAYS

Farm	Days Open			Conception rate %	
	Mean		Range	#	
A	69.5	(10)	46- 90	100	(10/10)
B	480.8	(6)	49-691	69	(9/13)
C	88.2	(6)	63-120	80	(16/20)
D	*129.3	(6)	48-207	0	(0/11)
E	**286.6	(6)	50-511	0	(0/36)
F	640.7	(3)	634-647	60	(3/ 5)

Figures in parenthesis = No. of animals.

* Studied for 207 days with zero conception.

** Studied for 511 days with zero conception.

TABLE VII. EFFECT OF MANAGEMENT ON ATTAINMENT OF PUBERTY

Parameters	Farm	
	A	B
No. of heifers	5	3
No. ovulated	3	1
Average age (days) at ovulation	774 (3)	796 (1)
Average weight (kg) at ovulation	180	204 (134 cm heart girth)
Average age (days) of heifers yet to ovulate	724 (2)	117 (2)

Figures in parenthesis = No. of heifers.

4. DISCUSSION

The differences between farms in the intervals from calving to first ovulation and conception, and conception rates in the various farms, indicate the effect of management on the productivity of Bunaji cows. This is similar to the observation made for other breeds of cattle [5]. Individual cow variations in performance within farms were also evident. The lack of influence of body weights and condition scores on the parameters measured may be attributed to the significant changes in the weight and condition of the animals during the study as much of the calvings occurred in the same season. The long intervals from calving to first ovulation observed for some of the animals, especially in farms B, E and F will obviously contribute to the long calving intervals already reported for this breed of cattle under the traditional husbandry system [2, 6]. Based on the management practices and the results obtained from screening of the animals for diseases in the different farms, in addition to the effect of suckling in all the farms, the causes of delay in post-partum resumption of ovarian activity and conception varied from a combination of poor nutrition, milking and disease, in farms E and F, and the effects of milking and disease in farm D. The delaying effect of suckling on ovulation and conception and the advantage of improved nutrition on conception rate in Bunaji cattle have been reported [7, 8]. As earlier observed, uterine involution does not appear to constitute a problem in the reproductive performance of Bunaji cattle since management did not affect its duration [9].

The fact that heifers on farm A ovulated earlier than those on farm B is again an indication that management plays a big role in attainment of puberty. This result was not surprising, as the animals in farm A were obviously better managed than those in farm B, especially in terms of nutrition and veterinary care. The heifers in the two farms however, reached puberty later than was earlier reported for the same breed under supplementary feeding [8]. The average weight at puberty for farm A animals was similar to that reported by Oyedipe *et al.* [10] for heifers that received a medium protein diet (180 vs 187 kg) but different from those that received high and low protein, thus pointing to the effect of management on attainment of puberty by these animals.

From the overall results it can be concluded that management affects reproductive performance and thus productivity of Bunaji cattle with nutrition and disease being the major contributing factors.

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CROISSANCE ET PREMIERES OVULATIONS DE LA GENISSE SANTA-GERTRUDIS AU MAROC

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Abstract–Résumé

GROWTH AND FIRST OVULATIONS OF SANTA-GERTRUDIS HEIFERS IN MOROCCO

The objective of this study was to study the variations in body weight and rate of cyclicity during the 7 months prior to the mating season (September - January), and to study the effects of these variations on the fertility of Santa-Gertrudis heifers kept under a "Ranching" management system A total of 91 heifers divided into 2 groups, 47 females born in December - January (early) and 44 born in March (late), were included in the study The animals were weighed and blood sampled for the assay of progesterone weekly Two months after the end of the mating season pregnancy was diagnosed by rectal palpation The study demonstrated a highly significant ($P < 0.001$) influence of season of birth on body weight In the early heifers a significant loss ($P < 0.001$) in body weight and a decrease in rate of cyclicity were observed between July and November The average body weight decreased from 298 ± 3 1 kg($\overline{X}$ ± s e m) to 272 ± 2 8 kg and the percentage of animals cycling decreased from 75% to 57% in this period Between November and January, the early heifers showed a significantly ($P < 0.001$) higher increase in body weight than the late heifers In January the average body weight and rate of cyclicity of all heifers was 288 ± 3 8 kg and 64% respectively The animals cyclicing at the beginning of the mating season (15 January) showed a higher body weight gain ($P < 0.05$) than the non-cycling ones Fifty five percent of the heifers were found pregnant by rectal palpation In addition, the pregnant animals showed a significantly ($P < 0.05$) higher body weight gain than the non-pregnant animals during the period November-February These results indicate that variations in body weight and rate of cyclicity do not allow an optimal conception rate of 80%

CROISSANCE ET PREMIERES OVULATIONS DE LA GENISSE SANTA-GERTRUDIS AU MAROC.

L'objectif de cette étude est de caractériser les variations, du poids corporel et du taux de cyclicité, au cours des sept mois qui précèdent la saison de reproduction (de juillet à janvier), et d'étudier leurs effets sur la fertilité des génisses Santa-Gertrudis élevée en système "Ranching" Un ensemble de 91 génisses reparties en deux lots 47 femelles nées en décembre-janvier (précoces) et 44 nées en mars (tardives) parti de l'etude Des pesées mensuelles et des prises de sang hebdomadaires pour le dosage de la progestérone ont été réalisées Le diagnostic de gestation a été établi par palpation transrectale, deux mois apres la fin de la saison de reproduction Ces investigations ont permis de faire ressortir une influence hautement significative ($P < 0,001$) de la saison de naissance sur le poids corporel Par ailleurs chez les precoces, une perte de poids importante ($P < 0,001$) et une baisse de taux de cyclicité s'observent entre le mois de juillet et novembre Ainsi, le poids moyen est passé de 298 ± 3,1 kg ($\overline{X}$ ± s e m) à 272 ± 2,8 kg et le pourcentage de femelles cyclées a baissé du 75% à 57% Pour la période de novembre a janvier, les génisses ont manifesté une reprise du gain de poids significativement supérieure ($P < 0,001$) pour les précoces et une augmentation du taux de cyclicité leur poids est alors de 288 ± 3,8 kg et leur taux de cyclicité de 64% Les femelles cyclées lors de la mise à la reproduction (15 janvier) ont manifesté un gain de poids supérieur ($P < 0,05$) comparativement au non cyclées Cinquante sept pourcent des génisses ont été retrouvées gestantes De plus, les femelles gestantes ont présenté un gain de poids significativement supérieur ($P < 0,05$) aux non-gravides durant la période s'étalant du mois de novembre au mois de février Ces résultats indiquent que les variations du poids corporel et du taux de cyclicité ne permettent pas un taux de conception optimal de 80%

1. INTRODUCTION

Les bovins de race Santa-Gertrudis sont au Maroc depuis plusieurs décennies. La raison de leur introduction, de leur multiplication et de leur diffusion est leur aptitude à valoriser des pâturages de qualité moyenne, dans des conditions de parcours supérieures à celles de la vache locale. Les variations saisonnières des disponibilités alimentaires des pâturages imposent que la période de reproduction soit saisonnière, comprise entre la fin de l'hiver et le début du printemps. Ces animaux à vocation bouchère sont aussi caractérisés par une grande souplesse d'adaptation à diverses conditions d'environnement généralement considérées comme hostiles [1]. L'aptitude à l'engraissement des mâles, leur coefficient de transformation et le rendement en carcasse enregistrés sont économiquement avantageux. Les femelles de race Santa-Gertrudis se caractérisent par des qualités maternelles affirmées, dont la facilité au vêlage pour la plus grande partie d'entre elles [2] et leur niveau de production laitière, évaluée par le taux de croissance des veaux avant le sevrage [3]. En outre, le taux de mortalité des veaux jusqu'au sevrage reste inférieur à 2% [3]. Cependant, les performances de reproduction enregistrées au Maroc restent médiocres: les taux de vêlage ne sont en moyenne que de 75% pour les vaches et 62% pour les génisses [4], alors que l'objectif imposé par l'économie du troupeau est de 80% [5].

Ainsi, la faible efficacité de reproduction observée chez les génisses constitue un facteur limitant principal de l'exploitation économique de ces troupeaux. La variation au cours de l'année des disponibilités alimentaires entraîne une vitesse de croissance irrégulière des génisses avant leur mise à la reproduction. Pour comprendre ces observations, l'hypothèse suivante peut-être avancée: la variation du poids corporel des génisses durant l'automne et le début de l'hiver précédant la saison de reproduction ne leur permet pas de manifester une activité ovarienne cyclique suffisante lors de la mise à la reproduction.

L'objectif de cette étude est de déterminer, pendant une période de six mois avant la mise à la reproduction, l'impact des variations du poids corporel sur la cyclicité et sur le taux de conception des génisses Santa-Gertrudis, à la fin de la saison de reproduction.

2. MATERIEL ET METHODES

2.1. Les animaux

L'étude a porté sur 91 génisses de race Santa-Gertrudis réparties selon leur période de naissance en deux groupes: 1) groupe 1, n=47 femelles, nées entre décembre et janvier, dites de naissance précoce; et 2) groupe 2, n=44 femelles, nées en mars, groupe dites de naissance tardive.

L'âge et le poids moyens des génisses au début de l'étude sont respectivement de 562 ± 17,7 ($\overline{X}$ ± s.e.m.) jours et 317 ± 4,3 kg pour le groupe 1 et de 492 ± 7,1 jours et 277 ± 4,5 kg pour le groupe 2.

2.2. L'élevage

L'étude a été réalisée au Ranch Adarouch, situé au Piémont du Moyen Atlas à 33°50'N et 5°30'0 à une altitude de 1200 m. Cette région est caractérisée par des sols acides et pauvres. La pluviométrie annuelle moyenne est de 380 mm répartie entre les mois de décembre et mars. Les températures moyennes minimales et maximales sont de 15°C (janvier) et 35°C (août). Le nombre moyen annuel de gelées est de 10 jours, survenant pendant les mois de décembre et janvier.

Les animaux paccagent en permanence sur des parcours de qualité moyenne. La charge à l'hectare de surface pâturée, en équivalent unité gros bétail (U.G.B.), est égale 0,35. La production d'unités fourragères (UF) est estimée à 800 U.F./ha/an [5]. Les disponibilités alimentaires satisfont les besoins des animaux entre février et juillet mais sont insuffisantes entre août et janvier. Pendant la période dite de soudure alimentaire, septembre à janvier, les animaux reçoivent une supplémentation journalière à base de mélasse et de 2 kg de paille d'avoine.

2.3. La reproduction

La saison de reproduction s'étale du 15 janvier à la fin du mois de mai. Les taureaux sont introduits dans des troupeaux de 300 femelles à raison de 1 géniteur pour 20 vaches. Les génisses sont mises à la reproduction à l'âge de 24 à 30 mois Elles représentent 20% du cheptel reproducteur. Le sevrage est réalisé à 6 mois d'âge environ, à deux périodes déterminées: juin et septembre.

Pendant les 6 mois précédents la saison de reproduction (juillet à janvier), les génisses ont été pesées mensuellement, à l'aide d'une bascule. L'évaluation de l'activité ovarienne pendant la même période a été faite à l'aide de prélèvements sanguins hebdomadaires destinés au dosage de la progestérone plasmatique. Les prélèvements sanguins ont été réalisés à partir de la veine caudale. Ils sont centrifugés dans les 30 minutes, à 3000 tours/minute, pendant 10 minutes. Les plasmas sont alors congelés jusqu'au dosage de la progestérone, qui a été fait par la technique RIA proposée par l'Agence Internationale de l'Energie Atomique (A.I.E.A.). Le début de la cyclicité est défini comme la période à partir de laquelle une valeur de la concentration de la progestérone supérieure à 1 ng/ml, est observée. La poursuite de la cyclicité est définie comme la durée pendant laquelle deux prélèvements espacés de 28 jours sont positifs.

Les génisses ont été laissées avec cinq taureaux de fertilité connue du 15 janvier à fin mai. Le diagnostic de gestation a été réalisé par exploration rectale, 60 jours après la fin de la saison de reproduction.

2.4. L' étude statistique

Les données ont été traitées à l'aide du logiciel de gestion de bases de données DBASE III plus. Les tests statistiques ont été faits à l'aide des logiciels STATI TCF (Institut technique des cultures fourragères, France), MODLI (Institut National de Recherche Agronomique de Versailles, France) et DBSTAT (A.I.E.A.), pour la comparaison des moyennes et l'analyse de la variance. Le seuil de probabilité de 0,05 a été retenu pour la signification des différences [6, 7].

3. RESULTATS

3.1. Les variations de poids des génisses

La figure 1, illustrant les variations du poids corporel des génisses, montre une baisse de poids régulière pour la période allant du mois de juillet au mois de novembre. Aussi, le poids corporel est passé de 298 ± 3,1 kg pour le mois de juillet à 272 ± 2,8 kg pour le mois de novembre soit une perte de 26 ± 1,4 kg. Durant la période de novembre à février, les animaux accusent un gain de poids de 32 ± 1,4 kg pour atteindre le poids de 301 ± 2,9 kg à la fin du mois de février.

Par ailleurs, la saison de naissance conditionne de manière hautement significative, le poids corporel ($P < 0,001$). Ainsi les génisses dites de naissance précoce montrent un poids corporel significativement supérieur à celui des tardives. Les variations du poids sont influencées par la saison de naissance (Fig. 2.).

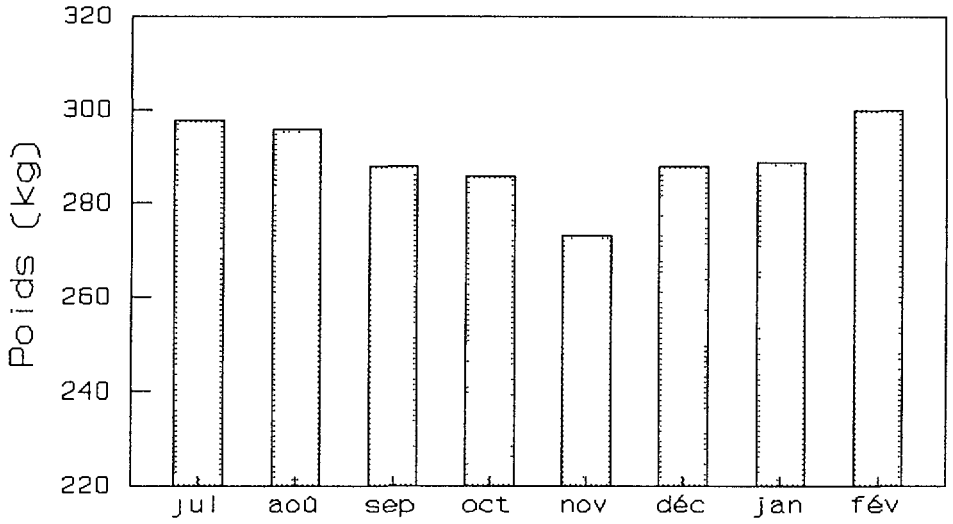

Fig. 1. Variation du poids corporel des génisses avant la mise la reproduction. Poids moyen global.

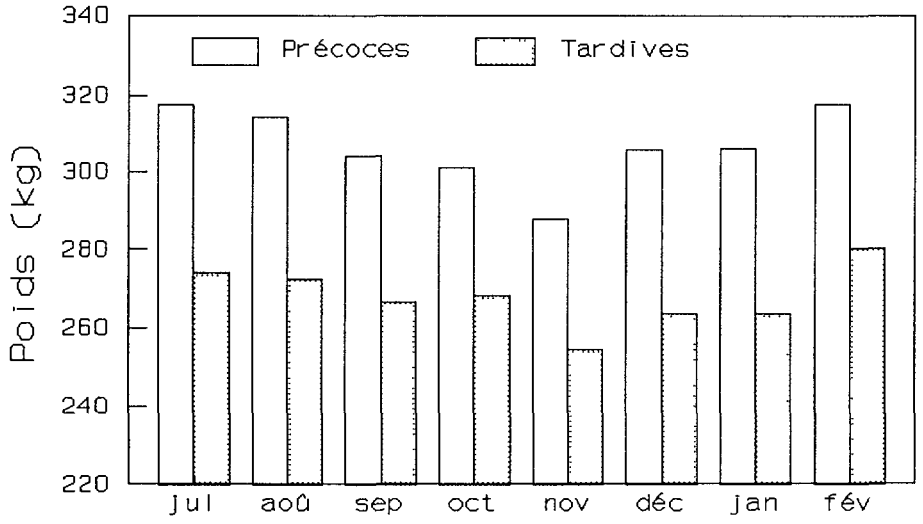

Fig. 2. Variation du poids corporel des génisses avant la mise à la reproduction. Poids moyen selon la saison de naissance.

La perte de poids enregistrée chez les précoces pour la période du juillet à novembre, est significativement supérieure ($P < 0.005$) à celle des tardives. Les valeurs respectives sont de 30 ± 2,0 kg et de 21 ± 2,0 kg. En revanche, du mois de novembre au mois de février, les précoces montrent un gain de poids significativement supérieur ($P < 0,001$) aux tardives. Les valeurs respectives sont de 38 ± 1,8 kg et de 27 ± 1,8 kg.

3.2. Les variations de la cyclicité ovarienne

Les variations du taux de génisses cyclées, illustrées par les figures 3 et 4, montrent une baisse régulière entre les mois de juillet au mois de novembre suivie d'une augmentation de novembre à janvier. Ainsi 74,7% des génisses sont cyclées au mois de juillet et 57,1% au mois de novembre. Seuls 63,7% des animaux sont cyclés lors de la mise à la reproduction au mois de janvier.

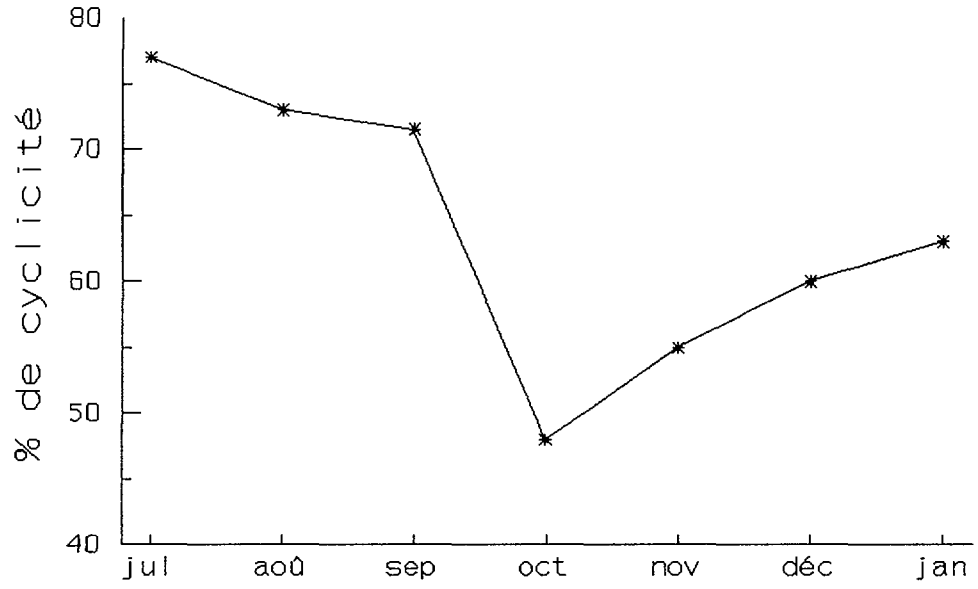

Fig. 3. Variation de taux de cyclicité avant la mise à la reproduction. Cyclicité global.

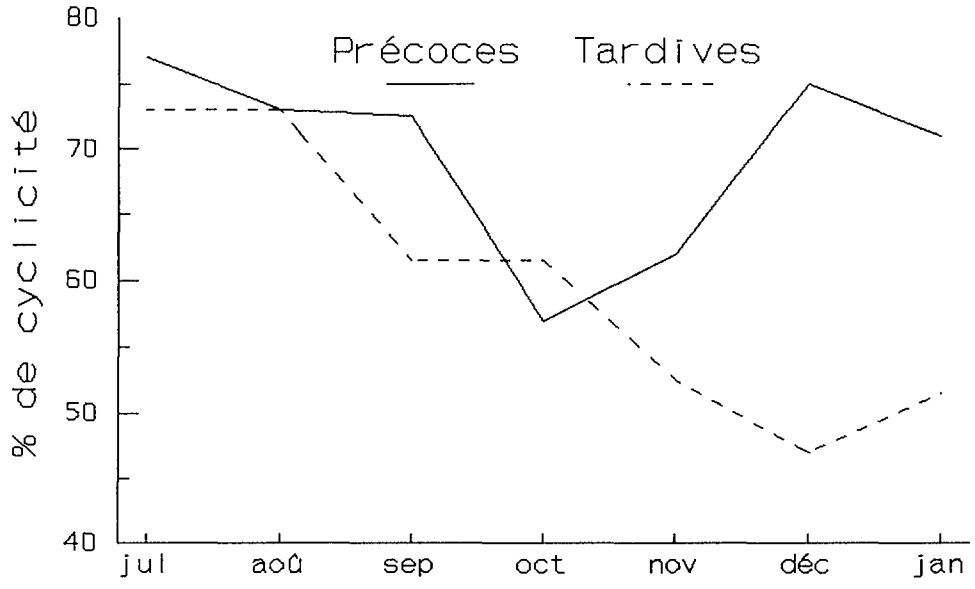

Fig. 4. Variation de taux de cyclicité avant la mise à la reproduction. Cyclicité selon la saison de naissance.

Il se dégage de ces résultats, qu'il y a une variation parallèle du poids corporel et du taux de cyclicité. Au mois de juillet, les femelles cyclées sont significativement plus lourdes ($P < 0,001$) que les non cyclées. Les valeurs respectives sont de 305 ± 7,1 kg et 277 ± 4,0 kg (Tableau I).

De plus, les femelles retrouvées cyclées lors de la mise à la reproduction, ont manifesté un gain de poids significativement supérieur ($P < 0,005$) à celui des femelles non cyclées, pour la période de novembre à janvier. Les valeurs respectives sont de 19 ± 1,7 kg et 11 ± 2,2 kg (Tableaux I et II).

TABLEAU I. POIDS ET CYCLICITE DES GENISSES SANTA GERTRUDIS AVANT LA MISE A LA REPRODUCTION, DANS LES CONDITIONS MAROCAINES

	Poids en kg ($\bar{x}$ ± s.e.m.)				
	juillet (P1)	novembre (P2)	janvier (P3)	P2 - P1	P3 - P2
Cyclées	305^a ± 7,1	276 ± 4,9	293 ± 4,6	-26 ± 2,0	19^c ± 1,7
Non cyclées	277^b ± 4,1	267 ± 4,2	280 ± 6,0	-26 ± 2,3	11^d ± 2,2
TOTAL	298 ± 4,1	272 ± 3,2	288 ± 3,8	-26 ± 1,5	16 ± 1,4

a vs b: P< 0,001
c vs d: P< 0,005

TABLEAU II. POIDS, AGE ET TAUX DE CYCLICITE DES GENISSES SANTA GERTRUDIS LORS DE LA MISE A LA REPRODUCTION

	N	%	Poids corporel en kg ($\bar{x}$ ± s.e.m.)	% de femelles cyclées	Âge moyen en jours ($\bar{x}$ ± s.e.m.)
Précoces	47	52	308^a ± 4,1	70% *(33)	778^c ± 1,98
Tardives	44	48	267^b ± 4,3	57% (25)	707^d ± 2,0
TOTAL	91	100	288 ± 2,9	64% (58)	743 ± 1,4

a vs b: P< 0,001

c vs d: P< 0,001

*( ) : Nombre de femelles cyclées.

3.3. Les variations du taux de gestation

Cinquante sept pour cent des génisses sont retrouvées gestantes deux mois après la fin de la saison de reproduction. Le facteur explicatif important est le poids corporel relevé 45 jours après la mise à la reproduction. Ce poids était significativement supérieur (P< 0,05) pour les gestantes. Les valeurs respectives pour les gestantes et les non-gravides sont de 308 ± 4,7 kg et 292 ± 5,4 kg. Il en va de même pour le gain de poids entre novembre et février. Aussi les gestantes ont manifesté un gain de poids significativement supérieur (P< 0,05). Les valeurs sont de 35 ± 1,8 kg et 29 ± 2,1 kg (Tableau III).

D'autre part, la cyclicité avant la mise à la reproduction interfère avec le taux de gestation. C'est ainsi que 87%, 65% et 69% des génisses retrouvées gestantes étaient cyclées, respectivement, au mois de juillet, novembre et lors de leur la mise à reproduction. Les valeurs pour les non-gravides étaient de 59%, 46% et 56% (Tableau IV).

TABLEAU III. TAUX DE GESTATION ET VARIATION DU POIDS CORPOREL AVANT LA MISE A LA REPRODUCTION DES GENISSES SANTA GERTRUDIS, AU MAROC

	N	%	Poids en kg ($\bar{x}$ ± s.e.m.)						
			jui. (P1)	nov. (P2)	jan. (P3)	fév. (P4)	P2-P1	P3-P2	P4-P2
Gestantes	52	57	299 ± 5,0	273 ± 4,3	291 ± 4,8	308[a] ± 4,7	-27 ± 1,9	18 ± 1,8	35[c] ± 1,8
Vides	39	43	296 ± 5,8	271 ± 4,9	285 ± 5,6	292[b] ± 5,4	-25 ± 2,3	14 ± 2,3	29[d] ± 2,1
TOTAL	91	100	298 ± 3,8	272 ± 4,9	288 ± 3,7	301 ± 3,6	-26 ± 1,5	16 ± 1,4	32 ± 1,4

a vs b: P< 0,05
c vs d: P< 0,05

TABLEAU IV. TAUX DE GESTATION ET VARIATION DU TAUX DE CYCLICITE AVANT LA MISE A LA REPRODUCTION DES GENISSES SANTA-GERTRUDIS

	N	%	Pourcentage de femelles cyclées		
			juillet	novembre	janvier
Gestantes	52	57	87%[a] (45)	65% (34)	69% (36)
Vides	39	43	59%[b] (23)	46% (18)	56% (22)
TOTAL	91	100	75% (68)	57% (52)	64% (58)

a vs b: P<0,005
( ) : Nombre de femelles cyclées.

L'analyse de la variance a relevé que la différence est hautement significative (P< 0,001) pour le pourcentage de femelles cyclées, entre le groupe des gestantes et les non-gravides au mois de juillet.

Le taux de gestation relevé chez les précoces et les tardives a été respectivement de 64% (30/47) et de 50% (22/44). Toutefois cette différence est non significative.

4. DISCUSSION

La baisse du poids corporel durant la période préalable à la mise à la reproduction est la conséquence d'une alimentation inadéquate. En effet, durant cette période, les disponibilités alimentaires au pâturage sont très faibles et la complémentation à base de mélasse et de paille d'avoine reste insuffisante pour maintenir un poids corporel en croissance durant cette période critique. Des résultats similaires ont été rapportés par Joubert [8] et Lamond [9]. Ils ont démontré que les conditions alimentaires hivernales affectent l'état corporel des génisses.

Dans une étude plus récente réalisée dans les conditions marocaines, Tibary et col. [10] décrivent

une baisse du poids chez des génisses Santa-Gertrudis durant le mois précédant la mise à la reproduction. Dans cette étude, la saison de naissance, que reflète en réalité l'âge, influence de manière hautement significative le poids corporel. Cette constatation s'explique par le fait que les femelles précoces ont plus de temps pour croître que les tardives. Des résultats similaires ont été rapportés par Lofti [3], pour les poids au sevrage. Les avantages des naissances précoces en système "Ranching" ont été décrits par Short et col.[11] et Lesmeister et col. [12]. La reprise du gain de poids, entre novembre et février, est la résultante d'une amélioration des disponibilités alimentaires au pâturage.

D'après nos résultats, le pourcentage de génisses cyclées varie parallèlement à l'augmentation du poids corporel. Ainsi, la perte de poids s'accompagne d'une baisse du taux de cyclicité.

Ces résultats concordent parfaitement avec ceux rapportés par Imakawa et col. [13]. Fabienne et col. [14] décrivent une chute du pourcentage de génisses charolaises cyclées, concomitante d'une diminution de gain de poids moyen quotidien. Le taux de femelles cyclées un mois avant la mise à reproduction est de 62%. Ce pourcentage de femelles cyclées est supérieur au taux de 43% rapporté par Tibary et col. [10]. Cette différence s' explique par les méthodes utilisées dans l'estimation de l'activité ovarienne. Dans notre étude, des prélèvements sanguins hebdomadaires ont été réalisés pour le dosage de la progestérone, alors que dans l'expérience citée, la palpation transrectale est le seul examen. De plus, l'effet "année" est un facteur explicatif important pour ce type d'élevage. En effet, la précocité et la régularité des pluies à la fin de l'automne conditionnent les disponibilités en pâturage et l'état d'enbonpoint des animaux.

En outre, notre étude a concerné les génisses de race pure alors que celles utilisées dans l'étude de Tibary et col. [10] concerne des génisses de race pure et des génisses croisées.

Petit et Chupin [15] rapportent pour les Salers et Charolaises une variation parallèle du poids corporel et du pourcentage de femelles cyclées. Le pourcentage de femelles cyclées lors de la mise à la reproduction est corrélé positivement au gain moyen quotidien dans les deux mois précédents. D'après nos résultats, le taux de cyclicité est corrélé au poids corporel. Ce constat est confirmé par les résultats rapportés par plusieurs auteurs [11,16]. Tibary et col. [10] décrivent que 73% des génisses Santa-Gertrudis dont le poids est supérieur à 270 kg sont cyclées et seulement 43% le sont pour poids compris entre 250 et 270 kg.

Seulement 57% des génisses ont été retrouvées gestantes à la fin de la saison de reproduction. Ce résultat est faible par rapport à celui rapporté par Tibary et col. [10] dans les mêmes conditions, du fait de la réduction de la durée de la saison de reproduction de 180 à 120 jours. Dans les conditions de cette étude, les génisses avant la mise à la reproduction passent par deux phases, une période de 4 mois s'étalant de juillet à novembre se caractérisant par une perte de poids et une baisse du taux de cyclicité. La deuxième période du 15 novembre au 15 janvier est caractérisée par une reprise du gain de poids moyen quotidien, qui reste faible (130 g/j) et un rétablissement du taux de cyclicité optimal.

Les génisses qui deviendront gestantes sont celles qui auront manifesté, tout au long de l'étude, le taux de cyclicité supérieur. De plus, les femelles ayant gagné le plus de poids dans les 60 jours avant la mise à la reproduction auront un taux de gestation le plus grand.

En conclusion, dans les conditions de ces élevages, les pertes de poids se manifestent surtout avant la mise à la reproduction, pendant la période de restriction alimentaire. Ces variations du poids, accompagnées d'une diminution de la cyclicité ovarienne sont incompatibles avec des performances de reproduction optimales. Aussi, dans le futur, il serait nécessaire d'entreprendre des études concernant l'effet d'une supplémentation alimentaire adéquate avant la mise à la reproduction sur les performances de reproduction et de dégager la rentabilité d'une telle pratique pour le gestionnaire.

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REPRODUCTIVE PERFORMANCE OF TANZANIAN MPWAPWA CATTLE AT PUBERTY AND POST-PARTUM

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Abstract–Résumé

REPRODUCTIVE PERFORMANCE OF TANZANIAN MPWAPWA CATTLE AT PUBERTY AND POST-PARTUM

Twenty one Mpwapwa heifers between 1 and 1 5 years of age were included in an experiment to determine age and weight at puberty Background information about the animals was obtained from farm records The animals were weighed at specific intervals Weekly blood samples for progesterone concentration determination were obtained by jugular venipuncture Twenty two cows of the same breed were included in another experiment to determine the length of post-partum acyclic period Cows in oestrus were naturally bred Starting from the first week of calving, blood samples for progesterone determination were obtained on a weekly basis until the cows were diagnosed pregnant

Seventeen heifers attained puberty at an average age of 916 ± 106 (mean ± sd) days The range was between 742 and 1123 days Heifers born in the dry season reached puberty at a later age (P< 0 01) than those born in the wet season but all attained similar bodyweight (215 ± 17) kg when ovarian cycles commenced The mean interval between calving and initiation of ovarian activity was 104 ± 50 days Fifteen out of the 19 cows conceived again during the period under study, the mean interval between calving and conception was 158 ± 86 days

It can be concluded that Mpwapwa heifers reach puberty at an advanced age and cows of the same breed have a long post-partum acyclic period Strategies such as dry season supplementary feeding should be implemented to improve reproductive performance

PERFORMANCE DE REPRODUCTION DES BOVINS MPWAPWA DE TANZANIE A LA PUBERTE ET POST-PARTUM

Vingt et une génisses Mpwapwa âgées de 1 an à 1,5 an ont fait l'objet d'une étude en vue de déterminer leur âge et leur poids à la puberté Les registres des exploitations ont fourni des renseignements de base sur les animaux Ces derniers ont été pesés à des intervalles donnés Des échantillons de sang destinés à analyser les taux de progesterone ont été prélevés chaque semaine par ponction des veines jugulaires Une autre expérience a porté sur 22 vaches de la même race, en vue de déterminer la durée de la période acyclique post-partum Les vaches en chaleur se sont accouplées de façon naturelle A partir de la première semaine après le vêlage, des prélèvements hebdomadaires d'échantillons de sang pour l'analyse de la progesterone ont eté effectués jusqu'à obtention d'un diagnostic de gestation

Dix-sept génisses ont atteint la puberté à un âge moyen de 916 ± 106 (moyenne ± écart type) jours La fourchette était de 742 à 1123 jours Les génisses nées pendant la saison sèche ont atteint la puberté plus tard (P < 0,01) que celles nées pendant la saison humide, mais toutes ont atteint un poids similaire (215 ± 17 kg) lors des premiers cycles ovariens L'intervalle moyen entre le vêlage et la reprise de l'activité ovarienne a été de 104 ± 50 jours Sur les 19 vaches, 15 ont conçu de nouveau durant la période étudiée et l'intervalle moyen entre le vêlage et la conception a été de 158 ± 86 jours

On peut conclure que les génisses Mpwapwa atteignent la puberté tardivement et que les vaches de la même race ont une longue période acyclique post-partum Des techniques telles qu'un complément d'alimentation pendant la saison sèche devraient être mises en oeuvre pour améliorer la performance de reproduction

1. INTRODUCTION

Subsistence and emerging farmers throughout Tanzania rely on their indigenous cattle (*Bos indicus*) for meat and milk. Direct selection for enhanced milk or meat production has never been practised on these animals but natural adaptation provides disease resistance and the ability to supply some milk and beef. Under most conditions therefore, a dual purpose animal that can achieve reasonably high productivity and good reproductive efficiency is desirable.

The Mpwapwa breed, derived from Indian and East African Zebu plus some proportion of European genotypes, has considerable potential but very limited availability and distribution. Even under traditional or only slightly improved husbandry, cows of the Mpwapwa breed may produce several thousand litres of milk per lactation [1]. For example, lactation yields of cows of the breed retained in the breeding herd at the Mpwapwa Research Station were: first lactation 1200 -1530 kg; second lactation 1425-1675 kg; and third lactation 1475-1800 kg [2]. These yields are substantially higher than those of non-improved indigenous cattle under similar management. Likewise, the average bodyweight of Mpwapwa is 25-30% higher than that of non-improved indigenous cattle under similar conditions of husbandry. Although a relatively new strain with apparent potential, the Mpwapwa breed of cattle has been described as being endangered [3]. Thus the government of the United Republic of Tanzania supports research to further evaluate the true genetic potential of the breed and to increase numbers for possible introduction into other areas.

The Mpwapwa breed, like almost all other indigenous, exotic or cross bred cattle in semi-arid environments does not reach sexual maturity and first calving until relatively advanced ages [2] and suffers from prolonged inter-calving intervals [4]. Malnutrition has been singled out as one of the constraints leading to this poor reproductive performance [5]. There are several locally available feed resources such as crop residues, agricultural by-products and forage trees that could be used to supplement grazing, particularly during the dry season when animals lose weight. As a practical step towards the conservation and more efficient utilization of the Mpwapwa breed, this study was undertaken with the broad aim of collecting baseline reproductive data of the breed and later to conduct practical feed supplementation trials to determine how locally available feed resources might be used to improve the reproductive performance. The specific objectives of this initial part of our study were to determine age and weight at puberty as well as the length of post-partum acyclicity of the Mpwapwa cattle.

2. MATERIALS AND METHODS

2.1. Study area

This study was carried out at farms belonging to the Central Zone Research and Training Centre (CZRTC) at Mpwapwa. Mpwapwa is located at latitude 6° 20' S and longitude 36° 30' E within the semi-arid zone of central Tanzania. Its altitude is about 1000 metres above sea level. The climate is characterized by two distinct seasons, the rainy season commencing in December and ending in April while the dry season extends from May to November. The average annual rainfall is 720 mm of which 90% falls between December and April. The average minimum temperature is 16°C, with the coolest month being August, and the average maximum temperature is 28°C with November being the warmest month. The soils are sandy loams on the slopes and clay loams along valley bottoms. Soils are generally low in nitrogen and phosphorus but adequate in potassium. The pH of the topsoil varies between 5.6 and 7.7 while that of subsoil lies between 5.3 and 8.6. The predominant grass species for grazing are *Chloris gayana, Cynodon dactylon, Hyperrhenia rufa*, and *Themeda* spp.

2.2. Animals

Animals used in this study were pure Mpwapwa cattle belonging to the CZRTC. These animals normally graze on natural pastures during the day and only lactating cows receive supplementary feed. This

is based on agricultural by-products such as maize bran when available, but mostly consists of dried leucaena leaves mixed with maize stover. Supplementary feed is given during the dry season only. Animals are weighed at birth, weaning (75 days), 36 weeks, 72 weeks, just before joining the mating group and at the end of the breeding season. There are two breeding seasons each of three months duration, March to May and September to November, during which both natural service and AI are practised. Cows suckle their calves for the first two days after calving. Then up to weaning the calves are reared indoors in individual pens where they are bucket fed with whole milk (2 l/calf, morning and evening) per day. Heifers are selected to join the breeding herd for the first time when they attain a bodyweight of 200 kg. Disease control activities include vaccinations against endemic diseases such as Foot and Mouth Disease, Haemorrhagic Septicaemia and Brucellosis, as well as deworming to control internal parasites twice a year. Ticks and other external parasites are controlled by dipping once weekly using Toxaphene. Common diseases of cattle are mastitis and tick borne diseases.

2.3. Determination of age and weight at puberty

Twenty one growing heifers ranging in age from 1 to 1.5 years were selected for this study. Body weights were recorded at regular intervals so changes in weight of these heifers from birth to the time of joining the mating group were obtained from herd records. The pre-breeding weight, taken just before joining the mating group, was retrospectively used to estimate weight at puberty.

A blood sample was collected from each heifer once weekly by a jugular venipuncture using heparinized vacutainer tubes. The blood sample tubes were immediately put into a coolbox with ice-water and transported to the laboratory within two hours of collection. The samples were then centrifuged at 3000 revolutions per minute for 15 min. Plasma was decanted into plastic tubes and stored at -20°C until day of progesterone concentration determination. Blood sampling was continued until progesterone profiles indicated that a heifer had reached puberty. A heifer was deemed to have reached puberty when the first elevation in plasma progesterone concentration above 1 nmol/l was followed by at least two elevated concentrations in the next three consecutive samples. That is, in a group of four consecutive samples at least three progesterone concentrations are above 1 nmol/l. It was assumed that the first such rise in progesterone concentration was preceded by an ovulation 3-4 days earlier. Plasma progesterone concentration was determined by radio-immunoassay using the solid phase coated tube system employing ^{125}I as tracer supplied in kit form by the Joint FAO/IAEA Division, Agriculture Laboratory, Seibersdorf.

2.4. Determination of the length of the post-partum acyclic period

Twenty two cows aged between 4 and 12 years which had calved between June and July, 1990, were included in this experiment. This was the dry season calving group.

Visual detection of oestrus, as judged by standing to be mounted by a bull or another cow, was performed by herdsmen when the animals were grazing or congregated for other farm activity. The herdsmen then reported their observations for recording. Breeding in this herd was by natural service only. Pregnancy was confirmed by rectal palpation performed about 60 days post-breeding.

Blood for progesterone concentration determination was collected once weekly and handled in the same way as described in section 2.3. Blood sampling was started from the first week of calving and continued until cows were either confirmed pregnant or six months post-calving. The same criteria as for initiation of cyclicity at puberty was used to judge initiation of ovarian activity post-partum.

2.5. Statistical analysis

The Students t-test was used to find out if there were statistically significant differences in age and weight at puberty between heifers born in different seasons. Means and standard deviations were calculated for each group.

3. RESULTS

3.1. Age and weight at puberty

Two heifers in the experiment to determine age and weight at puberty died after both had suffered from prolonged diarrhoea. Two other heifers in the same group were sold to individual smallholder farmers for breeding purposes. The remaining 17 heifers showed a first rise in plasma progesterone concentration, indicating attainment of puberty, at an average age of 916 ± 106 days. The range was between 742 and 1123 days. This first rise in plasma progesterone concentration occurred at an average live weight of 215 ± 17 kg.

Heifers born in the dry season (n = 8) reached puberty at an average age of 1011 ± 60 days and a bodyweight of 220 ± 15 kg whereas those born during the wet season (n = 9) attained puberty at an average age of 832 ± 49 days and bodyweight of 213 ± 18 kg. There was a statistically significant difference ($P < 0.01$) in the age at puberty between heifers born in the two seasons, but the difference in mean bodyweight at puberty for heifers born in the two seasons was not significant. The frequency distribution of age at puberty for heifers born in each season is shown in Table I.

Five out of the 17 heifers born during the dry season exhibited irregular pulses of plasma progesterone elevations when at an average age of 718 ± 100 days and an average bodyweight of 196 kg. This was about six months earlier than the time of actual puberty as shown by regular ovarian activity on progesterone profiles.

TABLE I. FREQUENCY DISTRIBUTION OF AGE AT PUBERTY FOR HEIFERS BORN IN EACH SEASON

Age at puberty (days)	Season of birth	
	Dry	Wet
700 - 749	-	1
750 - 799	-	1
800 - 849	-	4
850 - 899	-	2
900 - 949	1	1
950 - 999	3	-
1000 - 1049	3	-
1050 - 1099	-	-
1100 - 1149	1	-
Total	8	9

TABLE II. AVERAGE LIVE WEIGHT ($\bar{x}$ ± sd, kg) OF MPWAPWA HEIFERS AT VARIOUS STAGES OF GROWTH

	($\bar{x}$ ± sd, kg)
Birth weight	25.2 ± 3.2
Weaning weight (75 days)	53.0 ± 3.8
Weight at 36 weeks	81.6 ± 16.9
Weight at 72 weeks	118.8 ± 12.7
Pre-breeding weight	215.4 ± 17.2

Changes in bodyweight from birth to breeding occurred as shown in Table II. The average daily gain from birth to weaning was 0.37 kg/d and that between weaning and 72 weeks of age was 0.15 kg/d.

3.2. Length of post-partum acyclic period

Of the 22 cows included in this study, three were culled because of relatively low milk yield. Results for the remaining 19 cows were as follows. There were 15 cows that subsequently conceived again and four others did not conceive up to the end of this study. The four cows that did not conceive were cyclic non breeders (repeat breeders) as shown by their progesterone profiles and breeding records.

The mean interval between calving and initiation of ovarian activity, as indicated by the first rise in plasma progesterone concentration followed by regular cyclicity, was 104 ± 50 days and values ranged between 45 to 182 days. There were 10 cows that showed a first rise in plasma progesterone concentration between days 45 to 100 post-partum. By day 150 post-partum, 14 cows had shown a resumption of ovarian activity. The remaining 5 cows resumed ovarian activity between 150 to 182 days after calving.

Of the 15 cows that eventually conceived again, the mean interval between calving and conception oestrus was 158 ± 86 days with a range of 59 to 283 days. Nine cows had a calving to conception interval of between 59 and 115 days. The remaining six cows had a calving to conception interval of between 261 and 283 days. This rather big gap is a result of the breeding practice followed at the station whereby a cow failing to conceive in one mating season which normally lasts for 3 months would have to wait for another 3 months before being bred again.

Two of the 15 cows that subsequently conceived again, resumed ovarian activity within two months of calving. An example of this group of cows which exhibited an early start of ovarian activity post-partum is shown in Figure 1a in which Cow No. 3042 had a low plasma progesterone concentration up to day 38 after calving. The first progesterone rise was noted on day 45 post-partum and on day 59 the cow was bred and conceived.

One cow (No. 2824) was noted in oestrus and bred on days 65 and 83 after calving. However, her progesterone profile was persistently low through this period as shown in Figure 1b. The cow started normal ovarian cyclicity at day 103 and was successfully mated one oestrous cycle later.

Some cows had a rather late start of ovarian activity after calving as exemplified by Cow No. 21229 shown in Figure 1c. She had a first rise in plasma progesterone concentration on day 115 after calving. The cow was noted in oestrus on day 137 and bred but did not conceive. The cow was again in oestrus on Day 158 after calving and conceived following that service.

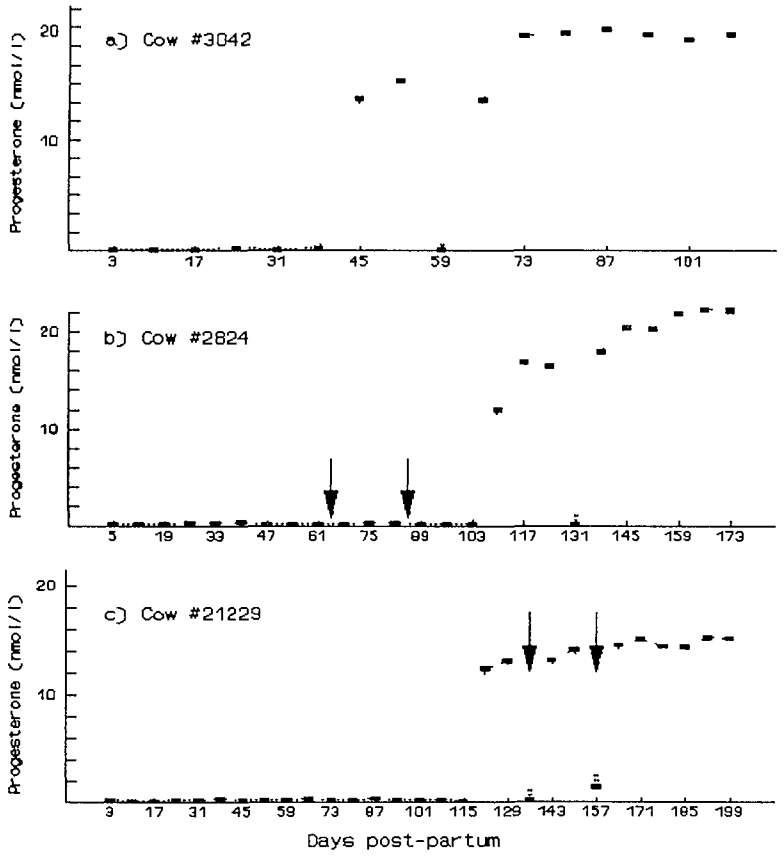

Fig. 1a. Sequential plasma progesterone concentrations from a cow commencing cyclic ovarian activity within a reasonable period after parturition.

Fig. 1b. Sequential plasma progesterone values from a cow demonstrating several periods of oestrous behaviour (arrows) without any subsequent increase in concentrations. Presumably due to follicular cyst with spontaneous recovery.

Fig. 1c. Sequential plasma progesterone concentrations for a cow with late start of ovarian activity. Arrows indicate service.

4. DISCUSSION

Values for a number of production-reproduction related traits obtained from previous studies performed on Mpwapwa cattle and herd records are presented in Table III. Unfortunately the authors have either indicated the mean or range without mention of variances.

Estimates of age at puberty in *Bos indicus* cattle in the tropics and subtropics range between 16 and 40 months. The average age at puberty in cows of well defined breed is reported to be between 24 and 30 months while in nondescript breeds the period may extend to beyond 36 or 48 months [6]. The Mpwapwa heifers in the present study attained puberty at about the same age as that reported in the literature for indigenous cattle in the tropics.

TABLE III. PRODUCTION AND REPRODUCTION CHARACTERISTICS OF MPWAPWA CATTLE

Trait	Range/Mean	Reference
Birth weight (kg)	21-23	[2]
Weaning weight (kg)	52-56	[2]
Weight at 224 days (kg)	165-170	[2]
Age at first mating (months)	27-30	[2]
Age at first calving (months)	36-42	[2]
Age at first calving (months)	45.7	[4]
Calving interval (days)	446.5	[4]
Average daily gain of steers one year old (kg)	0.26-0.33	[2]
Live-weight at slaughter (kg)	425.9	[5]
Warm carcass weight (kg)	243.0	[2]

Age at puberty depends more on body growth rate than chronological age. The role of nutrition in attainment of puberty has been reported [7, 8-10]. One study found a negative correlation between birth weight and age at first progesterone rise [11], implying that the lower the birth weight of the calves at birth the longer it takes them to reach puberty and especially in farms with management constraints. In the present study, perhaps because of the small sample size, no such clear relationship could be established.

Inadequate supply of poor quality feed adversely affects the growth rate of heifers and results in their late age at sexual maturity [12, 13, 14]. However, although poor nutrition delays puberty, very high levels of feeding do not necessarily result in earlier puberty than that obtained with adequate diets. Efforts to make heifers reach puberty earlier should be aimed at raising the plane of nutrition to involve quantitative and/or qualitative elements so that there is continuous growth rate and an increased body weight at an early age [15]. In the present study heifers reached puberty at a rather advanced age because of uneven feed supply within and between years. This is a result of inadequate and poor feed supply during the dry season when animals lose condition greatly.

The major factors controlling the onset of puberty are bodyweight and growth rate rather than age [16-18]. Until heifers reach a particular (target or critical) weight, oestrus is unlikely to occur. There seems to be substantial evidence that dietary supplementation of heifers during their growth will reduce the interval from birth to first calving [12, 19, 20] probably because heifers that grow faster will cycle earlier [21, 22]. In the present study all heifers attained puberty at about the same bodyweight but at different ages which concurs with other reports in the literature.

Parturition is usually followed by a period of ovarian inactivity and sexual quiescence before reproductive cycles recommence. The length of this period is variable and can be influenced by several environmental factors including nutrition [23, 24]. Cows fed on a high energy diet after calving conceive sooner than those with a lower energy intake [8, 25, 26]. Supplemental energy feeding before calving reduced the post-partum acyclic period in *Bos taurus* beef cows so more females exhibited oestrus before the breeding season and subsequent pregnancy rates were increased [27].

Improved post-partum fertility appears to be related to the early onset of cyclic ovarian function and expression of oestrus. It is generally known that tropical cattle have periods of prolonged post-partum

acyclicity or suppression of overt behaviourial signs of oestrus despite ovulation, leading to extremely long calving to service intervals [28]. However, the measurement of progesterone concentration in body fluids has provided a better understanding of the onset of ovarian activity in tropical cattle.

In a review of cattle reproduction in the tropics [28] it is said that in Droughtmaster cows, only 50% of the herd was cycling at 120 days post-partum. In another study [29] it was shown that 80% of Kedan-Kelantan cows were cycling by 90 days post-partum. Another study [30], where the authors worked with Holsteins in Cuba, found that by 120 days post-partum 72% of the cows had luteal activity, as shown by progesterone concentration. Other researchers, when comparing the onset of ovarian activity in Holstein and Jamaica Hope cattle raised in the tropics, found cyclic concentrations of progesterone indicative of ovarian activity as early as 20 days post-partum [31]. This difference in interval between calving and initiation of ovarian activity after calving as reported in the literature shows that there is a variation depending on the breed, management and location. Our findings for this interval in the present study agree with previous reports [29, 32] but it was longer than that reported in [31] with different breeds under a different system of management.

As a follow up study to the present one, we are conducting a feed supplementation trial using maize stover and grounded pods of *Acacia tortilis*, which are locally available, to even out feed supply during the dry season. Our objective is to study the effect of feed supplementation during the dry season on the age and weight at puberty or length of post-partum acyclic period in Mpwapwa cattle.

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ETUDES SUR L'INFLUENCE DU NIVEAU ALIMENTAIRE AVANT ET APRES LA MISE BAS SUR LA REPONSE DES BREBIS DE RACE BARBARINE A L'"EFFET MALE" EN TUNISIE

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Abstract–Résumé

STUDIES ON THE INFLUENCE OF NUTRITION BEFORE AND AFTER LAMBING ON THE RESPONSE OF BARBARY EWES TO THE "RAM EFFECT" IN TUNISIA.

The aim of this work was to study the effect of the nutritional level during the last 12 weeks of pregnancy and the first 18 weeks of lactation on the response of Barbary ewes to the "ram effect", in spring. The experiment was conducted on 140 adult females divided, according their nutritional level during pregnancy, into 2 groups H (High) and L (Low) and into 4 groups HH (High pregnancy, High lactation), HL (High pregnancy, Low lactation), LH (Low pregnancy, High lactation) and LL (Low pregnancy, Low lactation), during lactation. The ewes were mated by rams of the same breed. The ovarian activity of ewes was controlled by coelioscopy at Day-1 Day+4, Day+9, and some days after the first oestrus.

The results of this study showed that the response of ewes to the "ram effect" was not related to their nutritional level during pregnancy and lactation, provided they were well fed between weaning of lambs and mating. In fact, the introduction of rams into the flock induced ovulation in all of the ewes. However, undernutrition during pregnancy and/or lactation decreased the percentage of cyclic females before teasing (HL:31%, LH:35%, LL:33%) in comparison with the well fed ewes (HH:66%) and increased the proportion of the short induced ovarian cycles (HL:67%, LH:75%, LL:79%, against only 45% in the HH group). The effect of flushing on the ovulation rate was shown in the LL group which had the highest ovulation rate (1.79) in comparison with the other groups. On the other hand, teasing had a similar effect to flushing since the induced ovulation rate was higher than that of the following ovulations.

ETUDES SUR L' INFLUENCE DU NIVEAU ALIMENTAIRE AVANT ET APRES LA MISE BAS SUR LA REPONSE DES BREBIS DE RACE BARBARINE A L'"EFFET MALE" EN TUNISIE.

Le but de ce travail est d'étudier l'influence du niveau alimentaire pendant les 12 dernières semaines de la gestation et les 18 premières semaines de la lactation chez les brebis de race Barbarine sur leur réponse l'"effet mâle", au printemps. Cent quarante brebis adultes sont réparties, en fonction de leur niveau alimentaire, en deux lots H at B (haut et bas), pendant les 12 dernières semaines de la gestation et en quatre sous-lots après la mise bas: HH, HB, BH at BB. La lutte est réalisée à l'aide de béliers de la même race. L'activité ovarienne est contrôlée par des examens coelioscopiques à J-1, J4, J9 et quelques jours après l'apparition du comportement d'oestrus.

Les résultats de cette étude montrent que la réponse des femelles à l'"effet bélier" ne dépend pas de leur niveau alimentaire pendant la gestation et la lactation, à condition que ces brebis soient bien alimentées entre le sevrage des agneaux et leur mise à la lutte. En effet, l'introduction des mâles dans le troupeau a provoqué une ovulation chez la totalité des animaux. Par ailleurs, la sous-alimentation pendant la gestation et/ou la lactation: 1) diminue la proportion de femelles cyclées avant l'introduction des béliers (HB:31%, BH:35%, BB:33%) par rapport aux femelles bien alimentées pendant les deux phases (HH:66%); et 2) augmente la proportion de cycles courts induits (HB:67%, BH:75%, BB:79% contre 45% seulement dans le lot HH). L'influence du "flushing" sur le taux d'ovulation est mis en évidence dans le lot BB qui montre le taux d'ovulation le plus élevé (1,79) par rapport aux autres lots. D'autre part l'introduction des béliers dans le troupeau joue un rôle comparable à celui du "flushing"" puisque le taux d'ovulation induite est supérieur à celui des ovulations suivantes.

1. INTRODUCTION

L'activité sexuelle des femelles dépend étroitement de leur état corporel [1, 2]. En effet, un amaigrissement excessif provoqué par une sous-alimentation sévère peut entraîner une disparition complète de l'activité ovarienne chez la Brebis [3]. Néanmoins, d'après d'autres auteurs [4], l'activité ovarienne des brebis n'est pas influencée par l'évolution de leur poids vif. La restauration de l'activité ovarienne par l'"effet mâle" chez les femelles en anoestrus saisonnier dépend à la fois de leur poids vif et de son évolution [2].

Le but de cette étude est de définir l'effet du niveau alimentaire pendant les 12 dernières semaines de la gestation et les 18 premières semaines de la lactation, sur l'intensité de l'anoestrus saisonnier chez des brebis de race Barbarine et leur réponse à l'introduction du bélier en contre saison sexuelle, au printemps.

2. MATERIEL ET METHODES

2.1. Animaux

Cent quarante brebis Barbarines, adultes, du troupeau expérimental de la Station de l'INRAT à Bou-Rébiaa (région semi-aride du Zaghouanais) sont réparties en deux lots H at B pendant les 12 dernières semaines de leur gestation et en quatre sous-lots après la mise bas (HH, HB, BH et BB), selon leurs niveaux alimentaires (Tableau I):

- Lot HH: brebis recevant un haut niveau alimentaire avant et après la mise bas.
- Lot HB: brebis recevant un haut niveau alimentaire avant la parturition et bas pendant la lactation.
- Lot BH: brebis recevant un niveau alimentaire bas avant la parturition et haut pendant la lactation.
- Lot BB: brebis recevant un niveau alimentaire bas avant et après la parturition.

TABLEAU I. QUANTITES D'ALIMENTS DISTRIBUEES EN kg/TETE/JOUR, AVANT ET APRES LA PARTURITION, EN FONCTION DES LOTS

	Gestation 12 dernières semaines		Lactation 18 semaines	
Lots	foin de vesce avoine	concentré	foin de vesce avoine	concentré
HH	ad lib	0,400	ad lib	0,800
HB	ad lib	0,400	1	0,200
BH	1	0	ad lib	0,800
BB	1	0	1	0,200

Le poids vif moyen des brebis au début de l'expérience est de 51 kg. Les animaux sont pesés une fois par semaine ainsi que 24 heures après la mise bas. Les agnelages ont lieu au cours de la 1ère quinzaine du mois d'octobre. Les femelles non gestantes, ayant donné naissance à des agneaux mort-nés ou ayant perdu leurs produits au cours des deux mois d'allaitement, sont éliminées de l'expérience.

2.2. Alimentation

Les brebis sont maintenues en bergerie et les quantités d'aliments offertes et refusées sont pesées quotidiennement. Les quantités d'aliments distribuées sont ajustées en fonction de l'évolution du poids vif moyen de chaque lot. Après le sevrage (28 février), le poids vif moyen des brebis des 4 lots est ramené à une valeur sensiblement identique en début de lutte (30 avril). Ce poids vif moyen est de l'ordre de 47 kg.

2.3. Contrôle de l'activité ovarienne

L'activité ovarienne des brebis est contrôlée par:

- des examen coelioscopiques selon la méthode décrite par Thimonier et Mauléon [5], à J-1, J4, J9 et 8 à 12 jours après l'apparition du premier oestrus, J0 étant le jour de l'introduction des béliers (30 avril). Ces derniers sont utilisés à raison de 1/10 femelles.
- le dosage de la progestérone plasmatique: des prises de sang sont effectuées dans des tubes sous vide, à raison d'une fois par jour, à partir de J1. La dosage est radioimmunologique. Le matériel en permettant la réalisation est fourni par l'Agence Internationale de l'Energie Atomique.

2.4. Contrôle de l'oestrus

La détection des chaleurs est effectuée quotidiennement, matin et soir, à l'aide de béliers entiers selon la méthode décrite par Mauléon et Dauzier [6], le critère de comportement d'oestrus étant l'immobilisation des femelles pendant le chevauchement par le mâle.

2.5. Analyse statistique

La comparaison des différents lots est effectuée par une analyse de variance pour les variations de poids et par le test CHI^2 pour les autres paramètres.

3. RESULTATS

3.1. Variation du poids vif des brebis

La figure 1 montre que le poids vif des femelles bien nourries avant la mise bas (HH et HB) augmente d'une façon très importante jusqu'à la parturition, tandis que celui des femelles sous-alimentées (BB at BH) reste pratiquement constant. La variation de poids des femelles pendant la phase d'allaitement est significativement ($P < 0,01$) affectée par leur niveau alimentaire post-partum. Cette variation de poids dépend également du niveau alimentaire pre-partum. En effet la perte de poids est plus faible chez les brebis soumises à une restriction alimentaire avant la mise bas, tandis que les femelles bien alimentées pendant la gestation et sous-alimentées pendant la lactation accusent une chute très importante de leur poids vif.

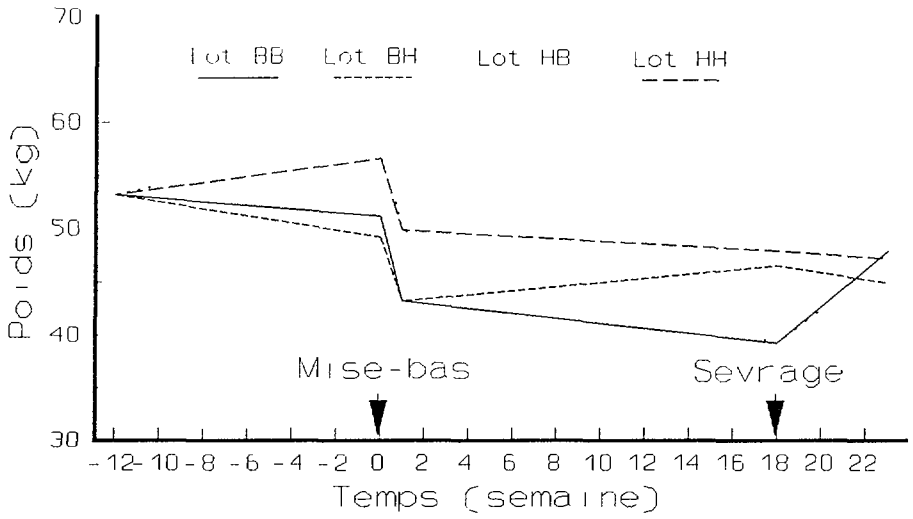

Fig. 1. Evolution du poids vif des brebis.

3.2. Activité ovarienne

3.2.1. Activité ovarienne avant l'introduction des mâles (Tableau II)

La sous-alimentation à long terme avant ou/et après la mise bas réduit de moitié le pourcentage de femelles cyclées avant l'introduction des béliers. En effet ce pourcentage varie de 31 à 35 % pour les brebis ayant souffert de la sous-alimentation à un stade quelconque de leur cycle de reproduction (gestation ou lactation). Il est environ du double (66%) pour les femelles bien alimentées (HH).

Les chiffres présentant des lettres identiques ne sont pas en petits caractères de significativement différents au seuil de 5%.

TABLEAU II. POURCENTAGE DE FEMELLES CYCLEES AVANT L'INTRODUCTION DES BELIERS

Lots	Nombre total de femelles	femelles cyclées	
		Nombre	Pourcentage
HH	32	21	66[a]
HB	26	8	31[b]
BH	31	11	35[b]
BB	21	7	33[b]

3.2.2. Induction de l'ovulation chez les femelles non cyclées avant l'introduction des béliers (Tableau III)

L'ovulation est induite pour la totalité des femelles des quatre lots durant les 4 jours qui suivent l'introduction des béliers. La sous-alimentation sévère des brebis pendant la gestation et/ou la lactation ne semble donc pas affecter leur réponse à l'"effet mâle" à condition de bien les nourrir entre le sevrage et la lutte.

TABLEAU III. NOMBRE DE BREBIS NON CYCLEES AYANT REPONDU A L'"EFFET MALE" ET NOMBRE DE CYCLES COURTS INDUITS PAR CET EFFET

Lots	femelles	femelles ayant ovulé		cycles courts	
		nombre	%	nombre	%
HH	11	11	100	5	45
HB	18	18	100	12	67
BH	20	20	100	15	75
BB	14	14	100	11	79

3.2.3. Durée du premier cycle ovarien

L'ovulation induite est suivie chez la totalité des femelles d'une seconde ponte ovulaire. Cette deuxième ovulation se produit, chez un grand nombre d'entre elles,à la suite d'une régression prématurée du corps jaune induit, donnant naissance à des cycles ovariens de courte durée. La fréquence de ces cycles

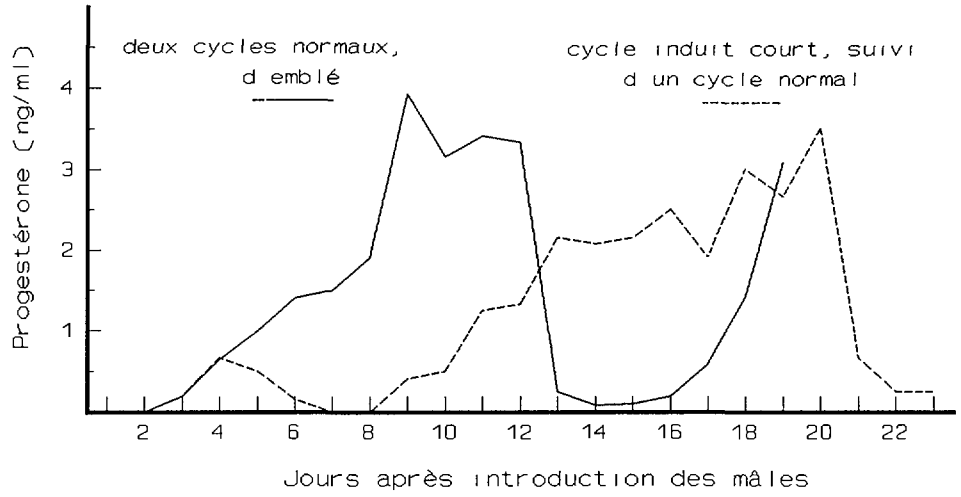

Fig. 2. Evolution de la progestérone plasmatique périphérique après l'introduction des bélieres chez les brebis préalablement en anoestrus.

courts est plus élevée dans les lots BH(75%), HB(67%) et BB(79%) que dans le lot HH(45%) (Tableau III). Néanmoins, les différences entre les 4 lots ne sont pas significatives, au seuil de 5%.

Les profils de la concentration de la progestérone plasmatique sont représentés sur la figure 2. Celle-ci montre les deux catégories de femelles:

- celles qui présentent un cycle de courte durée au cours duquel la concentration en progestérone plasmatique périphérique ne dépasse pas 0,8 ng/ml, suivi d'un cycle normal.

- les autres, pour lesquelles le cycle induit par l'introduction des béliers est d'emblé normal, et dans sa durée, et pour les concentrations plasmatiques de progestérone de sa phase lutéale.

3.2.4. Taux d'ovulation

Les brebis des 4 lots ayant été ramenées au même poids vif au moment de la lutte présentent des taux d'ovulation différents (Tableau IV). Cette différence apparaît nettement entre les lots BB (1,79) et

TABLEAU IV. TAUX D'OVULATION LORS DES CYCLES CONSECUTIFS A L'EFFET MALE CHEZ LA BREBIS EN ANOESTRUS PRELABLE

Lots	ovulation induite	2ème ovulation		3ème ovulation	1er oestrus
		cc	cn	(a)	
HH	1,27	1,40	1,17	1,60	1,36
HB	1,35	1,08	1,20	1,08	1,12
BH	1,50	1,13	1,25	1,31	1,30
BB	1,79	1,27	1,50	1,27	1,31
Moy	1,47	1,22	1,28	1,31	

cc: après un cycle court

cn: après un cycle normal

(a) 3ème ovulation après un cycle normal précédé d'un cycle court

HH (1,27). Par ailleurs, le taux d'ovulation induite est, en moyenne, pour les 4 lots plus élevé que celui des ovulations suivantes. En effet, de 1,47 lors de la première ovulation, il diminue à 1,22 au cours de la deuxième ovulation lorsque celle-ci suit un cycle court et à 1,28 lorsque ce cycle est de durée normale.

3.2.5. Fertilité et prolificité

Nous allons considérer:

- le taux de fertilité apparent: $\frac{\text{nombre de brebis ayant mise bas}}{\text{nombre de brebis mises à la lutte}} \times 100$
- le taux de prolificité: $\frac{\text{nombre d'agneaux nés}}{\text{nombre de brebis metant bas}} \times 100$

Les résultats sont représenteés dans le Tableau V.

TABLEAU V. FERTILITE ET PROLIFICITE DES BREBIS NON CYCLEES AVANT L'INTRODUCTION DES BELIERS ET DONT L'OVULATION A ETE INDUITE PAR L'EFFET MALE

Lots	Fertilité apparente %	prolificité %
HH	91^{ab}	130^{a}
HB	94^{ab}	118^{a}
BH	100^{b}	142^{a}
BB	77^{a}	130^{a}

La fertilité apparente varie de 77 à 100 dans les quatre lots. Le plus faible taux est observé pour les brebis du lot BB. Ces résultats montrent que la sous-alimentation prolongée de part et d'autre de la mise bas provoque une diminution assez importante de la fertilité, même si les brebis sont suralimentées après le sevrage.

La prolificité des femelles des quatre groupes varie de 118 à 142%; la valeur la plus élevée est observée dans le lot BH et la plus faible dans le lot HB. Ces différences ne sont pas statistiquement significatives.

4. DISCUSSION

L'introduction des béliers dans le troupeau à la fin du mois d'avril ou au début du mois de mai permet d'interrompre l'anoestrus saisonnier chez les femelles de race Barbarine. La reprise de l'activité ovarienne est bien synchronisée.

La cyclicité ovarienne des brebis de race Barbarine au printemps dépend étroitement de leur état corporel. Des femelles en mauvais état peuvent suspendre leur activité ovarienne cyclique [3]. D'après nos résultats, bien que toutes les brebis des quatre lots aient des poids moyens semblables (45 ± 1 kg) au moment de l'introduction des béliers, il existe une différence dans le pourcentage de femelles cyclées, entre les groupes.

Nous avons constaté que la sous-alimentation des brebis pendant les 12 dernières semaines de la gestation et/ou les 18 semaines de la lactation affecte le pourcentage de femelles cyclées (HB 31%, BH 35%, BB 33%); l'effet, à long terme, de la sous-alimentation avait déjà été démontré par Khaldi [2] chez la même race. Cependant, d'autres auteurs [4] suggèrent que l'évolution du poids des brebis n'a pas d'effet sur l'activité ovarienne. Ce résultat a également été trouvé par Khaldi [2] lorsqu'il a travaillé sur une période de 9 semaines avant l'introduction du bélier.

La réponse à l'"effet bélier" est complète pour les 4 lots; en effet toutes les femelles ont répondu à l'introduction du bélier par une ovulation induite dans un délai de 4 jours. Ceci confirme les résultats trouvés par Oldham et col. [7] et Khaldi [2]. Ces derniers constatent que les ovulations induites ont lieu dans les 54 heures qui suivent l'introduction du bélier, la synchronisation semble être parfaite. L'importance des facteurs nutritionnels dans le fonctionnement de l'axe hypothalamo-hypophyso-ovarien a déjà été mise en évidence chez la Brebis [1, 8]; ainsi un niveau alimentaire bas peut entraîner une déficience dans la synthèse des hormones gonadotropes et/ou une insensibilité de l'ovaire à celles-ci.

L'ovulation induite est suivie d'un cycle ovarien qui n'a pas toujours une durée normale. Ceci est dûy à une régression prématurée du premier corps jaune.

L'effet du niveau alimentaire à long terme apparaît clairement dans la fréquence des cycles courts chez la Brebis Barbarine. La sous-alimentation avant et/ou après la mise bas entraîne une fréquence élevée de cycles courts (HB:67%, BH:75% et BB:79%), alors que les femelles bien nourries n'ont qu'un taux de 45% de cycles courts. Ceci est en accord avec les résultats de Khaldi [21] qui trouve que la fréquence des cycles courts est plus élevée chez les femelles légères avant l'introduction des béliers. Cet effet de la sous-alimentation prolongée confirme les résultats de Cahill [9] et Haresign [10]; il aboutirait à un développement folliculaire insuffisant qui engendrerait un fonctionnement anormal des corps jaunes induits.

D'après les résultats que nous avons obtenus, le taux d'ovulation induite ne semble pas être influencé par le poids vif des femelles au moment de l'ovulation, puisque ce taux varie de 1,27 dans le lot HH à 1,79 dans le lot BB, les valeurs étant intermédiaires dans le lot HB (1,35) et dans le lot BH (1,50), malgré un poids vif comparable dans les 4 lots. L'absence de l'effet du poids vif chez la race Barbarine est en contradiction avec ce qu'ont trouvé Gunn et Doney [11, 12] qui ont mis on évidence un effet du poids vif sur le taux d'ovulation. En revanche, l'effet "dynamique", qui agit par l'évolution du poids, apparaît clairement à travers le taux d'ovulation le plus élevé du lot BB. Cet effet du "flushing" est retrouvé chez d'autres races [10, 12, 13].

Le plus faible taux d'ovulation observé chez les femelles du lot HH pourrait être dû à l'effet néfaste de leur état d'engraissement. Cette observation a déjà été faite par d'autres auteurs [2, 14].

Cette influence des niveaux alimentaires semble s'exercer sur les follicules en modifiant les processus d'atrésie. L'augmentation du niveau énergétique dans la ration entraîne une amélioration du taux d'ovulation [15]. Par ailleurs, la présence des béliers pourrait avoir un effet comparable à celui du "flushing" puisque le taux d'ovulation induite est plus élevé que celui des ovulations ultérieures.

La fertilité des brebis est liée au niveau d'alimentation. En effet, d'après nos résultats, le plus faible taux de fertilité est observé dans le lot BB (77%) où la sous-alimentation des brebis a duré environ 30 semaines, ce résultat est en accord avec les travaux de Cumming [16] et Cockrem [17]. Dans le lot BH, la fertilité est égale à 100%. Ceci montre l'effet bénéfique du "flushing" chez les brebis, à condition que la sous-alimentation ne soit pas trop prolongée. La diminution des pertes embryonnaires serait une des explications à l'amélioration de la fertilité [18].

5. CONCLUSION

Les résultats de cette expérience montrent l'importance de l'alimentation au cours des différents cycles de production de la Brebis. La sous-alimentation prolongée des femelles ovines de race Barbarine pendant la gestation et la lactation a des repercussions néfastes sur les caractéristiques de leur reproduction, même si celles-ci sont suralimentées après la sevrage.

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EFFETS DE LA PROGESTERONE SUR LA QUALITE DU CORPS JAUNE INDUIT PAR L'EFFET MALE CHEZ LA BREBIS DE RACE BARBARINE EN TUNISIE

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Abstract–Résumé

EFFECT OF PROGESTERONE ON THE RAM-INDUCED CORPUS LUTEUM LIFE SPAN IN THE BARBARY EWE IN TUNISIA.

Ovulation is induced in seasonal anestrous Barbary ewes by using the "ram effect". Heats induced by this technique are distributed over 10 days (between day 13 and 23). The existence of short ovarian cycles following the induced ovulation is responsible for this dispertion of oestrus. The aim of this work is to improve the natural technique of the "male effect" by associating it to a progestative treatment leading to a better synchronization of heats.

Thirty adult Barbary ewes were distributed into 2 groups: 1) a control group ("ram effect"); and 2) a treated group ("ram effect + 20 mg of progesterone). The injection of progesterone did not affect the response to the "male effect" since all treated ewes ovulated during the first 4 days after the introduction of rams. Moreover, this treatment prevented the occurence of the short ovarian cycles. The preovulatory LH surge occured 20.5 ± 10.78 and 58.9 ± 10.10 hours after the introduction of males in the control and treated groups respectively. Thus progesterone delayed the preovulatory surge of LH. This result suggests that this hormone induces normality of corpora lutes by lengthening the period of gonadotrophin priming of follicules before ovulation, or progesterone may affect the preovulatory follicles directly. Moreover, the effect of treatment on the distribution of oestrus was effective. The heats were synchronized during 3 days (between days 17 and 20 after the introduction of males) . Even though this distribution was dispersed in the control group (between days 14 and 23).

EFFETS DE LA PROGESTERONE SUR LA QUALITE DU CORPS JAUNE INDUIT PAR L'EFFET MALE CHEZ LA BREBIS DE RACE BARBARINE EN TUNISIE.

L'ovulation peut être induite chez les brebis Barbarines en anoestrus saisonnier en utilisant l'"effet bélier". Les chaleurs déclenchées par cet effet sont réparties sur 10 jours (entre J13 et J23). L'existence de cycles courts qui suivent l'ovulation induite est responsable de cette dispersion de l'oestrus. Ce travail vise à améliorer la technique naturelle de l'"effet mâle" en lui associant un traitement progestatif qui permet une synchronisation plus groupée des chaleurs. Pour ce faire, 30 brebis de race Barbarine sont réparties en deux lots: 1) 1 lot témoin ("effet mâle"); et 2) 1 lot traité ("effect mâle" + 20 mg de progestérone).

L'injection de progestérone n'affecte pas la réponse à l'"effet mâle", puisque toutes les brebis traitées ovulent au cours des 4 premiers jours suivant l'introduction des béliers. Par ailleurs, ce traitement empêche l'apparition des cycles ovariens de courte durée. L'apparition du pic préovulatoire de LH a lieu 20,5 ± 10,78 et 58,9 ± 10,10 heures après l'introduction des mâles dans les lots témoin et traité respectivement. Le moment d'apparition du pic se trouve décalé par l'injection de progestérone. Ce résultat montre que celle-ci pourrait agir en allongeant le temps d'action des hormones gonadotropes sur les follicules avant l'ovulation, ou en agissant directement sur les follicules préovulatoires. Par ailleurs, l'effet du traitement sur le groupement des oestrus est efficace. En effet, les chaleurs se trouvent groupées en 3 jours (entre le 17^{eme} et le 20^{eme} jour après l'introduction des béliers), alors que la répartition des chaleurs est plus dispersée dans le lot témoin où l'oestrus apparaît entre le 14^{eme} et le 23^{eme} jour.

1. INTRODUCTION

Pendant l'anoestrus saisonnier des brebis de race Barbarine, l'ovulation induite par l'introduction des béliers dans le troupeau, n'est généralement pas accompagnée d'oestrus. "L'effet bélier" est particulièrement intéressant dans les pays méditerranéens où l'obtention de gestations à contre saison (printemps) est souhaitée.

Une très grande proportion de brebis ovulent en réponse à l'"effet bélier" [1]. La première ovulation est le plus souvent non accompagnée de chaleurs et aboutit à la formation d'un corps jaune normal ou régressant après 5 à 6 jours [1, 2, 3].

Les brebis ayant une fonction lutéale de durée normale manifestent un premier comportement d'oestrus à leur deuxième ovulation, environ 17 jours après l'introduction des mâles. Les corps jaunes à courte durée de vie persistent pendant 5 à 7 jours, ils sont suivis de corps jaunes normaux et l'oestrus n'apparaît donc que 24 jours environ après l'introduction des béliers [1, 3]. Des travaux étrangers, effectués sur d'autres races [4, 5] ont montré qu'une simple injection intra-musculaire de 20 mg de progestérone administrée lors de l'introduction de béliers, induisait des oestrus fertiles, synchronisés.

Le but de ce travail est d'étudier l'effet d'un prétraitement des brebis de race Barbarine à l'aide de progestérone sur le moment d'apparition du pic préovulatoire de LH (Luteinizing Hormone) et sur la durée de leur premier cycle ovarien, induit par l'"effet mâle".

2. MATERIEL ET METHODES

L'expérience est réalisée à la station expérimentale de Bou-Rébiâa appartenant à l'INRAT. Cette station est située à 25 km de Tunis, à une latitude de 36° 38' Nord et une longitude de 10° 7' Est.

2.1. Animaux

Trente brebis adultes de race Barbarine âgées de 3 à 7 ans et ayant un poids moyen de 41,5 kg sont isolées du troupeau 1 jour avant l'introduction des béliers, à la suite d'une endoscopie montrant leur état d'anoestrus saisonnier. Ces femelles sont réparties en deux lots égaux: un lot témoin et un lot traité avec 20 mg de progestérone à J0 (jour de mise en présence des mâles). Juste avant l'introduction des béliers, les 15 brebis du lot traité subissent une injection intramusculaire de 20 mg de progestérone diluée dans de l'huile d'olive neutralisée. Le lot témoin ne reçoit rien. Les mâles sont ensuite introduits dans les deux lots à raison d'un bélier pour 10 femelles (le 9 mai).

2.2. Endoscopies

Les endoscopies sont réalisées selon la méthode décrite par Thimonier et Mauléon [6] sans anesthésier les animaux. Cet examen des ovaires est effectué pour chaque brebis à:

- J-1, pour éliminer les brebis cyclées,
- J+4, pour éliminer les brebis qui n'ont pas ovulé en réponse à l'effet mâle,
- J+9, pour déceler les corps jaunes qui regressent prématurément,
- une autre endoscopie est réalisée 8 à 12 jours après l'oestrus.

2.3. Contrôle de l'oestrus

Le contrôle des chaleurs est effectué deux fois par jour, matin et soir, à l'aide de béliers entiers, selon la méthode décrite par Mauléon et Dauzier [7].

2.4. Prélèvements de sang

Tous les échantillons de sang sont prélevés dans la veine jugulaire dans des tubes vacutainers héparinés. Ils sont centrifugés et les plasmas sont conservés à -18°C jusqu'au moment des dosages de la progestérone et de la LH. Pour le dosage de la progestérone le sang est prélevé une fois par jour, à la même heure, pendant 8 jours à partir de J-1. En ce qui concerne le dosage de la LH, les prélèvements de sang débutent juste avant l'introduction des mâles et se poursuivent toutes les 4 heures, pendant 72 heures.

2.5. Dosage des hormones

La progestérone est dosée par la méthode radioimmunologique, le matériel étant fourni par l'Agence Internationale de l'Energie Atomique. Le dosage est effectué en phase solide; l'hormone est marquée à l'iode 125. Le compteur utilisé est du type gamma. Les coffrets contiennent des valeurs standards comprises entre 0,1 et 12,58 ng/ml. Le dosage est effectué sur une prise aliquote de 100 μl de plasma.

La LH est dosée par radioimunologie [8]. Les analyses sont effectuées au laboratoire des dosages d'hormones, à la Station de Physiologie de la Reproduction de Nouzilly (INRA-France). La concentration est exprimée en ng/ml de plasma.

2.6. Analyse statistique

La comparaison des deux lots est effectuée par une analyse de variance (moment d'apparition du pic préovulatoire de LH) et par un test chi^2 (durée des cycles ovariens et distribution des chaleurs).

3. RESULTATS

3.1. *Intensité de l'anoestrus saisonnier*

L'intensité de l'anoestrus saisonnier peut être appréciée par le pourcentage de brebis ovulant spontanément avant l'introduction des béliers. Ce pourcentage est de 46. En effet, sur un total de 94 brébis à J-1, 44 d'entre elles avaient une activité ovarienne spontanée.

Sur les 30 brebis non cyclées, réparties en deux lots, une seule femelle appartenant au lot témoin, n'a pas ovulé à la suite de leur mise en présence des mâles. Le traitement n'a donc aucun effet sur la proportion des femelles répondant à l'"effet mâle" (Tableau I).

Dans le lot témoin, la moitié des brebis ayant répondu à l'"effet bélier" présentent des corps jaunes qui régressent prématurément, la durée du premier cycle ovarien étant de 5 ± 1,3 jours dans ce cas. Cette durée est normale (15 ± 1,2 jours), pour l'autre moitié. En revanche, le traitement par la progestérone donne 100% de cycles de durée normale (17 ± 1,3 jours). La différence entre les deux lots est hautement significative ($P < 0,001$). Le traitement progestatif élimine donc totalement les cycles ovariens de courte durée.

TABLEAU I. NOMBRE DE BREBIS AYANT OVULE APRES LEUR MISE EN PRESENCE DES BELIERS ET POURCENTAGE DES CYCLES COURTS INDUITS

Lots	Nombre de femelles	Nombre de brebis ovulant après l'introduction des mâles	Nombre de brebis ayant présenté un cycle court induit	% des cycles courts
Témoin	15	14	7	50
Traité 20 mg de P4	15	15	0	0

3.2. Apparition de l'oestrus

La figure 1 montre la distribution de l'apparition de l'oestrus chez les femelles des deux lots. La répartition des chaleurs au cours des 23 jours qui suivent l'introduction des mâles est signiticativement ($P<0,001$) différente dans les deux lots. En effet, dans le lot de brebis traitées à l'aide de la progestérone,

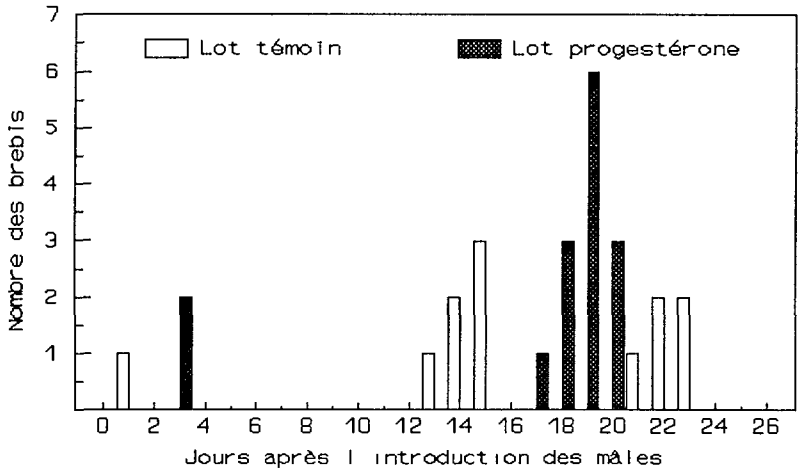

Fig. 1. Distribution des chaleurs.

les chaleurs sont groupées entre le 17eme et le 20eme jours après l'introduction des mâles, avec un pic au 19eme jour. L'ovulation induite, qui est généralement sans manifestations oestrales, est accompagnée de chaleurs chez seulement 2 brebis de ce lot.

En revanche, dans le lot témoin, les chaleurs sont beaucoup moins synchronisées. Elles apparaissent entre le 14eme et le 16eme jours pour 6 brebis, soit 43,8%, et entre le 20eme et le 23eme jours pour 7 brebis, soit 50%. Dans ce lot, l'ovulation induite est accompagnée de chaleurs chez une seule brebis. Cette répartition s'explique par l'existence des cycles ovariens de courte durée.

3.3. Concentration de la progestérone plasmatique

L'évolution du taux de progestérone dans la veine jugulaire des brebis est représentée sur la figure 2. Le taux de progestérone des brebis ayant des corps jaunes induits normaux augmente jusqu'à 2,02 et 1,39 ng/ml dans les lots témoin et traité, respectivement. En revanche, la valeur maximale atteinte à J+4 pour

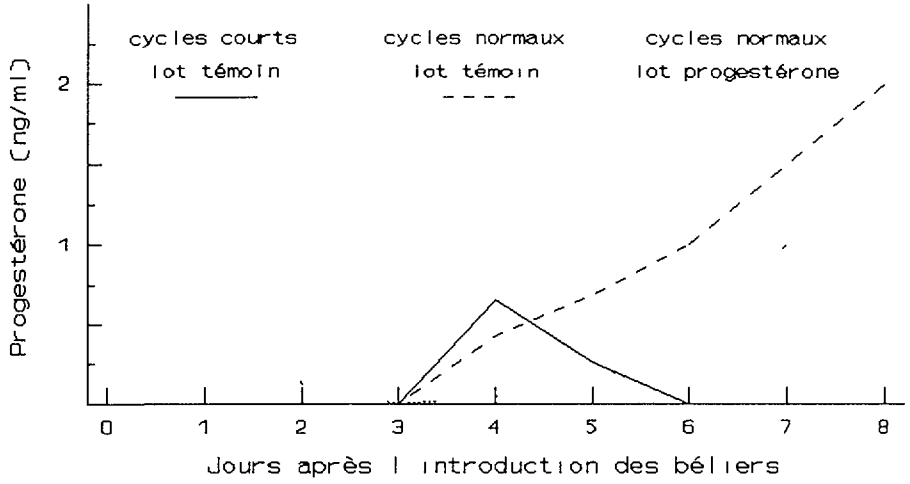

Fig. 2. Evolution de la progesterone plasmatique chez les brebis en anoestrus avant l'introduction des beliers.

les brebis ayant un corps jaune anormal n'est que de 0,43 ng/ml; elle décroît jusqu'à zéro à J+7. Ceci indique que la durée de vie du corps jaune anormal est de 5 à 6 jours. Le taux élevé de progestérone observé à J+1 dans le lot traité est dû à l'injection des 20 mg de progestérone le jour de l'introduction des béliers.

3.4. Le pic préovulatoire de LH

Le moment d'apparition du pic préovulatoire de la LH est défini comme étant le 1er temps où la concentration de LH s'élève et se maintient à un niveau supérieur à 10 ng/ml en deux points successifs à partir de l'introduction des mâles.

Le délai moyen d'apparition de ce pic est de 21 ± 10,8 heures après l'introduction des béliers pour le lot témoin. L'intervalle introduction des mâles - apparition du pic préovulatoire de LH est nettement plus long pour le lot traité par la progestérone ($P<0,001$), il est alors estimé à 58,9 ± 10,1 heures.

Dans le lot témoin, les femelles ayant des corps jaunes anormaux (cycles induits de courte durée) présentent un délai moyen d'apparition du pic préovulatoire de LH de 17 ± 8,2 heures après l'introduction des béliers. En revanche, pour les brebis à cycle normal, ce délai se trouve augmenté à 24 ± 12,6 heures. La différence entre les deux catégories de femelles n'est cependant pas statistiquement significative.

4. DISCUSSION

Les résultats de cette expérience montrent qu'une injection d'une dose de 20 mg de progestérone, juste avant l'introduction des mâles dans un troupeau de femelles en anoestrus saisonnier, permet de prévenir l'apparition des cycles ovariens de courte durée. Il est établi qu'un traitement progestatif à l'aide d'éponges vaginales imprégnées de FGA permet d'éliminer les cycles courts et d'avoir des ovulations induites accompagnées d'un comportement d'oestrus [9]. Une stimulation par la progestérone avant l'ovulation serait donc suffisante pour assurer un rétablissement normal de l'activité ovarienne induite par l'"effet mâle". Le problème semble, dans le cas des cycles courts, être d'origine ovarienne (développement folliculaire insuffisant ou phase folliculaire induite par l'"effet mâle" de trop courte durée).

Le pic préovulatoire de LH apparaît 21 heures après le moment d'introduction des béliers pour le lot témoin, et après 59 heures pour le lot traité avec la progestérone. Celle-ci retarde donc l'apparition du pic préovulatoire de LH; ce résultat est en accord avec celui de Martin et col. [10]. Ce retard permet d'allonger le temps d'exposition des follicules aux hormones gonadotropes hypophysaires, et aboutit à la formation de follicules mûrs au moment de l'ovulation. McLeod et col. [11,12], et McNeilly et col. [13] arrivent à la même conclusion. McLeod et col. [11,12] induisent des corps jaunes normaux chez seulement 5 brebis sur 19. Ces brebis avaient présenté un pic préovulatoire de LH 20 heures après une injection de GnRH. En revanche, tous les corps jaunes ont une durée de vie normale quand les pics sont retardés par un traitement progestatif.

Cognie et col. [4] montrent qu'en utilisant des doses inférieures à 20 mg de progestérone, les cycles courts sont maintenus. La plus faible dose nécessaire et suffisante est donc de 20 mg de progestérone par brebis.

McLeod et Haresign [14] émettent l'hypothèse que la progestérone peut agir directement sur le développement des follicules préovulatoires ou indirectement en modifiant les sécrétions endogènes des hormones gonadotropes ou retardant le "rétro-contrôle" positif de l'oestradiol.

D'autre part, les corps jaunes de courte durée de vie ne sécrètent pas des taux élevés de progestérone. Ceci malgré leur apparence tout à fait normale dès le 4eme jour suivant l'introduction des béliers. Ces résultats sont en accord avec ceux de Knight et col. [15], Southee et col. [16] et Chemineau [17].

5. CONCLUSION

Les résultats de cette étude montrent qu'un traitement progestatif (20 mg de progestérone), par voie intramusculaire, associé à l'"effet mâle", pendant la saison d'anoestrus chez la Brebis Barbarine, permet d'induire et de grouper d'une manière sensible l'oestrus pour la totalité des femelles. Cette méthode s'avère pratique et peu onéreuse par rapport aux techniques hormonales plus complexes. L'élimination des cycles ovariens de courte durée semble être en liaison étroite avec le retard du moment d'apparition du pic préovulatoire de LH consécutif à l'utilisation de la progestérone.

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REPRODUCTIVE PERFORMANCE OF ZAMBIAN GOATS UNDER DROUGHT CONDITIONS

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Abstract–Résumé

REPRODUCTIVE PERFORMANCE OF ZAMBIAN GOATS UNDER DROUGHT CONDITIONS

Goats play a very important role in integrated farming in Zambia Two surveys of husbandry practices in Gwembe Valley and Siavonga District, Southern Province, were carried out Herd sizes varied from 3 to 300 goats with a buck doe ratio of 1 18

In two separate experiments, serum progesterone levels were measured in goats on-station to determine the duration of the oestrous cycle This duration varied between 10 and 26 days The average duration of the oestrous cycle was 17 6 and 19 8 days in the first and second experiment respectively

A survey including over 60 goats belonging to 10 farmers in Lusitu, Siavonga District, is being undertaken The region has suffered a severe drought, but the goats have showed no loss in weight and have maintained total serum protein and blood cell levels

PERFORMANCE DE REPRODUCTION DES CHEVRES DANS DES CONDITIONS DE SECHERESSE EN ZAMBIE

Les chèvres jouent un rôle très important dans les exploitations de polyculture-élevage en Zambie Deux enquêtes ont été effectuées sur les pratiques d'élevage de la vallée de Gwembe et du district de Siavonga (Province du Sud) La taille des troupeaux varie entre trois et 300 chèvres, avec un rapport mâles/femelles de 1 18

Lors de deux expériences distinctes, les taux de progestérone dans le sérum ont été mesurés sur des chèvres en station afin de déterminer la durée du cycle oestrien Cette durée variait entre dix et 26 jours Elle était en moyenne de 17,6 jours dans la première expérience et de 19,8 jours dans la seconde

Une enquête portant sur plus de 60 chèvres appartenant à dix agriculteurs de Lusitu, District de Siavonga, est en cours La région a subi une grave sécheresse, mais les chèvres n'ont pas perdu de poids et leurs teneurs en protéines du sérum et en globules se sont maintenues

1. INTRODUCTION

There is a growing appreciation of the importance of goats in small scale integrated farming systems in developing countries [1]. Goats have a number of beneficial characteristics which make them an extremely useful asset to a small farmer. They generally use feed not being utilized elsewhere, they have a short reproductive cycle with a high incidence of multiple births, and they are a convenient protein source coming in family-sized packages.

In Zambia there are about 500 000 goats, which are mainly kept under village-level management. However, a few commercial farms, keeping imported breeds, also exist. In certain areas, e.g. river valleys, goats are of particular importance due to their trypanotolerance.

Goat production is limited by environmental factors, nutrition, disease and reproductive performance. Efforts must therefore be made to identify and eliminate constraints that reduce the contribution of goats to the socio-economic development of small farmers.

Goat management is minimal, with the animals being allowed to browse freely during daylight hours. At night, the goats are confined within fences or huts, some with slatted floors through which the faeces can

fall. Zambian goats are remarkably healthy considering that they receive hardly any veterinary care. They are browsers, and during periods of drought their diet contains leaves of legumes [Lovelace and coworkers, unpublished observations] and they can maintain body weight when there is no grass for cattle.

Problems observed commonly in goats in Zambia include mange, ticks, gastrointestinal tract roundworms, pneumonia, heartwater, fascioliasis and foot rot [K.J. Stafford, personal communication].

This study was initiated to obtain some basic management and biological data about indigenous Zambian goats following preliminary studies by Quartermain [2]. In Quartermain's study data were collected on weights, kid growth rates, diet selection and nitrogen intake. It was concluded that goats have a low productivity and are a costless enterprise [2].

Our village study is now in progress, and involves sixty goats owned by ten farmers in five villages in the Siavonga district in the Zambezi Valley. The results of the first seven months are presented in this communication. The objective of the present investigation is to extend the preliminary work through evaluating the effects of season and management practices on goat productivity under village husbandry conditions.

2. MATERIALS AND METHODS

2.1. Survey

2.1.1. Sites

Two surveys were carried out in the Zambezi Valley, Southern Province, to look at goat characteristics, goat management and social background of the farmer, in order to evaluate the contribution of goats to the family activities of the area. Two areas of the Zambezi Valley were chosen: the Gwembe Valley, where the largest population of goats occurs, and Lusitu in the Siavonga area, where an additional field study is taking place (see section 2.5). A total of 36 questionnaires, 26 in Gwembe from 3 villages and 10 in Lusito from 5 villages, were filled in after consultation with farmers.

2.1.2. Climatic conditions

The climate of Zambia can be divided into three seasons, wet - warm (December - April), dry - cool (May - August) and dry - hot (September - November). However, in the year of the field study, (1991 - 1992), Zambia experienced the worst drought in 25 years. In Lusitu a total of 401 mm of rain fell between December 1991 - June 1992, compared with the usual 861 mm. This has led to a complete crop failure in the area studied.

2.2. Animals

All goats involved in the studies were typical of those from the Zambezi Valley in Southern Province and fell into the category of "Small East African" as described by Mason and Maule [5]. In the villages the goats were left under management of the farmer owner, whereas they were kept in enclosed pens for the nutrition study on-station and on grass paddocks for the other studies. In the pens they were fed hay plus supplement and cleaned out daily.

2.3. Measurements

2.3.1. Weight determination

In the first survey, weight was estimated using heart girth measurement, and the formula: weight of goat = 0.89 (heart girth in cm) - 33.78 [J.C.N. Lungu, unpublished work]. In other experiments goats were weighed suspended on a hanging scale.

2.3.2. Body condition score

Body Condition Score (BCS) was measured using the method recommended by Honhold *et al.* [4] which was calibrated on Zimbabwean goats using the muscle mass on the lumbar vertebrae.

2.3.3. Blood collection

In the field survey, blood samples were collected by venipuncture from the jugular vein using vacutainer tubes. One sample (5 ml) was collected into plain tubes for biochemical analysis, another sample (2 ml) was collected into EDTA tubes for haematology. In the oestrous cycle study, one sample (5 ml) was collected into heparinized tubes for the assay of progesterone.

2.3.4. Progesterone measurement

An ELISA developed at the University of Galway [5], using donkey anti-rabbit antiserum, progesterone-horse radish peroxidase conjugate and o-phenylenediamene substrate was used.

For the Radio-immunoassay (RIA) FAO/IAEA RIA kits were used. These kits use ^{125}I-labelled progesterone as a tracer. This RIA involves competition between labelled an unlabelled progesterone for binding sites on a solid phase, i.e. the inside wall of a polypropylene tube. The counts per minute (C.P.M.) of the tubes were determined using a Mini-Instruments Type 6-90, single well gamma counter.

2.3.5. Haematological studies

Blood samples were mixed, and a cell counter (Baker 100 Series, Model 130) used to measure haemoglobin concentration, red blood cell and white blood cell count. Packed Cell Volume was measured using a haematocrit centrifuge.

2.3.6. Biochemical studies

Blood was left to clot and the serum was removed after centrifugation. Total serum protein was estimated using the Biuret method [6].

2.4. Studies on length of oestrous cycles and level of progesterone

Two studies were carried out on-station. In the first study 11 goats were synchronized using prostaglandin PGF2α and blood samples were collected in heparinized tubes every second day for 50 days following synchronization. The plasma progesterone levels were measured using ELISA.

In the second experiment, 17 non-synchronized goats were allowed to run with two bucks and blood sampled every second day for 120 days. In this study plasma progesterone was measured using RIA.

2.5. Village study on the productivity of village goats

Sixty female goats of reproductive age were selected belonging to 10 farmers in Lusitu, Siavonga area of the Zambezi Valley. The goats were left to browse all day, and were confined at night. Once a month, the body condition score was measured, the weight was taken and blood samples for serum and haematology were collected.

Twice a month, blood samples were collected in plain vacutainers for the assay of progesterone. The serum was placed in a paraffin freezer until transport to the RIA laboratory. New kids were weighed and ear tagged during monthly visits by the project staff.

The survey was started in November 1991, but full sampling commenced only in December 1991. Results collected during the first 7 months (i.e. December 1991 through June 1992), are presented in this communication.

3. RESULTS

3.1. Survey of farmers

3.1.1. Husbandry Practices

The herd size of goats in households interviewed varied from 30 to 300 animals. All farmers had poultry, with some farmers having guinea-fowl, as well as cattle, sheep and pigs. Goats are given minimum attention and no veterinary care. The goats are left to browse during the day and are only herded in the rainy season to prevent damage to crops. No restriction to breeding is practised. At night the animals are enclosed, less than half having a full shelter. Goats are slaughtered for meat and traditional ceremonies, while their products of milk, manure and skins are also used. Table I shows some additional results from the Gwembe Valley Survey.

The age of the female goat is on average 3-4 years. Males average less than 2 years, as they are sold at an early age. The herds are composed of 75% females, with a mean buck: doe ratio of 1:18 in Gwembe, and 1:18.5 in Lusitu. Some farmers have no bucks.

TABLE I. CHARACTERISTICS OF GOATS IN THE ZAMBEZI VALLEY

Location	Mean No. of Goats/House	Total No. of Goats	Sex	Age (years) $\bar{x}$ ± sd	Weight* (kg) $\bar{x}$ ± sd	Height at Withers (cm) $\bar{x}$ ± sd
Sinazeze	13.2	132	F	3.3 ± 1.3	32.0 ± 4.5	58.8 ± 5.5
			M	1.4 ± 0.7	21.1 ± 7.9	53.1 ± 9.0
Sinazongwe	117.8	707	F	2.3 ± 0.9	30.0 ± 5.2	54.5 ± 4.6
			M	1.8 ± 0.9	28.9 ± 9.1	57.0 ± 7.7
Mwezia	22.4	224	F	3.0 ± 1.5	29.9 ± 5.3	56.5 ± 4.5
			M	1.3 ± 0.7	18.3 ± 7.6	50.6 ± 7.9
Overall Means			F	2.9 ± 1.3	30.6 ± 4.5	56.8 ± 5.1
			M	1.5 ± 0.8	22.8 ± 9.1	53.6 ± 8.4

* The predicted weight was determined by the prediction Weight (kg) = 0.89 x {Heart girth,(cm)} - 33.78

3.2. Oestrous cycle length

In the first study the duration of the oestrous cycle ranged between 10 and 26 days. The mean oestrous cycle length of the 2 cycles observed on progesterone profiles was 17.6 ± 5.3 ($\bar{x}$ ± sd) days. The mean concentration of progesterone at mid-luteal phase was 24.2 ± 6.0 nmol/l compared with 3.5 ± 1.0 nmol/l at second oestrus. The progesterone concentration at oestrus directly after synchronisation was very low with a mean of 0.2 nmol/l and was not considered typical.

Seventeen goats in the second study showed an oestrous cycle length averaging 19.8 ± 5.0 days, with serum progesterone values that were very similar to those obtained in the first study.

Serum progesterone concentrations above 3.5 nmol/l were thought to indicate the presence of a corpus luteum, whereas levels of serum progesterone below 3.5 nmol/l were thought to indicate a follicular phase or acyclicity.

3.3. Village Study of goat productivity in Lusitu

3.3.1. Weight, body condition score, haematology and total serum protein

Table II shows the means and range of all parameters studied. Each month samples were taken from an average of 60 goats. However, each time a few goats were missing and could not be sampled. The goats did not lose weight during the period studied (Table III) and the mean weight increased during the period under study. The weight increase in May and June may have been be influenced by pregnancies.

The body condition scores remained constant, and at a medium value. The haematology data showed lower red blood cell (RBC) values in February but white blood cell count (WBC) was higher in December and January, than during the other months.

TABLE II. BIOCHEMICAL PARAMETERS OF ADULT FEMALE ZAMBIAN GOATS IN LUSITU DECEMBER 1991 - JUNE 1992

Parameter	$\bar{x}$ ± sd	Range
Age (years)	3.5 ± 1.2	1.0 - 6.0
Weight (kg)	26.8 ± 4.6	13.2 - 40.8
Body condition score	2.0	1.0 - 4.0
Total serum protein (g/100 ml)	7.8 ± 0.8	5.8 - 11.6
Red Blood Cell Count ($x10^6/mm^3$)	12.7 ± 3.2	6.3 - 29.7
Haemoglobin (g/100 ml)	10.5 ± 1.3	6.5 - 14.0
White Blood Cell Count ($x10^3/mm^3$)	16.6 ± 6.4	4.0 - 52.0
Packed Cell Volume (%)	33.8 ± 4.4	20.0 - 50.0

3.3.2. Kiddings and mortality

No female adults were lost due to disease. Two adult females were lost due to poaching. Thirty two kids were born during the study; they had an average weight of 3.5 kg two weeks after birth. Two peaks of kidding were observed, one in March and one in June - July (Figure 1). At the end of the reported study

TABLE III. BIOCHEMICAL PARAMETERS OVER MONTHS OF DROUGHT IN LUSITU

Month	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Estimate of population sd
Weight (kg)	23.9	26.2	26.7	26.1	27.3	27.7	28.8	4.38
Total Serum Protein (g/100 ml)	8.5	7.3	7.7	8.0	7.3	7.9	-	0.70
RBC ($x10^6/mm^3$)	13.3	10.5	8.1	15.1	14.4	14.0	14.0	2.38
WBC ($x10^3/mm^3$	20.0	23.1	18.5	15.2	13.7	12.9	12.9	5.28
Hb (g/100 ml)	10.7	10.4	10.1	10.6	10.5	9.5	9.5	1.13
PCV (%)	30.8	33.3	31.0	34.2	34.8	35.5	35.4	3.99

Differences between months were highly significant ($P < 0.001$) for all parameters.

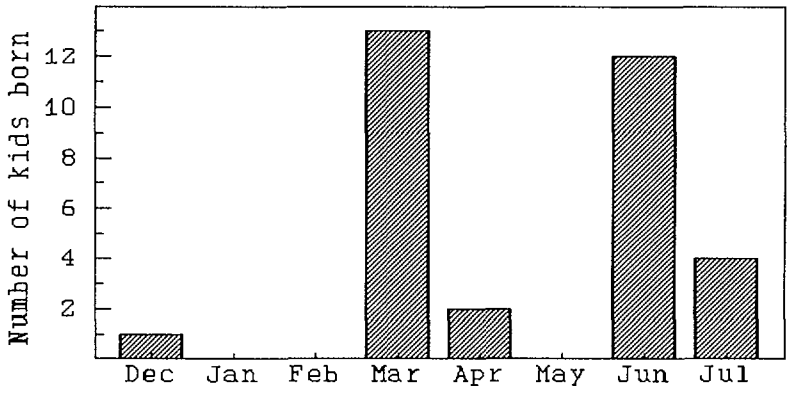

Fig. 1. Number of kids born each month in Lusitu area, Zambia.

19 out of the 60 goats involved in the experiment were pregnant. An approximate average kidding interval was estimated using the formula:

$$\frac{\textit{Total number of days all animals in survey}}{\textit{Total number of kiddings}}$$

The duration of this interval was found to be 492 days. This value is preliminary, as the study has not yet covered a whole year, and many goats were pregnant at the end of the reported period (July).

4. DISCUSSION

Goat management in the Zambezi Valley was observed to be simple Goats are given minimum attention and their good survival rate as adults is due to their adaptation to their environment and their discerning choice of browse plants. Quartermain [2] reported an average weight of 24 kg for females in both wet and dry seasons, which is similar to those reported here of 31 kg in Gwembe and 27 kg in Lusitu.

The oestrous cycles measured in our small study had an average duration of 18 days. The levels of plasma progesterone of 3.5 ± 1.0 nmol/l and 24 ± 6 nmol/l during the follicular phase and mid-cycle respectively, agree reasonably with other observations [7, 8]. The mid-cycle figure is lower than that quoted

for Saanen does of 42.6 nmol/l [7], but this discrepancy might represent differences in methodology rather than biology.

It is concluded that progesterone measurement can be used reliably for the determination of pregnancy in goats. However, several workers have pointed out the difficulties of early pregnancy diagnosis in goats, as problems of anoestrus, short oestrous cycles, prolonged follicular and luteal phases can complicate this [7, 8].

The haematology results showed that the goats appeared to maintain reasonable red blood cell levels throughout pregnancy. The mean level of 12.7 x 10^6 RBC/μl in this experiment falls below the range of reported values for Nigerian goats [9] but was comparable with values of Zambian goats from Luangwa District measured in our laboratory. The mean serum protein levels were very similar to those from goats in the Luangwa District, with a mean 7.8 g/dl. Even on a low protein diet, total protein and albumin can remain fairly constant, and it is reported that there is a time lag of approximately two months before nutritional changes are reflected by changes in blood proteins [10].

Our village study showed that the reproductively mature females did not lose weight during the seven months studied, even under severe drought conditions. Studies in Zimbabwe indicated that goats have very low maintenance requirements [11]. Hence, severe drought resulting in poor availability of feed do not directly lead to weight losses. Selection of browse is probably the most important factor in successful survival under these harsh conditions. Our previous studies in Luangwa, further down the Zambezi Valley, indicated that goats chose particular shrubs when no grass was available, which included several tree legumes. Other studies in Gwembe District [2] indicate that the main rainy season feeds are annual grasses, but shrubs and fallen seed pods are used in the dry season, and studies in Tanzania indicate goats prefer bushes [12].

Previous studies in Gwembe reported that kids are born at all times of the year [2]. However, in Zimbabwe two peak seasons, April and July, are reported [12]. Our results so far indicate a peak of kidding in March and in June through August. Kyomo [13] suggests that does conceive better in a good rainy season so the severe drought during the initial stages of this investigation may have depressed kidding in the later stages.

None of the adult goats in our survey died from disease during the study. Helminths can be a major cause of loss of productivity, but their prevalence is much reduced in a drought year. The total serum protein and the haematology levels are lowered by helminths, but the levels recorded in the study were not low and agreed with results in our earlier Luangwa study and other workers [14]. Furthermore, as these levels did not show a significant drop, it appears that protein and blood cell levels can be maintained on limited diets.

Kid mortality was reported by Quartermain [2] as being 21% and in Zimbabwe as 35% up to 150 days old [11]. Our study is now being extended to look at ways of increasing kid survival. The mothers will be supplemented during the month before and after parturition. The supplement is being made of locally available materials not needed for other uses, i.e. maize and sunflower cake.

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ETUDE DE L'ACTIVITE OVARIENNE CYCLIQUE CHEZ LES GENISSES PREPUBERES ET CHEZ LES VACHES EN POSTPARTUM DE RACE ZEBU GOBRA AU SENEGAL

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Abstract–Résumé

STUDIES ON CYCLIC OVARIAN ACTIVITY IN PRE-PUBERAL HEIFERS AND POST-PARTUM COWS OF THE GOBRA ZEBU BREED IN SENEGAL.

The objective of this study was to determine the age at the onset of puberty in heifers, and the resumption of ovarian activity post-partum in cows of the Gobra Zebu breed. The study was conducted at the Centre de Recherches Zootechniques (CRZ) in Dahra. The CRZ is located in the sylvo-pastoral zone of Senegal. The female offspring were kept with their mothers until weaning at an age of 7 months. After this age they were grazed on natural pasture with ad-libitum watering. The heifers and cows were monitored for 14 and 4 months respectively. This monitoring included the detection oestrous behaviour, weighing, and RIA of progesterone in blood plasma.

The heifers showed an average daily weight gain of 418 and 235 g/d prior to and after weaning respectively. At an age of 14 months, 17 of the 21 heifers had shown signs of oestrous behaviour at least once. The average age at first plasma progesterone rise was 413 ± 64 days ($\overline{X}$ ± sem) with an average body weight of 176 ± 22.2 kg. This age is correlated with the body weight at weaning.

In cows the resumption of ovarian activity post-partum proceeded progressively. Based on heat observations, 4 and 6 out of 13 cows resumed ovarian activity 50 and 60 days post-partum respectively. Based on plasma progesterone levels, resumption of ovarian activity occurred between 36 and 48 days post-partum in 7 out of the 13 animals. Other data collected showed that Gobra Zebu cattle have a late age at first calving (51 months) and long calving intervals (430 to 530 days).

This study shows that the Zebu Gobra can commence cyclic ovarian activity at an early age, and that the duration of post-partum acyclicity can be short. This allows the development of strategies to improve the productivity of Zebu Gobra cattle.

ETUDE DE L'ACTIVITE OVARIENNE CYCLIQUE CHEZ LES GENISSES PREPUBERES ET CHEZ LES VACHES EN POSTPARTUM DE RACE ZEBU GOBRA AU SENEGAL.

L'élevage du Zébu Gobra, en ferme, en zone sylvo-pastorale révèle des âges tardifs au 1er vêlage (51 mois) et des intervalles entre mises bas relativement longs (430 à 530 jours). La présente étude se rapportant à 21 génisses et 13 vaches de race Zébu Gobra a été menée au CRZ de Dahra dans le but de déterminer en station, l'âge d'apparition de la cyclicité chez la génisse ainsi que sa régularité et le délai de reprise de l'activité cyclique après le vêlage. Les jeunes femelles sont maintenues avec leur mère jusqu'au sevrage (7 mois); après cet âge elles sont, comme les vaches, entretenues sur parcours naturels avec un abreuvement à volonté. Les génisses ont présenté des GMQ, avant et après sevrage, respectivement de 418 et 235 g/J.

Les observations ont duré 14 et 4 mois respectivement chez les génisses et les vaches; elles ont porté sur le suivi des modifications du comportement et du niveau de la progestérone plasmatique. Globalement, chez les génisses, 81% (17/21) des animaux ont manifesté au moins une fois des signes d'activité sexuelle pendant les 14 premiers mois d'âge. L'âge moyen d'apparition de la 1ère élévation du niveau de progestérone est de 413 ± 64 jours pour un poids moyen de 176 ± 22,2 kg. Cet âge est corrélé avec le poids au sevrage. Chez les vaches, la reprise de l'activité sexuelle après le vêlage s'est faite de façon progressive; le taux de reprise, selon l'observation des chaleurs, est passé de 30% au 50e jour à 46% au 62e jour. Selon la progestéronemie, la reprise a été effective entre les 36e et 48e jours pour 7 femelles parmi les 13 (54%).

Ces résultats, en mettant en évidence chez le Zébu Gobra un âge relativement précoce des premières ovulations pour les génisses, et des délais courts de reprise de l'activité ovairienne après des vêlages de saison post-hivernale, chez la vache, permettent d'établir des stratégies d'amélioration de la productivité numérique du cheptel Zébu Gobra.

1. INTRODUCTION

Le Zébu Gobra, élevé pour le lait (autoconsommé), assure avec le taurin Ndama et le métis Djakoré, 5,5 kg de viande par habitant et par an.

Son aire d'exploitation se situe en zone dite sylvo-pastorale, comprise entre les 12° et 16° de longitude Ouest et les 13°5 de latitude Nord. Elle représente la zone d'élevage la plus importante du Sénégal avec un effectif bovin estimé à 54% du cheptel bovin national (2 200 000 têtes).

L'élevage y est de type extensif. Le pâturage y constitue la base essentielle de l'alimentation et, pendant la saison sèche, les animaux sont obligés de parcourir de longues distances en quête de pâturages.

Les résultats des suivis en système d'élevage traditionnel dans cette zone, mettent en évidence une reproduction insuffisante. Les âges assez tardifs au 1er vêlage sont de l'ordre de 51 mois [1, 2] et les intervalles entre vêlages sont de 550 jours.

Quoique meilleures en station, ces performances sont encore peu compatibles avec l'exploitation plus intense de ces animaux dans un tel milieu; ainsi leur âge moyen au 1er vêlage et les intervalles entre vêlages sont respectivement de 45 mois et 430 jours [3].

Ce taux de reproduction insuffisant résulte d'une part, chez la génisse, d'un déclenchement tardif de la cyclicité ou d'une irrégularité de celle-ci et d'autre part, chez la vache, d'une longue période avant la reprise de la cyclicité après le vêlage. L'amélioration des conditions d'élevage doit pouvoir réduire l'intervalle "mise bas - cyclicité" et améliorer la précocité sexuelle de la femelle Zébu Gobra.

Le but de cette étude est de déterminer dans des conditions d'élevage en station:

- l'âge d'apparition de la cyclicité chez la génisse et sa régularité,
- le délai de la reprise de l'activité cyclique après le vêlage.

2. MATERIEL ET METHODE

2.1. Le milieu

L'étude a pour cadre le Centre de Recherches Zootechniques de Dahra, situé en zone sylvo-pastorale, entre la latitude 19°23 Nord et la longitude 15°30 Ouest. Le climat y est du type sahélo-continental avec une température moyenne annuelle de 28°C. Il comporte quatre saisons:

- L'hivernage ou saison des pluies: juillet à septembre,
- Le post-hivernage ou saison des récoltes: octobre à novembre,
- La saison sèche froide: décembre à février.
- La saison sèche chaude: mars à juin.

La végétation, base essentielle de l'alimentation du bétail, est composée de graminées (*Cenchrus eragrostis, Schoenefeldia, Pennisetum...*), de légumineuses (*Zornia glochidiata, Alysicarpus...*), d'autres espèces herbacées (*Tribulus, Borreria*) et de ligneux (*Acacia, Pterocarpus, Combretum, Balanites*).

Son installation et son développement sont fortement tributaires des pluies, et elle peut assurer des niveaux de productivité en matière sèche variant de 100 à 1500 voire 2000 kg/ha [4].

Les observations, commencées en 1988, se sont poursuivies en 1989 et 1990. Les hauteurs d'eau enregistrées pour ces années sont respectivement de 424,9 mm, 548,7 mm en 30 jours et de 230 mm en 21 jours de pluies.

2.2. Les animaux

Les animaux utilisés sont des génisses et des vaches de race Zébu Gobra.

Les jeunes femelles, au nombre de 21, sont nées aux mois de septembre et octobre, avec un poids moyen à la naissance de 27 kg.

Les vaches, au nombre de 13, ont été choisies parmi celles qui ont vêlé au mois d'octobre, et sont réparties comme suit:

- 3 primipares,
- 6 multipares: 2 à 3 vêlages,
- 4 multipares: 4 vêlages et plus.

2.3. Méthode

2.3.1. Conditions d'entretien des animaux et contrôle de performance

Les jeunes femelles sont maintenues avec leur mère jusqu'au sevrage fixé entre 6 à 7 mois. Après cet âge, elles sont, comme les vaches, entretenues sur parcours naturels avec un abreuvement à volonté et font l'objet d'un suivi sanitaire (vaccination contre la peste bovine, la péripneumonie contagieuse bovine, le botulisme et déparasitage interne systématique).

Les génisses ont été pesées tous les mois. Les produits des vaches sont pesés aussi tous les mois et leur croissance de la naissance à trois mois, permet d'estimer indirectement les capacités laitières des mères [5].

2.3.2. Protocole expérimental

Les observations sur les génisses ont débuté à leur sevrage, elles portent sur une période de 14 mois. Celles se rapportant aux vaches ont été commencées une semaine après le vêlage, elles durent 4 mois (post-hivernage et saison sèche fraîche).

Elles comportent:

- Un suivi des modifications comportementales par détection des chaleurs, deux fois par jour (8 h et 18 h), grâce à un taureau muni d'un harnais marqueur chez les génisses et par observation directe du berger chez les vaches. Les signes retenus sont: le chevauchement, les tentatives de saut par le taureau avec acceptation de la femelle;
- Un suivi de la concentration de progestérone plasmatique par des prises de sang hebdomadaires et dosage de la progestérone par la méthode radio-immunologique (RIA) préconisée par l'Agence Internationale pour l'Energie Atomique (AIEA).

Pour les prélèvements, le sang est recueilli au niveau de la veine jugulaire à l'aide d'un tube sous-vide (vacutainer) hépariné, soigneusement identifié (n° animal, date). Ensuite, le sang est centrifugé à 3 000 tours/mn pendant 10 mn, juste après le prélèvement. Le plasma est recueilli dans des conditions stériles dans des flacons en verre correctement identifiés (n° animal, date de prélèvement) pour être conservé dans un congélateur jusqu'au moment du transfert au laboratoire de la ferme de Sangalkam situé à 270 km de Dahra.

Conformément aux résultats obtenus par Mbaye et col., en 1990 [6], le taux de 0,80 ng/ml a été retenu comme révélateur de l'initiation d'une activité ovarienne.

2.3.3. Analyse des données

Les tests statistiques suivants ont servi à l'analyse des données:

- Le test de Student pour les rapports entre l'état général, apprécié par le biais de l'évolution pondérale et l'activité ovarienne;
- L'analyse de variance pour l'étude du post-partum;
- L'étude de la corrélation entre l'âge d'apparition des signes de puberté et les poids à âges types: 3 mois et 7 mois;
- Le test de Chi deux pour les relations entre les valeurs qualitatives.

3. RESULTATS

3.1. Génisses

3.1.1. Evolution ponderale

Leur poids moyen passe de 27 kg à la naissance à 70 kg environ à 12 mois (Figure 1). Leur croissance se caractérise par des Gains Moyens Quotidiens (GMQ) avant et après sevrage respectivement de 418 et 235 g/jour.

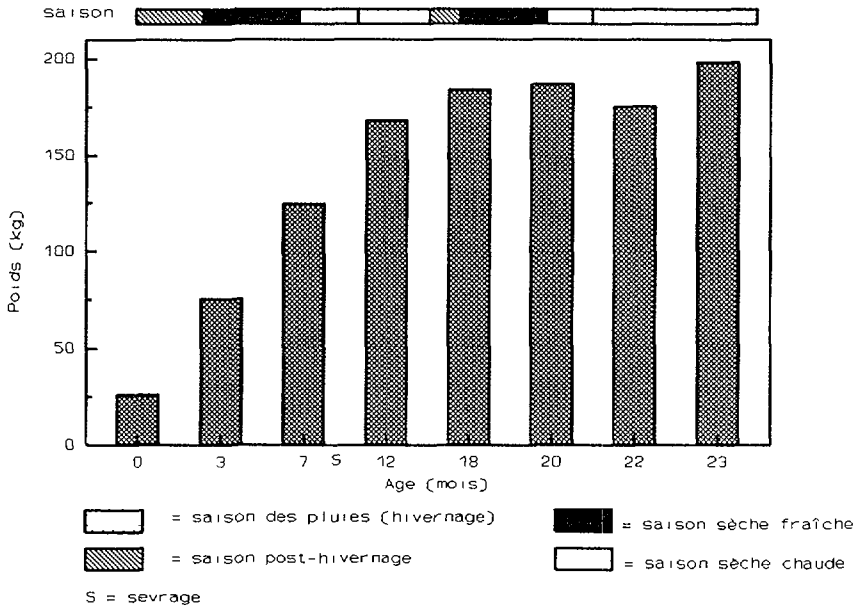

Fig. 1. Evolution ponderale des génisses.

3.1.2. Premières manifestations du comportement d'oestrus et de l'activité ovarienne

Toutes les génisses ont été vues au moins une fois en chaleurs pendant les 14 mois de l'étude. Les premiers signes du comportement d'oestrus ont été observés à un âge moyen de 362 jours (270-551) (soit environ 12 mois) et avec un poids moyen de l'ordre de 164 ± 25,8 kg.

La première élévation du niveau de progestérone à un taux moins égal à 0,80 ng/ml est observée sur 17 génisses soit 81% de l'effectif, à un âge moyen de 412 jours (248-504) (soit environ 13 mois) et avec un poids moyen de 176 ± 22,2 kg. Les quatre génisses restantes, sans élévation de progestérone avaient été vues en chaleurs à la fin de la période d'observation (Tableau I).

TABLEAU I. AGE ET POIDS D'APPARITION DES PREMIÈRES MANIFESTATIONS DU COMPORTEMENT D'OESTRUS ET DE L'ACTIVITE OVARIENNE

	génisses avec oestrus comportemental *uniquement*	génisses avec oestrus comportemental et seule *élevation de la progestéronémie*	génisses avec oestrus compartmental et 2 à 3 élevations de la progestéronémie
Effectif	4	7	10
1ere manifestation de l'oestrus			
âge (jour)	469 ± 103,0	323 ± 55,8	372 ± 88,2
poids moyen (kg)	179 ± 29,5	152 ± 23,4	165 ± 24,7
1ere élevation de la progestéronémie (>0,80 ng/l)			
âge (jour)	-	422 ± 61,2	388 ± 84,0
poids moyen (kg)	-	179 ± 26,8	173 ± 19,6

L'âge moyen d'observation des premières chaleurs et celui de la 1ere élévation de la progestéronémie sont correlés (r = 0.41) au poids à 7 mois (P = 0,10).

Le Tableau I présente les caractéristiques d'âge et de poids de 3 catégories d'animaux selon que l'on prend en compte la composante de comportement (observations d'oestrus), la composante hormonale (élévation de la progestéronémie) et la régularité ultérieure de cette cyclicité (combinaison de ces 2 composantes).

La 1ere catégorie regroupe 4 animaux observés une fois en chaleurs en fin de période. La seconde assemble 7 femelles vues en oestrus mais n'ayant présenté qu'une élévation de la concentration de progestérone et la troisième est constituée d'individus ayant eu ultérieurement plusieurs cycles sexuels.

Un cinquième des animaux ont eu une seule chaleur observée à un âge moyen de plus de 15 mois et à un poids proche de 200 kg. Un tiers des femelles ont eu une seule élévation significative de progestérone plasmatique. Lors de leur premier oestrus celles-ci avaient près de 5 mois de moins que les femelles du groupe précédent et pesaient près de 30 kg de moins que ces dernières.

Ainsi que l'illustre la Figure 2, les manifestations comportementales des premières chaleurs se sont rélevées principalement au cours de la saison d'hivernage. Cependant des premières observations de chaleurs ont aussi été faites aux trois autres saisons. En revanche, les premières élévations de la progestérone plasmatique ont été notées aux trois premières saisons selon une distribution plus régulière.

La Figure 3 rapporte les poids durant les trois premières saisons des femelles ayant présenté une élévation de la progestéronemie plasmatique (femelles cyclées) et des femelles n'ayant pas présenté cette élévation (non cyclées). Elle montre que pendant les deux premières saisons des pluies et saison de post-hivernage, aux âges de 8 à 12 mois, les femelles cyclées avaient par rapport aux non-cyclées, un poids moyen superieur de 40 kg en saison des pluies, et 15 kg en post-hivernage. Cette différence de poids s'estompe durant la 3eme saison (sèche fraiche).

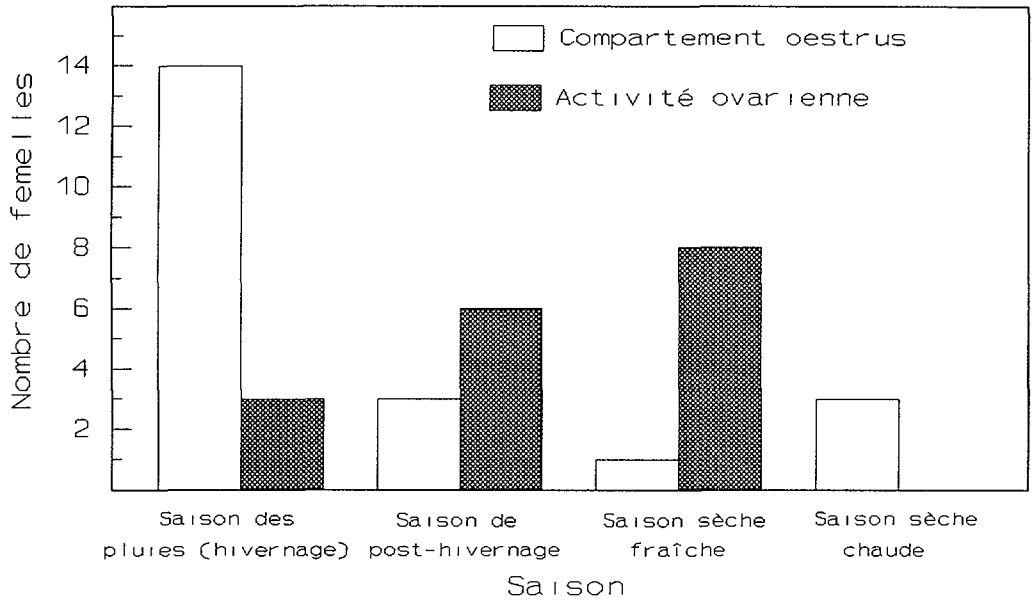

Fig. 2. Activité ovarienne et comportement oestrus selon la saison.

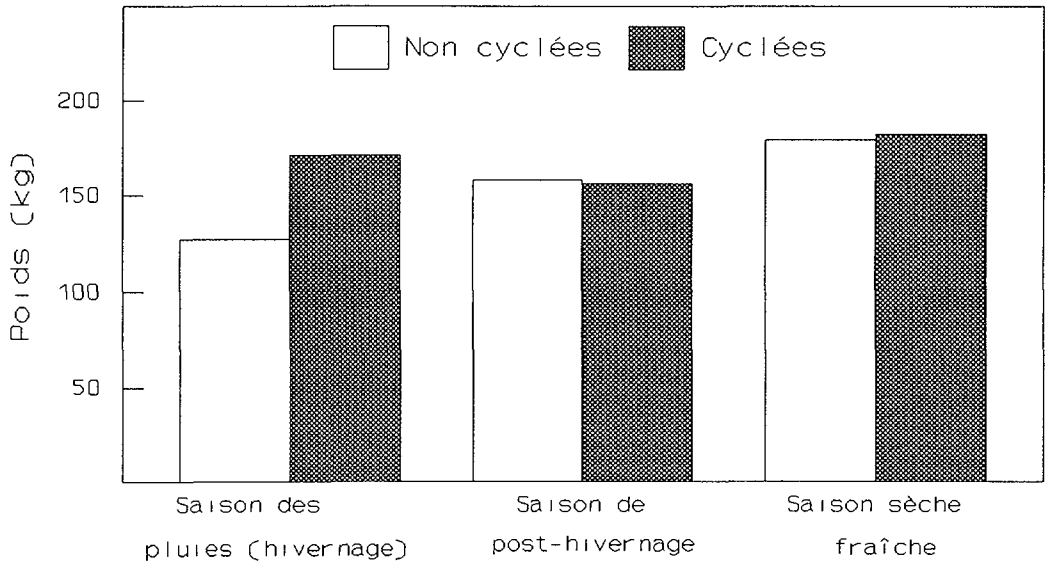

Fig. 3. Poids des femelles cyclées et non cyclées selon la saison.

3.1.3. Relation entre chaleurs et activité ovarienne chez les génisses

Les premières manifestations du comportement d'oestrus, observées sur les 21 génisses, n'étaient pas associées à une phase lutéale. Toutefois, pour les 17 génisses ayant présenté une première élévation de la progestéronémie (taux ≥ 0,80 ng/ml) 8 ont manifesté en même temps des signes extérieurs de chaleurs tandis que les 9 autres ont eu des ovulations sans comportement sexuel.

3.1.4. Régularité de l'activité sexuelle chez la génisse pubère

Globalement, pour les 17 génisses ayant manifesté une première élévation de la progestérone plasmatique, 10 (59%) (Tableau I - 3eme catégorie) ont présenté une seconde augmentation du niveau de la progestérone après un intervalle moyen de 65 jours, variable selon la saison et les individus. Leur âge moyen au premier oestrus était supérieur à celui-ci de la catégorie 2 (+50 jour en moyenne) mais leur poids était voisin.

Parmi ces 10 génisses, 4 ont présenté une troisième augmentation de la progestéronémie dans un intervalle moyen de 87,7 jours après la seconde élévation, variable selon la saison et les individus.

Cependant, les intervalles moyens constatés entre deux manifestations du comportement d'oestrus sont de 36,4 jours entre les premiers et deuxièmes oestrus observés sur 18 génisses, 40,2 jours entre les troisièmes et quatrièmes oestrus extériorisés par 6 génisses.

3.1.5. Relation entre la régularité de l'activité sexuelle et l'état général des animaux

Au moment de la première manifestation des signes d'activité ovarienne, les poids moyens étaient de 173 ± 19,4 et 178 ± 26,8 kg respectivement pour les génisses ayant présenté ensuite 2 à 3 phases lutéales et celles avec une seule phase lutéale. Cependant, la croissance qui s'en est suivie a été plus rapide chez les femelles cyclées régulièrement. Le gain moyen mensuel est de 6,5 kg et 3,3 respectivement pour les deux groupes de génisses. Toutefois la différence constatée n'est pas significative ($P > 0,05$).

3.2. Activité ovarienne chez la vache après le vêlage

En prenant comme critère l'apparition des chaleurs sur les 13 vaches suivies, 6 femelles (46%) ont été vues en chaleurs entre les 43e et 62e jours du post-partum; deux d'entre-elles sont revenues en chaleurs, une trois fois et l'autre une seule fois. Cette reprise se fait de façon progressive. Au 43e jour du post-partum, une seule femelle a manifesté des signes de chaleurs. Au 50e jour le pourcentage de femelles vues en chaleurs est égal à 30% et atteint 46% au 62e jour. Au delà, aucune nouvelle vache n'a été vue en chaleurs.

Selon le niveau de la concentration de la progestérone plasmatique, l'activité ovarienne est recouvrée entre les 36e 48e jours du post-partum pour 54% de ces femelles.

L'analyse comparée des observations des chaleurs et des estimations de l'activité cyclique ovarienne par la mesure de la progestérone permet de constater que:

- Sur les 6 femelles ayant des signes de chaleurs, seules 4 soit 66% ont eu une phase lutéale témoin d'une ovulation. (progestéronémie ≥ 0,80 ng/ml)
- Sur les 7 vaches en anoestrus comportemental, après 65 jours de post-partum, 4 sont en anoestrus vrai et 3 ont été l'objet d'élévations de la progestéronémie (anoestrus cyclique).

La production laitière, estimée indirectement par le GMQ des veaux de la naissance à l'âge de trois mois, semble influencer le délai de reprise de l'activité cyclique ovarienne. En effet, parmi les 5 vaches dont les veaux ont eu un GMQ inférieur à 500 g/j, 4 ont été cyclées dans les 62 jours qui suivent le vêlage, tandis que pour les 8 autres dont les veaux ont eu un GMQ supérieur à 500 g/j, seules 3 d'entre elles étaient cyclées au terme des 62 jours qui suivaient la mise bas. Le faible effectif nous interdit cependant de mettre en évidence un effet significatif de cette production laitière.

4. DISCUSSION

4.1. Age à la puberté

Les premières manifestations de l'activité ovarienne apparaissent à l'âge moyen de 413 ± 63,7 jours, soit environ 13 mois. Cet âge semble plus précoce que ceux cités (16 à 40 mois d'âge) pour des Zébus d'Afrique [7, 8, 9, 11, 12] et ceux d'Asie et d'Amérique [6, 12, 13, 14, 15, 16, 17]. Toutefois, il reste dans l'intervalle de 10 - 15 mois obtenu sur des bovins en zone tempérée [18].

Certes, dans la présente étude, la première augmentation de la progestéronémie plasmatique a été suivie d'une activité cyclique très irrégulière avec des longs intervalles entre deux élévations de progestérone. L'installation difficile de l'activité ovarienne à la puberté doit être en rapport avec l'effet des conditions de l'environnement sur la reproduction (température élevée, appauvrissement qualitatif du pâturage naturel) déjà signalé par Thimonier et col. [19] et Sauyer et col. pour la brebis [20].

La corrélation mise en évidence entre cet âge et le poids à 7 mois est conforme aux observations faites par Werre [5], Arije et col. [21] et Steffan et col. [22]: les génisses, avec une vitesse de croissance plus grande, atteignent la puberté plus tôt.

4.2. Poids à la puberté

Le poids de 176 ± 22,2 kg à l'âge d'apparition des premiers signes d'une activité ovarienne représente 54 - 58% du poids moyen cité pour la femelle Zébu à l'âge adulte et enregistré au CRZ de Dahra (300 - 320 kg). Ce rapport est proche de celui obtenu chez le Zébu éthiopien, 60% [23] et se situe en partie dans la fourchette retenue pour les bovins à viande (45 - 55%) [24].

Les premières manifestations de l'activité ovarienne ont surtout coïncidé avec la saison d'hivernage et la saison sèche froide, durant lesquelles le pâturage naturel est de bonne qualité et en quantité suffisante, d'où un effet probable du niveau alimentation, qui a été mis en évidence par Manco et col. [25], Oyedipe [9].

4.3. La reprise de l'activité ovarienne cyclique après le vêlage

Les premières manifestations des signes de reprise de l'activité ovarienne apparaissent entre les 36e et 48e jours du post-partum chez 53% des femelles. Ces résultats sont proches de ceux observés sur des bovins de races africaines [26, 27, 28, 29, 30], asiatiques [31] et des pays tempérés [31, 32, 33, 34, 35, 36].

L'évolution des taux cumulés de femelles manifestant des signes de reprise de l'activité sexuelle post-partum est analogue à celle observée par Dawuda et col. [27] et Tan et col. [37].

Cependant, cette reprise est marquée par des cas de chaleurs anovulatoires et des cycles courts. De telles observations ont été faites sur des bovins Bunaji [26] et des bovins laitiers [31, 38].

L'absence de relation significative entre la production laitière et la reprise de l'activité ovarienne après le vêlage est contraire aux observations faites sur des bovins d'Afrique [24, 26], asiatiques [37], du Brésil [39] et des pays tempérés [13, 34, 36, 40, 41]. La méthode d'évaluation de la production laitière et l'effectif réduit dans cette étude en sont peut-être les causes.

5. CONCLUSION

Chez la génisse pubère, les premières ovulations surviennent à l'âge de 13 mois. Chez la vache Zébu Gobra, la reprise de l'activité ovarienne après des vêlages de post-hivernage, se fait dans des délais relativement courts, 36 à 46 jours.

Avec ces résultats, il est possible d'envisager une amélioration de la productivité numérique du cheptel Zébu Gobra, en intervenant, par exemple, sur le mode d'élevage, la vitesse de croissance, pour atteindre l'autosuffisance alimentaire en produits carnés, par l'intensification des productions animales.

De telles stratégies, applicables chez les éleveurs, permettraient une réduction de l'intervalle entre vêlages et celle de l'âge au 1er vêlage donc une augmentation de l'offre de produits animaux issus de l'élevage traditionnel.

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IMPROVING THE PRODUCTIVITY OF INDIGENOUS GOATS IN ZIMBABWE

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Abstract–Résumé

IMPROVING THE PRODUCTIVITY OF INDIGENOUS GOATS IN ZIMBABWE.

The productivity of indigenous goats was monitored in two areas which are situated in semi-arid regions of Zimbabwe. Both had low and erratic rainfall (400-600 mm per year) and three seasons were identified: hot wet (November to March), cool dry (April to July) and hot dry (August to October).

Goats had long kidding intervals (370 d and 311 d, respectively), had slow growth rates (45 and 50 g/d) and high mortalities (41% and 36% by weaning age) in both areas. Seasonal effects were prominent for all production parameters but there was no season that consistently improved the productivity of goats.

In one of the areas which had the highest incidence of births during the dry season, feed availability was the major constraint. An on-station feeding trial with pregnant does was carried out to investigate the effect of improved doe nutrition on kid performance. Does were offered three levels of feeding, High, Medium and Low pre-partum and does on each level were further allocated to either high or low feeding level post-partum. Pre-partum feeding levels did not affect kid birth weight (mean 3.0 kg), but improved doe live-weight at parturition. Post-partum feeding increased kid growth rate up to 42 d post-partum but had no effect on subsequent growth up to 105 d which was approximately 90 g/d. This growth rate was double that observed in communal area flocks. Strategic supplementation would improve productivity of indigenous goats in smallholder farming systems in Zimbabwe.

AMELIORATION DE LA PRODUCTIVITE DES CHEVRES INDIGENES AU ZIMBABWE.

La productivité des chèvres indigènes a été étudiée dans deux zones situées dans des régions semi-arides du Zimbabwe. Dans les deux zones, les précipitations étaient faibles et irrégulières (400-600 mm par an) et trois saisons ont été identifiées: chaude et humide (novembre à mars), fraîche et sèche (avril à juillet), chaude et sèche (août à octobre).

Dans les deux zones, les intervalles entre les mises bas étaient longs (370 et 311 jours respectivement), les taux de croissance faibles (45 et 50 g jour) et la mortalité élevée (41% et 36% avant l'âge du sevrage). Les effets saisonniers étaient importants pour tous les paramètres de la production mais la productivité des chèvres ne s'améliorait pas régulièrement à une saison particulière.

Dans l'une des zones où le pic des naissances se produisait pendant la saison sèche, le principal problème était l'insuffisance de nourriture. Un essai d'alimentation en station sur des femelles gravides a été mené afin d'étudier l'effet d'une meilleure alimentation de la mère sur les performances des chevreaux. Les femelles ont reçu pendant la gestation trois niveaux d'alimentation (haut, moyen et bas); chaque groupe a ensuite reçu après la parturition deux niveaux d'alimentation (haut et bas). Le niveau d'alimentation pendant la gestation n'a pas influé sur le poids des chevreaux à la naissance (moyenne 3,0 kg), mais a amélioré le poids des mères à la parturition. L'alimentation post-partum a augmenté le taux de croissance des chevreaux pendant 42 jours après la mise bas, mais n'a pas eu d'effet sur leur croissance ultérieure jusqu'au 105ème jour (environ 90 g/jour). Ce taux de croissance était deux fois supérieur à celui observé dans les troupeaux pacageant sur les communaux. Une complémentation bien menée permettrait d'améliorer la productivité des chèvres indigènes dans les petites exploitations du Zimbabwe.

1. INTRODUCTION

Zimbabwe has a goat population of 2.6 million, 99% of which are found in communal areas under smallholder ownership. Communal areas are mainly in the drier marginal areas of the country where crop production often fails due to erratic and low rainfall pattern coupled with poor sandy soils. Goats are an integral, though secondary, component of these farming systems and serve as sources of ready income through live sales or slaughter and sale of meat. Additionally, goats provide manure for gardening and serve in various socio-cultural ceremonies.

Despite the importance of goats in communal area farming systems, very little research has been done on the management and productivity of goats in this sector. Most research on goats has been carried

out in research stations where resources are often not limiting. Results emanating from such research, while indicative of the biological potential of indigenous goats, are not readily transferable into sustainable extension recommendations for communal areas where resources are very limited.

This study aimed to provide quantitative data on the performance of indigenous goats under traditional communal area management, identify constraints to productivity and test possible low-cost sustainable interventions to alleviate the effect of the constraints. The study also aimed at establishing the climatic variations that the goats are subjected to and possible effects of these on goat productivity.

2. MATERIALS AND METHODS

2.1. Research sites

The research was carried out in communal areas in Nyanga North and Gwanda South. Nyanga North is in the north eastern part of Zimbabwe (latitude 17°36' South and longitude 32°49' East) and has an altitude of 870 m above sea level. The communal areas are completely surrounded by mountains which are a barrier to rain. The vegetation is mainly scrubland grass and trees on sandy soils. Gwanda South is in the south western part of the country (latitude 21°23' South and longitude 28°59' East) and has an altitude of 770 m above sea level. The vegetation is mainly acacia/mopane tree savanna on sandy soils.

2.2. Sample size

In Nyanga North, where flock sizes were small (6-16 goats per farmer), 15 farmers were asked to amalgamate their flocks in a communal kraal of wire mesh and poles. The farmers shared management chores, mainly herding, and each farmer had full ownership rights over their animals. In Gwanda South, where flock sizes are larger (50 or more animals), flocks were not amalgamated and only 10 farmers were surveyed. The goats were kraaled overnight in large circular enclosures built from thorny branches or dried poles. In the Gwanda South farming system goats were let out to graze unattended during the day whilst in Nyanga North the goats were herded.

The goat breeds kept in the two communal areas studied differ in mature size. In Nyanga North the goats are of the Mashona type which is similar to the Small East African breed which has a mature weight of approximately 30 kg. In Gwanda South the goats are of the Matebele type which has a mature weight of approximately 45 kg.

2.3. On farm studies

2.3.1. Climatic data

Data on monthly variations in rainfall, mean minimum and mean maximum temperatures and relative humidity were collected at meteorological substations closest to the research sites from 1988 to 1990. Data for years 1980 to 1987 were also collected from Department of Metereology Head Office for both sites. The data collected was used to define seasons.

2.3.2. Animal productivity

The goats were ear-tagged for individual identification and were weighed fortnightly and births, purchases, sales, slaughters, deaths, and disappearances from each flock were recorded during each visit for a period of four years in Nyanga North and three years in Gwanda South. Where possible, causes of deaths

were established through interviews with farmers. Only data on kidding intervals and weights at 14, 90 and 150 d, growth rates and survival of kids up to 150 days will be reported.

2.3.3. Statistical analysis

Data were analyzed using General Linear Models procedures of the SAS statistical package [1]. Factors included in the model were year, season damage, sex of kid and birth type.

2.4. On station studies

2.4.1. Animals

Forty-five multiparous does purchased from communal areas were hand mated and blood was collected by venipuncture for progesterone assay using FAO/IAEA RIA kits. Does that persistently showed progesterone values 1 ng/ml or higher were assumed to be pregnant and on the 100th day of gestation were randomly allocated to three treatments in a completely randomized design. The animals were housed in pens with concrete floors and separated from each other with wire mesh.

2.4.2. Treatments

There were 3 feeding levels:High (H), Medium (M) and Low (L) based on energy allowance. The energy allowance for treatment L was 0.42 MJ ME/$kg^{0.75}$ and for treatment M and H, energy allowances were 1.5 x L and 2.0 x L, respectively. The basal diet consisted of whole maize grain, lucerne hay and grass hay in proportions of 0.2:0.24:0.56 of total ME intake. The chemical composition of the dietary ingredients is shown in Table I and intake in Table II.

Maize and lucerne were offered together between 07:00 and 08:00 h after which grass hay was offered in equal portions twice daily. Drinking water and an iodized mineral lick (Agrifoods, Zimbabwe) were available *ad libitum*.

TABLE I. CHEMICAL COMPOSITION OF MAIZE GRAIN, LUCERNE HAY AND GRASS HAY FED TO PREGNANT DOES IN THEIR LAST TRIMESTER OF GESTATION

	Maize	Lucerne hay	Grass hay
Dry Matter (g/kg)	900	901	912
Crude protein (g/kg Dry Matter)	82	181	128
Ash (g/kg Dry Matter)	16	95	108
ME (MJ/kg Dry Matter)	11.9	7.5	5.5

TABLE II. DRY MATTER INTAKE (g/d) OF MAIZE GRAIN, LUCERNE HAY AND GRASS HAY AND ME INTAKE (MJ/d) OF PREGNANT DOES IN THREE LEVELS OF FEEDING

	Feeding Level		
	High	Medium	Low
Maize grain	180	107	74
Lucerne hay	370	220	150
Grass hay	930	520	360
ME	10.23	5.91	4.08

After parturition, does within each feeding level were reallocated to two feeding levels, High (H_{Lact}) and Low (L_{Lact}) where energy content of L_{Lact} was calculated as L (from pregnancy) + 5.2 MJ ME and H_{Lact} was 2 x L_{Lact}.

2.4.3. Measurements

Feed refusals were collected daily, weighed and subsampled and then composite weekly samples were stored for analysis of content of dry matter, crude protein and ash [2].

The does were weighed before morning feeding and body conditioned [3] weekly up to 21 weeks postpartum. Kids were weighed within 8 h of birth and weekly subsequently until weaning at 105 d of age.

2.4.4. Statistical analysis

Data were analyzed using the General Linear Models procedure of SAS [1]. The factors considered in the model for live-weight of does were treatments during pregnancy and lactation.

3. RESULTS

3.1. On farm studies

3.1.1. Climatic data

The mean monthly rainfall for the ten year period 1980/81 to 1989/90 and the monthly rainfall for the years 1988/89 and 1990/91 are shown in Figure 1. The rainy season starts in October and extends to March in Nyanga North and extends to April in Gwanda South. The mean annual rainfall for Nyanga North is 943.3 mm (range 401 - 1586 mm) whilst for Gwanda South it is 359.3 mm (range 260 - 666 mm). There is distinct seasonality in the rainfall and temperature and these were used to divide the year into three seasons, namely: 1) HW Hot and Wet (November to March), 2) CD Cool and Dry (April to July), and 3) HD Hot and Dry (August to October).

Nyanga North is warmer than Gwanda South (Fig. 2) with mean minimum temperatures of approximately 9°C in the coldest months of June and July compared to means of 6°C in Gwanda South. However, mean maximum temperatures are higher for all months in Gwanda South than in Nyanga North. Mean relative humidity is eleven units higher in Nyanga North (61.3 ± 1.02) than in Gwanda South 50.0 ± 0.72) (Figs. 3).

3.1.2. Animal productivity

3.1.2.1. Kidding intervals

The overall mean kidding interval at Nyanga North was 370 ± 21.9 days. However if season of kidding is considered, the averages of the subsequent kidding intervals were 265 ± 10.7 d for season HW and 382 ± 27.1 d for season HD. Very few does kidded in season CD. In Gwanda South the overall mean kidding interval was 311 ± 5.28 d for all does. The means for each season were: 339 ± 11.7 d, 353 ± 8.8 d and 307 ± 23.3 d for seasons HW, HD and CD, respectively. In Nyanga North 234 kiddings occurred, of which 30 % were in season HW, 16% in CD and 54% in HD whilst in Gwanda South 534 kidding occurred, of which 64% were in the CD season, 13% in the HW and 23% in the HD.

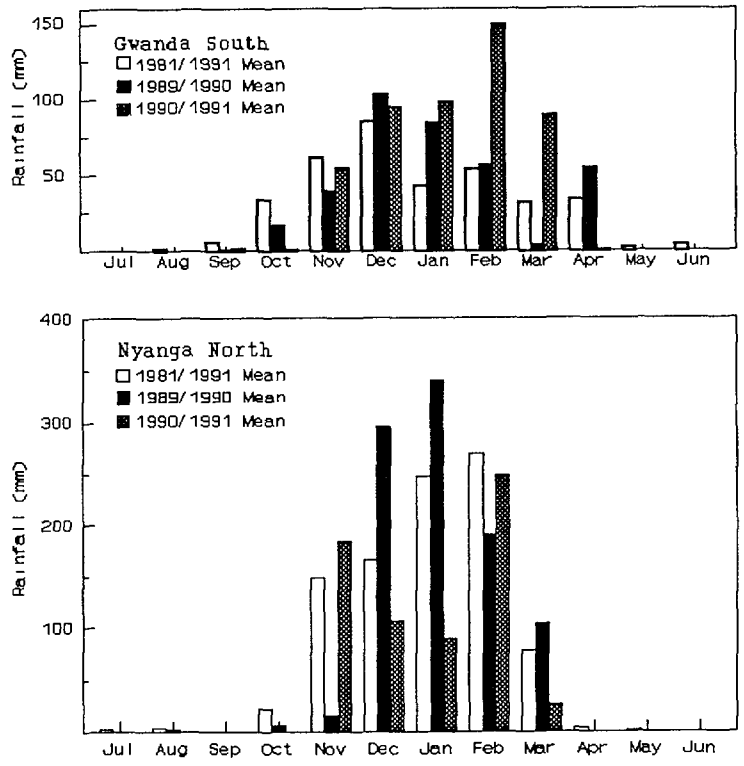

Fig. 1. Monthly rainfall patterns for Gwanda South and Nyanga North.

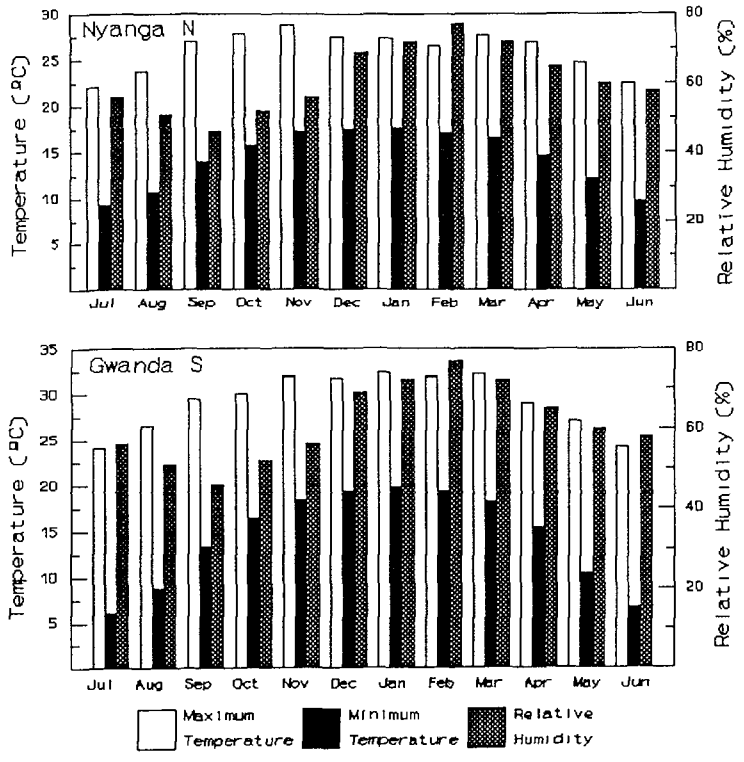

Fig. 2. Mean climatic data for Nyanga North and Gwanda South.

3.1.2.2. Growth of kids up to weaning

The mean weights at 14, 90 and 150 d of age were 2.74 ± 0.57, 6.4 ± 2.8 and 9.2 ± 3.8 kg respectively for Nyanga North and 4.3 ± 0.04, 9.2 ± 0.07 and 11.5 ± 0.11, respectively for Gwanda South. Season of birth significantly affected weights at all ages (Fig. 3). At 14 d of age, in Nyanga North, kids born in season HD were 7% heavier than kids born in the other two seasons whilst in Gwanda South kids bornin season CD were 21% heavier than those born in seasons HW and HD. In Nyanga North this superiority in weight was maintained up to weaning. In Gwanda South the weight advantage was lost by age 90 d - the kids born in season HD were heaviest and maintained this through to weaning.

The growth rate from 14 d to 150 d of age was affected by season of birth (Fig. 4) with season HD showing the highest growth rates in both areas.

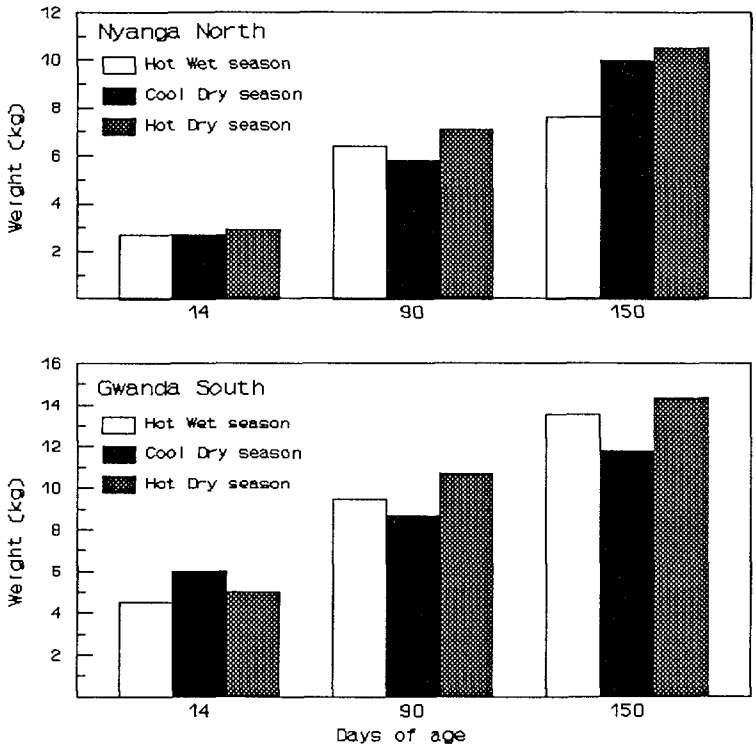

Fig. 3. Effect of season of birth on weight of kids at various ages.

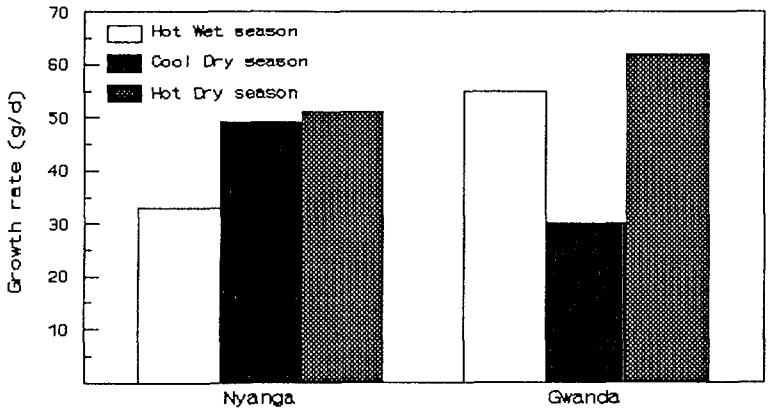

Fig. 4. Effect of season of birth on kid growth rate at Nyanga North and Gwanda South.

3.1.2.3. Mortality of kids by 30 and 150 d of age

Mortality of kids by 30 d of age was 14.0% and 17.1% of the kids born for Nyanga North and Gwanda South, respectively and by age 150 d, 44.5 and 43.8% of kids born were dead for the two areas (Table III and IV). The effect of season of birth on mortality is shown in Table V. In Nyanga North the proportion of kids born in season HD that were dead by 30 d after parturition was twice that of kids born in the CD and HW seasons. In Gwanda South, kids born in the CD season had the least exits by 30 d of age.

TABLE III. CAUSES OF MORTALITY AND NUMBER OF DEATHS OF KIDS IN NYANGA NORTH BY 30 d AND 150 d OF AGE

	Age of kids (d)			
	30		150	
Cause	% of total	n	% of total	n
Missing	0.9	2	19.7	46
Unknown	9.4	22	16.2	38
Predators	0	0	1.7	4
Disease	3.4	8	6.0	14
Slaughtered	0	0	0.4	1
Total	13.7	32	44.0	103

n = number of goats.
% = as a percent of total kids born.

TABLE IV. CAUSES OF MORTALITY AND NUMBER OF DEATHS OF KIDS IN GWANDA SOUTH BY 30 d AND 150 d OF AGE

Cause	Age of kids			
	30		150	
	%	n	%	n
Death within 48 h	11.8	63	11.8	63
Missing	1.3	7	10.3	55
Unknown	3.4	18	10.1	54
Predators	0	0	2.4	13
Gid/heartwater	0.5	2	7.6	41
Disease	0.6	3	9.0	48
Slaughtered	0	0	0.2	1
Total	91	17.1	234	43.8

n = number of goats.
% = percentage of numbers born.

In Nyanga North most losses were due to animals that went missing (44% of the total losses) and death from unknown causes (37% of total losses) (Table III) whilst in Gwanda South animals that went missing accounted for 24% and those dying from unknown causes accounted for 23% of total losses (Table IV). In Gwanda South data were collected in a manner that enabled calculation of the number dead within

48 h of birth. This category represented 27% of total deaths at weaning (Table IV). A third of the total pre-weaning deaths occurred before the animals were 30 d old in both areas (Tables III and IV).

TABLE V. THE EFFECT OF SEASON OF BIRTH ON EXITS[a] OF KIDS BY 30 d AND 150 d AFTER BIRTH IN NYANGA NORTH AND GWANDA SOUTH FLOCKS

	Nyanga North		Gwanda South	
Days after birth season	30	150	30	150
Hot wet	18	61	17	34
Cool dry	9	44	9	28
Hot dry	9	28	23	59

[a] Exits are expressed percentage of kids born in each season.

3.2. On station study

3.2.1. Doe live-weights

Level of feeding during pregnancy significantly affected ($P<0.05$) doe weight at week 21 of gestation and immediately post kidding (Table VI). The doe weights tended to increase with increasing level of feeding.

The level of feeding during late gestation did not affect intake during lactation and dry matter intakes were 2.02 and 1.20 kg per day for H_{Lact} and L_{Lact} treatments respectively. Equivalent values for ME intakes were 14.3 and 8.7 MJ/d. However, level of feeding during late pregnancy affected ($P<0.05$) live-weight of does at 15 weeks postpartum (Table VII).

TABLE VI. THE EFFECT OF FEEDING LEVEL DURING LATE GESTATION UPON LIVE-WEIGHT (kg) AND NET LIVE-WEIGHT CHANGE (kg) OF THE DOES FROM DAY 100 OF GESTATION TO IMMEDIATELY POST-PARTUM

	Feeding Level			
	High	Medium	Low	s.e.d.
Initial weight	36.4	33.1	35.6	1.45
Weight before kidding	43.3[a]	39.5[b]	37.5[c]	0.77
Post-partum weight	39.8[a]	36.0[b]	33.6[c]	0.92
Net weight change	4.8[a]	0.9[b]	-1.5[c]	0.86

Live-weights for week 21, post-partum and the net weight change were adjusted by the use of live-weight at week 14 as a covariate.

The birth-weight of kids was not affected by level of feeding of the doe pre-partum (Table VIII) but there was evidence of interaction between pre- and post-partum levels of feeding of doe on kid weights at 42 and 105 d (Table VII). Both pre- and post-partum feeding levels affected growth rate up to 42 d but had no effect on growth rate from 42 to 105 d. Growth rates after 42 d were 32-42% lower than growth rates

achieved prior to 42 d except for kids of does on L_{Lact} which were previously on L feeding level. The decrease in growth rates for these kids was only 10%.

TABLE VII. THE EFFECT OF FEEDING LEVEL DURING LATE GESTATION AND EARLY LACTATION ON LIVE-WEIGHT (kg) AND DAILY LIVE-WEIGHT GAIN (g/d) OF DOES AT 15 WEEKS POST-PARTUM

	FEEDING LEVEL					
LACTATION	HIGH			LOW		
PREGNANCY	H	M	L	H	M	L
Post kidding weight	40.1^{a}	35.1^{b}	33.4^{b}	41.3^{a}	34.4^{b}	34.5^{b}
Week 15 weight	39.2^{ab}	38.0^{ab}	39.4^{ab}	40.6^{a}	35.8^{b}	36.6^{b}
Daily gain	-9^{c}	29^{b}	59^{a}	-6^{c}	13^{ab}	20^{b}

a, b, c values in the same row with different superscripts differ ($P < 0.05$).

TABLE VIII. EFFECT OF LEVEL OF FEEDING OF DOE PRE- AND POST-PARTUM ON WEIGHT (kg) OF KIDS AT BIRTH, 42 AND 105 DAYS OF AGE AND ON DAILY LIVE-WEIGHT GAIN (g/d)

	Lactation	High			Low			
	Pregnancy	H	M	L	H	M	L	S.E.D.
Birth-weight		3.3	2.7	2.7	3.1	3.1	3.1	0.319
42 day weight		9.3	8.5	8.2	8.6	8.1	7.9	0.634
105 day weight		15.4	13.6	14.2	13.7	13.0	14.1	0.678
0-42 day gain		144	138	130	131	121	112	13.008
42-105 day gain		97	80	96	80	77	99	10.075

4. DISCUSSION

Variations in rainfall, temperature and, to a lesser extent, relative humidity within any given year indicate three distinct seasons. A hot-wet season from November to March, a cool dry season from April to August and a hot dry season from September to October. The seasonality of rainfall also means that feed quality and quantity vary seasonally - increasing during the rainy season and decreasing in the dry seasons. The wide variation in rainfall between years observed in the two study sites is typical of marginal areas in semi-arid regions. Gwanda South also exhibits wide variations in temperatures within the year, ranging from cold months of June (6°C) to hot months of January (32°C). Livestock productivity in communal areas is dependent on natural pasture. Very little supplementary feeding is practised consequently livestock production is directly affected by the prevailing climatic conditions. It is therefore essential to determine the effects of climatic conditions on productivity of communal area livestock, particularly goats which receive scant management.

In Nyanga North season of kidding affects the subsequent kidding interval with goats kidding in the hot dry season when feed is least available having longer kidding intervals than goats kidding in the hot wet season. Poor nutrition in the last trimester of pregnancy and early-lactation has been shown to cause long post-partum periods of acyclicity in cattle [4, 5] and in goats [6]. In Gwanda South there was no seasonal effect on kidding interval. The reasons for this are not clear.

The kids born in the hot, dry season in Nyanga North grew 20% faster than kids born in the other two seasons up to 90 d of age. These kids had access to young nutritious grass that comes with early rains and could therefore supplement any nutrient deficiency due to inadequate milk supply by the doe. It has been shown that a functional rumen develops relatively early in goats if exposed to forages of high quality [7]. Kids born during the hot wet season performed poorly (28% lighter at weaning) despite the fact that they had access to good nutritious feed during the period prior to weaning. A possible cause of this retarded growth is infestation with internal parasites. Mean monthly rainfalls in December and January are high in Nyanga North and the resultant hot moist conditions are conducive to proliferation of helminths. Thus, during the first three months after birth, these animals are exposed to a high helminthic challenge and, since no dosing with anthelmintics is practised, the debilitating effect of the parasites persists throughout their growing period.

In Gwanda South, where there is less rain, the kids born in the hot dry season also outperformed the kids born in the other two seasons but were only 11% heavier than kids born in the hot wet season by 90 d and this was reduced to 5% by weaning time. It would seen that internal parasites are not a major constraint to kid growth in this area. The kids that performed the worst were those born in the cool dry season. These kids were reared to weaning during a period of scarce feed availability and thus did not have access to good quality forage to supplement reduced milk yield by the does.

Overall, the growth rates observed in this study are low but are comparable to others obtained under extensive husbandry systems [8, 9, 10]. These low growth rates could be indicative of poor nutrition and/or parasite infestations as growth rates of similar breeds under research station management are higher [11, 12, 13].

In Nyanga North 54% of the kiddings occurred in the hot dry season which also has the highest growth rate. This coincidence of peak kidding and kid growth augurs well for the farming system. In Gwanda however, 64% of the kiddings occur in the cool dry season which has the slowest growth rates. Poor nutrition appears to be the major cause of this poor growth and therefore there is a need for supplementary feeding in this farming system.

In a meat producing enterprise, survival of offspring is as important as, if not more important than, growth of the offspring. In our study the hot dry season had the highest mortalities up to 30 d of age with 19% and 23% of total kids born in Nyanga North and Gwanda South respectively, dying in this season. Most of the deaths occurred in less than 7 d post-partum and were probably related to poor mothering, low birth weights and starvation. There were very few cases of deaths due to identified diseases in this season. However, it is possible that farmers failed to recognise some of the diseases that caused neonatal mortalities and classified them as unknown causes.

By weaning age 61% of the kids born in the hot wet season in Nyanga North had exited from the flocks as missing animals or had died of unknown causes. In the hot wet season farmers are preoccupied with cropping activities and goats are not well catered for. Often young kids are allowed to follow their does on

the range without adequate herding and the kids get lost. In Gwanda North, 59% of the kids born in the hot dry season had exited from the flocks at weaning age. Again the major cause of exits were missing animals.

It would appear that in both farming systems losses past 30 d are mainly due to lack of management of goats. Prior to this, nutrition seems to be the prime constraint. This is substantiated by results from an on station trial carried out to investigate the effect of improved nutrition on the growth and survival of kids. The growth rates obtained on station were more than double those obtained on-farm and by 105 d the kids weighed more than kids of same age in communal areas. No mortalities were recorded on station. It would appear that supplementary feeding of the doe during late pregnancy and early lactation could greatly increase productivity of communal area flocks.

Providing supplementary feed throughout late gestation and early lactation could be costly and unattainable to most communal area farmers. However, it appears that providing supplementary feeding postpartum is as effective, since there were no differences in growths between kids of does that received a high level of feeding pre- and post-partum and those that received a low level pre-partum but got a high feeding level post-partum.

5. CONCLUSION

Productivity of communal area goats is affected by seasons and there is no one season which is best for kidding interval, growth and mortality. The hot-wet season results in shorter kidding intervals in Nyanga North but it also resulted in poor kid growth and higher mortalities. In Gwanda South the cool dry season resulted in highest incidence of kidding but poor growth rates. Nutritional constraints restricted kid growth on-farms since on-station supplementation resulted in high growth rates.

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STUDIES ON THE REPRODUCTIVE PERFORMANCE OF INDIGENOUS BEEF CATTLE BREEDS RAISED ON-FARM IN GHANA

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Abstract–Résumé

STUDIES ON THE REPRODUCTIVE PERFORMANCE OF INDIGENOUS BEEF CATTLE BREEDS RAISED ON-FARM IN GHANA.

Studies were undertaken to investigate the reproductive performance of a mixture of N'dama and West African Shorthorn (N'dama/WASH) and Sanga cattle raised under traditional management conditions on four privately owned small-holder farms The first study involved an analysis of reproductive records and the measurement of plasma progesterone concentration to delineate the onset of various reproductive phenomena, including age at puberty and first calving, post-partum resumption of ovarian activity and other abnormal events like abortions The second study investigated the influence of dry-season feed supplementation on reproductive performance

In study 1 the ages at first plasma progesterone rise (puberty), first mating and first calving for N'dama/WASH cattle on three farms averaged 981, 1016 and 1296 days respectively The calving interval, calving-to-progesterone rise and calving-to-mating averaged 412, 129 and 114 days respectively Significant differences existed among farms with Farms 1 and 2 out-performing Farm 3 The respective mean ages at first progesterone elevation, first mating and first calving for Sanga cattle (Farm 4) were 964, 990 and 1271 days while calving-to-progesterone rise, calving-to-mating and calving intervals averaged 107, 150 and 431 days

In study 2, dry-season feed supplementation generally reduced ages at puberty and first calving as well as the interval of post-partum acyclicity

ETUDES SUR LA PERFORMANCE DE REPRODUCTION DE RACES BOVINES INDIGENES ELEVEES A LA FERME AU GHANA

Des études sur la performance de reproduction de troupeaux mixtes composés des races N'dama et West African Shorthorn (N'dama/WASH) et d'un troupeau de race Sanga élevé dans des conditions traditionnelles sur quatre petites exploitations privées ont été effectuées La première étude comprenait une analyse des données de reproduction et la mesure des taux de progestérone dans le plasma, afin de dresser un tableau de différents phénomènes de la reproduction âge à la puberté et au premier vêlage, reprise de l'activité ovarienne après la parturition et événements anormaux (avortements par exemple) La seconde étude devait déterminer l'effet sur la performance de reproduction d'une complémentation alimentaire à la saison sèche

Dans la première étude, qui portait sur les troupeaux N'Dama/WASH de trois fermes, l'âge moyen lors de la première montée de progestérone dans le plasma (puberté), du premier accouplement et du premier vêlage était respectivement de 981, 1016 et 1296 jours L'intervalle entre les vêlages et les intervalles vêlage-montée de progestérone et vêlage-accouplement étaient en moyenne de 412, 129 et 114 jours respectivement Les exploitations présentaient des différences significatives, les fermes 1 et 2 ayant une performance supérieure à celle de la ferme 3 Pour le troupeau Sanga (ferme 4), l'âge moyen lors de la première montée de progestérone, du premier accouplement et du premier vêlage était respectivement de 964, 990 et 1271 jours, tandis que les intervalles vêlage-montée de progestérone, vêlage-accouplement et vêlage-vêlage étaient en moyenne respectivement de 107, 150 et 431 jours

L'étude 2 a montré qu'une complémentation alimentaire à la saison sèche diminuait d'une manière générale l'âge à la puberté et au premier vêlage, et avançait la reprise des cycles après la parturition

1. INTRODUCTION

Ghana, unlike its neighbouring sub-Saharan countries, is a net importer of beef and beef products due to the underdevelopment of the livestock industry. Rahman [1] reported in 1983 that Ghana imported

up to 80% of all the beef consumed in the country, a situation that has not changed since then according to the Ghana Ministry of Agriculture data.

Most of the cattle production in Ghana is in the hands of private small-holders. The West African Shorthorn (WASH) constitute about 90% of all beef cattle in Ghana followed by the Sanga and N'dama in that order. The WASH and the N'dama breeds are preferred because they are trypanotolerant, hardy and more disease-resistant than other African or exotic breeds. In recent times, however, many farmers have shifted to Zebu animals largely because of their larger body size in comparison with the N'dama or WASH.

There is a paucity of research data on the performance of cattle in Ghana especially those raised under traditional management conditions (on-farm) where the logistics involved have made data collection very difficult. The little information available shows that these animals have poor reproductive performance [2, 3] which is characterised by late ages at puberty and first calving, prolonged post-partum acyclicity and high rates of mortality among calves. While poor nutrition has been identified as a major factor contributing to the poor performance of tropical cattle, there is little systematic investigation of the link between nutrition and reproduction in Ghanaian cattle.

These studies were therefore conducted to gather diagnostic data on the reproductive performance of on-farm cattle and to investigate possible beneficial effects of dry-season feed supplementation.

2. MATERIALS AND METHODS

2.1. Location of cattle farms

Four farms, located near Kumasi in the Ashanti region of Ghana, were studied. Farms 1, 2, and 3 contained a mixture of N'dama and West African Shorthorn (WASH) while Farm 4 contained Sangas. Total animal populations were 70, 60, 25 and 65 respectively. All the farms are in the semi-deciduous forest zone characterized by a hot and humid climate. Rainfall is bimodal and averages 1300 mm per annum. Up to 55% of the rains fall between April and July (major rains), 30% from September to October (minor rains), with the rest occurring in August (short dry spell) and the main dry season from November to March. Temperatures range from 18°C at night to 36°C in the afternoon with a mean of 24-26°C. The relative humidity varies from 97% in the early morning during the rainy season to 30% or less during the dry season.

2.2. Cattle herd management

Animals on all the farms were herded and grazed from approximately 09:00 h to 17:00 h (local time) on natural grasslands near main roads and water bodies. The grasslands consisted largely of guinea grass (*Panicum maximum*), giant star grass (*Cynodon plectostachyus*) and elephant grass (*Pennisetum purpurem*) with spots of *Centrosema pubescens* in various places. All farms practised natural mating with the service bulls running freely with the females. Calves were weaned naturally at ages ranging from 6-9 months. Older calves followed their dams to pasture while younger ones were isolated and penned up until the return of their dams. The herdsmen at all farms hand milked cows for human consumption, although milking was irregular. Routine disease prevention included annual vaccination against rinderpest and spraying regularly to control ectoparasites, mostly ticks. Deworming was done at three-monthly intervals.

2.3. Studies conducted

The studies were conducted in two phases. Phase 1 (study 1) involved the analysis of previously compiled data on the reproductive performance of beef cattle and the use of plasma progesterone measurements to diagnose the problem affecting reproductive efficiency of on-farm cattle (the diagnostic phase). Phase 2 (study 2) was concerned with the effects of dry-season supplementation with brewers' spent grain on the performance of heifers and cows.

Twenty heifers (10 supplemented, 10 control) and 32 cows, both N'dama/WASH from Farms 1 and 3 (18 supplemented and 14 control) were used in phase 2. Supplemented heifers received 500 g sun-dried brewers' spent grain daily per head from the age of 10 months until the commencement of ovarian activity, defined as the first rise in plasma progesterone above 2.0 nmol/l. Supplemented cows however received 1.0 kg brewers' spent grain per head per day, commencing within 48 h of calving and continuing until the onset of the rainy season in March or April since the main purpose of supplementation was to overcome dry season feed shortage. Supplementation was done after the day's normal grazing at 17:00 h (local time). Brewers' spent grain was obtained in the wet form from a local brewery and spread out on a concrete floor to dry for 4 days. Sun-dried brewers' spent grain on chemical analysis contained 24% crude protein.

2.4. Parameters studied

The parameters studied included the ages at puberty, first mating and first calving; intervals from calving to resumption of ovarian cyclicity and post-partum mating; body condition scores, blood haemoglobin and packed cell volume as well as other significant events like abortions and stillbirths.

The age at puberty and the resumption of post-partum ovarian cyclicity were determined by measuring plasma progesterone of experimental animals. Blood samples were collected from all animals at the start of the study and then at 10-day intervals. Progesterone was assayed using the FAO/IAEA coated antibody radio-immunoassay technique. A plasma progesterone concentration of 2.0 nmol/l or more was taken as evidence of ovarian activity. Pregnancy was confirmed by elevated plasma progesterone levels at 21 and 42 days post-coitus.

Body condition scores were assessed once monthly according to the system developed at the International Livestock Centre for Africa [4] while blood packed cell volume and haemoglobin were measured according to Varley [5].

The occurrence of oestrus on all farms was detected with the aid of behaviourial signs and service bulls fitted with chinball markers.

2.5. Statistical procedures

Analysis of variance using the Dbstat Computer Programme [6] was used to investigate the effects of farm and supplementation.

3. RESULTS AND DISCUSSION

3.1. Diagnostic data collection phase

Table I summarizes of the main reproductive parameters for beef animals managed under traditional methods. As described earlier, farms 1, 2 and 3 contained both N'dama and West African Shorthorn

(WASH) cattle while Farm 4 contained Sangas. No clear distinction was made between N'dama and WASH since breeding on all farms was uncontrolled and it was difficult to isolate pure animals.

TABLE I. SUMMARY OF THE MAIN REPRODUCTIVE PARAMETERS OF HEIFERS IN GHANA ($\bar{x}$ ± sd)

Farm*	No. Animals	Age first P_4 rise (days)	Age first mating (days)	Age first calving (days)
1	24	915 ± 20.3[a]	933 ± 23.7[a]	1216 ± 24.1[a]
2	18	910 ± 24.0[a]	924 ± 28.1[a]	1213 ± 28.5[a]
3	10	1116 ± 39.2[c]	1194 ± 45.9[b]	1459 ± 46.5[c]
$\bar{x}$ (1-3)	52	952 ± 14.6	980 ± 17.1	1262 ± 17.3
4	19	964 ± 23.0[b]	990 ± 27.0[a]	1271 ± 27.4[b]

* Farms 1, 2 and 3 contained a mixture of N'dama and West African Shorthorn cattle. Due to indiscriminate mating, no attempt has been made to distinguish pure animals. Farm 4 contained Zebus.

[a,b,c] Means in a column with different superscripts significantly different ($P < 0.01$).

Mean intervals to first P_4 rise, first mating and first calving for the heifers are shown in Table I. The age at first plasma progesterone elevation (puberty) for N'dama/WASH animals ranged from 910 ± 24.0 to 1116 ± 39.2 days while the age at first mating ranged from 924 ± 28.1 to 1194 ± 45.9 days between farms. The differences among the farms for both variables were significant ($P < 0.01$). The age at first calving, calving interval, calving-to-progesterone rise and calving-to-mating interval averaged respectively 1262, 413, 111 and 130 days. Significant differences existed among farms for all parameters measured except for calving interval. Farm 3 animals were oldest at the first plasma elevation, age at first mating and at first calving; they were however intermediate between Farm 1 and Farm 2 animals with respect to calving interval and calving-to-mating interval. The results for Sanga cattle on Farm 4 were generally intermediate between the best and the worst N'dama/WASH farms. These data indicate that beef heifers in Ghana did not show oestrous activity (mating) until on the average of 10 to 80 days after the first rise in plasma progesterone. This observation also has been made for N'dama and Friesian X N'dama heifers kept on-station [7]. It has been suggested that the absence of behaviourial oestrus at the initial progesterone elevation indicates that endocrinological events at puberty may be abnormal [8].

The age at first calving for the beef animals compares favourably with observations for N'dama cattle in Senegal and Ghana [9, 10] where it has been suggested that indigenous tropical cattle normally calve for the first time between approximately 1094 and 1459 days [11]. The calving intervals recorded in these studies are much better than those for on-station N'dama [7] and are in the range of values observed for Jersey, Brahman and *Bos indicus* cattle (441, 456 and 462 days respectively) in the tropics [12]. The corresponding figure for N'dama in Senegal was 495 days [9]. The calving-to-progesterone rise intervals indicated that there was generally a delay of up to 40 days from the first post-partum ovarian cycle to the subsequent mating. These results emphasize the point that the reproductive performance of beef cows in Ghana is influenced to a large extent by breaks in ovarian function in the pre-oestrous period or the occurrence of silent oestrus. Figure 1a shows the case of one cow that showed one progesterone peak at day 75 post-partum and did not

show any further ovarian activity until 150 days later. This must be interpreted with caution, however, since profile evaluation was based only on concentration determinations every 10 days.

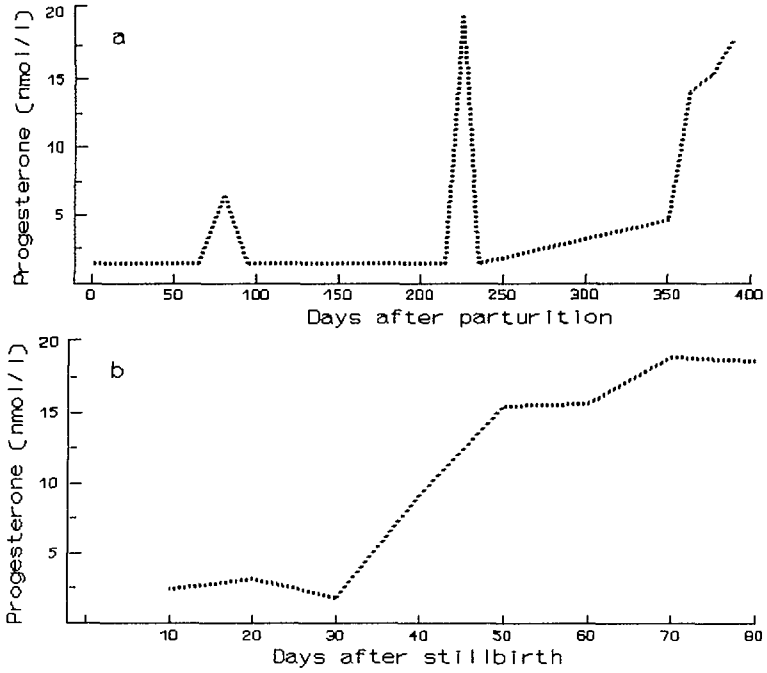

Fig. 1a. Progesterone profile of a cow culled for poor reproductive performance.
Fig. 1b. Progesterone profile following a stillbirth.

Where cows lost their calves as a result of abortion, stillbirths, or early death (before 14 days post-delivery) such cows resumed ovarian activity within 41 ± 28.6 days (Fig.1b). Apparently the absence of suckling shortens the post-partum acyclic period [13, 14]. While this may indicate beneficial effects of early weaning, the practice is fraught with problems under on-farm conditions that make its widespread adoption impossible in the short term at least. The gestation length for all delivering animals (n = 88) averaged 282 days and is within the normal range of values for cattle [12, 15].

The effects of the season of birth or calving on reproductive performance are summarized in Tables II-IV. Slightly more calves were born in the wet than in the dry season contrary to the situation on-station where 57% of births occurred in the dry season [7]. However, heifers born in the wet season appeared to reach puberty and breed earlier than those born in the dry season, although the differences were not significant ($P > 0.05$). Similarly, wet season-born heifers calved for the first time slightly, but not-significantly, earlier than those born in the dry season. This finding agrees with earlier observations [7]. Calving interval, calving-to-mating and calving to the resumption of ovarian activity were reduced if cows calved in the dry season compared to calving in the wet season and agree with previous reports [7]. It was explained that cows calving in the dry season soon enter the rainy season and so have access to nutritious pasture coinciding with the early rains [7] and this promotes earlier ovarian function [12]. Season had no significant effect on the length of gestation, body condition scores and blood parameters (Table V) of beef cattle in the humid zone of Ghana.

TABLE II. EFFECTS OF SEASON ON REPRODUCTIVE PERFORMANCE OF COWS BRED ON-FARM IN GHANA ($\bar{x}$ ± sd)

Farm*	No. Animals	Calving interval (days)	Calving to mating interval (days)	Calving to P_4 rise (days)
1	19	367 ± 32.8	85 ± 32.6[a]	77 ± 28.9[a]
2	27	436 ± 29.9	153 ± 26.7[b]	118 ± 23.7[b]
3	13	433 ± 45.1	147 ± 44.7[b]	147 ± 39.6[b]
$\bar{x}$ (1-3)	59	413 ± 19.9	130 ± 18.9	111 ± 16.7
4	24	431 ± 32.8	150 ± 28.4[b]	107 ± 25.2[b]

* Farms 1, 2 and 3 contained a mixture of Ndama and West African Shorthorn cattle. Due to indiscriminate mating, no attempt has been made to distinguish pure animals. Farm 4 contained Zebus.

[a,b] Means in a column with different superscripts significantly different ($P < 0.01$).

TABLE III. EFFECTS OF SEASON ON REPRODUCTIVE PERFORMANCE OF HEIFERS BRED ON-FARM IN GHANA ($\bar{x}$ ± sd)

Season	No. born	No. animals	Age first P_4 rise (days)	Age first mating (days)	Age first calving (days)
Dry	41	31	990 ± 20.6	1020 ± 24.2	1302 ± 24.5
Wet	47	40	962 ± 16.8	1001 ± 19.7	1277 ± 20.0

TABLE IV. EFFECTS OF SEASON ON REPRODUCTIVE PERFORMANCE OF COWS ON-FARM IN GHANA ($\bar{x}$ ± sd)

Season	No. born	No. animals	Calving-to mating (days)	Calving to P_4 rise(days)	Calving interval (days)
Dry	41	47	117 ± 21.3	105 ± 18.8	400 ± 21.4
Wet	47	36	151 ± 24.7	119 ± 21.9	433 ± 24.9

TABLE V. EFFECTS OF SEASON ON PACKED CELL VOLUME (PCV), HAEMOGLOBIN AND BODY CONDITION SCORES (BCS) OF ON-FARM BEEF CATTLE.

	PCV	Haemoglobin (g %)	BCS
Season	($\bar{x}$ ± sd)	($\bar{x}$ ± sd)	($\bar{x}$ ± sd)
Dry	32.7 ± 2.1	12.1 ± 0.99	2.2 ± 0.37
Wet	32.3 ± 1.9	11.2 ± 1.22	3.0 ± 0.40
Both seasons	32.5 ± 1.8	11.6 ± 1.5	2.6 ± 0.40

Figure 2 shows the monthly distribution of calvings. Most calvings (75%) occurred between the months of September and January, with October (late rains) and November (early dry season) being the peak months (45% of calvings). It is not clear why most calvings occurred during the late rains and the dry season since this period coincides with the presence of relatively lower quality forage. It might be tempting

therefore to recommend restricting calvings to the rainy season to coincide with abundant forage. On the other hand, dry-season calvings seem to hasten the onset of post-partum ovarian activity (Table IV). A compromise solution may be to confine calvings to the late dry season and early rains so that animals have the advantage of a long wet period with plentiful grass or forage cover.

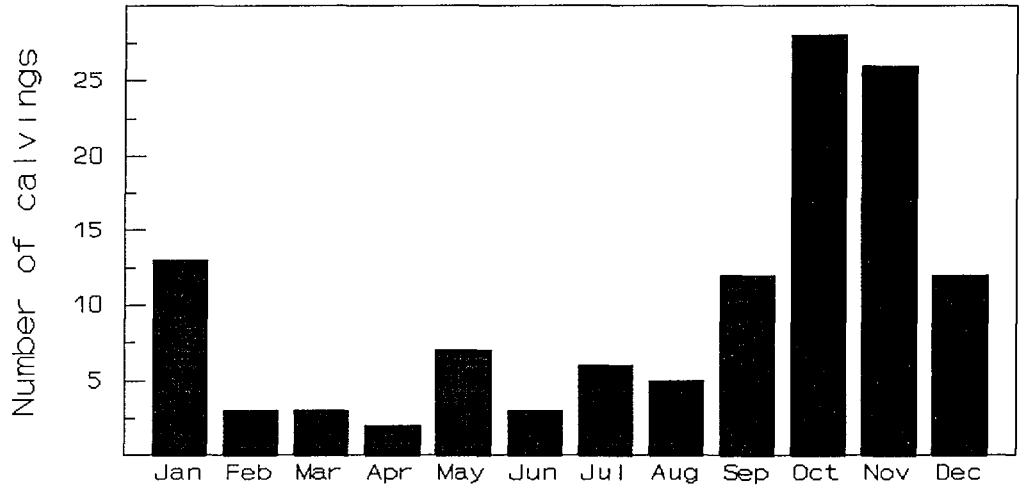

Fig. 2. Distribution of calvings by month.

The causes of calf loss are listed in Table VI. Abortions and starvation accounted for 53% of all calf losses while stillbirths accounted for 42%. Starvation losses were due either to the fact that cows did not produce adequate milk or would not allow the calves to suckle. Such losses can be reduced or even prevented by bottle-feeding or by foster-mothering.

Table VII indicates that approximately 30% of N'dama/WASH were cycling 60 days post-partum while up to 97% were cycling by 180 days. The corresponding figures for Sanga cattle were 50 days and 95% respectively.

TABLE VI. CAUSES OF CALF LOSS IN BEEF CATTLE ON-FARM IN GHANA[a]

Cause	No. of calves	Percent of total mortality
Abortions	5	26
Stillbirths	8	42
Starvation[b]	5	26
Calf abnormalities[c]	1	5

[a] Total calf loss = 16% of births

[b] Calves starved because cows would not allow suckling or produced little extractable milk, calves died within 14 days of birth

[c] Crooked legs making it impossible for calf to stand and suckle

TABLE VII. RATE OF RESUMPTION OF OVARIAN ACTIVITY POST-PARTUM IN BEEF CATTLE IN GHANA

	Percentage of cows cycling	
Days post-partum	N'dama/WASH[a]	Sanga
1-60 d	30	50
61-120 d	52	25
121-180 d	16	20
180 d	2	5
	(50)[b]	(20)

[a] WASH = West African Shorthorn.
[b] Total number of cows studied.

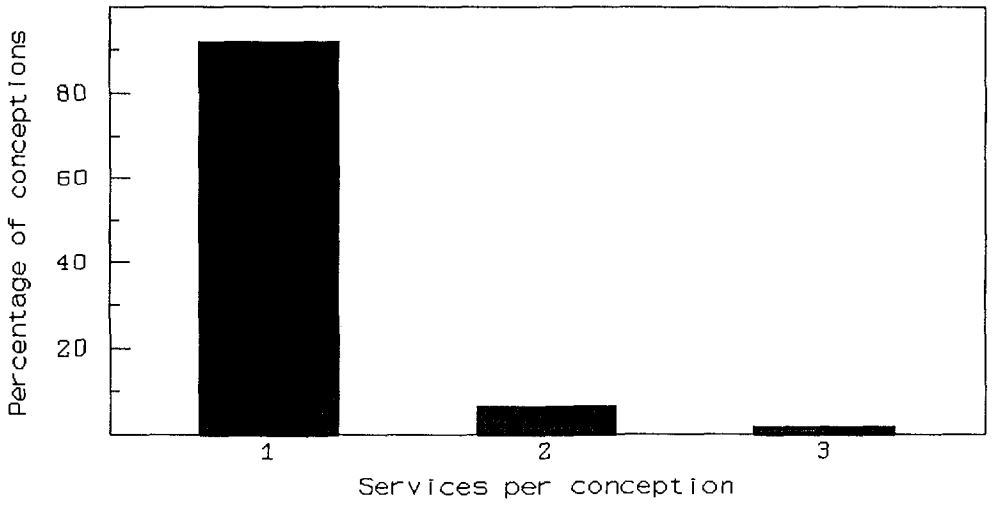

Fig. 3. Number of services per conception.

Data pertaining to the number of services per conception were obtained in 88 cases for N'dama/WASH and 35 for Sanga cattle, with the percentage distribution of this data shown in Figure 3. The mean services/conception were 1.1. and 1.0 respectively for N'dama and Sanga, confirming earlier findings [7]. These results indicate that the failure to conceive after mating is not a major problem in Ghanaian beef cattle.

3.2. Supplementary feeding phase

The effects of dry season feed supplementation on reproductive performance of on-farm beef cattle are presented in Table VIII and IX. In general, supplementation improved reproductive performance by reducing the age at puberty (69 days), calving-to-mating interval (40 days), calving-to-progesterone rise (17 days), calving to conception interval (40 days) and calving interval (36 days) compared with female cattle receiving no supplementation in the dry season. These differences were, however, not statistically significant,

possibly because of small sample size. Supplemented counterparts were generally in better body condition than their unsupplemented counterparts (3.0 versus 2.7 respectively). The beneficial effects of supplementary feeding are well documented for heifers as well as for cows in other studies [17, 18].

TABLE VIII. EFFECTS OF DRY SEASON SUPPLEMENTATION ON REPRODUCTIVE PERFORMANCE OF HEIFERS ($\bar{x}$ ± sd)

Treatment	No. of animals	Age at puberty (days)	Age at first calving (days)
No supplement	10	894 ± 24.9	1189 ± 39.0
Supplement	10	826 ± 24.9	1109 ± 36.4

TABLE IX. EFFECTS OF DRY SEASON SUPPLEMENTATION ON REPRODUCTIVE PERFORMANCE OF COWS ($\bar{x}$ ± sd)

Treatment	No. of animals	Calving to mating (days)	Calving to P_4 rise (days)	Calving to conception (days)	Calving interval (days)
No supplement	14	145 ± 27.2	109 ± 25.2	147 ± 27.2	428 ± 25.0
Supplement	18	105 ± 23.7	92 ± 22.0	107 ± 23.7	392 ± 21.8

4. CONCLUSIONS

The results reported here indicate that beef cattle kept on-farm in the humid forest zone of Ghana perform in a manner comparable to their on-station counterparts. On-farm animals were generally older at puberty and mating [7, 16] while they had shorter calving intervals. It appears that on-farm animals are disadvantaged early in life but initial stress factors are cancelled out by the time cows have their second calf. There is apparently an advantage to dry season supplementation of beef cattle in Ghana. However, the economics of such a practice need serious consideration with particular reference to small-scale resource poor farmers.

Culling rates were low (almost non-existent) on all farms. This factor must be considered in any discussion of the reproductive performance of indigenous cattle. Old and unthrifty animals must be removed.

ACKNOWLEDGEMENTS

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REPRODUCTIVE PERFORMANCE OF THE INDIGENOUS ZEBU AND FRIESIAN x ZEBU CROSSBRED COWS UNDER SMALL HOLDER MANAGEMENT CONDITIONS IN ETHIOPIA

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Abstract–Résumé

REPRODUCTIVE PERFORMANCE OF THE INDIGENOUS ZEBU AND FRIESIAN x ZEBU CROSSBRED COWS UNDER SMALL HOLDER MANAGEMENT CONDITIONS IN ETHIOPIA.

Data on the reproductive performance of Zebu and crossbred cows raised on smallholder farms were analyzed for a total of 142 calvings. Gynaecological examinations were carried out at 7 to 10 days intervals starting at 10 to 15 days after calving until pregnancy was confirmed by rectal palpation of the conceptus. Nutritional status of cows was assessed by body condition scoring (BCS) at calving. Ovarian activity was monitored using milk progesterone (P_4) concentrations determined by Radioimmunoassay (RIA).

Overall mean (± sd) interval from calving to complete uterine involution, first ovulation and conception were 29 ± 7.4, 104 ± 26.2 and 171 ± 67.1 days, respectively. Uterine involution occurred significantly ($P< 0.05$) earlier in the Zebu than in the crossbred cows, and in primipara than in pluripara cows. Season of calving and BCS at calving did not influence the interval to uterine involution. Both intervals from calving to first ovulation and to conception were significantly ($P< 0.05$) affected by genotype and BCS, but not by parity and season of calving. Crossbred cows resumed ovarian activity and conceived significantly earlier than the Zebu cows. Cows with BCS of equal or above 4 at calving had significantly ($P< 0.05$) shorter intervals from calving to first ovulation and to conception than cows with BCS of less than 4. Milk progesterone profiles revealed that abnormal ovarian activities (acyclic, erratic and cessation of cyclic activity) occurred in 62 and 49% of the Zebu and crossbred cows, respectively. Pregnancy rates were 48 and 60% in the Zebu and crossbred cows.

It was concluded that crossbred cows had better post-partum reproductive performance than the Zebu and good body condition at calving improved post-partum reproductive performance in both genotypes of animals. However, establishment of the appropriate level of supplementary feeding for optimum postpartum reproductive performance remains to be investigated.

PERFORMANCE DE REPRODUCTION CHEZ LE ZEBU INDIGENE ET LES VACHES CROISEES FRISONNE x ZEBU DANS LES CONDITIONS DE PETITES EXPLOITATIONS EN ETHIOPIE.

Des données portant sur 142 vêlages au total et relatives à la performance de reproduction des zébus et des vaches croisées élevés dans de petites exploitations ont été analysées. Des examens gynécologiques ont été effectués à des intervalles de sept à dix jours à partir du 10ème au 15ème jour après vêlage, jusqu'à ce qu'un diagnostic de gestation soit confirmé par palper rectal du foetus. L'état nutritionnel des vaches a été estimé par évaluation de l'état corporel (BCS) au moment du vêlage. L'activité ovarienne a été suivie par radio-immunodosage (RIA) des taux de progestérone (P_4) dans le lait.

Les intervalles moyens d'ensemble (± écart type) entre le vêlage et l'involution utérine complète, la première ovulation et la conception ont été respectivement de 29 ± 7,4, 104 ± 26,2 et 171 ± 67,1 jours. L'involution utérine s'est produite de façon significative ($P < 0,05$) plus tôt chez les zébus que chez les vaches croisées, et chez les vaches primipares que chez les multipares. La saison du vêlage et l'état corporel au vêlage n'ont pas influé sur l'intervalle entre ce dernier et l'involution utérine. Les intervalles entre le vêlage et la première ovulation et entre le vêlage et la conception sont liés de façon significative ($P < 0,05$) au génotype et à l'état corporel, mais non au nombre de gestations ni à la saison du vêlage. La reprise de l'activité ovarienne et la conception sont intervenues significativement plus tôt chez les vaches croisées que chez les zébus. Chez les vaches ayant un BCS égal ou supérieur à 4 au moment du vêlage, les intervalles séparant le vêlage de la première ovulation et de la conception étaient significativement ($P < 0,05$) plus courts que chez les vaches ayant un BCS inférieur à 4. Les profils de progestérone dans le lait ont montré que des anomalies dans l'activité ovarienne (activité acyclique ou irrégulière, arrêt de l'activité cyclique) se produisaient chez les zébus et chez les vaches croisées dans 62 et 49% des cas respectivement. Les taux de gestation ont été respectivement de 48 et 60%.

En conclusion, les vaches croisées ont une meilleure performance de reproduction post-partum que les zébus, et un bon état corporel au moment du vêlage améliore la performance de reproduction post-partum chez les deux génotypes. Cependant, il faut encore mener des travaux pour déterminer le niveau approprié du complément nutritionnel à apporter pour optimiser la performance de reproduction post-partum.

1. INTRODUCTION

The Ethiopian cattle population, numbering some 31 million head, is the largest in Africa [1] with the majority of these animals owned by smallholder farmers and managed in traditional ways [2]. The indigenous Zebu reach puberty relatively late, have long postpartum acyclicity and have depressed signs of oestrus [3, 4, 5]. It is believed that the extended interval from parturition to resumption of oestrous cycles is mainly responsible for the poor reproductive efficiency of these cows. It is also very damaging economically, as it increases the life-time maintenance costs and reduces the productivity of cattle in the region as a whole.

In most developing countries, the improvement of milk production has been initiated through the introduction of temperate dairy breeds for crossbreeding programmes with the local Zebu cattle [6]. The resulting crossbred cows often experience environmental stresses and the challenges of high diseases risk [3] which influence both productive and reproductive performances. Data on the influences of these environmental factors on performance traits are limited. Much of the research conducted was also carried out under relatively controlled conditions at research stations and/or institutional herds and thus has limited application to the smallholder production systems in Africa. The objectives of this investigation therefore were:

(i) to evaluate the postpartum reproductive performance of Zebu and Friesian x Zebu crossbred cows under smallholder management conditions in Ethiopia;

(ii) to determine factors affecting the reproductive function of post-partum cows so as to ultimately find solutions to constraints.

2. MATERIALS AND METHODS

The study was undertaken in the central highlands of Ethiopia around Debre Zeit town which is located 50 km southeast of Addis Ababa. The area is situated at 8°44' N latitude and 39°02' E with an altitude of 1880 m and annual mean temperature of 19.1°C. The mean annual rainfall is 866 mm, of which 84% falls during the long rainy season between June and September. The short rainy season occurs from March to May and the dry season extends from October to February.

The study was carried out between June 1987 and May 1992. A total of 126 cows and heifers located on 21 smallholder representative farms with 3 to 9 animals each and similar management conditions provided data for the study. The cows were kept for dairying and grazed on natural pastures or were fed on grass hay and supplemented with local brewers grain and/or wheat bran. Cows were hand-milked after calf suckling to stimulate milk let-down. Body condition was scored (1 = emaciated, 9 = fat) at calving using the method of Nicholson and Butterworth [7]. Clinical gynaecological examinations were performed at 7 to 10 day intervals beginning 10 to 15 days post-partum and continuing until pregnancy was confirmed by rectal palpation of the conceptus.

Composite milk samples were collected twice weekly. Sodium azide tables were used as milk preservative. The milk samples were kept at ambient temperature for about 10 min and were subsequently stored at 4°C until assayed. Milk progesterone concentrations were determined by the radioimmunoassay (RIA) technique using reagents regularly obtained from FAO/IAEA.

Postpartum ovulation was assumed to have occurred if milk progesterone concentrations were ≥ 10.0 nmol/l in two consecutive weeks. Following ovulation, cows were classified into the following categories based on milk progesterone profiles.

- Normal: high progesterone concentrations for about two weeks, alternating with low levels for about one week;
- Acyclic: progesterone concentrations continued at basal levels;
- Erratic: the group with irregular progesterone profiles, that is those cows demonstrating high and low values but not in a normal cyclic pattern;
- Cessation: when normal ovarian cycles ceased and progesterone concentrations fall to low levels for over a period of two weeks. This also includes profiles with a decline in progesterone concentrations to low levels after over 30 days of elevation.

All records were chronologically compiled for each postpartum cow and the day of first postpartum ovulation determined from these profiles. Data were analyzed by analysis of variance. Intervals from calving to uterine involution, first postpartum ovulation and conception were used as dependent variables in evaluating the effects of genotype, parity, body condition score at calving and season of calving.

3. RESULTS AND DISCUSSION

Some 29 cows and one farm were gradually excluded from the study for various reasons. Cow losses resulted from: abortion (3 cases), dystocia (5 cases), death (6 cases) and culling of animals by farmers (15 cases). The results described are from 142 calvings of 54 Zebu and 43 crossbred cows.

Table I shows the post-partum reproductive performance of the Zebu and Friesian x Zebu crossbred cows. The overall mean (± sd) interval from calving to complete uterine involution was 29 ± 7.4 days and was influenced significantly by genotype and parity ($P < 0.05$). The interval to complete uterine involution was longer for crossbreeds than Zebus (32 ± 7.5 vs 26 ± 6.0 days) and in the pluripara compared to primipara cows (30 ± 7.2 vs 24 ± 7.0 days). Body condition score at calving and season of calving did not influence the interval to uterine involution. However, in other studies the interval from calving to uterine involution was prolonged following abnormal calvings and during certain seasons [8].

The overall mean interval from calving to first ovulation was 104 ± 26.2 days. This interval was longer ($P < 0.05$) in the Zebu and than in the crossbred cows (116 ± 24.2 vs 96 ± 26.7 days). This significant difference indicates a clear advantage of the crossbreeds over the indigenous Zebu in terms of better postpartum reproductive activity, providing a potential for shorter calving intervals. These findings are in agreement with previous reports of Alberro [3] and Garcia *et al.* [9]. Cow parity did not influence the interval from calving to first ovulation. This did not agree with the reports of Mukasa-Mugerwa *et al.* [10] who found a significant effect of dam parity on the interval. However, data on primipara cows came from relatively few animals, and this may explain the discrepancy. Although cows calving during the dry season had slightly shorter interval to first ovulation than those calving during the long and short rainy seasons, season of calving did not influence the interval.

TABLE I. LEAST SQUARE MEANS AND VARIANCE (sd) FOR POST-PARTUM REPRODUCTIVE TRAITS OF INDIGENOUS ZEBU AND FRIESIAN X ZEBU CROSSBRED COWS UNDER SMALLHOLDER MANAGEMENT CONDITIONS IN ETHIOPIA

	Interval from calving to					
	Uterine involution		First ovulation		Conception	
Sources of variation	n	Mean	n	Mean	n	Mean
Overall	142	29 ± 7.4	142	104 ± 26.2	78	171 ± 67.1
Genotype						
Zebu	77	26 ± 6.0[a]	77	116 ± 24.2[a]	38	188 ± 60.0[a]
Crossbred	65	32 ± 7.5[b]	65	96 ± 26.7[b]	40	155 ± 70.0[b]
Parity						
Primipara	25	24 ± 7.0[a]	25	107 ± 29.7	10	178 ± 70.2
Pluripara	117	30 ± 7.2[b]	117	103 ± 25.5	68	170 ± 67.1
BCS[1]						
2	26	26 ± 6.6	26	121[a] ± 19.4	6	207 ± 52.9[a]
3	31	30 ± 6.3	31	115[a] ± 26.1	14	205 ± 65.5[a]
4	21	28 ± 9.2	21	99[b] ± 26.9	14	158 ± 27.1[b]
5	27	30 ± 7.8	27	96[b] ± 25.3	18	161 ± 48.9[b]
6	15	28 ± 8.0	15	93[b] ± 22.8	9	158 ± 82.7[b]
≥ 7	22	30 ± 8.5	22	95[b] ± 15.4	17	149 ± 73.5[b]
Season[2]						
Dry	22	28 ± 6.3	22	98 ± 18.4	13	190 ± 110.0
Short rain	64	29 ± 7.3	64	106 ± 26.8	32	171 ± 64.2
Long rainy	56	29 ± 8.0	56	103 ± 28.0	33	164 ± 46.3

[1] BCS = Body Condition Score; 1 = thin, 9 = fat.

[2] Dry = Oct. - Feb.; short rainy = Mar. - May; Rainy = June - Sept.

[a,b] Column means within groups differ significantly ($P < 0.05$).

Further analysis of the data on the interval from calving to first ovulation also revealed that cows with a body condition score of 4 and above resumed ovarian cyclic activity earlier than those with body condition score of 3 and 2 (99 ± 26.9 vs 115 ± 26.1 days; $P < 0.05$; Table I). This supports previous findings that cows having body condition scores below the critical level have poor reproductive performance [5]. Moreover, our data show that when properly and carefully applied, body condition scoring has a practical relevance in assessing the nutritional status of cows, particularly under smallholder production systems where field facilities are limited.

Figures 1, 2 and 3 show the distribution of calvings, resumption of ovarian cyclicity and conceptions in the Zebu and crossbred cows. Although there are fluctuations in the quality and quantity of supplementary feeds

available, the farms included in our study practised year-round supplementary feeding of milking cows using industrial by-products. Hence, seasonal variations in nutrition may not have been severe enough to make marked impact on reproductive performance.

The overall mean (± sd) interval from calving to conception for 78 cows was 171 ± 67.1 days. The crossbred cows conceived significantly ($P < 0.05$) earlier than the Zebu cows (155 ± 70.0 vs 188 ± 60.0 days; Table I). However, there were no significant influences of dam parity and season of calving on the interval to conception. BCS at calving, nevertheless, exerted a significant ($P < 0.05$) effect on the calving to conception interval. Cows which calved with BCS of 4 and above had calving to conception intervals of 156 days while those with BCS of 2 and 3 had 206 days. In these two group of cows, the mean differences between calving to conception and to first ovulation intervals were 60 and 88 days; this suggests that cows with poor BCS at calving had longer service intervals than those with good BCS.

Based on milk progesterone profiles, postpartum ovarian activities of cows in both genotypes were categorized into normal and abnormal. Abnormal categories included cows which were acyclic, cows with erratic progesterone concentrations and cows which ceased to cycle after ovarian cyclic activity had commenced (Table II). The total number of cows with abnormal profiles was 49 (62%) in the Zebu and 33 (49%) in the crossbred cows. The conception rates of cows with different categories of progesterone profiles following the first postpartum ovulation are also presented in Table II. The mean conception rate was 48% for Zebu and 60% for

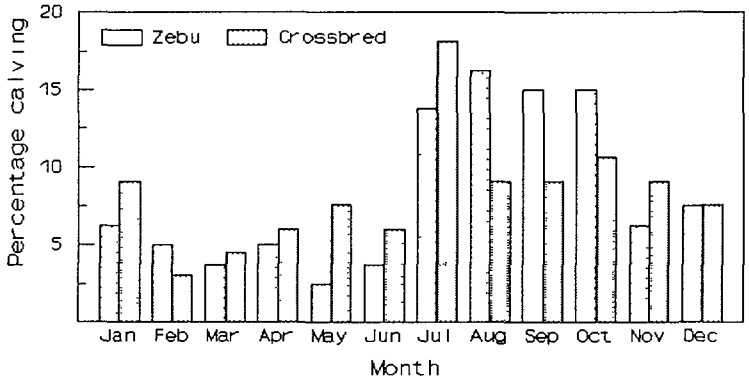

Fig. 1. Percentage distribution of calvings by month in Zebu and crossbred cows (n = 146).

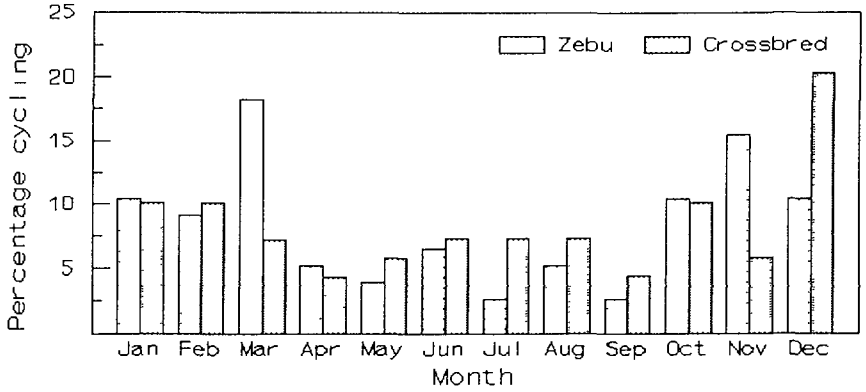

Fig. 2. Percentage distribution of resumption of cyclicity by month in Zebu and crossbred cows (n = 146).

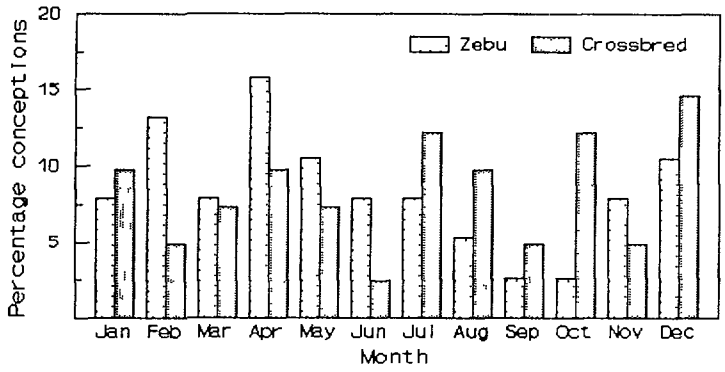

Fig. 3. Percentage distribution of conceptions by month in Zebu and crossbred cows (n = 79).

crossbred cows. None of the totally acyclic or cows which ceased to cycle conceived. However, a relatively high percentage of cows with erratic progesterone profiles conceived. The relatively high percentage of cows with abnormal progesterone profiles observed in the present study could be associated with abnormal ovarian functioning [11, 12] and this could have resulted in lower conception rates [13].

In conclusion, the intervals from calving to the resumption of ovarian activity and to conception were relatively shorter in the crossbred than in the Zebu cow. These intervals were also shorter in cows which calved with body condition score of 4 and above compared with a BCS of 3 and below, indicating the importance of

TABLE II. CLASSIFICATION OF OVARIAN ACTIVITY BASED ON SEQUENTIAL PROGESTERONE PROFILES FOLLOWING THE FIRST OVULATION AND SUBSEQUENT CONCEPTION RATES IN POSTPARTUM ZEBU AND FRIESIAN X ZEBU CROSSBRED COWS KEPT ON SMALLHOLDER FARMS IN ETHIOPIA

Classification of ovarian activity	Zebu		Friesian x Zebu	
	n	Conception rate, %	n	Conception rate, %
Normal	30	93.3	34	91.2
Acyclic	24	0.0	11	0.0
Erratic	11	90.9	13	69.2
Cessation	14	0.0	9	0.0
Total	79	48.1	67	59.7

[a] Includes cows with decline in progesterone concentrations to low levels after over 30 days of elevation.

nutritional status of cows at calving in influencing the postpartum reproductive activity. Moreover, the incidence of abnormal ovarian functions as measured by milk progesterone profiles was relatively smaller and conception rate was higher in the crossbred than in the Zebu cows. In general, the crossbred cows had better post-partum reproductive performance than the Zebu cows.

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LE CONTROLE DE LA FONCTION SEXUELLE DU JEUNE TAURILLON DANS UN PROGRAMME D'INSEMINATION ARTIFICIELLE

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Abstract-Résumé

BREEDING SOUNDNESS AND ITS RELEVANCE TO THE AI-BULLS.

The present review indicates some of the conditions following which an accurate evaluation of the breeding soundness of young post-pubertal bulls can be made. This relies on to the following components: sexual behaviour, testis morphology, sperm production, hormonal profiles, semen output. A combination of these traits results in discarding up to 20 - 25% of the bulls prior to their entry into AI centers. This finally results in contributing to improve the mean potential of fertility in a given population hence giving an additionnal advantage to this remarkable technique, namely Artificial Insemination.

LE CONTROLE DE LA FONCTION SEXUELLE DU JEUNE TAURILLON DANS UN PROGRAMME D'INSEMINATION ARTIFICIELLE.

La présente revue précise les conditions selon lesquelles un contrôle précis de la fonction sexuelle peut-être mis en place dans le cadre de l'Insémination Artificielle bovine. Les composantes de cette fonction comprennent le comportement sexuel, la morphologie testiculaire, la production de spermatozoïdes, les concentrations hormonales et le spermogramme. L'élimination des plus mauvais individus (parfois jusqu'à 20 - 25%) contribue à améliorer le potentiel de fertilité de la population ajoutant ainsi à l'Insémination Artificielle, la vertu de contribuer à l'amélioration de la fertilité.

1. INTRODUCTION

L'Insémination Artificielle est l'outil zootechnique privilégié de l'amélioration du bétail pour deux raisons principales: son efficacité au plan de l'amélioration génétique et sa sécurité au plan sanitaire. A ces deux vertus, il en est une troisième, désormais, qui est celle de contribuer a améliorer la fertilité du troupeau. Cette contribution passe ici par ce qu'il est convenu d'appeler la voie mâle, c'est à dire la production de doses de semence ayant un potentiel de fertilité maximal à la fois en effet direct, vis à vis de la femelle qui recevra cette dose, et, en effet indirect, par la transmission aux générations ultérieures de ce potentiel. La figure 1 illustre ce concept et montre pour la filière mâle (partie inférieure du schéma) les 3 maîtres mots - Santé-Technicité-Fertilité.

Ces observations expliquent l'intérêt de se préoccuper de la filière mâle en complément de toutes les présentations portant sur les femelles rassemblées dans le présent projet coordonne de recherches de l'IAEA en Afrique.

La difficulté d'évaluation de la fonction sexuelle mâle est indiscutable et ceci a encore été récemment discuté par Thibier, 1991 [1]. En bref, elle résulte d'abord du fait de la double interférence du milieu entre valeur génotypique de Reproduction et valeurs phénotypiques de ces composantes. Elle provient aussi du fait que chacune de ces composantes se rassemblent dans leur expression par la valeur fécondante de l'éjaculat, elle-même appréciée indirectement par le nombre de gestations obtenues à partir des doses préparées de tels éjaculats.

Finalement, la fonction sexuelle s'apprécie par les 4 composantes principales suivantes: comportement sexuel, morphologie testiculaire, production intra-testiculaire de spermatozoïdes et sécrétion

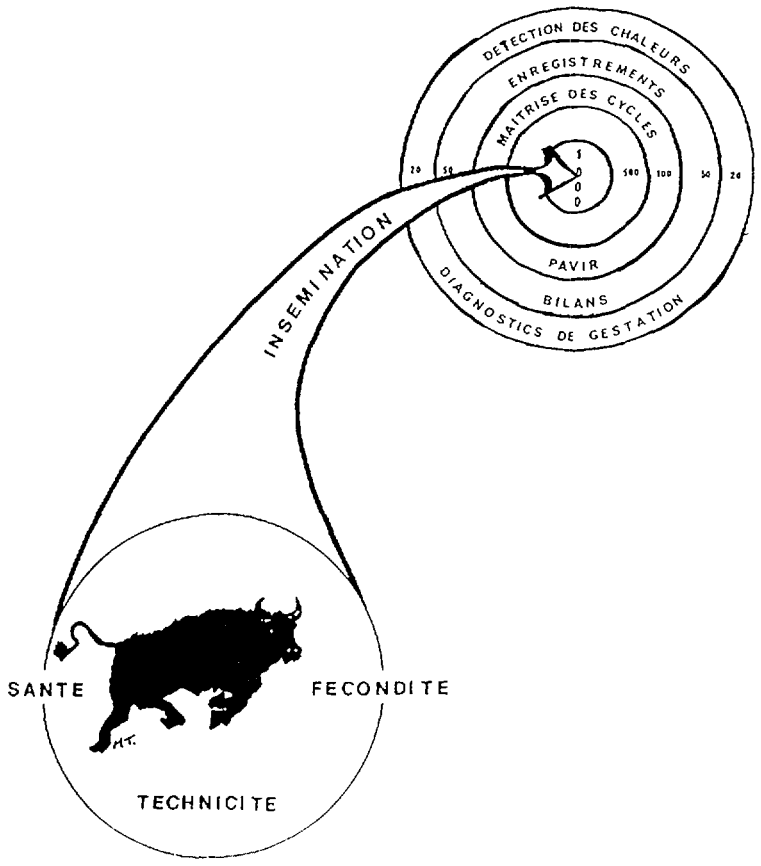

Fig. 1. Schéma intégré d'amélioration de la fertilité bovine par le recours à l'Insémination Artificielle.

hormonale. Pour un futur Reproducteur, il est impossible d'estimer directement la production intra-testiculaire de spermatozoïdes. Celle-ci sera donc indirecte, à la fois par l'estimation de la morphologie des testicules et les caractéristiques du spermogramme.

Le but de cette revue est de présenter brièvement les modalités d'un tel contrôle, puis quelques uns des éléments essentiels de chacune des composantes y contribuant, soit le comportement sexuel, la morphologie testiculaire, la sécrétion hormonale et le spermogramme.

2. MATERIEL ET METHODES

2.1. Modalité du contrôle de la fonction sexuelle

Dans les schémas français d'amélioration génétique et d'Insémination Artificielle, tous les jeunes taurillons procréés après accouplements raisonnés sont introduits comme veaux dans des stations appropriées. Ils sont alors soumis à des conditions d'environnement identiques pendant toute la phase d'élevage [2]. En race laitière, il sont soumis à un contrôle de croissance et d'efficacité alimentaire entre 7 et 10 mois environ. Puis à partir de 12 mois et pendant 3 mois environ ils sont l'objet de ce contrôle de fonction sexuelle portant sur l'évaluation de divers paramètres ainsi qu'il est indiqué ci-après. Les plus mauvais individus, selon ces critères, sont alors éliminés avant d'entrer dans les Centres d'Insémination Artificielle.

2.2. Composante de comportement sexuel

Celle-ci se caractérise par la manifestation d'un comportement inné mais différé, qui ne commence à s'exprimer grossièrement qu'en période immédiatement pré-pubère. Elle suit alors l'évolution classique de tels comportements et en particulier l'apprentissage. La figure 2 illustre ces caractéristiques:

- Dès la première mise à l'épreuve (ici à l'âge de 12 mois environ), près de 50% des animaux de race Holstein Française acceptent le saut. Ce pourcentage est moindre chez les Blonds d'Aquitaine (30%) et traduit la moindre précocité sexuelle classiquement observée chez les animaux de race à viande.

- Au fur et à mesure qu'on répète les épreuves (ici hebdomadaires), les pourcentages de jeunes taurillons exprimant cette fonction s'accroissent.

- Quelques-uns ne le feront jamais, dans les conditions de salles de monte réalisées ici, et ceux-ci sont éliminés de la filière d'Insémination Artificielle. En Europe, cela prévaut pour 5% environ des individus mais peut atteindre 25 à 30% dans d'autres situations telle que celle de jeunes taurillons Baoulé (expériences de Bobo Dioulasso, Burkina Faso, Chicoteau, 1989 [3] et communic. personnelle.)

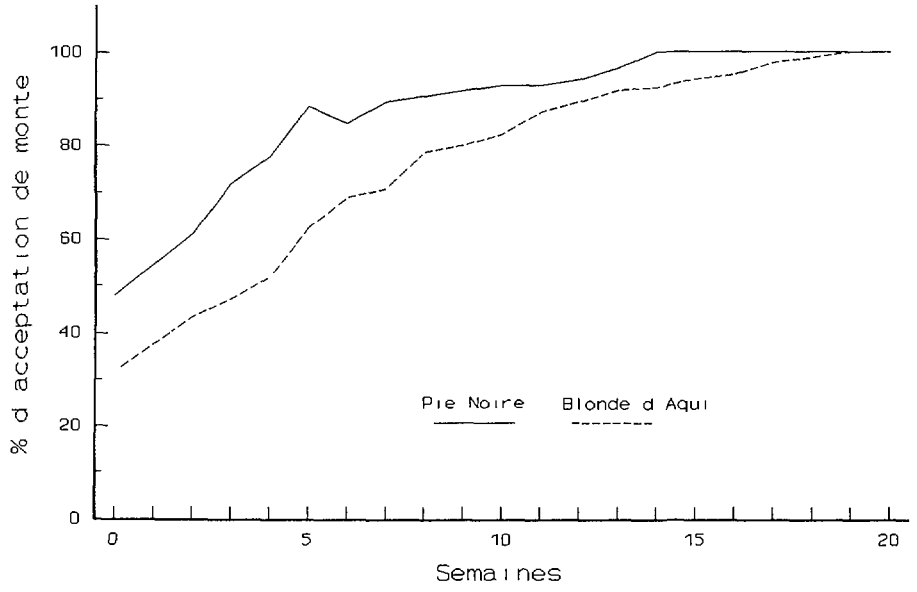

Fig. 2. Courbe d'apprentissage du comportement sexuel en salle de monte chez 74 animaux de race Pie Noire et 67 animaux de race Blonde d'Aquitaine.

2.3. Composante de morphologie testiculaire

Celle-ci peut-être appréciée *in vivo* par d'une part la circonférence scrotale, estimée à l'aide d'un mètre ruban, d'autre part la hauteur testiculaire. Ces deux mesures résument suffisamment l'information et il n'est pas nécessaire d'y ajouter la largeur ou l'épaisseur du testicule pour différencier un individu de ses contemporains. Le tableau I rapporte quelques-unes des valeurs moyennes observées en France sur des animaux de races diverses, âges de 12 ou 15 mois.

Il a été montré [1] que ces mesures étaient hautement corrélées (r = 0,7 environ) non seulement à la taille testiculaire estimée post-mortem mais aussi à la Quantité Journalière de Spermatozoïdes Produits (QJSP) par le testicule et à la Quantité Journalière de Spermatozoïdes Ejaculés (QJSE) dans le cas d'un rythme intensif d'éjaculation (9 récoltes de sperme hebdomadaires).

TABLEAU I. CIRCONFERENCE SCROTALE (CM) DES TAURILLONS A 12 ET 15 MOIS (SELON PAREZ ET THIBIER, 1983) [4]

Races	Stations	N	12 mois	15 mois
FFPN	AMMILLY	74	33,6 ± 2,0	34,6 ± 1,7
Métis FFPN X HOLSTEIN	AMILLY	15	35,7 ± 2,3	36,7 ± 2,6
Normand	AMMILLY	26	33,3 ± 1,9	34,6 ± 2,0
	L'AIGLE 1)	110	33,5 ± 1,6	34,9 ± 1,7
	L'AIGLE 2)	150	32,0 ± 1,9	33,5 ± 1,8
Montbéliard	CEYZERIAT	103	33,7 ± 2,1	35,7 ± 2,2
Abondance	CEYZERIAT	18	34,2 ± 1,9	36,0 ± 1,8
Blond Aquit.	SOUAL	59	32,9 ± 2,1	34,3 ± 2,0
Blond Métis	SOUAL	15	33,3 ± 1,8	33,9 ± 1,1

2.4. Composante hormonale

Dès 1973, il a été montré [5] que les concentrations plasmatiques de LH et de testostérone fluctuaient au cours de la journée. Cette découverte contestée à l'époque, a maintenant reçu un vaste consensus puisqu'une telle pulsatilité est la façon dont les différents partenaires de cette composante hormonale dialoguent entre eux [6]. Pratiquement, ceci, à l'inverse du cas de la progestérone chez la femelle, interdit toute utilisation "spontanée" de ces concentrations. En revanche, un test de freinage stimulation par le recours à l'injection combinée de Dexaméthasone (DXM) - Gonadolibérine (GNRH) [7-8] permet de caractériser un individu par rapport à ses contemporains par la surface sous la courbe de LH, voire de FSH. Une telle réponse est, en outre, positivement mais faiblement corrélée (r = 0,3 environ), aux caractéristiques du spermogramme de tels individus, post-pubères [9].

2.5. Composante du spermogramme

Celui-ci comprend les caractérisques du nombre de spermatozoïdes éjaculés et aussi celles de motilité et d'anomalies des spermatozoïdes. Le tableau II illustre quelques-uns des éléments de ce spermogramme. Ce dernier constitue l'essentiel du jugement et de l'évaluation d'un individu.

Un cinquième des animaux entrant dans un tel schéma est éliminé pour une ou plusieurs caractéristiques insuffisantes: absence de libido, ou morphologie testiculaire réduite ou encore et surtout insuffisance du spermogramme (oligospermie persistante, asthénospermie ou pourcentage d'anomalies morphologiques des spermatozoïdes excessifs).

Ceci a permis de constater (Ouali in Thibier 1991)[1] une forte héritabilité de ces caractérisques ainsi mesurées de façon répétitive. Celle-ci s'est en particulier traduite par une augmentation considérable de la concentration moyenne en spermatozoïdes d'un éjaculat à partir de fils de taureaux pères eux-mêmes soumis quelques 5 à 10 ans auparavant à ces mêmes tests et qui avaient été retenus parce que leur fonction sexuelle avait été parmi les meilleures. Cette augmentation a été de plus du double passant en moyenne en quelques 150 mois, de 0,6 milliard de spermatozoïdes par ml d'éjaculat à 1,4 milliard/ml environ (Fig. 3).

TABLEAU II. NOMBRE DE SPERMATOZOIDES RECUEILLIS PAR EJACULAT (X 10^9) (SELON PAREZ ET THIBIER, 1983) [4]

Race	Station	Nbre. taureaux	1ers éjaculats	2es éjaculats
FFPN	A	57[a]	2,5	2,9
Métis FFPN X Holstein	B	432[b]	3,3	3,2
Normand	A	16[a]	2,3	2,7
Normand	L	826[c]	3,2	2,7
Montbéliard	C	31[a]	1,4	1,3
		593[b]	2,7	2,4
Abondance	C	10[a]	1,6	1,8
Blond d'Aquit.	S	58[d]	1,5	1,6
Métis Blond d'Aquit.	S	19[d]	1,0	1,3
Limousin (S. optimale)	N	10[e]	4,6	4,4
Souche INRA 95	N	6[f]	4,8	4,2

[a] récoltés entre 9 et 15 mois; [b] récoltés entre 11 et 15 mois; [c] récoltés entre 12 et 15 mois; [d] récoltés entre 10 et 15 mois; [e] récoltés entre 15 et 18 mois (3 récoltes par quinzaine); [f] récoltés entre 18 et 21 mois (3 récoltes par quinzaine).

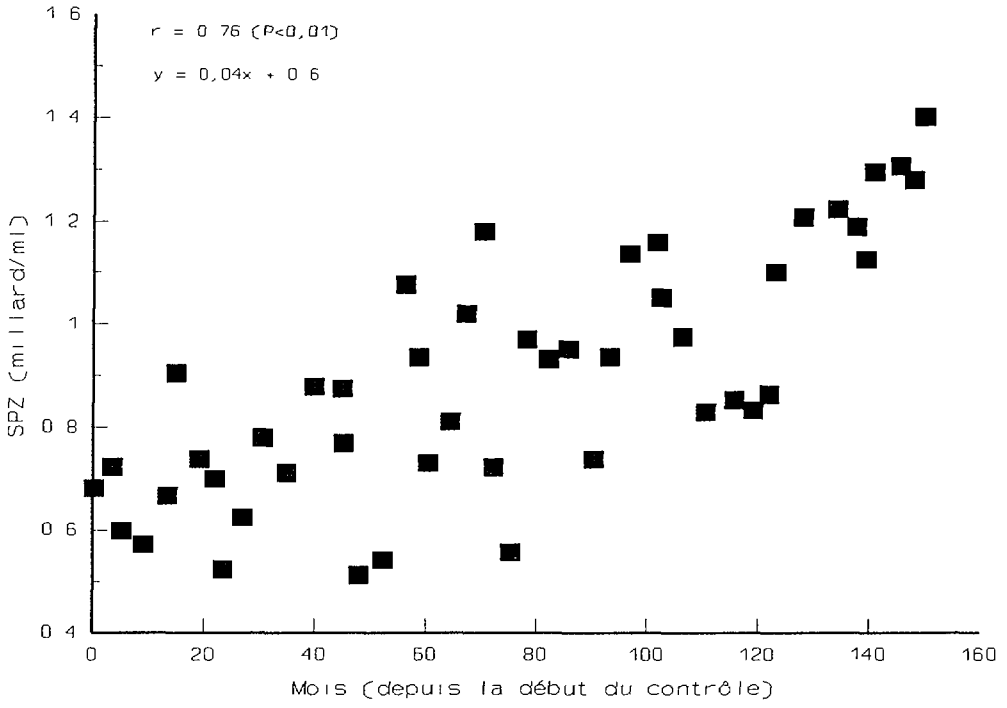

Fig. 3. Evolution de la concentration en spermatozoïdes (SPZ) des éjaculats de jeunes taureaux Montbéliards pendant 13 années consécutives.

3. CONCLUSION

Le contrôle de la fonction sexuelle chez le jeune taurillon post-pubère permet une évaluation précise de cette fonction pour chaque individu et ainsi une sélection de ceux-ci. Ce choix permet d'éliminer les jeunes mâles pour lesquels de telles caractéristiques sont insuffisantes. Ceci conduit à améliorer le niveau moyen de potentiel de fertilité de la population tant mâle que femelle et constitue ainsi pour l'Insémination Artificielle un atout supplémentaire.

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PATHOPHYSIOLOGY, DIAGNOSIS AND THERAPY OF OVARIAN DISORDERS POST-PARTUM IN DAIRY CATTLE

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Abstract–Résumé

PATHOPHYSIOLOGY, DIAGNOSIS AND THERAPY OF OVARIAN DISORDERS POST-PARTUM IN DAIRY CATTLE.

The neuroendocrine events leading to the development of a dominant follicle and ovulation are described, and pathogenesis, clinical symptoms, diagnosis and therapy of cystic ovarian disease discussed. In addition, descriptions of follicular growth and endocrine changes in post-partum cows, reasons for prolonged post-partum acyclicity, and hormonal methods to induce first oestrus and ovulation are given.

PHYSIOPATHOLOGIE, DIAGNOSTIC ET THERAPIE DES TROUBLES OVARIENS POST-PARTUM CHEZ LES VACHES LAITIERES.

Le mémoire comprend une description des phénomènes neuro-endocriniens qui conduisent au développement d'un follicule dominant et à l'ovulation, ainsi qu'un exposé de la pathogénie, des symptômes cliniques, du diagnostic et de la thérapie des kystes ovariens. En outre, il décrit la croissance des follicules et les changements endocriniens survenant chez la vache après la parturition, les raisons pouvant expliquer une absence post-partum prolongée des cycles, ainsi que des méthodes hormonales permettant de provoquer un premier oestrus et une ovulation.

1. INTRODUCTION

An important factor affecting the reproductive performance of dairy cattle is the calving to service interval. Apart from the efficiency of heat detection, this interval is affected by the postpartum interval to resumption of development of a dominant follicle and the exposure of this follicle to a Luteinizing Hormone (LH) surge. This combination of physiological events will then result in the first postpartum ovulation.

The aim of this presentation is to review the endocrine pattern leading to ovulation in the normal cyclic cow and to compare this with the endocrine events in abnormal onset of ovarian activity, leading to the development of cystic ovarian disease. Furthermore, attention will be paid to factors affecting the delay of follicular growth postpartum. The hormonal regimes to initiate return of normal cyclicity in these cases will be discussed.

1.1. Neuro-endocrine regulation of folliculogenesis and ovulation

Folliculogenesis and ovulation are the result of positive and negative feedback mechanisms between hypothalamus, pituitary and ovary. The occurrence of these processes in relation to each other needs to be strictly timed. In the theca interna of the antral follicle receptors for LH are present. Stimulated by successive small pulses of LH released from the pituitary, growing antral follicles develop ability to synthesize androgens in the theca cells surrounding the follicle. The androgens will be transported to the granulosa cell layer where they act as precursors for the synthesis of oestrogens. This process, the conversion from androgens to oestradiol-17ß takes place in the granulosa cells and is stimulated by Follicle Stimulating Hormone (FSH).

A number of follicles will grow at the same time. The largest follicle of such a cohort, often referred to as the dominant follicle, produces a protein called inhibin. This hormone exerts a negative

feed back on the pituitary resulting in a inhibition of FSH release. All other follicles except the dominant one will undergo atresia.

In the presence of a progesterone producing corpus luteum, the dominant follicle will also become atretic, due to the shortage of gonadotropic support from the central system, through the negative feedback of progesterone on that system. However, when the corpus luteum is regressing and progesterone levels are declining, the dominant follicle will increase the oestrogen production to quantities that will induce oestrus behaviour. Another consequence of the high oestradiol-17ß level is that through a positive feedback on the hypothalamus it will stimulate the release of Gonadotropin Releasing Hormone (GnRH) from the hypothalamus resulting in a LH peak surge from the pituitary. This LH peak surge will occur approximately at the onset of behaviourial oestrus, last for about 8 h and will induce a number of essential changes in the dominant follicle and its oocyte.

The pre-ovulatory LH peak surge initiates differentiation in the granulosa cells, transforming them from oestrogen producing cells to progesterone producing lutein cells. This will result in an inhibition of the oestradiol-17ß synthesis and in an increase of the progesterone concentration in the follicular fluid.

The second activity of the pre-ovulatory LH peak surge is to induce final maturation of the oocyte resulting in the ability to be fertilized after ovulation. This maturation process includes a nuclear maturation, resumption of meiosis and cytoplasmatic maturation.

The third activity of the LH peak is to induce the synthesis of proteolytic enzymes in the follicular wall. Provided all preceding events occur in a normal sequence, the follicular wall apex disintegrates, resulting in ovulation approximately 24 h after the LH peak surge.

To summarize the activities of FSH and LH:

- FSH stimulates the growth of small antral follicles and is required for the conversion of androgens to oestradiol-17ß in the granulosa cells.
- The pulsatile release of LH stimulates the androgen synthesis in the theca cells of the growing follicle, while the pre-ovulatory peak surge induces the differentiation from granulosa cells to lutein cells, the oocyte maturation process and ovulation.

1.2. Cystic ovarian disease

1.2.1. Pathogenesis

Cystic ovarian follicles are anovulatory structures occurring spontaneously in cows and pigs, but they are also described in the rat and the human. Particularly by their negative influence on fertility they have been subject of research over more than 50 years. In the beginning this research was focused on the morphology and on the effect on the oestrous cycle and fertility. As our knowledge of the hormonal regulation of follicular growth and ovulation increased, the endocrine approach received more attention.

Although it is generally accepted that follicular cysts develop as a result of a dysfunction of the neuro-endocrine system regulating maturation and ovulation of the follicle, the true nature of the defects leading to cyst formation is still not elucidated.

The main problem in studying cyst formation is that by the time cysts are diagnosed the conditions that caused their development are no longer present. Under such circumstances it is not possible to draw conclusions about the causes of cyst formation by studying existing cysts. Thus, it is almost impossible to conduct investigations during the process of spontaneous cyst formation. In most pathogenesis studies cysts are experimentally induced [1], with the assumption that the resulting abnormality will not differ from cyst that have developed spontaneously.

The majority of follicular cysts will develop before the first ovulation postpartum. Several authors suggest an abnormal release of the first pre-ovulatory LH peak surge after calving to be the main cause of cyst formation. It is theorized that a defect in the response of the hypothalamus to the positive feed back of oestradiol-17ß, produced by the dominant follicle, prevents the hypothalamus from releasing

GnRH so the pre-ovulatory LH peak surge will not appear or will be abnormal. This will lead to anovulation and cyst formation. Perhaps, depending on the amount of LH that will be released, it is possible to distinguish between follicular cysts and lutein cysts. The latter often shows a partial luteinization of the granulosa cell layer. In these cases the blood progesterone values will be elevated, while in the presence of follicular cysts progesterone concentrations will be basal.

A number of experiments support the hypothesis of a lowered responsiveness of the hypothalamus to oestradiol-17ß:

(i) Injecting cows just before the onset of standing heat with an antiserum raised against bovine LH will prevent the receptors in the granulosa cells to be occupied by the endogenous LH. This will lead to anovulation and cyst formation [2]. When cystic cows are injected with GnRH, a LH peak surge of normal magnitude will occur. Thus, the conclusion must be that the pituitary is able to react on GnRH stimulation. The question remains whether this is also the case during the time of cyst formation.

(ii) The chance that an injection of oestradiol 17-ß administered during the first 4 to 5 weeks post-partum will result in an LH peak surge is much smaller than when the injection is given later [3]. This suggests that the hypothalamus is less sensitive to the positive feedback of oestradiol shortly after calving. However, follicles can grow as soon as 8 to 10 days post-partum. Although these follicles produce oestrogens they are not able to evoke a GnRH release from the hypothalamus and may become cystic. Follicles that develop later have a greater chance of ovulation. It has been observed that the majority of the cysts develop before the first ovulation post-partum and more than 60% of these early developing cysts recover spontaneously and are followed by a normal cyclicity support this hypothesis.

(iii) In another experiment [4], the onset of follicular growth was studied in 92 animals by ultrasound scanning of the ovaries starting on day 12 after calving. Ovarian activity based on the first determination of a follicle with a diameter larger than 10 mm, the first dominant follicle, started significantly earlier in cows that developed cysts compared to cows that ovulated normally.

In conclusion, the lowered sensitivity of the hypothalamus for the positive feedback of oestrogens seems to be a valid hypothesis for cyst formation in the cow.

1.2.2. Clinical symptoms

Anoestrus behaviour prevails in cows suffering from cystic ovarian disease early in the post-partum period. When cysts are left untreated or do not disappear spontaneously, irregular short cycle intervals may occur or even constant oestrous like behaviour, called nymphomania, may be seen. These animals are very restless, milk production will drop dramatically and the broad pelvic ligaments may be relaxed. In chronic cases male-like behaviour may develop.

1.2.3. Diagnosis

Ovarian cystic disease may be diagnosed by rectal palpation of the ovaries and genital tract. A positive diagnosis requires presence of follicular structures with a diameter of 2.5 cm and more that persist on one or both ovaries for more than 10 days in the absence of a functional corpus luteum. In contrast to findings when a cow is in heat, the uterus will be flaccid. Sometimes cystic structures can be palpated in the presence of a normal functional corpus luteum in cycling and even in pregnant cows. These structures do not interfere with the cycle or pregnancy and will disappear spontaneously. The cows will show no clinical symptoms.

Differentiation between follicular cysts and luteinized cysts by rectal palpation is hardly possible. This can only be done by progesterone determination in blood or milk or by ultrasound scanning of the ovaries. Confusion in the diagnosis of cysts may arise when a normal corpus luteum with a large central cavity is present, but this structure will not interfere with normal cyclicity.

1.2.4. Therapy

Therapeutic measures are always directed towards creating increased blood progesterone concentrations to mimic the luteal phase of a normal cycle. Elevated progesterone will exert a negative feed back on the central system and will inhibit release of gonadotropins. At the end of such a period of elevated progesterone the so called rebound effect will regulate the normal onset of a new ovarian cycle. Elevated progesterone concentrations may be achieved by different therapeutic measures [5]:

(i) An injection with GnRH will stimulate the pituitary to release a peak surge of LH. The cyst will not ovulate after this LH surge, but when the wall of the cyst still contains normal granulosa cells, they should transform into luteal cells and start producing progesterone. The luteinized tissue of the cyst will disappear after about 18-23 days and the animal should start a normal cycle. To shorten the period between treatment and subsequent service one can give an injection of prostaglandins 14 days after the initial treatment.

(ii) Another possible mechanism to increase the progesterone concentration is to inject the animal with human chorionic gonadotropin (hCG), a hormone with an LH-like activity. This also will result in luteinization of the granulosa layer of the cysts.

(iii) A third method, mainly used when the other treatments have failed or when the diagnosis is made very long after calving and assuming the presence of degenerated granulosa cells, is to administer progesterone directly to the animal. The most practical way to do this is by means of a Progesterone Releasing Intravaginal Device (PRID). The progesterone impregnated in this coil will be taken up by blood vessels in the vaginal wall and will mimic the presence of a corpus luteum. After 12 days the coil is withdrawn from the vagina, inducing the regression of this artificial corpus luteum. Within 2 to 4 days the cow will come into heat and can be served at that time.

(iv) When luteal cysts are diagnosed properly, treatment with prostaglandins may induce the onset of a normal cycle within 3-4 days.

1.3. Postpartum acyclicity

1.3.1. Follicular growth and endocrine changes in postpartum cows

An excellent review on post-partum anoestrus was published recently in the proceedings of the 12th International Congress on Animal Reproduction [6]. What follows is mainly derived from this paper.

Following calving, follicular development involves growth and regression of follicles less than 8 mm in diameter until the first post-partum dominant follicle (DF) of approximately 10 mm is detected. This follicle will increase in diameter 2-3 mm per day. Ovulation of the DF will only occur when an LH pulse occurs every 40-60 minutes to stimulate maximum oestradiol production, positive feedback and an ovulatory peak surge of LH. Thus, FSH is mainly responsible for recruitment and selection of the DF while exposure of an oestrogen active DF to frequent LH pulses is the key to final maturation and ovulation of the DF. Inadequate LH pulse frequency results in low oestradiol production and the DF will not ovulate but will undergo atresia.

Factors that suppress LH pulse frequency in the post-partum period will delay first ovulation. The suckling stimulus and calf presence suppress the release of LH. Calf removal or reducing the suckling frequency increases LH pulse frequency. Nutrition is a second factor that is probably involved in regulation of GnRH secretion and hence LH pulse frequency.

There is an interaction between the duration of the period of negative energy balance and the LH pulsatility, leading to prolonged intervals from calving to first ovulation. Nutrition can also affect the diameter of the DF and poor body condition in beef cows results in large follicles with less oestrogen synthetic activity. Thus, bad body condition at the time of calving affects LH synthesis and release, and the added suppressive effects of either suckling or low nutrition are effective in suppressing pulse frequency in the early post-partum period. Under such conditions any dominant follicles that develop may undergo atresia rather than ovulation.

1.3.2. Hormonal methods to induce first oestrus and ovulation

The most important cause of delayed ovulation in cows is an inadequate GnRH pulse frequency. Thus, the initial consideration in advancing first ovulation would be to use GnRH. Experiments have shown that it is possible to ovulate the first DF by an injection of GnRH as soon as the first DF is detected by ultrasound. However, this results in a high number of short ovarian cycles, usually unaccompanied by behaviourial oestrus. To overcome lack of concurrent expression of oestrus and the occurrence of short cycles, progesterone treatment has been used.

In the dairy cow not under nutritional stress, experiments were carried out to determine the effect of the post-partum interval on oestrus response to a 12 day progesterone treatment (PRID) [7]. Cows calved for more than 30 days had a high (95%) oestrus response following PRID removal, while only 45% of cows calved less than 30 days were detected in oestrus after PRID removal. Macmillan and Day (1987) showed that in dairy cows that are under nutritional stress, 48% of animals given an intravaginal device similar to the PRID were inseminated within 7 days of removal, compared to 22% in control anoestrus cows [8]. Injection of 400 to 800 IU PMSG at removal of the device increased the oestrous response to 75%. Fertility was similar in control and treated cows.

Progesterone treatment in association with PMSG might be a possible way to induce oestrus and ovulation postpartum in indigenous cattle.

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PRODUCTIVITE ET ACTIVITE OVARIENNE DE LA BREBIS PEULE DANS LE SYSTEME D'ELEVAGE TRADITIONNEL AU NIGER

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Abstract–Résumé

PRODUCTIVITY AND OVARIAN ACTIVITY OF PEUL SHEEP UNDER INDIGENOUS MANAGEMENT IN NIGER

Parameters of reproduction and various ovarian activities were studied in Peul ewes bred in traditional management The litter size was 1,1 ± 0,05 ($\bar{x}$ ± s e m), it was not affected by season and rank of birth The intervals between successive parturitions lasted for 325 ± 12 days This interval was affected by the wet season, but it was not affected by the rank of parturition There were births all through the year The maximum frequency of birth was found during the second part of wet season and during post rain period The minimum frequency of birth was found during the dry season and during the first part of the wet season The rate of reproduction was 1,25 lambs per ewe per year The normal ovarian activity was characterized by the luteal phase, which lasted for 13 ± 0,2 days with a highest level of progesterone of 2,5 ± 0,2 ng/ml The normal follicular phase lasted for 4 ± 0,2 days with progesterone levels varying between 0 and 0,2 ng/ml During the year, normal ovarian activity was interrupted by short luteal phases (duration = 9 ± 0 days, frequency 10%) during the dry/cold season, and by prolonged follicular phases (duration = 20 ± 4,1 days, frequency = 39%) all through the year The incidence of these anomalies after kidding was estimated at 25% The resumption of the ovarian activity occurred between 32 and 191 days after parturition This parameter was not affected by the season, but it was correlated negatively with the weight of animals during the first month after parturition (r = - 0,77, P< 0,05)

These results suggest that the Peul sheep kept on a poor diet preserve good reproductive potentials The results also suggest that the improvement of diet during post-partum would allow the Peul sheep to increase their reproductive capacities

PRODUCTIVITE ET ACTIVITE OVARIENNE DE LA BREBIS PEULE DANS LE SYSTEME D'ELEVAGE TRADITIONNEL AU NIGER

Les paramètres de reproduction ainsi que les différents types d'activité de l'ovaire ont été étudiés dans un troupeau de brebis peules élevées selon le système traditionnel La taille moyenne de la portée est de 1,1 ± 0,05 ($\bar{x}$ ± s e m), elle n'est affectée ni par la saison, ni par le rang de naissance L'intervalle entre mises bas successives est en moyenne de 325 ± 12 jours, il est influencé par la saison humide, mais non par le rang de mise bas Les naissances ont lieu tout au long de l'année avec un maximum de fréquence situé en milieu de saison humide et en période post-pluviale Le minimum de naissances a été observé en saison sèche et en début de saison humide Le taux annuel de reproduction est de 1,3 jeunes par brebis et par an Le cycle sexuel normal est caractérisé par une phase lutéale dont la durée moyenne est de 13 ± 0,2 jours et le niveau maximum de progestérone mesuré est en moyenne de 2,5 ± 0,2 ng/ml La phase folliculaire dure en moyenne 4 ± 0,2 jours et la concentration de progestérone varie entre 0 et 0,2 ng/ml I 'activité cyclique normale de l'ovaire est interrompue en saison seche fraîche par des phases lutéales courtes (durée moyenne = 9 jours, fréquence = 10%) et tout au long de l'année par des phases folliculaires allongees (durée moyenne = 20 ± 4,1 jours, fréquence = 39%) I 'incidence de ces anomalies ovariennes sur les possibilites d'ovulation est estimée à 25% La reprise de l'activité ovarienne après la parturition varie de 32 à 191 jours Elle n'est pas influencee par la saison, mais elle est corrélée négativement à l'evolution du poids des animaux durant le premier mois post-partum (r = - 0,77, P< 0,05)

Il ressort de ces resultats que la brebis peule elevée selon le système traditionnel ou les disponibilites alimentaires sont reduites presente de bonnes performances de reproduction L'amélioration du niveau nutritionnel des animaux durant le premier mois apres la mise bas devrait permettre d'accroître ces performances

1. INTRODUCTION

L'élevage des petits ruminants est pratiqué par plus de la moitié des familles nigériennes (54% à 90%) en zone agropastorale [1] Il constitue à la fois un bien de subsistance et de prestige [1], et peut être considéré comme élément de diversification du risque en cas de catastrophes climatiques ou sanitaires [2].

Le principal atout de cet élevage réside dans la rusticité des animaux, caractère qui leur permet de s'adapter à des conditions de milieu difficiles, notamment la résistance aux maladies, la précarité du

disponible fourrager et des eaux de surface [1, 3]. Cependant, le niveau de productivité du troupeau est faible, et le taux de mortalité des jeunes reste très élevé [2]. Les actions de développement de l'élevage des petits ruminants, exprimé en terme d'amélioration de la productivité numérique du troupeau, doivent par conséquent prendre en compte ces contraintes. En particulier, il sera utile non seulement de connaître avec précision les effets des conditions d'un élevage traditionnel sur les paramètres de reproduction tels que la fécondité, l'intervalle entre mises bas, la taille de la portée qui conditionnent le nombre de jeunes par femelle et par an [4], mais également d'en comprendre les mécanismes physiologiques. Ces informations peuvent être obtenues grâce à l'évaluation des performances en milieu réel.

Le but de cette étude est de caractériser chez la Brebis peule en système d'élevage traditionnel:

(1) Les paramètres zootechniques de reproduction.

(2) La reprise de l'activité cyclique ovarienne après l'agnelage.

(3) Les diverses modalités de l'activité cyclique ovarienne au cours de l'année.

2. MATERIEL ET METHODES

2.1. Milieu naturel

L'expérience a été effectuée à Niamey (latitude 13°30 N, longitude 2°08 E, altitude 216 m), située dans l'ouest du territoire nigérien.

Le trait marquant du climat est la sécheresse. Celle-ci est liée à deux facteurs: l'insuffisance de précipitations et les températures élevées. Le régime pluviométrique (600 mm/an) est marqué par une longue saison sèche (8 mois: octobre à mai) et une courte saison humide (4 mois: juin à septembre).

La température moyenne mensuelle dépasse 30°C durant 6 mois de l'année. L'amplitude thermique journalière varie selon la saison avec un maximum de 20,5°C en décembre, et un minimum de 9°C en juillet. Le cycle annuel des quatre facteurs climatiques est rapporté à la Figure 1.

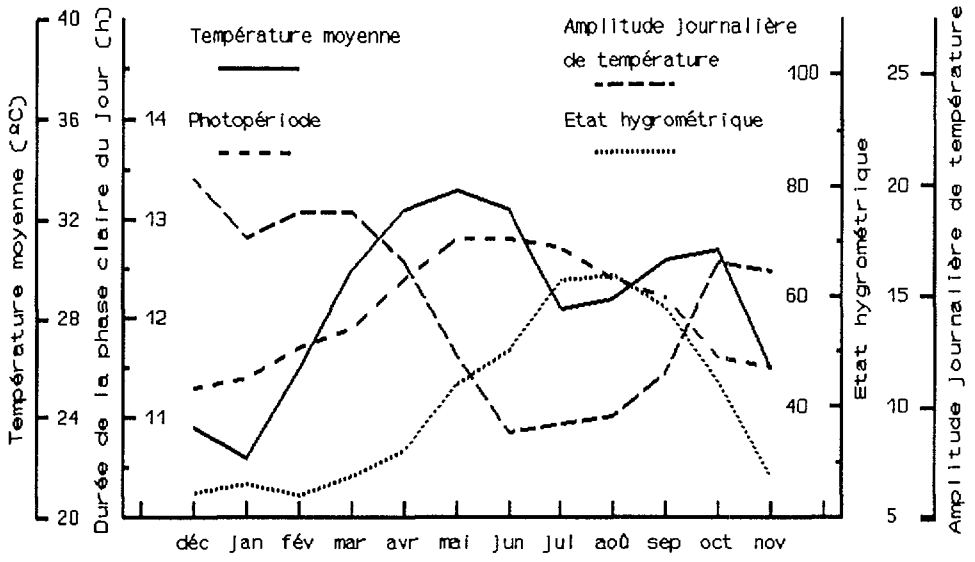

Fig. 1. Variation annuelle des facteurs climatiques.

La végétation naturelle au lieu de pâturage est dominée par des *combretaceae*. Le pâturage est constitué essentiellement de graminées comme *Andrapogon gayanus*, *Aristida adsencionis* et *Brachiaria Xantholenca*.

2.2. Animaux et conduite d'élevage

L'étude a porté sur un lot de 35 brebis de race peule, appartenant à trois petits exploitants. Ces animaux pâturent toute la journée aux alentours de la ville (3 à 5 km) et reviennent à l'enclos le soir où ils reçoivent quelquefois un complément de son de mil ou de maïs. Les brebis sont en contact permanent avec les béliers au pâturage.

2.3. Enregistrement des données et prélèvements sanguins

Les animaux utilisés au cours de cette étude ont été suivis de décembre 1987 à août 1992. Les mises bas et le nombre d'agneaux nés vivants sont notés afin de calculer les intervalles entre mises bas, les fréquences des naissances au cours de l'année et la taille de la portée.

Au cours de la présente expérience, le sang a été prélevé 3 fois par semaine pendant un an au niveau de la veine jugulaire et la concentration de progestérone mesurée afin de déterminer la durée de l'anoestrus post-partum et d'étudier les diverses modalités de l'activité cyclique ovarienne. Le poids des animaux a été enregistré le jour de la mise bas, puis tous les 15 jours pendant 3 mois.

2.4. Dosage de progestérone

La concentration de progestérone a été mesurée selon la technique décrite par FAO/IAEA, dont les critères de validité sont rapportés dans le présent ouvrage.

2.5. Définition des paramètres de reproduction

2.5.1. Phase lutéale et phase folliculaire

La concentration moyenne ($\bar{x}$) de progestérone est calculée à partir de toutes les valeus (N) les plus faibles (0 à 0,3 ng/ml) mesurées pendant un an sur l'ensemble des animaux prélevés, et une bande de confiance du type $\pm\ 2\sigma$ contenant 95% des données est déterminée (σ = écart-type des valeurs). Les valeurs situées au-dessus de la limite supérieure de la bande de confiance correspondent soit à la fin de la sécrétion de progestérone par un corps jaune, soit au début de la sécrétion de progestérone par un nouveau corps jaune.

La durée de la phase lutéale est définie comme étant l'intervalle de temps compris entre le début et la fin de la sécrétion de progestérone par un corps jaune. L'intervalle entre deux phases lutéales consécutives correspond au temps où l'on sort de la limite supérieure de la bande de confiance, et définit la phase folliculaire.

2.5.2. Activité cyclique normale

L'activité cyclique ovarienne est considérée normale lorsque, d'une part la durée de la phase lutéale ($\bar{y}_1$) et celle de la phase folliculaire ($\bar{y}_2$) sont comprises respectivement entre $\bar{y}_1 \pm 2\sigma_1$ et $\bar{y}_2 \pm 2\sigma_2$ ($\bar{y}_1$ et $\bar{y}_2$ moyennes des durées des phases lutéales et folliculaires, $\sigma_{1,2}$ = écart-type des valeurs considérées), d'autre part le niveau maximum de progestérone atteint au cours de la phase lutéale est compris entre $\bar{z} \pm 2\sigma_3$ (z = moyenne des niveaux maximaux de progestérone).

2.5.3. Phase lutéale courte et phase folliculaire allongée

La phase lutéale est considérée courte lorsque sa valeur est inférieure à $y_1 - 2\sigma_1$ (y_1 = moyenne de la durée des phases lutéales et σ_1 = écart-type des valeurs). La phase folliculaire est considérée longue lorsque sa valeur est supérieure à $y_2 + 2\sigma_2$ (y_2 = moyenne de la durée des phases folliculaires et σ_2 = écart-type des valeurs).

2.5.4. Incidence des phases lutéales courtes et des phases folliculaires allongées sur l'ovulation

L'incidence des anomalies ovariennes sur l'ovulation est estimée de la manière suivante connaissant les durées moyennes de la phase lutéale et de la phase folliculaire des cycles ovariens normaux chez la Brebis peule, il est possible d'estimer le nombre théorique de phases lutéales qu'elle pourrait avoir pendant la période d'observation s'il n'existe ni prolongation de la phase lutéale, ni allongement de l'intervalle séparant 2 phases lutéales consécutives. Il est supposé qu'à toute phase lutéale est associée une ovulation. Le nombre de phases lutéales réellement observées est alors exprimé en pourcentage du nombre théoriquement possible, ce qui correspond au pourcentage d'ovulation.

2.5.5. Anoestrus post-partum

L'anoestrus post-partum est défini comme étant le délai entre le jour de la mise bas et le moment d'apparition de la 1° phase lutéale.

2.5.6. Taux annuel de reproduction

Il correspond au nombre de jeunes nés vivants par femelle reproductrice et par an. Il est calculé comme suit: taille portée x 365/intervalle de parturition.

2.6. Analyses statistiques

La signification statistique a été déterminée soit par un test T de Student [7] pour la comparaison de la durée moyenne des intervalles entre mises bas selon les saisons, soit par le test non paramétrique de Mann et Whitney [8] pour l'étude des effets des conditions d'élevage, de la saison, de la portée, sur la durée de l'anoestrus post-partum ou le poids des animaux.

Le coefficient de corrélation de rang de Spearman [9] a été utilisé pour la recherche de corrélation entre le délai de reprise de l'activité ovarienne après agnelage et l'évolution du poids des Brebis.

3. RESULTATS

3.1. Paramètres zootechniques de reproduction (Tableau I)

Dans le système de production péri-urbain utilisé, les données ont été obtenues à partir de femelles dont le temps de présence dans le troupeau est d'au moins deux ans.

3.1.1. Taille de la portée

Elle a été calculée à partir du nombre d'agneaux nés au cours de 33 mises bas de 15 Brebis appartenant à 3 exploitations. Le nombre de jeunes nés vivants par mise bas et par brebis est en moyenne de 1,12 ± 0,05 (moyenne ± s.e.m.). Le rang de naissance ainsi que la saison n'affectent pas de manière significative ce paramètre ($P > 0,05$).

TABLEAU I. PARAMETRES DE REPRODUCTION DE LA BREBIS PEULE, EN SYSTEME D'ELEVAGE TRADITIONNEL, OBSERVES DANS TROIS EXPLOITATIONS

Paramètres de reproduction	Taille de la portée	Intervalle entre mises bas (jours)	Durée anoestrus post-partum (jours)	Taux annuel de reproduction
Moyenne ± s.e.m.	1,1 ± 0,05	325 ± 12,0	73 ± 9,5	1,3[a]
	(n = 15)	(n = 15)	(n = 14)	(n = 15)

[a] rapport moyen indiquant le nombre moyen d'agneaux nés par brebis reproductrice et par an.
n = nombre d'animaux.
s.e.m = ecart type sur la moyenne.

3.1.2. Intervalle entre mises bas successives et répartition des naissances au cours de l'année

Au cours de la période d'observation allant de 1988 à 1991, 35 mises bas de 15 Brebis ont été enregistrées. La durée moyenne des intervalles entre mises bas successives est de 325 ± 12,0 jours. La saison humide (juin à septembre) influence de manière significative cet intervalle ($P < 0,05$) en l'allongeant. En revanche, le rang de mises bas n'affecte pas la durée de l'intervalle entre mises bas ($P > 0,05$).

L'observation des fréquences moyennes mensuelles des naissances au cours de quatre annés, consécutives (Fig. 2) montre que les mises bas interviennent tout au long de l'année avec une répartition non homogène. Le maximum de naissances (70%) a lieu en saison humide (août à septembre) et post-pluviale (octobre à décembre), ce qui correspond aux saillies de saison sèche chaude (mars à mai) et humide (juin à août), respectivement.

Le minimum de mise bas (30%) est enregistré en saison sèche (février) et en début des pluies (juin, juillet), les saillies fécondantes ayant eu lieu respectivement en fin de saison humide (septembre) et en saison sèche fraîche (janvier, février).

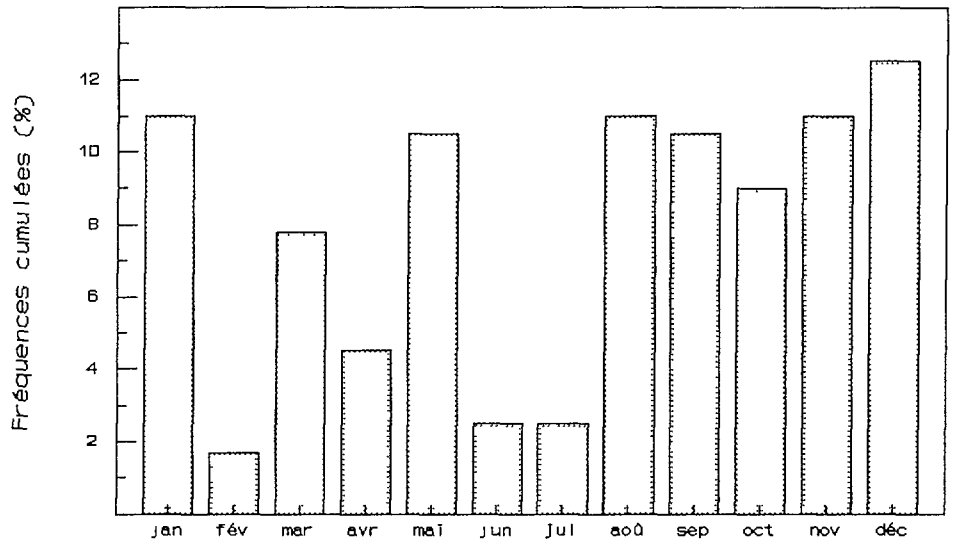

Fig. 2. Pourcentage de répartition des naissances des agneaux de quatre campagnes consecutives (n = 67 naissances).

3.1.3. Taux annuel de reproduction

Le nombre de jeunes nés vivants par Brebis et par an est de 1,3.

3.2. Reprise de l'activité ovarienne après agnelage

La reprise de l'activité ovarienne après la mise bas a lieu entre 32 jours et 191 jours. En saison sèche (octobre à mai), la durée moyenne de l'anoestrus post-partum a tendance à s'allonger (75 ± 11,2 jours) par rapport à la saison humide (juin à septembre) (60 ± 15,2 jours) mais la différence n'est pas significative (P> 0,05). Le premier cycle lutéal consécutif à la première ovulation après mise bas présente des caractéristiques semblables à celles d'un cycle lutéal normal (durée = 12 ± 0,8 jours; niveau maximum de progestérone = 2,5 ± 0,3 ng/ml) (Fig. 3a).

L'évolution du poids des animaux durant le premier mois post-partum est corrélé négativement à la durée de l'anoestrus post-partum (r = - 0,77; P< 0,05). Cette corrélation n'existe plus si l'on considère une évolution du poids corporel durant les 3 mois après la mise bas. La saison humide n'influence pas de manière significative (P> 0,05) l'évolution du poids corporel durant le premier mois post-partum.

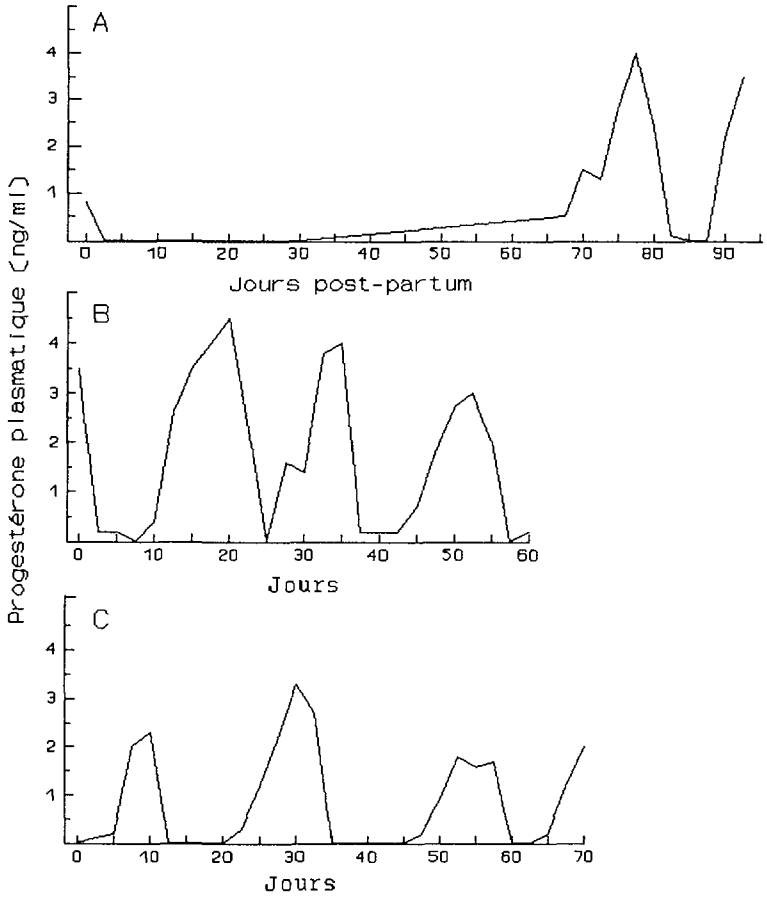

Fig. 3. Evolution du niveau plasmatique de progestérone chez la brebis peule au cours:
a) d'une période d'acyclicité prolongée
b) d'une activité ovarienne normale
c) d'une activité ovarienne moins régulière que B.

3.3. Les différents types d'activité cyclique ovarienne

L'étude de l'évolution de progestérone dans le sang périphérique va permettre la mise en évidence des différents types d'activité cyclique de l'ovaire.

3.3.1. Activité ovarienne normale

Les phases lutéales normales ont une durée moyenne de 13 ± 0,2 jours ($\bar{y}_1$ ± s.e.m.) et le niveau maximum de progestérone atteint au cours de cette phase est en moyenne de 2,5 ± 0,2 ng/ml ($\bar{z}_1$ ± s.e.m.) (Fig. 3b). La durée de la phase folliculaire est en moyenne de 4 ± 0,2 jours et la concentration de progestérone oscille entre 0 et 0,2 ng/ml.

3.3.2. Phase lutéale courte

Les phases lutéales courtes ont une durée moyenne de 9 jours et un niveau maximum moyen de progestérone de 1,7 ± 0,5 ng/ml (Fig. 3c). Ce niveau de progestérone ne diffère pas de manière significative de celui d'une phase lutéale normale (P> 0,05). Les phases lutéales courtes ont été observées chez 4/11 Brebis soit 36%; leur fréquence d'apparition varie entre 17% et 50% selon l'animal.

3.3.3. Phase folliculaire allongée

La durée moyenne des phases folliculaires allongées est de 20 ± 4,1 jours et la concentration moyenne de progestérone de 0,1 ± 0,01 ng/ml (Fig. 3 C). Neuf Brebis sur onze, soit 82% ont manifesté des allongements de phase folliculaire à une fréquence variant entre 13% et 100%.

3.3.4. Variation saisonnière des fréquences d'apparition des anomalies ovariennes

L'activité ovarienne subit une variation saisonnière caractérisée par l'apparition de phases lutéales courtes et de phases folliculaires anormales longues en condition d'élevage traditionnel.

Quatre-vingt quinze pourcent des phases lutéales observées sont courtes. Elles n'apparaissent qu'en saison sèche fraîche (décembre à février) (Tableau II). Trente neuf pourcent des phases folliculaires sont allongées; elles sont réparties tout au long de l'année avec un maximum de fréquence au cours de la saison sèche fraîche (décembre à février) et en période post-pluviale (octobre). Le minimum de fréquence est observé en saison sèche chaude (mars à mai) et en début de saison humide (juin/juillet).

TABLEAU II. VARIATION SAISONNIERE ET INCIDENCE SUR L'OVULATION DES FREQUENCES D'APPARITION DES PHASES LUTEALES COURTES ET DES PHASES FOLLICULAIRES ALLONGEES AU COURS D'UNE ANNEE

Période de l'année	décembre à février (3 mois)	mars à novembre (9 mois)	décembre à novembre (12 mois)
Fréquence des phases lutéales courtes (durée < 10 jours)	21%	0%	9%
Fréquence des phases folliculaires allongées (durée > 5 jours)	58%	33%	39%
Pourcentage ovulation	69%	79%	75%

Les anomalies de fonctionnement de l'ovaire ont une incidence sur le nombre total de cycles lutéals observés. La phase lutéale a été observée dans 75% des cas théoriquement possibles, ce qui correspond au pourcentage d'ovulations exprimé. Au total, 4 brebis sur 11, soit 36% ont manifesté les 2 types d'anomalies ovariennes.

4. DISCUSSION

La Brebis peule élevée en système agropastoral sahélien présente des capacités de reproduction comparables à celles d'autres races de mouton du Sahel [2, 10, 11, 12]: la taille de la portée est en moyenne de 1,12; l'intervalle entre mises bas dure 325 jours en moyenne, l'anoestrus post-partum varie de 32 à 191 jours, et le taux de reproduction annuel est de 1,25 jeunes par femelle et par an.

Dans nos conditions expérimentales, certaines de ces performances comme la taille de la portée sont l'expression du potentiel génétique réel de la Brebis peule puisque sa valeur est comparable au nombre moyen d'ovulations enregistré chez cette race de mouton (1,3 ± 0,04) [6].

D'autres performances comme l'intervalle entre mises bas successives sont influencées par la saison humide qui a pour effet de l'allonger par rapport aux mises bas de la saison sèche. Pourtant, le délai de reprise de l'activité ovarienne après la mises bas est similaire entre les 2 saisons et la proportion de cycles ovariens anormaux est plus élevée en saison sèche qu'en saison humide. La raison de l'allongement de l'intervalle entre mises bas en saison humide doit alors être recherchée au niveau de la fertilité des mâles qui peut subir une variation saisonnière et retarder ainsi la période de saillie fécondante. Toutefois, cette hypothèse mérite d'être vérifiée ultérieurement.

Il est important de noter que les naissances ont lieu tout au long de l'année, avec un maximum (70%) en saison humide et post-pluviale, périodes où les pâturages sont abondants. Cette synchronisation entre le période des mises bas et les disponibilités alimentaires peut être la conséquence des variations thermiques journalières importantes observées en saison sèche fraîche qui induisent chez la Brebis peule un anoestrus saisonnier peu profond [6]. Nos résultats qui montrent l'existence de cycles sexuels caractérisés par des phases lutéales courtes et des phases folliculaires anormalement longues en saison sèche fraîche, corroborent cette interprétation. Ces différents types d'activité ovarienne traduisent un ralentissement de la vitesse de croissance et/ou une atrésie des follicules [3] dûs à une diminution de la fréquence de libération de LH [13]. Le rythme de la libération de cette hormone gonadotrope est lui-même influencé par les variations saisonnières de l'amplitude thermique journalière, de l'hygrométrie [6, 13], et du niveau alimentaire [14].

Les phases lutéales courtes et les phases folliculaires allongées réduisent les possibilités d'ovulation de la Brebis peule qui sont ramenées à 75% en système d'élevage traditionnel. Cette valeur est comparable à celle obtenue chez la Brebis peule élevée en station (86%) [6]; elle montre que la Brebis peule a un potentiel de reproduction important.

La reprise d'activité ovarienne estimée à partir de l'évolution du niveau de progestérone a lieu entre 32 et 191 jours après la mise bas. Ces valeurs sont supérieures à celles que nous avons trouvées chez la même race élevée en station, elles sont alors en moyenne de 32 jours [5].

La durée de l'anoestrus post-partum en condition d'élevage traditionnel n'est pas influencée par les saisons humide et sèche, mais dépend de l'évolution du poids des animaux durant le premier mois après la

mise bas. Ce résultat met en évidence le rôle primordial de l'alimentation au cours de la période du post-partum dans le rétablissement de l'activité sexuelle normale chez la brebis. La reprise tardive de l'activité ovarienne après la mise bas, constatée chez la Brebis peule élevée en système traditionnel est probablement dûe à l'effet de l'alimentation sur les paramètres hormonaux notamment FSH et LH [15]. Il sera utile ultérieurement de vérifier cette hypothèse.

La reprise de l'activité ovarienne après la mise bas se traduit par une évolution normale du niveau de progestérone au premier cycle lutéal, contrairement à ce qui est observé en station où la phase lutéale est courte [5]. Ceci est conforme aux observations de certains auteurs [15] qui montrent que la première phase lutéale a une évolution normale dans 74% des cas si elle débute 20 jours après la mise bas. On peut donc supposer que la Brebis peule élevée selon le système traditionnel est potentiellement capable de conduire une gestation dès la première ovulation post-partum soit en moyenne 73 jours après la mises bas.

5. CONCLUSION

La Brebis peule élevée en système traditionnel où les disponibilités alimentaires sont réduites présente de bonnes performances de reproduction. Des recherches sur la fertilité du mâle en saison des pluies et l'amélioration du niveau nutritionnel en période post-partum laissent entrevoir une augmentation de la productivité numérique des troupeaux.

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ETUDE DE LA CROISSANCE ET DE LA PUBERTE CHEZ LES GENISSES DE RACES TRYPANOTOLERANTES N'DAMA ET BAOULE EN COTE D'IVOIRE

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Abstract–Résumé

STUDY ON THE GROWTH RATE AND PUBERTY IN HEIFERS OF TRYPANOTOLERANT N'DAMA AND BAOULE BREEDS IN COTE D'IVOIRE.

Growth rates and ovarian activity were monitored in heifers of trypanotolerant N'dama and Baoulé breeds (10 N'dama and 20 Baoulé) between the ages of 12 and 18 months. The onset of puberty was determined by RIA of progesterone in blood plasma. Only 18 animals (5 N'dama and 13 Baoulé) attained puberty during the study. Body weight at onset of puberty was around half of the adult body weight. Relationships between level of nutrition and onset of puberty, daily growth rate and ovarian cyclicity could not be demonstrated.

ETUDE DE LA CROISSANCE ET DE LA PUBERTE CHEZ LES GENISSES DE RACES TRYPANOTOLERANTES N'DAMA ET BAOULE EN COTE D'IVOIRE.

La croissance pondérale a été étudiée chez des génisses de races trypanotolérantes N'dama et Baoulé (10 N'dama et 20 Baoulé) entre l'âge de 12 mois et l'âge de 28 mois. L'apparition de la puberté a été surveillée chez ces jeunes femelles par des dosages de la progestérone plasmatique périphérique. La cyclicité ovarienne n'a débuté, durant l'essai, que chez 18 animaux (5 N'dama et 13 Baoulé), pour un poids proche, pour chacune des races, de la moitié du poids de l'adulte. Aucune relation, ni entre le niveau alimentaire et l'apparition de la puberté, ni entre le gain de poids moyen quotidien et l'initiation de la cyclicité ovarienne, n'a pu être observée.

1. INTRODUCTION

Les bovins de races trypanotolérantes sont bien adaptés aux régions tropicales humides infestées de glossines. Ces races représentent 80% du cheptel bovins ivoirien. Elles sont élevées en troupeaux communautaires confiés à des bouviers peulhs. Il s'agit plutôt, d'une capitalisation que d'une exploitation. Une intensification de cet élevage s'impose en raison de l'insuffisance de la production ivoirienne de viande. Celle-ci ne couvre que 25% des besoins nationaux.

Malgré leur petite taille (hauteur au garrot de 116 cm chez le mâle N'dama et de 110 cm chez le mâle Baoulé) [1], ces races paraissent avoir une vocation bouchère affirmée, en raison de leur vitesse de croissance et de leur bon rendement en carcasse lorsqu'elles sont dans des conditions zootechniques correctes [2]. Mais l'efficacité de leur exploitation est limitée par leur productivité médiocre. Celle-ci est due, entre-autre à l'âge élevé des femelles à leur premier vêlage, dans les élevages traditionnels [1].

La raison de ce premier vêlage tardif peut être une puberté et/ou une nubilité tardive due à une croissance inadéquate, ou encore à des problèmes de fertilité.

La présente étude s'est fixée comme objectif de déterminer le moment de début de l'activité ovarienne cyclique grâce à la mesure des concentrations plasmatiques périphériques de progestérone par rapport à la croissance pondérale des jeunes femelles bovines de races trypanotolérantes N'dama et Baoulé.

2. MATERIEL ET METHODES

2.1. Les animaux

L'étude a porté sur 30 jeunes femelles: 10 de race N'dama et 20 de race Baoulé. Elles sont nées en début de saison sèche et fraîche, en novembre - décembre. C'est au cours de cette saison que l'on observe le maximum de vêlages. Leur croissance a été suivie à partir de l'âge de 13 mois environ, ceci pendant 18 mois.

Au début de l'essai les génisses N'dama pesaient en moyenne 110 ± 14,2 kg et les Baoulé 84 ± 10,2 kg.

2.2 Elevage des animaux

Tous les animaux ont connu les mêmes conditions d'élevage. Ils sont élevés, en station, à IDESSA BOUAKE, en pâturage permanent.

Durant l'experimentation la pluviométrie a été de 1200 mm. Elles s'est répartie d'avril à octobre. Les températures minimales ont été enregistrées en août (22°C), les maximales en mars (30°C) [3].

Les animaux disposent en permanence d'une pâture de panicum, en végétation toute l'année. Une supplémentation est faite, en fin de journée, à l'auge.

Dix femelles Baoulé (Lot Baoulé 1) ont reçu un complément leur apportant quotidiennement 0,87 Unité Fourragère (UF) et 98 gr. de Matière Azotée Digestible (MAD). Les 10 femelles N'dama et les 10 autres femelles Baoulé (appelées lot Baoulé 2) ont reçu, de la même façon, 1,35 UF et 186 gr de MAD.

2.3 Suivi des animaux

Une double pesée des animaux est effectuée tous les 15 jours, le matin entre 8 h. et 9 h. Des prises de sang ont été faites à la veine jugulaire, à l'aide des tubes héparinés, sous vide. Ces prélèvements sont ensuite centrifugés à 3000 tr./min, pendant 10 minutes. Le plasma est congelé jusqu'au dosage de la progestérone. Les dosages ont été réalisés, grâce à une technique radioimmunologique dont les réactifs sont délivrés sous forme de coffrets par l'Agence Internationale de l'Energie Atomique.

Une concentration de progestérone supérieure ou égale à 0,5 ng/ml est considérée comme étant le reflet d'une activité ovarienne [4].

3. RESULTATS

3.1. Croissance des animaux

La figure 1 présente les courbes de croissance des génisses N'dama et Baoulé. ces courbes sont parallèles. La différence de supplémentation entre les deux lots de femelles Baoulé n'a pas provoqué de gains de poids différents pendant la période expérimentale. Les poids des animaux Baoulé se rejoignent à la fin de l'essai.

3.2. Apparition de la puberté

Seules 5 femelles N'dama sur 10 et 13 femelles Baoulé sur 20 (6 dans le lot 1 et 7 dans le lot 2) ont présenté une concentration de progestérone plasmatique périphérique supérieure ou égale à 0,5 ng/ml durant la période d'observation.

Pour les femelles N'dama celle-ci survient à l'âge786 ± 63,4 j (± s.d.), pour un poids de 153,4 ± 22,5 kg. Pour les femelles Baoulé ce début de l'activité cyclique ovarienne a été constaté à l'âge de 585 ± 37,0 j (lot 1) et 673 ± 54,3 j (lot 2) pour un poids de 101,7 ± 10,4 kg (lot 1) et 122,6 ± 21,4 kg (lot 2) (Tableau I).

Toutes ces génisses dont la puberté a été constatée ont présenté au moins une autre élévation de progestérone entre 35 et 75 jours plus tard.

Cependant, 5 femelles N'dama d'un poids moyen de 167 ± 11,4 kg, agées de 916,8 ± 11,6 j à la fin de l'observation et 7 femelles Baoulé de 136,2 ± 4,7 kg (lot 1) et 129,0 ± 6,1 kg (lot 2) âgées de 933,0 ± 2,3 j (lot 1) et 926 ± 5,5 j (lot 2), n'ont jamais présenté d'activité cyclique ovarienne pendant la durée de l'expérimentation (Tableau II).

Il convient d'ajouter que la puberté a été constatée, dans ces conditions: pour les femelles N'dama pour un poids compris entre 134 et 182 kg (entre 540 et 887 jours d'âge) et pour les femelles Baoulé pour un poids compris entre 75 et 154 kg (entre 485 et 870 jours d'âge).

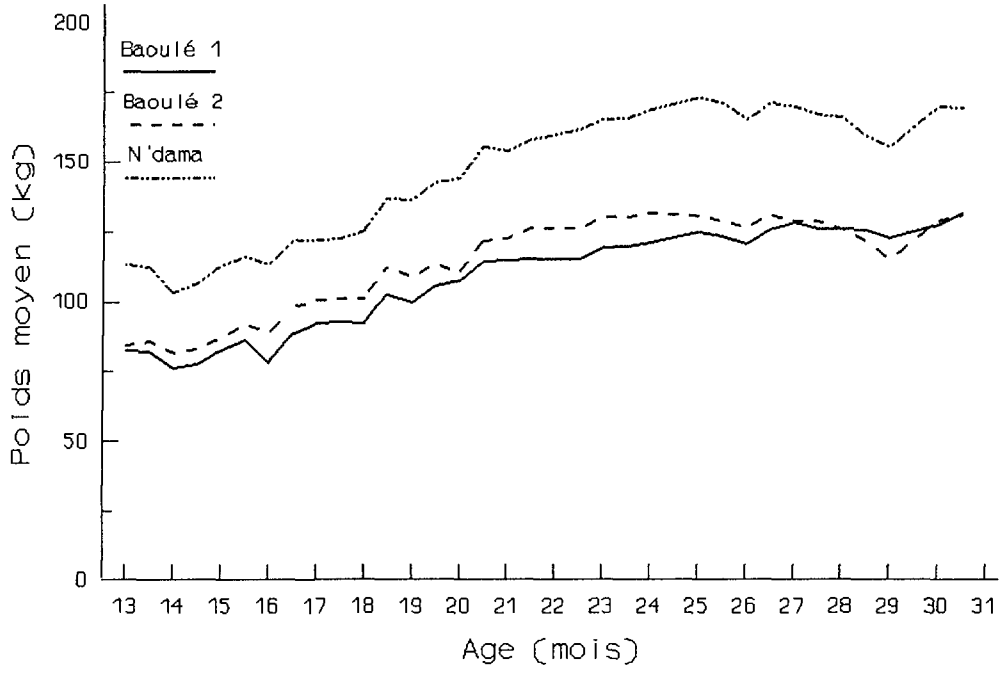

Fig. 1. Evolution ponderale des génisses au course de l'expérimentation.

TABLEAU I. AGE ET POIDS A LA PUBERTE

Groupes	Age à la puberté (j) ($\bar{x}$ ± s.d.)	Poids a la puberté (kg) ($\bar{x}$ ± s.d.)
N'DAMA	786 ± 63,4	153,4 ± 22,5
BAOULE 1	585 ± 37,0	101,7 ± 10,4
BAOULE 2	673 ± 54,3	122,6 ± 21,4

TABLEAU II. AGE ET POIDS A LA FIN DE L'OBSERVATION

Groupes	Age à la fin de l'observation (j) ($\overline{X}$ ± s.d.)	Poids à la fin de l'observation (kg) ($\overline{X}$ ± s.d.)
N'DAMA	917 ± 11,6	167,0 ± 11,4
BAOULE 1	933 ± 2,3	136,2 + 4,7
BAOULE 2	926 ± 5,5	129,0 ± 6,1

4. DISCUSSION

Il est classiquement admis que la puberté apparaît chez les mammifères pour un poids corporel spécifique. Le déclenchement de la cyclicité ovarienne dépend plus du poids que de l'âge, il se produit alors que la croissance n'est pas encore achevée [5]. Par ailleurs, il existerait un gain de poids moyen quotidien optimal qui favoriserait l'apparition de l'activité sexuelle [6]. Malheureusement notre étude n'a pas vérifié dans les conditions de l'essai, ces données pour les deux races bovines trypanotolerantes. Il ne semble pas cependant que l'absence de cyclicité ovarienne, ou son installation tardive soient dues à une croissance inadéquate, comme le prouve l'apparition de la puberté chez des animaux relativement légers. Il faut rechercher l'origine de ces anomalies fonctionnelles ovariennes dans d'autres domaines: sanitaires, zootechniques ou climatiques.

Le manque de différence en fonction du niveau alimentaire est peut-être dû au fait que l'influence de celui-ci ne se manifeste que lorsque la restriction alimentaire est importante [7].

Au Burkina Faso, les génisses Baoulé ont présenté la première élévation de la progestéronémie à 414 ± 66 jours au poids de 120 ± 21 kg [8]. La différence d'âge par rapport à nos résultats est sans doute liée à la période de naissance et aux conditions d'environnement [9]. Les génisses de cette étude sont nées pendant la saison sèche, leur mère ne disposait que d'une faible quantité de fourrage. De plus elles n'ont reçu une complémentation alimentaire que durant l'essai.

L'âge à la puberté chez les génisses de race trypanotolérante est plus élevé que celui rapporté par de nombreux auteurs chez *Bos taurus* de races allaitantes des régions tempérées (10 à 13 mois) [10,11,12,13,14,15]. Il existe aussi d'importantes variations en fonction de la race. Ces variations vont de 6 à 24 mois [10]. Chez le Zébu, elle a lieu vers 22 mois et seulement vers 15 mois chez les croisés Zébu x Taurins [16].

Chez les N'dama, au Ghana, la première montée de progestérone a été observée à un âge de 729 ± 141 jours [17]. Ce résultat est conforme au nôtre. Il en est de même de ceux obtenus par Ralambofiringa au CRZ de Bouaké en 1978 [18].

5. CONCLUSION

La puberté semble tardive chez les génisses de races trypanotolérante N'dama et Baoulé lorsqu'elles sont soumises à une alimentation précaire.

Lorsque nous l'avons observé, la puberté apparait chez la génisse N'dama, comme chez la génisse Baoulé, pour un poids corporel voisin de la moitié du poids de la femelle adulte (environ 280 kg pour la

vache N'dama et 230 kg pour la vache Baoulé). Cependant nous n'avons pas démontré de relation entre le gain de poids et l'âge d'apparition de la puberté. Cette initiation de l'activité ovarienne est suivie d'une importante irrégularité de la cyclicité ovarienne dont l'étiologie est encore inconnue.

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APPENDICES

APPENDIX I

VALIDATION OF THE FAO/IAEA RIA KIT FOR THE MEASUREMENT OF PROGESTERONE IN SKIM MILK AND BLOOD PLASMA

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Abstract–Résumé

VALIDATION OF THE FAO/IAEA RIA KIT FOR THE MEASUREMENT OF PROGESTERONE IN SKIM MILK AND BLOOD PLASMA.

Validation data for the FAO/IAEA RIA kit for the measurement of progesterone in blood plasma and skim milk obtained by Diagnostic Products Corporation, Los Angeles, USA, and the FAO/IAEA Agricultural Laboratory at Seibersdorf are given. The assay sensitivity as determined by FAO/IAEA was 0.3 nmol/l. Intra- and inter-assay variations were lower than 10% and 15% respectively. The accuracy of the assay was satisfactory. The percentage cross-reactivity for the potentially cross-reacting steroids were all acceptably low (i.e. below 2.4%). The assay characteristics for the RIA kit were therefore satisfactory.

HOMOLOGATION DE LA TROUSSE FAO/AIEA DE RADIO-IMMUNODOSAGE DE LA PROGESTERONE DANS LE LAIT ECREME ET LE PLASMA SANGUIN.

Ce mémoire présente les données d'homologation de la trousse FAO/AIEA de radio-immunodosage (RIA) de la progestérone dans le plasma sanguin et le lait écrémé obtenues par Diagnostic Products Corporation, Los Angeles (Etats-Unis), et le Laboratoire d'agriculture FAO/AIEA de Seibersdorf. La sensibilité du dosage déterminée par le Laboratoire FAO/AIEA a été de 0,3 nmol/l. Les coefficients de variation intra-dosage et inter-dosage ont été inférieurs respectivement à 10% et 15%. La précision du dosage a été satisfaisante. Les taux de réactivité croisée pour les stéroïdes susceptibles de telles réactions ont été dans tous les cas acceptables (c'est-à-dire inférieurs à 2,4%). Les caractéristiques des dosages effectués avec la trousse de RIA ont donc été satisfaisantes.

I.1. INTRODUCTION

All participants in the FAO/IAEA Co-ordinated Research Programme on "Improving the Productivity of Indigenous African Livestock using Radioimmunoassay and Related Techniques" measured progesterone (P_4) in skim milk and/or blood plasma to monitor the reproductive performance of female livestock. The FAO/IAEA Animal Production and Health Section has, therefore, provided these participants with standardized Radioimmunoassay (RIA) kits for the determination of progesterone concentrations in biological fluids and has organized an External Quality Control Service to monitor the performance of these kits.

The major objective for the development of the FAO/IAEA RIA kit was to provide counterparts with a standardized technique for the quantitative measurement of progesterone in blood plasma and skim milk that was robust, user-friendly and simple, requiring a minimum of equipment, training and safety precautions. Therefore the solid phase technology, and ^{125}I tracer were adopted.

The FAO/IAEA RIA kit for progesterone measurement is based on the Coat-A-Count Progesterone RIA kit from Diagnostics Products Corporation in Los Angeles, USA. However, some modifications to the assay protocol were made, and some of the kit components are produced at the FAO/IAEA Agricultural Laboratory in Seibersdorf, Austria.

The objective of this paper is to provide validation data for the FAO/IAEA RIA kit, as this data has not yet been provided in other technical documents.

I.2. MATERIALS AND METHODS

I.2.1. Assay protocol

A volume of 100 µl of standard progesterone concentration or unknown sample and 1 ml of tracer solution are added to progesterone antibody coated tubes. Additionally, 1 ml of tracer solution is added to duplicate tubes for the determination of the Total Counts (TC). All tubes are incubated at room temperature for periods ranging between 4 hours to overnight. Following the incubation, all except the TC tubes, are thoroughly decanted and counted for 1 min to obtain the counts per minute for each sample. The progesterone concentration of an unknown sample is calculated using a logit-log transformed standard curve.

The progesterone antibody coated tubes, tracer (progesterone labeled with ^{125}I), and standard progesterone concentrations in human blood plasma are obtained from Diagnostic Products Corporation (DPC), Los Angeles, USA. The standard progesterone concentrations in skim milk are produced at the FAO/IAEA Agricultural Laboratory in Seibersdorf, Austria. In the blood plasma assay, progesterone standard concentrations of 0 (zero standard), 0.3, 1.6, 6.4, 15.9, 31.8 and 63.6 nmol/l are used, whereas standard concentrations of 0, 2.5, 5, 10, 20, 40 and 80 nmol/l are used in the skim milk assay.

I.2.2. Determination of assay characteristics

I.2.2.1. Sensitivity

The sensitivity or "minimal detectable dose" is commonly defined as the apparent concentration two standard deviations (sd) below the counts obtained by assaying the zero standard (B0) [1].

For the determination of the sensitivity, assays were performed by DPC and FAO/IAEA on 40 zero standards in blood plasma along with a set of non-zero standards and quality control samples. Mean and standard deviation were calculated for the counts per minute of the 40 tubes containing zero standards. The apparent progesterone concentration was determined at increasing standard deviations from B0 using a logit-log transformed standard curve.

I.2.2.2. Precision

The precision of the assay procedure was assessed by FAO/IAEA and DPC by examining its reproducibility on 2 samples (FAO/IAEA) and 3 samples (DPC), selected to represent low, intermediate and high levels of progesterone.

The intra-assay variation was calculated from the assay results of samples assayed in 20 pairs of tubes in a single assay. The inter-assay variation was calculated from the assay results of samples assayed in duplicate in 20 different assays.

I.2.2.3. Accuracy

The accuracy of an assay can be tested by determining the spiking recovery [1, 2]. This was determined by DPC through preparation of a spiking solution containing 225.8 nmol/l of progesterone in blood plasma and diluting 10, 50, 100 and 250 µl of this solution up to 1 ml with the zero standard and 3

blood plasma samples containing different progesterone concentrations. All of these aliquots were assayed in their quality control laboratory.

I.2.2.4. Specificity

The specificity of the assay was also tested by DPC through performing the assay on different concentrations of several steroids that could potentially cross-react. The percentage cross-reactivity was calculated as the amount of progesterone causing a 50% reduction of the initial binding in the standard curve, divided by the amount of cross-reacting steroid which causes the same reduction [1, 2].

I.3. RESULTS AND DISCUSSION

The results of the determination of the assay sensitivity carried out by DPC are given in Table I.1.

The assay sensitivities found in the FAO/IAEA laboratory were 0.3 nmol/l for both the blood plasma and the skim milk RIA. These results show that the assay sensitivity is satisfactory. A minimal detectable dose of 0.09 nmol/l reported by DPC or 0.3 nmol/l determined by FAO/IAEA will allow kit users to discriminate between the absence and the presence of a progesterone secreting corpus luteum, since the progesterone concentrations in blood plasma and skim milk during the luteal phase of an oestrous cycle will be substantially higher than these values. The discrepancy between the sensitivity reported by DPC and FAO/IAEA may result through difference in pipetting and counting equipment between the two laboratories. A sophisticated, precision counting and pipetting system typical of a quality control laboratory should minimize variation in counts, and improve the sensitivity. In contrast, laboratory procedures at the FAO/IAEA Laboratory were carried out with simple equipment suitable for field use, but perhaps lacking in precise repeatability.

The results of the determination of the intra- and inter-assay variation carried out by DPC are given in Tables I.2. and I.3. respectively. The results of these determinations carried out by FAO/IAEA are given in Tables I.4. and I.5.

TABLE I.1. ASSAY SENSITIVITY AS DETERMINED BY DPC

Counts B0 Mean ± sd	Mean *minus*	Apparent conc.	Sensitivity
	1 sd	0.03	
31,453 ± 770	2 sd	0.09	0.09
	3 sd	0.18	

TABLE I.2. INTRA-ASSAY VARIATION, RESULTS OBTAINED BY DPC

Sample	Mean P_4 Conc. (nmol/l)	sd (nmol/l)	CV (%)
Low P_4	1.1	0.07	6.4
Interm. P_4	3.5	0.18	5.1
High P_4	16.3	0.42	2.6

TABLE I.3. INTER-ASSAY VARIATION, RESULTS OBTAINED BY DPC

Sample	Mean P_4 Conc. (nmol/l)	sd (nmol/l)	CV (%)
Low P_4	1.3	0.13	10.0
Interm. P_4	3.3	0.29	8.8
High P_4	15.9	0.81	5.1

TABLE I.4. INTRA-ASSAY VARIATION, RESULTS OBTAINED BY FAO/IAEA

Sample	Mean P_4 Conc. (nmol/l)	sd	CV
Intermediate P_4 skim milk	4.2	0.36	8.6
High P_4 skim milk	19.7	1.22	6.2
Intermediate P_4 blood plasma	4.1	0.23	5.6
High P_4 blood plasma	21.0	1.03	4.9

TABLE I.5. INTER-ASSAY VARIATION, RESULTS OBTAINED BY FAO/IAEA

Sample	Mean P_4 Conc. (nmol/l)	sd (nmol/l)	CV (%)
Intermediate P_4 skim milk	4.0	0.40	10.0
High P_4 skim milk	22.2	1.97	8.9
Intermediate P_4 blood plasma	3.9	0.34	5.6
High P_4 blood plasma	21.0	1.53	4.9

TABLE I.6. CROSS-REACTIVITY OF THE ANTI-PROGESTERONE ANTIBODY AS DETERMINED BY DPC

Steroid	Approx. cross-reactivity (%)	Steroid	Approx. cross-reactivity (%)
Progesterone	100	Oestradiol	ND
Androstenediol	ND	17α-Hydroxy-progesterone	0.3
Corticosterone	0.4	Medroxyprogesterone	ND
Cortisol	ND	Pregnane	ND
Danazol	ND	5ß-Pregnan-3α-ol-20-one	0.2
11-Deoxycortico-sterone	1.7	5α-Pregnan-3,20-dione	0.8
20α-Dihydroproge-sterone	2.0	Testosterone	ND
		Pregnenolone	ND

ND = not detectable.

The observed intra- and inter-assay variation for all progesterone concentrations found by DPC were lower than 6.4% and 10.0% respectively, and comparable results were obtained by FAO/IAEA. These values are satisfactory, as accepted limits for intra- and inter-assay variation for similar assays are 10% and 15% respectively [1].

The results of the testing for cross-reactivity are given in Table I.6. The percentage cross-reactivity for the potentially cross-reacting steroids tested are all below 2.4%. Therefore, cross-reactivity should not cause difficulties with the assay.

The results of the spiking recovery exercise performed by DPC are given in Table I.7. The percentage recovery (Observed P_4/Expected P_4) for all samples assayed was close to 100%. Hence the accuracy of this RIA is satisfactory [1].

TABLE I.7. SPIKING RECOVERY, RESULTS OBTAINED BY DPC

Sample	Observed P_4 conc. (nmol/l)	Expected P_4 conc. (nmol/l)	% O/E (%)
0 standard unspiked	0		
0 standard + 10 μl	1.91	11.45	86
0 standard + 50 μl	11.45	11.45	100
0 standard + 100 μl	25.12	22.58	111
0 standard + 250 μl	64.55	56.60	114
sample 1 unspiked	0.64		
sample 1 +10 μl	2.86	2.86	100
sample 1 + 50 μl	11.77	11.77	100
sample 1 + 100 μl	23.53	23.21	101
sample 1 + 250 μl	63.28	56.96	111
sample 2 unspiked	2.54		
sample 2 + 10 μl	4.77	4.77	100
sample 2 + 50 μl	14.95	13.67	109
sample 2 + 100 μl	28.62	24.80	115
sample 2 + 250 μl	68.05	58.51	116
sample 3 unspiked	3.82		
sample 3 + 10 μl	6.38	6.04	105
sample 3 + 50 μl	14.95	14.95	100
sample 3 + 100 μl	27.03	26.08	114
sample 3 + 250 μl	62.96	62.96	106

I.4. CONCLUSION

Assay characteristics for the FAO/IAEA RIA kit for measurement of progesterone in blood plasma and skim milk are satisfactory and the procedure performs well in laboratories throughout Africa.

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APPENDIX II

FIELD VALIDATION OF AN EIA KIT FOR PROGESTERONE MEASUREMENT IN MILK AND BLOOD PLASMA

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Abstract–Résumé

VALIDATION OF AN EIA KIT FOR PROGESTERONE MEASUREMENT IN MILK AND BLOOD.

An EIA kit for the measurement of progesterone in blood plasma and skim milk was validated and compared with the FAO/IAEA RIA kit at the FAO/IAEA Agricultural Laboratory at Seibersdorf and 9 other laboratories in developed and developing countries. The EIA kit performed well at the FAO/IAEA Laboratory. In the other laboratories high intra-assay variations and poor colour development were observed. The RIA kit performed satisfactory in all participating laboratories. It was concluded that the EIA kit should not be routinely supplied to FAO/IAEA counterpart staff. Some recommendations for further development of the EIA kit were given.

HOMOLOGATION D'UNE TROUSSE DE DOSAGE IMMUNO-ENZYMATIQUE DE LA PROGESTERONE DANS LE LAIT ET LE SANG.

Une trousse de dosage immuno-enzymatique (EIA) de la progestérone dans le plasma sanguin et le lait écrémé a été homologuée et comparée avec la trousse FAO/AIEA de radio-immunodosage (RIA) au Laboratoire d'agriculture FAO/AIEA de Seibersdorf et dans neuf autres laboratoires de pays développés et en développement. La trousse d'EIA a donné de bons résultats au Laboratoire FAO/AIEA. Dans les autres laboratoires, on a observé des coefficients de variation intra-dosage élevés et des réactions de coloration insuffisantes. La trousse de RIA a donné satisfaction dans tous les laboratoires participant à l'étude. On en a conclu que la trousse d'EIA ne devrait pas être fournie de façon systématique au personnel de contrepartie de la FAO/AIEA. Des recommandations ont été formulées en vue de poursuivre la mise au point de la trousse d'EIA.

II.1. INTRODUCTION

Through its Animal Production and Health Programme the Joint FAO/IAEA Division supports scientists in developing countries to conduct research into the causes of and solutions for the low productivity of indigenous livestock maintained under traditional management systems. These studies are greatly facilitated by utilizing immunoassay techniques to measure reproductive hormones, e.g. progesterone (P_4), in milk or blood, as the profiles of these hormones can be used to assist in the determination of the onset of puberty, the resumption of ovarian activity postpartum, pregnancy, seasonality of ovarian activity etc.

To enable counterpart staff to measure progesterone they are presently supplied with FAO/IAEA RIA kits by the FAO/IAEAs Agricultural Laboratory at Seibersdorf near Vienna. In 1989, this laboratory will send around 400 000 RIA assay units to institutes in Asian, African, Latin-American and some European countries.

In February 1987, a Coordinated Research Programme on "Immunoassay Techniques to Improve the Reproductive Efficiency and Health Status of Indigenous African Livestock" was initiated when

agreement was reached between the Ministry of Foreign Affairs of the Netherlands and the International Atomic Energy Agency (IAEA). This programme has two components, animal production and the diagnosis of haemoprotozoal diseases in livestock, and each component is covered by a separate network of laboratories and scientists within the framework of the overall programme.

From the onset, the scientists participating in the programme's production component have been supplied with FAO/IAEA RIA kits for P_4 determination. These kits were validated at the FAO/IAEA Agricultural Laboratory, Seibersdorf and at several other laboratories in 1986 and 1987.

It can be concluded from the results of an External Quality Control Service (EQCS) for these kits run by the IAEA, that the RIA performs well under the conditions found in laboratories in developing countries.

Recently however enzyme-immunoassay (EIA) techniques have been developed as an alternative to the conventional RIA [1, 2]. Many scientists in developed countries presently use EIA techniques for the measurement of hormones, the serodiagnosis of diseases etc. EIA has the potential advantage over RIA of not requiring a radioisotope marker, and this has been used extensively within the disease diagnosis programme of the Joint FAO/IAEA Division for the serodiagnosis of animal diseases in developing countries. EIA might, in some situations, also prove to be preferable to the RIA in the FAO/IAEA programme on animal production. The feasibility of introducing EIA for progesterone measurement in laboratories in developing countries is therefore being examined during the course of the Dutch funded programme through a collaborative study between the FAO/IAEAs Animal Production and Health Section and the Institute for Animal Production "Schoonoord" in Zeist (Netherlands). This study is financed by the Netherlands' Ministry for Development Cooperation and the Joint FAO/IAEA Division.

Before EIA kits can be introduced into African countries they have to be validated and compared with the corresponding RIA kit under both advanced laboratory and local conditions. Only after the completion of this phase can a decision be made on which kit is the more appropriate for use in African laboratories. The first phase of EIA kit validation was carried out both at the Institute for Animal Production "Schoonoord" in Zeist and the FAO/IAEA Agricultural Laboratory in Seibersdorf. A report on this validation was prepared in September 1988, (Activity Report on "Development of progesterone RIA and EIA kits for use in developing countries").

The main conclusion of this report was that the EIA method compared very well with that of RIA provided the assay was carried out by an experienced technician able to standardize each step of the assay. In the hands of an inexperienced technician and/or in a laboratory with a poor quality water supply or frequent power failures, high variations in measured progesterone (P_4) values were to be expected using EIA, due to the lower "robustness" of the EIA reagents as compared to the ^{125}I used in the RIA test.

However, it was also concluded that in order to obtain more comprehensive data on the performance of the two tests, the kit validation performed at Seibersdorf and "Schoonoord", Zeist, should be followed by a validation in other laboratories in both developed and developing countries which already have experience in performing enzyme-immunoassay techniques. It was decided to start with this validation of the EIA kit for P_4 measurement in skim milk, as initially the milk kit was produced and the validation of the plasma kit needed some more time. It was considered that if this kit performed well in these somewhat more advanced laboratories, then decisions could be made both on which other

laboratories in developing countries could be provided with the kit and the necessity of a field validation of the blood plasma EIA kit. If the milk test performed satisfactorily, the emphasis would then be given to introducing the EIA technique for progesterone measurement in African laboratories participating in the FAO/IAEA programme on animal reproduction funded by the Government of the Netherlands.

This report describes the results of the validation of the milk EIA kit. It also provides a conclusion concerning the introduction of this kit into African laboratories and recommendations for future research on EIA methods suitable for P_4 measurement in developing countries.

II.2. MATERIALS AND METHODS

II.2.1. Participating institutes

The following 10 institutes participated in the validation exercise:

Department of Biochemistry
Veterinary University
Vienna, Austria
Staff: Dr. E. Bamberg, Dr. Choi

Institute for Physiology
Sueddeutsche Versuchs und
Forschungsanstalt fuer Milchwirtschaft
Technical University of Munich
Freising, Germany
Staff: Dr. H. Meyer

Faculty of Veterinary Science
Sokoine University of Agriculture
Morogoro, Tanzania
Staff: Dr. B. Mutayoba, Dr. F. Mgongo

Department of Animal Science
Faculty of Agriculture
University of Zimbabwe
Harare, Zimbabwe
Staff: Dr. C. Llewelyn

Department of Biomedical Studies
Samora Machel School of
Veterinary Medicine
University of Zambia
Lusaka, Zambia
Staff: Dr. C. Lovelac

Institute for Animal Production
"Schoonoord"
Zeist, Netherlands
Staff: Dr. D. van de Wiel, Mr. W. Koops

Lalahan Nuclear Research Insitute of
Animal Health
Lalahan, Ankara
Turkey
Staff: Dr. B. Güven

Department of Reproduction and
Artificial Insemination
Agronomical and Veterinary
Institute Hassan II
Rabat, Morocco
Staff: Dr. A. Lahlou-Kassi

Centre for Research on Animal
Trypanosomiasis
CRTA
Bobo-Dioulasso, Burkina Faso
Staff: Mr. A. Bassinga, Dr. C. Cloe

Department of Reproduction
Faculty of Veterinary Medicine
National University of Mexico
Mexico City, Mexico
Staff: Dr. L. Zarco

II.2.2. Assay protocols

Details concerning to the collection and processing of samples (skim milk and blood plasma) for performing the assays are given in Appendix IIA (RIA) and Appendix IIB (EIA).

II.2.3. Materials provided to participating laboratories

- 1 EIA kit for P_4 measurement in skim milk containing 3 progesterone antibody-coated plates and reagents to perform assays on these plates;
- 1 booklet on the EIA kit, containing a protocol for the conduct of the test;
- 1 FAO/IAEA RIA kit for P_4 measurement in skim milk, plus manual;
- 33 vials containing freeze dried milk samples;
- forms for reporting results.

II.2.4. Work plan

Each participant was requested to carry out 3 EIAs (Assays 1, 2 and 3) and 1 RIA (Assay 4). The objective of Assay 1 was to allow the participants to become familiar with the kit before the actual validation was carried out in Assays 2 and 3. The assays were carried out on the standards and quality control samples provided and/or on samples provided by the participants.

In Assay 2 the Quality Control samples provided (QCA and QCB) were assayed in 35 times to enable determination of the intra-assay variation (i.e. to assess the precision of the assay).

In Assay 3, the 33 skim milk samples provided were assayed using ElA. In Assay 4 these samples were assayed using RIA, thereby enabling comparison between the two immunoassay techniques.

Participants were requested to report the measured P_4 concentrations in the Quality Control samples provided and the skim milk samples, as well as the standard curve of each assay. These standard curves were determined using logit-log transformation.

II.3. RESULTS

II.3.1. Standard curves

Table II.1. gives values for some of the parameters of the EIA standard curves quoted by the participating laboratories. Table II.2. gives the values for these parameters for the RlAs. Standard curves were linearized by means of the logit-log transformation. Linear regression was carried out on all the standards. A linear correlation coefficient (LCC) value of 0.98 and higher was considered to be indicative of a good standard curve.

In 6 laboratories, EIA standard curves were found with an LCC which was unacceptably low, i.e. lower than 0.98. However, in 2 of these laboratories acceptable EIA standard curves were also produced. By contrast, the RIA standard curves were acceptable in all the participating laboratories. The reasons for the unacceptable standard curves in EIA were lack of colour development and large differences in O.D. between duplicates.

The standard curves of the EIAs were generally steeper than those of the RIAs indicating a better separation between the standard points, i.e. a larger difference between the counts per minute (cpm) and Optical Density (O.D.) respectively for different P_4 concentrations, in the EIA than in the RIA. However in each laboratory the linear correlation coefficients (LCC) of the RIA standard curves were laboratory higher than those of the EIA. Hence the deviation between the observation points and the regression line, i.e. the standard curve, was higher in the EIA than in the RIA.

The O.D.'s of the BO samples (the standard containing no progesterone) are given in Figure II.1. In laboratories which received the kit within a few days after shipment from the IAEA Laboratory (i.e. 1-4), the O.D.s of the BO samples were sufficiently high, i.e. around 1. However, in some cases long delays (i.e. several weeks) were encountered with the customs clearance of the kits. When these kits were used, the colour development was very poor and O.D. values for the BO samples varied between 0.579 and 0.130. This shows that the EIA kits were not sufficiently stable during transport whereas similar delays in customs clearance did not seem to influence the performance of the RIA kits.

TABLE II.1. PARAMETERS OF EIA STANDARD CURVES

Assay	LCC	80% B0	50% B0	20% B0	slope	intercept	O.D. B0
L 1,1	0.993	6.2	17.2	47.2	-1.371	1.692	0.849
L 1,2	0.996	6.7	17.5	45.8	-1.433	1.795	1.718*
L 1,3	0.980	3.2	11.9	44.7	-1.046	1.123	0.964
L 2	0.967	3.8	15.4	62.4	-0.992	1.178	1.059
L 3,1	0.978	6.2	17.5	49.3	-1.336	1.659	0.630
L 3,2	0.991	5.2	20.8	84.2	-0.993	1.309	0.978
L 3,3	0.985	4.5	21.3	100.3	-0.895	1.190	0.955
L 4,1	0.985	2.6	11.0	43.4	-0.990	1.018	0.912
L 4,2	0.995	6.8	23.1	78.8	-1.132	1.544	0.841
L 4,3	0.995	5.8	18.3	57.8	-1.202	1.516	0.877
L 5,1	0.962	3.9	13.6	47.1	-1.155	1.263	0.567
L 5,2	0.990	7.1	22.6	71.3	-1.205	1.631	0.792
L 5,3	0.998	4.5	13.9	43.3	-1.210	1.393	0.579
L 6,1	0.989	4.2	16.3	62.9	-1.026	1.244	0.586
L 6,2	0.968	8.0	27.1	92.1	-1.133	1.623	0.579
L 7,1	0.927	1.6	7.4	34.7	-0.900	0.785	0.526
L 7,2	0.996	3.7	10.7	31.1	-1.301	1.339	0.608
L 8,1	0.990	3.7	13.5	49.8	-1.061	1.190	1.090**
L 8,2	0.991	4.5	16.6	61.8	-1.055	1.288	1.109**
L 8,3	0.991	5.0	19.0	72.1	-1.040	1.331	1.109**
L 9,1	0.430	0.4	7.3	147.3	-0.461	0.396	0.364
L 9,2	0.691	24.7	193.2	1512.3	-0.674	1.540	0.397
L 9,3	0.946	6.2	24.2	94.8	-1.014	1.403	0.412
L 10,1	No standard curves were determined as the O.D. values were too low						0.180
L 10,2							0.190
L 10,3							0.130

* = freshly coated plate used.

** = spectrophotometer probably malfunctionning.

LCC = Linear correlation coefficient standard curve after logit-log transformation.

L 1,1 = laboratory, 1 assay 1.

80% B0 = P_4 conc. at 80% B0 (nmol/l).

50% B0 = P_4 conc. at 50% B0 (nmol/l).

20% B0 = P_4 conc. at 20% B0 (nmol/l).

TABLE II.2. PARAMETERS OF RIA STANDARD CURVES

Assay	L1	L2	L3	L4	L5	L6	L7	L9	L10
LCC	0.999	0.989	0.996	0.996	0.998	0.994	0.993	0.980	0.998
80% B0	1.0	2.9	0.6	1.6	0.9	0.9	0.8	0.9	0.9
50% B0	6.4	12.1	4.8	9.9	6.1	6.7	6.5	12.5	6.1
20% B0	39.8	50.2	38.0	62.9	42.1	49.7	49.7	177.8	42.1
slope	-0.760	-0.975	-0.672	-0.751	-0.720	-0.687	-0.681	-0.522	-0.720
intercept	0.614	1.056	0.459	0.749	0.567	0.567	0.552	0.573	0.567

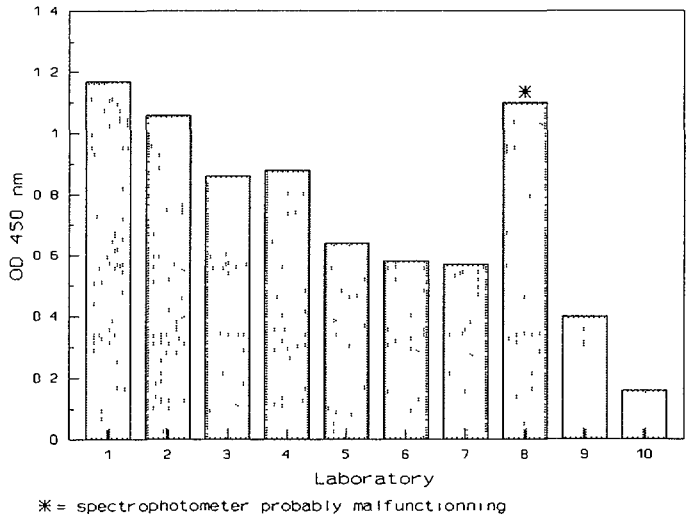

Fig. II.1. Optical densities BO.

TABLE II.3. INTRA-ASSAY VARIATION CONCENTRATIONS IN NMOL/L

Laboratory	Q.C. sample	exp. conc.	obs. conc.	C.V.	range	min.	max.	N
1	QCA	5	6.1	19.8	5.1	4.3	9.1	37
	QCB	20	24.5	7.3	10.0	21.0	31.0	37
2	QCA	5	8.3	54.2	9.7	4.3	14.0	4
	QCB	20	41.0	31.2	28.0	22.0	50.0	4
3	QCA	5	3.8	39.0	6.8	2.2	9.0	37
	QCB	20	21.8	12.6	12.0	16.0	28.0	37
4	QCA	5	3.4	53.4	8.6	0.8	9.4	37
	QCB	20	16.8	13.3	8.3	13.7	22.0	37
5	QCA	5	9.1	40.5	12.1	4.3	16.4	37
	QCB	20	23.6	33.3	38.4	12.9	51.3	37
6	QCA	5	11.5	39.2	18.5	5.0	23.5	37
	QCB	20	44.5	18.6	33.0	31.0	64.0	37
7	QCA	5	3.7	45.4	8.5	1.0	9.5	37
	QCB	20	17.7	31.2	25.5	8.5	34.0	37
8	QCA	5	5.4	30.0	6.2	3.3	9.5	37
	QCB	20	22.6	14.5	13.1	16.7	29.8	37

Note: The intra-assay variations for laboratories 9 and 10 were not determined because of non-acceptable standard curves.
exp. conc. = expected P_4 concentration; obs. conc. = average of observed P_4 concentrations.
Q.C sample = Quality Control sample; C.V. = coefficient of variation (%).
min. = minimum concentration; max. = maximum concentration.
N = number of observations.

II.3.2. Precision

The results of the determinations of the EIA intra-assay variations are given in Table II.3. The intra-assay variation of the EIA kit was found to be higher than 10% in all laboratories for Quality Control sample A (QCA) and in 9 of the 10 laboratories for QCB. In one laboratory the intra-assay variation of QCA was as high as 54%.

The results of the measurement of the P_4 concentration in the Quality Control samples with RIA are given in Table II.4. The average difference between observed and expected P_4 concentrations in RIA were 14.1% and 13.1% for QCA and QCB respectively. In EIA these differences were 38.0% for QCA and 29.9% for QCB. In laboratory 6 these differences were very high, the observed means for QCA and QCB being 11.5 nmol/l and 44.5 nmol/l respectively, whereas the expected P_4 concentrations of these samples were 5 nmol/l and 20 nmol/l respectively. The differences between observed and expected P_4 concentrations in the Quality Control samples were therefore much larger in EIA than in RIA.

TABLE II.4. QUALITY CONTROL IN RIA

Laboratory	Avg. QC A conc. (nmol/l)	Avg. QC B conc. (nmol/l)
1	4.5	20.5
2	5.5	31.0
3	4.9	19.0
4	5.1	22.9
5	5.1	18.2
6	4.5	18.0
7	4.4	20.0
9	2.5	16.5
10	6.1	22.0
Expected conc. (nmol/l)	5.0	20.0

II.3.3. Correlation between EIA and RIA

The correlations between the observed P_4 concentrations in EIA and RIA in the 33 milk samples provided are given in Table II.5. The correlation coefficients ranged from 0.80 to 0.93 between laboratories. It can therefore be concluded that both techniques correlate well but that this correlation varies between laboratories. In the laboratories with the best EIA standard curves, the correlation coefficient between the two techniques was higher than in the other laboratories.

TABLE II.5. CORRELATION EIA-RIA

Laboratory	corr. coeff.	regression
1	0.92	EIA = 0.944 x RIA + 1.80
2	0.80	EIA = 0.931 x RIA + 0.93
3	0.84	EIA = 0.939 x RIA + 0.69
4	0.93	EIA = 0.970 x RIA - 1.45
5	0.82	EIA = 0.687 x RIA + 1.66
6	0.83	EIA = 1.180 x RIA - 0.12
7	0.93	EIA = 1.270 x RIA - 0.94

Note: The correlations for laboratories 9 and 10 were not determined because of unacceptable standard curves. The correlation for laboratory 8 could not be determined as this laboratory did not carry out the RIA.

II.4. DISCUSSION

Six of the participating laboratories produced good EIA standard curves (LCC value of >0.98) and in these laboratories an acceptable correlation was found between the two immunoassay techniques.

These six laboratories, as well as the laboratories in which the EIA kit did not produce good standard curves, were situated in developed and developing countries. All laboratories had experience in carrying out progesterone measurements using enzyme-immunoassay techniques and some of the laboratories in which the EIA kit did not perform satisfactorily had excellent facilities for EIA. Hence, lack of experience in and facilities for EIA can only partially explain the unsatisfactory performance of the EIA kit. The RIA kit performed well in all participating laboratories.

The main problem was that during the field validation of the EIA kit, even in the laboratories that produced good standard curves, there was high intra-assay variation. To obtain reliable results in a quantitative immunoassay this variation should be below 15%. The External Quality Control Service (EQCS) for the FAO/IAEA RIA kits has shown that intra-assay variations below this level are found in the laboratories of the recipients of these kits. However, the intra-assay variation of the EIA kit was frequently found to be higher than 15% (in all laboratories for QCA and in 6 of the 10 laboratories for QCB).

High intra-assay variations and therefore low precision generally coincided with low colour development during the EIA. This low colour development indicates that the EIA kits were not sufficiently stable during transport, especially if long delays in custom clearance were encountered. In two of the laboratories the colour development of the EIA was so low (the O.D.s of BO were below 0.412), that the intra-assay variations were not calculated. By contrast, long holdups at the customs did not appear to influence the performance of the RIA kits.

As mentioned in the previous validation report, another factor that might contribute to high intra-assay variation is the high number of pipetting steps in the EIA as compared to the RIA. It is thought however that poor stability during travel, resulting in low optical densities, is the main reason for the lower precision of the EIA.

The conclusion from the previous validation report was that the RIA kit is more "robust" than the EIA kit. Enzymes are known to be sensitive to changes in water pH and quality, ambient

temperature and exposure to light. This is supported by the results of this study. It cannot be excluded that the sensitivity of the enzyme to external factors has influenced the results of this field validation. The skim milk EIA kit performed well under the standardized conditions of the IAEA Laboratory at Seibersdorf and the Institute for Animal Production "Schoonoord" in Zeist, but in other laboratories with poorer facilities to standardize the assay, the kit did not perform satisfactorily.

In this validation, kits were sent only once to the participating laboratories. If EIA kits had been supplied more frequently, the greater experience gained by the participants in using the kits might have improved the performance of the EIA. However, it is believed that the results of this study show that more research work is needed to improve the EIA kit before it can be supplied on a routine basis to developing countries. Presently only RIA kits are supplied to counterparts and, as mentioned previously, these kits have proven to perform very well. The scientists participating in the FAO/IAEA/Dutch production network will therefore, in future, also be provided with FAO/IAEA RIA kits.

Further research on the EIA kit should focus on increasing its precision and stability. It has been shown already that better precision can be achieved by introducing a second antibody technique, i.e. coating plates with anti-rabbit-IgG and incubating with rabbit-antiprogesterone-IgG, conjugate and progesterone [3]. Collaborative research at the Institute for Animal Production "Schoonoord" and the Technical University of Munich has demonstrated that the precision of the EIA can be improved by the introduction of this second antibody technique.

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[3] Prakash et al., Animal Reproduction Science, **16** (1988) 225-235.

APPENDIX IIA

RIA PROTOCOL

Polypropylene tubes coated with antibodies to progesterone and buffered Iodine 125 (^{125}I) progesterone were obtained from Diagnostic Product Cooperation (DPC), Los Angeles, USA. To each tube is added 100 μl of standard or unknown and 1 ml buffered ^{125}I progesterone. The standards used in the plasma assay contained 0, 1.25, 2.5, 5, 10, 20 and 40 nmol progesterone per litre whereas in the milk assay standards containing 0, 2.5, 5, 10, 20, 40 and 80 nmol progesterone per litre were used. All samples and standards were assayed in duplicate. Two tubes containing 1 ml buffered ^{125}I progesterone were included in each assay. The tubes were incubated overnight at room temperature. Following incubation, the tubes were decanted and the counts per minute (cpm) were measured using an automatic multichannel or manual single well gamma counter. The standard curve was determined using the logit-

log transformation. The progesterone concentrations of unknown samples were estimated from the standard curve by interpolation. For information on sample collection and sample processing, and the reconstitution of freeze-dried standards see Appendix IIB. More information on the FAO/IAEA RIA kit for P_4 measurement can be found in the booklet on this kit.

APPENDIX IIB

EIA PROTOCOL

IIB.1. MATERIALS SUPPLIED

IIB.1.1. Progesterone antibody-coated microtitre plates

The microtitre plates were coated with a polyclonal progesterone antibody. The antibody was raised in a rabbit against progesterone-7α-carboxyethylthioether-BSA. Second coating of the plates was carried out using a 1% BSA solution in assay buffer (0.04 M phosphate buffer containing 0.15 M NaCl and 0.02% thimerosal with a pH of 7.2).

The plates were packed in airtight sealed bags containing a drying agent and should be stored at -20°C. If no freezer is available then the plates should be stored in a refrigerator. The coated plates are stable for at least one year if stored at -20°C. If stored in a refrigerator they are stable for a few months.

IIB.1.2. Enzyme labelled progesterone (HRP-P_4)

Each vial contains 150 ng of freeze dried progesterone-6ß-ol-hemisuccinate-horse radish peroxidase and is sufficient for one assay (i.e. one plate). The freeze dried conjugate is stable at room temperature for at least a year. However peroxidase is light sensitive and therefore it should be stored in the dark. To reconstitute the conjugate add 5 ml of cold (4°C) assay-buffer to the vial. This solution is stable for at least three weeks if stored in a refrigerator.

IIB.1.3. Standards for blood plasma kit

The kit contains six vials, each containing freeze-dried progesterone standards and consisting of processed bovine plasma containing 0.1% thimerosal as an antibacterial agent. The standards should be stored refrigerated; they are stable for at least 30 days after opening.

These standards contain concentrations of progesterone which cover the physiological range found in most domestic livestock species: 0, 2.5, 5.0. 10.0, 20.0 and 40 nmol/litre. To convert nmol/litre into nanograms per millilitre (ng/ml) divide by 3.18.

Reconstitute the standards by adding 1 ml of distilled/deionized water; leave on the bench for 2-4 hours and then mix (Vortex) thoroughly.

IIB.1.4. Standards for skim milk kit

The kit contains seven vials of freeze-dried progesterone standards made up in processed skim milk containing potassium dichromate as an antibacterial agent. The standards should be stored

refrigerated and in the dark. They are stable at 2-8°C for at least 30 days after opening. These standards cover the physiological range found in most domestic livestock species: 0, 2.5, 5.0, 10.0, 20.0, 40.0 and 80.0 nmol/litre. Reconstitute the standards by adding 1 ml of distilled/deionized water; leave in a refrigerator overnight and then mix (Vortex) thoroughly.

IIB.1.5. Quality Control (QC) samples

Two freeze dried QC samples ("A" = low, and "B" = high) are included with each set of standards. They are used for internal quality control of the assay. Reconstitute in the same way as the standards.

IIB.1.6. Washing liquid

Transfer the content of the "washing liquid" bottle to 1 litre of deionized/distilled water. The final wash solution contains 0.05% Tween 80. If stored at 4-8°C the washing liquid is stable for at least 6 months.

IIB.1.7. Substrate kit

The substrate kit consists of one bottle containing a solution of tetramethylbenzidine (TMB, substrate kit component A) and one bottle containing peroxide solution (substrate kit component B). The substrate solution should be prepared 20 min before it is required. To prepare the substrate solution for one assay, add the contents of the bottle containing the TMB solution (5 ml) to the bottle containing the peroxide solution (5 ml). Immediately afterwards shake the mixture gently. Use the substrate solution only when it has reached room temperature. The components of the substrate kit are stable for at least 6 months if stored at 2-8°C.

IIB.1.8. Sulphuric acid

The kit contains a bottle with 20 ml of 4N H_2SO_4.

IIB.1.9. Assay buffer

The chemicals to make up 500 ml assay buffer are supplied. The assay buffer (PBS + 0.1% BSA, pH 7.2) contains 0.04 M phosphate , 0.15 M NaCl , 0.02% thimerosal and 0.1% bovine serum albumine (BSA). Two sachets are provided. The "PBS" sachet contains the chemicals to make up 500 ml Phosphate buffered saline (PBS), i.e. 0.72 g $NaH_2PO_4.2H_2O$, 6.5 g $Na_2HPO_4.12H_2O$, 4.3 g NaCl and 0.1 g Thimerosal. The "BSA" sachet contains 0.5 g BSA. To make up the buffer add the contents of the sachets to 500 ml distilled/deionized water. Only use the buffer when the contents are properly dissolved.

IIB.2. EQUIPMENT REQUIRED

IIB.2.1. Essential items

- A microtitre ELISA plate reader, manual or automatic, equipped with a 450 nm filter for the TMB substrate system
- Single channel variable volume pipettes, e.g. Digital Finnpipette 5-40 µl, 40-200 µl and 200-1000 µl (Supplier: Labsystems)
- A multichannel variable volume pipette, e.g. Costar multichannel 20-200 µl (Costar cat. no. 4880) or Titertek multichannel 50-200 µl (Flow cat. no. 77-705-00)
- Tips for pipettes (depending on the pipettes that are used), e.g. Eppendorf blue and yellow tips, Titertek Pipette tip 0.5-200 µl (Flow Cat. no. 77-890-07), or Costar VIP-TIP (10-200 µl) (Costar cat. no. 4860/3)
- Reagent reservoir (trough), at least 3, e.g. Titertek Reagent Trough (Flow. cat. no. 77-824-01)
- A plate washer, e.g. Titertek Handiwash 110, 12 channel (Flow cat. no. 78-440-00)
- A pump for the plate washer
- A water distillation unit
- A supply of suitable glassware, e.g. Erlemeyer and volumetric flasks, and volumetric cylinders.
- A refrigerator (4°C)
- A vortex mixer
- Tubes for sample dilution (microtubes), e.g. Beckmann 1 ml tubes or Micronic PPN tubes 45*8.8 mm (Flow cat. no. 61-226-C2)
- Rack for sample dilution tubes, e.g. Micronic PPN Tube Holder (Flow cat. no. 61-225-00) or Beckmann

IIB.2.2. Non-essential items

- An orbital plate shaker, e.g. Titertek Plate Shaker (Flow eat. no. 77-471-00)
- An incubator (+37°C)
- A freezer (-20°C)

IIB.3. HANDLING OF KIT

IIB.3.1. On receipt

Store the kit components when possible in a deep freeze. If no freezer is available then store the kit in a refrigerator. Record the lot number and arrival date in a suitable logbook, and arrange for the kit contents to be inspected for damage.

IIB.3.2. Safety matters

The kit does not contain any components that necessitate specific precautions. However users of the kit are advised to maintain normal laboratory safety regulations. Handle the sulphuric acid with the same precautions as each strong acid solution.

IIB.4. EIA PROCEDURE

(i) Take the antibody-coated microtitre plates, assay buffer, substrate kit, plasma or milk samples, standards and QC samples out of the refrigerator and allow them to reach room temperature.

(ii) Dilute milk samples and milk standards 100 times with assay buffer (for example 10 µl sample + 990 µl buffer). Plasma samples and plasma standards should be diluted 50 times with assay buffer (for example 20 µl assay buffer + 980 µl buffer). Use clean microtubes in combination with a microtube holder.

(iii) Prepare conjugate (HRP-P) solution (see ii).

(iv) Using a multichannel pipette, transfer 100 µl of each sample or standard dilution in duplicate onto the antibody-coated microtitre plate according to Figure II.1.

(v) Add 50 µl of conjugate solution to each well using a multichannel pipette. Mix gently.

(vi) Incubate the plate for 1 hour at 37°C or for 1.5 hours at 20°C in the dark.

(vii) Prepare the substrate solution (see ii) about 20 min before the end of the incubation time (see vi). **It is important that the substrate solution has reached the temperature of the incubated plate before it is added.**

(viii) Wash the plate 5 times with washing liquid (300 µl per well each time).

(ix) Add 100 µl of substrate solution to each well using a multichannel pipette. Shake the plate gently and incubate in the dark at room temperature for 40 min.

(x) Terminate the enzyme substrate reaction by adding 50 µl sulphuric acid solution (see ii) to each well. Mix gently.

(xi) Measure the Optical Density (OD) at 450 nm using a plate reader.

(xii) Prepare the calibration (standard) curve by using logit-log graph paper and plotting the percentage bound (%B/BO) on the vertical axis against the progesterone concentration on the horizontal axis; a slight curve or a straight line can be drawn between the points. The percentage bound (%B/BO) is calculated as:

$$\%B/BO = \frac{ODS}{ODSO} x100$$

ODS = Optical density of well containing sample.

ODSO = Optical density of well containing the standard containing no progesterone (zero standard).

The progesterone concentration of unknown samples can then be estimated from the line by interpolation.

IIB.5. RECOMMENDATIONS FOR SAMPLING AND SAMPLE PROCESSING

IIB.5.1. Blood samples

Blood samples for collection of serum/plasma should be chilled in an ice bath immediately after collection; as soon as possible thereafter, the blood should be centrifuged and the plasma/serum kept in a deep freeze at -25°C. If this is not possible, make sure that blood samples are centrifuged within 8 hours of collection, in order to minimize enzymatic progesterone degradation.

To be able to compare plasma/serum progesterone levels, **it is absolutely essential to standardize the sampling and sample processing.** Also standardize the time of day at which the blood sample is taken, as the progesterone concentration in blood shows a diurnal variation.

IIB.5.2. Milk samples

Sampling and sample processing can have a major influence on progesterone concentrations in milk samples. In order to achieve reliable results, it is of utmost importance to apply as consistent a sampling scheme as possible:

Always try to use samples from the same **milking stage** (fore milk **or** composite milk **or** strippings). If fore milk is sampled, do not sample the firstdraw of milk, as stimulation of milk let-down can have an effect on the progesterone concentration in the sample.

Always try to centrifuge milk (for skimming) at the same temperature (preferably at 4°C, if a refrigerated centrifuge is available) for about 10 min.

Add preservative to the sample (1 tablet of potassium dichromate, Merck 4858, per 10 ml). Do not add sodium-azide to the milk. Milk preserved with sodium-azide cannot be used for this EIA as sodium azide inactivates horse radish peroxidase.

Store preserved milk samples at 4°C (stable for at least 3 months) **or** deep-frozen (no negative effect on skim milk) **or** room temperature (stable for about 2 weeks with dichromate at 37°C).

Mix serum/plasma and skim milk thoroughly immediately prior to an assay, and ensure samples and other assay components achieve room temperature before starting the assay.

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