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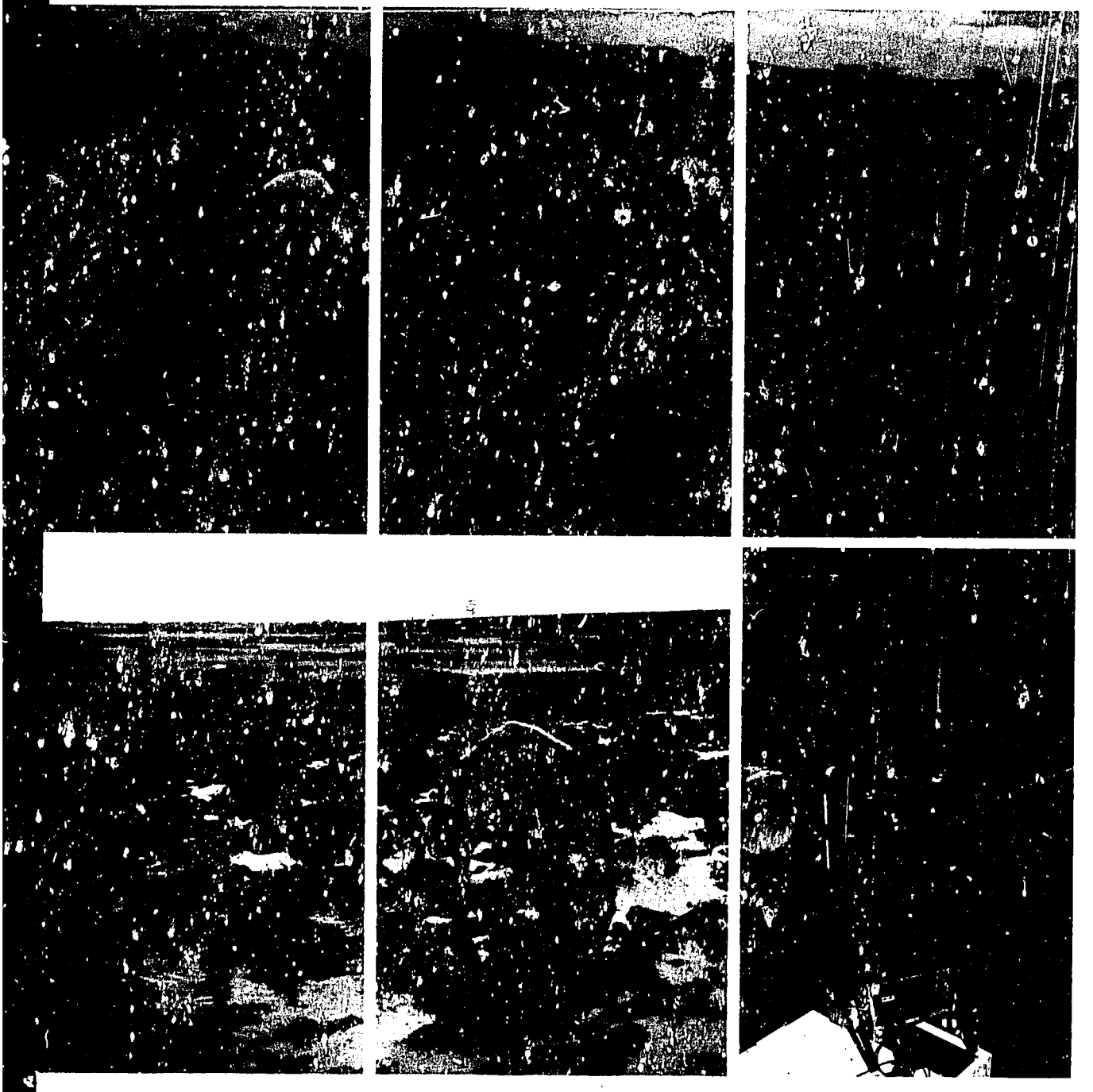
APPROACHES TO

RESEARCH ON DRAUGHT ANIMAL POWER

IN

INDONESIA, ETHIOPIA AND AUSTRALIA



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Approaches to

RESEARCH ON DRAUGHT ANIMAL POWER

in

Indonesia, Ethiopia and Australia

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International Livestock Centre for Africa
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ABBREVIATIONS USED

ACIAR	-	*Australian Centre for International Agricultural Research*
ADDM	-	*Apparent digestible dry matter*
AIDAB	-	*Australian International Development Assistance Bureau*
BPT	-	*Balai Penelitian Ternak* (Research Institute for Animal Production, Indonesia)
CGIAR	-	*Consultative Group on International Agricultural Research*
CP	-	*Crude protein*
CRIAS	-	*Central Research Institute for Animal Science* (Indonesia)
DAP	-	*Draught Animal Power*
DM	-	*Dry matter*
DMD	-	*Dry matter digestibility*
ICRISAT	-	*International Crops Research Institute for the Semi-Arid Tropics*
ILCA	-	*International Livestock Centre for Africa*
IRRI	-	*International Rice Research Institute*
ME	-	*Metabolisable energy*
MJ	-	*Megajoules*
NARS	-	*National Research Services*
PR	-	*Pulse rate*
RR	-	*Respiration rate*
RT	-	*Rectal temperature*

COLLABORATING INSTITUTIONS

The **ACIAR Draught Animal Power (DAP) Project** is a multidisciplinary study of draught animal systems in Southeast Asia, designed to identify ways of increasing farmer benefits from draught animal enterprises. Initially, the Project is operating in Indonesia, with supporting research in Australia. The Project is coordinated from James Cook University of North Queensland which also operates an informal DAP Network with linkages to ILCA and other animal traction networks in Africa, Asia and Europe. This publication was produced to inform a wider audience, including nonspecialists, about various approaches in draught animal power research.

The **ILCA Animal Traction Thrust** aims to increase and sustain agricultural production and incomes in smallholder farming systems of sub-Saharan Africa through a wider use of effective draught animal technologies. Collaborative research on animal traction is being carried out with national agricultural research services (NARS) through its programs in Ethiopia, Mali, Niger and Nigeria. ILCA is also working to establish an Animal Traction Research Network for sub-Saharan Africa which will link organisations and individuals with research, training and development activities in draught animal power.

Balai Penelitian Ternak, or the Research Institute for Animal Production, is the Indonesian institution primarily responsible for research on livestock production. Scientists from the main Institute at Ciawi, West Java, and from field centres in other Provinces are involved in joint research on DAP with scientists from James Cook University and the University of Melbourne, Australia.

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CHAPTER 1

INTRODUCTION

This publication arose from discussions held between scientists of the International Livestock Centre for Africa (ILCA) Animal Traction Thrust and the Australian Centre for International Agricultural Research (ACIAR) Draught Animal Power (DAP) Project. The discussions took place as part of a collaborative program of visits in Africa, Australia and Indonesia, financed by an Australian Special Purpose Grant to the Consultative Group on International Agricultural Research (CGIAR) centres.

This grant, administered by the Australian International Development Assistance Bureau (AIDAB), is intended to promote collaboration between Australian institutions and centres of the CGIAR system. In this case, funds were granted for a joint application by James Cook University of North Queensland and ILCA in Ethiopia, for funds to facilitate a cooperative program of visits by scientists of the ACIAR DAP Project and the ILCA Animal Traction Thrust.

Aims and Origin

The overall aim of the grant was to improve understanding and contact between scientists involved in research on draught animal power at Australian and CGIAR centres. The study and exchange visits were conducted with the more specific objective of documenting the different approaches to research on draught animal power in the three countries concerned.

Purpose and Intended Readership

The purpose of this review is to share information and impressions gained by participants, on the range of approaches and topics encountered in the field of draught animal power research.

The intended audience is scientists participating in DAP research, their donor organisations, and those planning to conduct or to sponsor research on animal traction in the future.

It is not intended here to present a complete report on DAP research in the countries or institutions visited, or a comprehensive range of research topics. The purpose is, rather, to document information on the range of DAP research topics covered at the organisations visited, and to discuss briefly the authors' impressions of the main **approaches** encountered.

Emphasis on Indonesia : Ethiopia : Australia

Although ILCA is involved in livestock research in a number of countries in Africa, and the ACIAR DAP Project has interest in Southeast (S.E.) Asian countries besides Indonesia, this review covers DAP research documented on the visits made within the host countries of ILCA and the ACIAR animal traction research programs, i.e. Ethiopia, Indonesia and Australia, respectively.

Reports on research on draught animal power in Australia are included as part of the work of the ACIAR DAP Project, which is, however, oriented towards DAP systems in S.E. Asia, particularly Indonesia.

As research on draught animal power in Australia, Indonesia and Ethiopia began relatively recently, both the volume and the range of research covered may be somewhat unrepresentative of research conducted elsewhere in Africa or Asia. Furthermore, some of the farming and draught animal systems in these selected countries are fairly unique, so that research for these systems is unlikely to have been conducted elsewhere.

The relatively new research projects on draught animal power that are operating in all three of the selected countries, provide the opportunity to review the approaches to DAP research, which are currently considered by scientists to be feasible and appropriate, at least for S.E. Asia and Africa. Some important types of research on DAP not being carried out in the three host countries are briefly mentioned in Chapter 3.

Types of Organisations Involved in Research on DAP

Organisations or departments of institutions (e.g. Universities) involved in research on DAP can be broadly categorised under those conducting:

. engineering research,
. livestock research (including nutrition, physiology, health, breeding),
. crop (or agronomic) research,
. economics research, and
. multidisciplinary research.

Emphasis in research on DAP within each of these categories tended to be biased towards the particular specialisation of the scientists working on DAP. However, institutions varied widely in the degree to which their scientists interact with other disciplines, and in the range of disciplines in which research is conducted. Thus, in some instances the research reflected a large degree of multidisciplinary interaction, whereas in others only a single discipline was emphasised.

Individual Research Topics on Draught Animal Power

In Chapter 2, examples of individual research topics on DAP encountered in Indonesia, Ethiopia and Australia, are arranged under the following headings:

. Animal health,
. Cropping,
. Economics,
. Engineering,
. Feed,
. Farming systems research (FSR),
. Physiology, and
. Work.

Each example is described under a standard set of headings - **Title, Aim(s), Origin of Aim(s), Location, Discipline(s) Involved, Methods / Treatments, Results / Conclusions, Application / On-farm Testing / Adoption / Further Research.** The names of the main **Investigators Involved** are also listed and reference is given to any **Documentation** that has resulted from the research.

Approaches to Research

In Chapter 3 an attempt is made to summarise the different approaches that have been taken by scientists to DAP research in the three countries involved in this study. In some cases, broad observations are made on the apparent strengths, weaknesses and relevance of various types of research, in the opinion of the authors.

Mention is also made of types of research on DAP that have been lacking in the three countries studied, and that may warrant higher priority for research in the future.

Accuracy and Responsibility

Considerable effort has been made to accurately summarise the individual research projects encountered. Most of the examples were written, or at least checked, by the investigator(s) themselves, but in a few cases, the scientists concerned could not be contacted or did not return their edited version.

The comments made about research approaches are entirely those of the authors and are in no way associated with the views of ACIAR, AIDAB, BPT or ILCA. The intent was to provide constructive criticism of all approaches and disciplines, and any apparent bias is regretted.

CHAPTER 2

EXAMPLES OF INDIVIDUAL RESEARCH TOPICS

In this Chapter, thirty-six examples of individual research topics are summarised in a standard format. Photographs are shown directly opposite these outlines, to assist the reader in gaining a mental picture of the environment in which the research was, or is being, conducted.

The examples presented are by no means exhaustive. Rather, it is intended to provide an idea of the types of studies that have been undertaken, with the scientists' aims and reasons for conducting the research. In each country, there are many cases of research which were not included, either because the particular type of study was already represented, or because access to information (e.g. aims, origin or results) could not be obtained from the investigators involved.

As research topics at various stages of completion are included in this Chapter, some descriptions show only the method and few results, while others include a summary and conclusion from the completed work. The main objective of the Chapter is to outline the different approaches to research that various scientists have taken, as well as the origin of the topics selected by researchers and the investigators' views of the possible applications of the results, on completion of the research.

Examples of Individual Research Topics are arranged alphabetically under eight disciplinary sections, viz. **Animal health**, **Cropping**, **Economics**, **Engineering**, **Feed**, **Farming Systems Research (FSR)**, **Physiology** and **Work**. Each Example is described under a standard set of headings and has been summarised in a two page format, including the photographs. This format, i.e. of disciplinary headings and of the subheadings within examples, is also followed in the discussion of approaches to research in Chapter 3.

By the time this publication goes to press, several new initiatives in DAP research in Indonesia, Ethiopia and Australia will have been started. It is envisaged that the simple format adopted in this book could be followed by authors in future years to provide updated information on approaches to DAP research.

TITLE

Animal health 1

Animal health in draught animal enterprises, Subang, West Java

AIM(S)
To document the occurrence and nature of the common animal health problems faced by rearers of draught animals, and to test cheap and simple remedies available in villages.

ORIGIN OF AIM(S)
In an initial study of draught animal systems in Subang villages, farmers indicated that certain health problems were common and their treatment often consumed considerable family labour. This study was designed to follow up the initial surveys, which identified animal health as one general constraint area (see *FSR 2*).

LOCATION Three villages in Subang, West Java.

DISCIPLINE(S) INVOLVED
Veterinarians, Livestock Services staff, and Farming Systems Research enumerators trained to treat common health problems.

METHODS / TREATMENTS
Three-monthly visits are made to each village, where farmers are asked to inform local enumerators of animal health problems. Sick animals are examined, farmers are questioned on the condition, and animals are treated with locally available, inexpensive remedies. Each case is documented and the incidence calculated as a percentage of total number of animals in the village. Results of treatment (and samples, e.g. faeces and blood examinations) are used to produce recommendations on future treatment of common conditions of ill health. Particular attention will be paid to conditions related to animal work (e.g. harness sores, lameness), in the main land preparation seasons.

RESULTS / CONCLUSIONS
After six months of study, the main conditions encountered were **burns** (from fires made at night to deter insects in pens), **skin conditions**, **eye disorders**, etc. Only one case of serious disease (trypanosomiasis - surra) has been recorded. Although the occurrence of **harness sores** is high (50% of farms) farmers do not consider this a problem. Local remedies are commonly used for internal parasites, sores and other common conditions. It appears that farmers face mainly minor animal health problems but that these can take up a lot of time, e.g. one hour per day treating burns, up to 2 hours per night tending fires to keep mosquitoes away.

APPLICATION/ON-FARM TESTING/ADOPTION/FURTHER RESEARCH
All work is on farms. Simple, cheap remedies are popular with farmers, but few of these are easily available in villages at present, and sound advice on reliable remedies is lacking. A main dificulty has been in ensuring that sick animals are not sold before examination and trial treatment.

Studies of animal health in draught animal enterprises in Subang, West Java. One of the most common injuries is burns resulting from fires lit at night in the pen, to deter mosquitoes and midges. Here a farmer is seen treating a burn by traditional means, i.e. cow dung applied and washed off daily.

INVESTIGATOR(S) INVOLVED Syahfur, R. Burton, S. Kenyon, A. Norhadi.

TITLE ***Animal health 2***

Effect of work on buffalo infected with Trypanosoma evansi

AIM(S)
To compare the response to infection with *T. evansi* of working and quiescent buffalo.

ORIGIN OF AIM(S)
It has been recorded in the literature that work stress may be a predisposing factor in outbreaks of disease due to *T. evansi*. This investigation attempted to analyse the correlation between work, parasitaemia and response to infection.

LOCATION Research Institute for Animal Health, Bogor, Indonesia.

DISCIPLINE(S) INVOLVED Veterinarians.

METHODS / TREATMENTS
Twelve 1-2 year old buffalo were divided into two groups of six. Animals in one group were each infected with *T. evansi*, the others formed a control, uninfected group. Both groups were subdivided into sub-groups of three. One infected sub-group and one control sub-group were made to walk for 3 hours each day, at speeds of between 1.11 and 1.39 m/sec, for 5 days a week to simulate work stress. The remaining two groups were confined. Daily body temperatures, haematocrits and parasitaemias were recorded.

RESULTS / CONCLUSIONS
1. Infected buffalo had a small but constant elevation in temperature.
2. Haematocrit levels were constantly lower in infected animals.
3. Work did not appear to exert a significant effect on the above observations.
4. Parasitaemias did not appear to be affected by the stress of working but rather by the ability of individual animals to control parasite levels.
5. Lower liveweight gains were achieved by working buffalo. The superimposition of trypanosomes appeared to amplify this effect.

It is possible that response to infection with *T. evansi* might result in diminished work output in draught animals.

APPLICATION/ON-FARM TESTING/ADOPTION/FURTHER RESEARCH
Data generated from investigations such as this, could be applied to develop strategies for parasite control at times of maximum risk from disease. The control strategies designed to maximise production must be tested on the farm. This was a preliminary investigation but the experiment can be repeated using a more exacting technique for applying work stress. Later it may be feasible to superimpose nutritional stress.

INVESTIGATOR(S) INVOLVED R. Payne, Sutijono.

DOCUMENTATION

PAYNE, R.C., PARTOUTOMO, S. SUKANTO, I.P. and WILSON, A.J. (1989). Studies on epidemiology and pathogenesis of *Trypanosomiasis evansi* in buffalo in Indonesia. Paper at ACIAR/IAEA Workshop on Buffalo. Rockhampton, February 1989.

Swamp buffalo grazing communally, on fallow rice fields in West Java, Indonesia. Most draught animals in Java are subjected to work stress for only 20-40 days per year.

TITLE

Cropping 1

Better utilisation of Vertisols in the Ethiopian highlands with a low-cost animal-drawn implement

AIM(S)
To increase grain and straw yields of crops by constructing broadbeds-and-furrows on Vertisols and soils with vertic properties, to remove the excess water and create a better crop-growing environment.

ORIGIN OF AIM(S)
There are 6-8 million ha of Vertisols and soils with vertic properties in the highlands of Ethiopia which are underutilised for crop production because of the waterlogging problem. Waterlogging is especially serious in areas of high rainfall (>800 mm of rain during the growing period). With the traditional flat cultivation methods, farmers' crop production does not exceed 700 kg/ha, while production can be more than doubled with a land management of broadbed-and-furrow, which is accomplished by modifying the traditional implement. Crop yields may be further raised if better cereal varieties and fertiliser could be added to the package.

LOCATION Ethiopian highlands.

DISCIPLINE(S) INVOLVED
Agronomists, Agricultural engineers, Animal scientists, Economists and Extension agents.

METHODS / TREATMENTS
The traditional method of "flat seedbed" cultivation was compared with a broadbed-and-furrow land management system, in crop production. The beds were made by two traditional ploughs (*maresha*), modified to form a broadbed maker.

RESULTS / CONCLUSIONS
Initial results show that higher grain and straw yields could be achieved by means of a broadbed and furrow land management system.

APPLICATION/ON-FARM TESTING/ADOPTION/FURTHER RESEARCH
On-farm verification trials are being carried out at five locations within the highlands, using farmers' fields and animals, and ILCA implements and other inputs.

INVESTIGATOR(S) INVOLVED
S. Jutzi, Abiye Astatke, Abate Tedla, Getachew Asamenew, Negussie Akalework and other members of the ILCA Vertisol team.

Broadbed-and-furrow construction in Vertisols, Ethiopia. The broadbed-maker is made from two traditional maresha and pulled by draught animals.

Planted broadbeds draining excess water from the field.

DOCUMENTATION

JUTZI, S., ANDERSON, F.M. and ASTATKE, ABIYE (1986). Low-cost modifications of the traditional Ethiopian tine plough for land shaping and surface drainage of heavy clay soils: preliminary results from on-farm verification trials. In P.H. Starkey and F. N'Diame (eds). Animal Power in Farming Systems. GATE/GTZ, Vieweg & Sohn : Wiesbaden, Germany. pp.127-132.

ILCA 1987. Joint ILCA/ICRISAT/IBSRAM GoETHIOPIA Project on improved management of Vertisols in Ethiopia. Progress Report Year 2 (1987) and Project Plans Year 3 (1988). Vertisol Programme Working Document. International Livestock Centre for Africa, Addis Ababa.

ILCA 1988. Making technology more appropriate. *ILCA Newsletter* 7(2): 1,4-6.

TITLE ***Cropping 2***

Alternative land preparation methods for early establishment of rice

AIM(S)
To compare different types of land preparation, implements and methods, with a view to improving crop production and income of farmers.

ORIGIN OF AIM(S)
Most farmers in Timor, Indonesia prepare ricefields by trampling with a large group of animals (*merancah*). Land preparation by trampling begins each year, only when sufficient rain has fallen to saturate the soil and when animal condition has picked-up. This practice tends to shorten the growing period, decrease yields and reduce the potential for a second crop. Most farmers have Bali cattle but in insufficient numbers for trampling their fields. They are therefore dependent on richer rearers for land preparation. At present, most villages have no ploughs and farmers have no knowledge of training animals for tillage. Metal ploughs are available but expensive.

LOCATION Kupang District, West Timor.

DISCIPLINE(S) INVOLVED
Livestock, Crop, Soil and Farming Systems scientists.

METHODS / TREATMENTS
The research began in 1987 by comparing different implements and methods on irrigated land. Ploughing with DAP implements is now being compared with the *merancah* method in trials on farmers' fields. Farmers have had to be trained to work their cattle and to make wooden implements. Comparisons will be based on yield of rice and second crops, and on farmer opinion of the practicality of the techniques and of rearing and training animals.

RESULTS / CONCLUSIONS
From over 40 farmers trained, indications are that many farmers will adopt simple DAP technology, as this allows them to plant earlier and to become independent of large cattle owners who demand one-third of the rice yield in payment for land preparation. Results of crop yield trials are not yet available.

APPLICATION/ON-FARM TESTING/ADOPTION/FURTHER RESEARCH
Farmers have shown enthusiasm and ability to make wooden Javanese ploughs and to train their animals. Some cooperating farmers have decided to rear their trained animals in the back yard (instead of grazing) and to sell these as fat stock after 2-3 years. The trials are being extended to upland maize areas, where implements for weeding will also be tested.

INVESTIGATOR(S) INVOLVED
C. Liem, H. Marawati, U. Tonga, A. Bamualim and R.J. Petheram.

Bali cattle (Bos javanicus) being used for trampling (merancah) in land preparation for rice in West Timor, Indonesia. Trampling can only be effective when the soil is saturated. The animals are used in groups of 10 to 400 head.

Alternative methods of land preparation for wet rice in West Timor. Hand cultivation is common, and animal-drawn ploughs are being introduced in some villages.

DOCUMENTATION

LIEM, C., MARAWALI, H., KANAHEBI, A., TONGA, U. and PETHERAM, R.J. (1988). Traction, trampling, tractors and toil in Tarus Village, West Timor, N.T. *DAP Project Bulletin*. 5: 11-15.

TITLE

Economics 1

Estimation of average and frontier production functions for rice farmers

AIM(S)
To determine whether Javanese rice farmers are technically efficient in their use of resources, especially Draught Animal Power (DAP).

ORIGIN OF AIM(S)
Part of a larger study in West Java. The research attempted to utilise some of the large amounts of existing data in Indonesia, to assess its value as a source of information on the economics of DAP in rice farming. An academic study related to Master's degree candidacy at the University of Melbourne.

LOCATION West and East Java, Indonesia.

DISCIPLINE(S) INVOLVED Economists.

METHODS / TREATMENTS
Secondary data were used from a farmer survey conducted by the Centre for Agro-Economic Research, Bogor, Indonesia. Linear 'average' and 'frontier' production functions were estimated using Ordinary Least Squares (OLS) and Maximum Likelihood Estimators (MLE), respectively.

RESULTS / CONCLUSIONS
The analysis indicated that farmers in the villages analysed were technically efficient in their production of rice, in that there were no statistically significant differences between the average and frontier production functions. **Draught animal power**, land area and urea were significant variables in explaining the variations in output of rice between individual farmers.

APPLICATION/ON-FARM TESTING/ADOPTION/FURTHER RESEARCH
The method used determines the marginal product of each input. The conclusion of technical efficiency relates only to the current technology levels and implies that, to increase productivity, new technologies are required (i.e. introduction of new technologies into the area, rather than selecting the "best" practices already existing among farmers within the area). The significant effect assigned to DAP infers that draught power as an input offers some promise of rewards to research.

INVESTIGATOR(S) INVOLVED
CAER staff responsible for the farmer survey. N. Esparon, N. Sturgess.

DOCUMENTATION
ESPARON, N. (1988). Estimated production functions for rice production in selected villages of West Java. *DAP Project Bulletin*. 5: 2-8.

Wet rice farming in West Java is highly labour intensive. Here, women are seen weeding young rice planted in a check-row pattern.

The human - animal - soil - water - riceplant interaction in Java.

TITLE

Economics 2

Linear programming models of farms in West Java, Indonesia

AIM(S)
To measure the current costs and benefits of DAP use, relative to other farm and non-farm enterprises operated by farmers.

ORIGIN OF AIM(S)
It is assumed that farmers are, in general, efficient in the allocation of their individual resources and in their use of those 'public' resources to which they have access. Suggested changes in the use or management of animals for DAP will have economic implications affecting costs, income and capital values. An LP model will estimate the economic consequences of these changes and assist in forecasting the 'worth' of these changes, relative to the value of other enterprises that the farm operates.

LOCATION
Subang village site, West Java, Indonesia; Centre for Animal Research, Bogor, Indonesia; University of Melbourne, Australia.

DISCIPLINE(S) INVOLVED Economists.

METHODS / TREATMENTS
A total of 80 farmers in two survey villages were trained to keep a daily diary. Within each village, 5 farmers are cattle rearers, 5 are buffalo rearers and 30 have no large ruminants but are potential users of DAP. Farmers record all inputs and outputs of their agricultural enterprises; all daily labour inputs and rewards for non-agricultural enterprises. A series of intermittent surveys record the changes in the farms' capital inventories. The daily diary approach has been used to obtain data of high accuracy and facilitates inter-farm comparison.

RESULTS / CONCLUSIONS
One full year's data was collected, covering either one or two complete cropping cycles for irrigated rice. Analysis commenced in late 1988. Of interest is the growth in tractor/hand-tiller preparation in the one sample village, which is more suitable for the operation of tractors.

APPLICATION/ON-FARM TESTING/ADOPTION/FURTHER RESEARCH
The results are to be used in conjunction with results from the Farming Systems and Nutrition studies, in preparing alternative livestock development plans.

INVESTIGATOR(S) E. Basuno, J. Perkins, N. Sturgess.

A training session for farmers on keeping a daily diary of economic records, Subang, West Java.

DOCUMENTATION

BASUNO, E. and PERKINS, J. (1988). A daily diary for data collection. *DAP Project Bulletin*. 6: 19-24.

TITLE

Engineering 1

Description and testing of traditional animal-drawn cultivation implements

AIM(S)
Collection and testing of primary cultivation implements used by farmers in Indonesia and examination of the need to design new implements to fit different conditions and soils for establishing upland crops after rice.

ORIGIN OF AIM(S)
For many types of soils found in Indonesia, puddling and submergence are favourable to rice cropping. The major disadvantages of puddling occur upon drying of the soil, when structural changes can be so severe as to prevent the growth of dryland crops after the rice crop. The time required to regenerate the soil, or the 'turnround period' (TAP) is dependent upon the soil texture, the clay mineralogy, the amount of organic matter and the structural stability of soil before puddling. The development of suitable tillage and other soil management practices to shorten the TAP, as well as suitable methods to establish upland crops after wetland rice are the main aims of the cropping systems research program of which this implement study is a component. A graduate student research topic.

LOCATION
Areas of East Java where dryland crops are grown after rice.

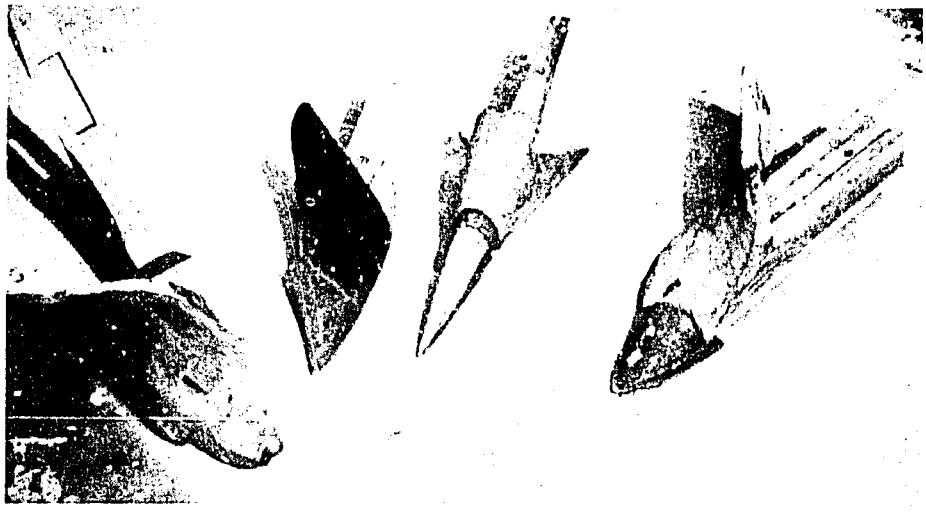
DISCIPLINE(S) INVOLVED Agricultural engineers.

METHODS / TREATMENTS
A survey of farms in the Malang district, where examples of each type of plough were purchased. Measurements of implements in terms of weight, size, shape, and other characteristics. A special template was developed to record the shape of ploughs. In the next stage of research, 27 different ploughs are to be tested on university land.

RESULTS / CONCLUSIONS
Initial studies around Malang show that almost every village has its own plough shape, for each major soil type or cropping season (e.g. wet rice and secondary dryland crops).

APPLICATION/ON-FARM TESTING/ADOPTION/FURTHER RESEARCH
As no previous research has been conducted on traditional implements in Indonesia, this area would appear to have potential for assisting farmers to choose plough designs which suit their particular conditions and needs.

INVESTIGATOR(S) INVOLVED
J. Plantenga, students from University of Brawijaya, Malang, East Java and Wageningen Agricultural University, The Netherlands.



A selection of traditional plough points from Java.

DOCUMENTATION

Student thesis, in preparation, Wageningen University.

TITLE ***Engineering 2***

Field performance of the traditional Ethiopian plough

AIM(S)
To study and evaluate the performance of the *maresha* in light soils.

ORIGIN OF AIM(S)
One aim of the Agricultural Implements Research and Improvement Centre (AIRIC)/Institute of Agricultural Research (IAR) is to characterise local and imported implements so that recommendations can be made for their use by farmers and for their possible improvement by engineers. The *maresha* is the only implement used for both primary and secondary tillage in Ethiopia.

LOCATION AIRIC/IAR Nazareth Research Centre, Melkassa, Ethiopia.

DISCIPLINE(S) INVOLVED Agricultural engineers.

METHODS / TREATMENTS
Three test plots 40 x 10 m were randomly selected and soil was tested for moisture, bulk density, shear strength and surface penetration. A pair of Ethiopian oxen pulled the *maresha* and recordings were made of speed, time, number of furrow passes, furrow profile, cross-section of furrow, working width, maximum and average depth of working, evenness of ploughing, weeding efficiency and draught. Calculations were made of unit resistance and power requirement of the implement, output and field efficiency.

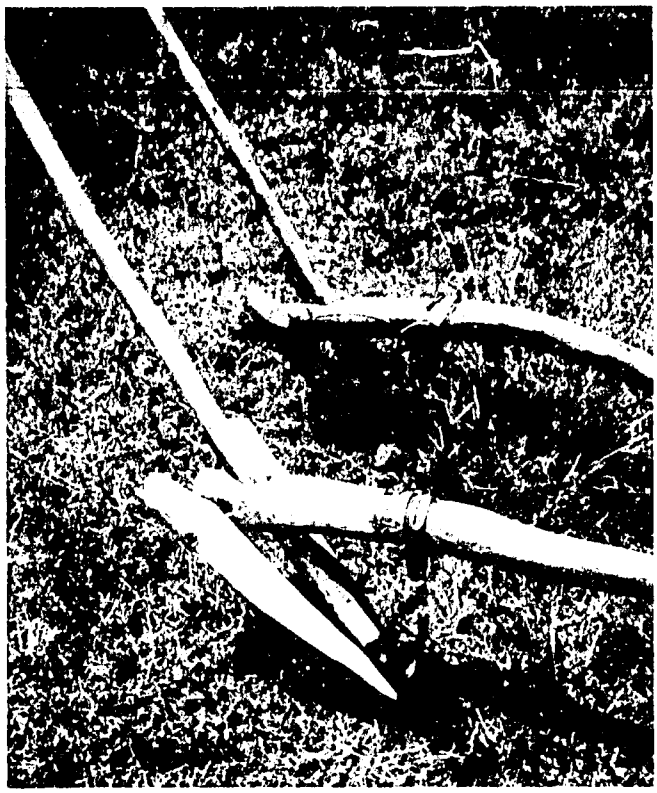
RESULTS / CONCLUSIONS
The *maresha* had an average depth of cut of 6.5 cm and a working width of 27 cm. Power requirement was around 680 watts, field efficiency 76%, unit resistance 0.7 kg/cm^2, evenness 0.56 and weeding efficiency 92%. Actual field capacity was 0.05 ha/hour.

APPLICATION/ON-FARM TESTING/ADOPTION/FURTHER RESEARCH
Contrary to general belief, the draught unit resistance and power requirement of the implement are high, in the context of the size of the local oxen. Evenness of ploughing is low. The results have led to testing of alternative (mouldboard type) implements for possible modification and replacement of the *maresha* in certain situations.

INVESTIGATOR(S) INVOLVED
Adunga Kebede, B.S. Pathak, staff of AIRIC.

DOCUMENTATION

AIRIC (1986). Field Performance of Maresha. Test Report Nos. 4, 16 & 18. Agricultural Implements Research and Improvement Centre, Institute of Agricultural Research, Melkassa : Ethiopia.



Two mareshas - traditional Ethiopian ards. Note the metal point and adjustable wooden wings (soles).

TITLE

Engineering 3

Pond excavation using ox-drawn scoops in Ethiopian Peasant Associations

AIM(S)

1. To determine the suitability of earth ponds constructed by ox-drawn scoops as a technology for farmers in peasant associations (PAs).
2. To determine the technical performance of scoops and animals.
3. To elaborate on likely organisational and other cultural factors in the large-scale use of the technology.

ORIGIN OF AIM(S)

Surveys show a serious shortage of good quality water for humans and livestock in the dry season. This shortage has serious implications for family welfare and productivity of agriculture and livestock.

LOCATION Ethiopian highlands.

DISCIPLINE(S) INVOLVED

Agricultural engineers, Economists, Animal scientists, Administrators.

METHODS / TREATMENTS

Construction methods were pre-tested on ILCA's research station in 1983 and farmers introduced to research through field days. Two Peasant Associations (PAs) requested assistance in pond excavation. Suitable sites were selected with Ministry of Agriculture and PA leaders. Funds for scoop manufacture were provided by Shell Ethiopia. Work input of oxen and excavation rates were recorded and compared with rates on station. Cost and benefits of stored water were estimated.

RESULTS / CONCLUSIONS

There were 17 work days available each month and each farmer worked animals every 6-9 days. About 18 pairs worked each day. Average load carried was 0.15 m^3/pair/ circuit. Each team completed 86 circuits/day and excavated about 8 m^3/day in the 1985 dry season; 1984 was drier, so rates of only 5.51 m^3/day were achieved, or less than half the rate on research station. The average work day was 6 hours. Total cost of water stored was US$1.20/$m^3$, including loan for scoops, feed and operator costs.

APPLICATION/ON-FARM TESTING/ADOPTION/FURTHER RESEARCH

The findings are considered to have wide application. The ox-scoop technology is well suited to use by PAs. Benefits to farmers are clear and the technology requires minimal foreign exchange. The major requirement is for strategic inputs by Government, such as skilful selection of pond sites (to minimise risk to farmers) and access to scoops. Numerous organisations are becoming involved in pond construction using animal traction and scoops.

INVESTIGATOR(S) INVOLVED Abiye Astatke and F.M. Anderson.

A pond siting exercise with farmers in Ethiopia.

Pond construction using ox-drawn scoops.

A completed pond at Debre Berhan, Ethiopia.

DOCUMENTATION

ASTATKE, ABIYE, BUNNING, S. and ANDERSON, F.M. (1986). Building ponds with animal power in the Ethiopian highlands: a manual. ILCA, Addis Ababa.

TITLE ***Engineering 4***

Characterisation of draught animal implements in Subang, West Java

AIM(S)
To describe the main animal-drawn implements in terms of their distribution, use by farmers, physical dimensions and weight, construction materials and draught requirements under local soil conditions.

ORIGIN OF AIM(S)
There is a lack of information concerning the variation in design, construction and power requirements of animal-drawn implements currently used in West Java. A simple classification of local implements is needed before improvement to implements can be suggested.

LOCATION Subang District, West Java.

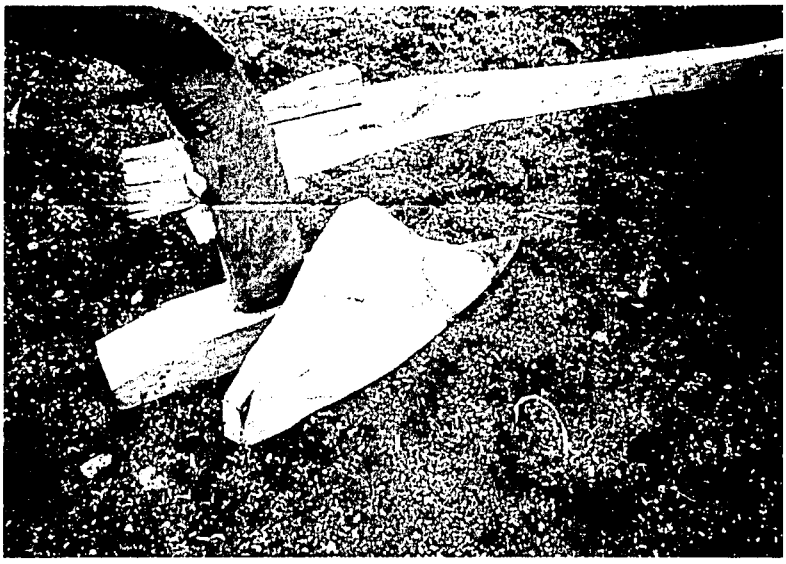
DISCIPLINE(S) INVOLVED
Animal scientists, with advice from Agricultural engineers.

METHODS / TREATMENTS
1. Measure and record physical characteristics of implements in use on farms. Include farmer information on adjustments and tasks performed.
2. Classify the range of implements - to identify the main categories of implements for subsequent field testing.
3. Measure, for each main implement and operation (e.g. first and second ploughing), the area cultivated per unit time, as well as soil hardness and wetness characteristics.
4. Measure draught force for each main implement type at the same time as (3) above, as well as tillage characteristics (e.g. depth and width of operation). Include a subjective assessment (or score) of quality of work.

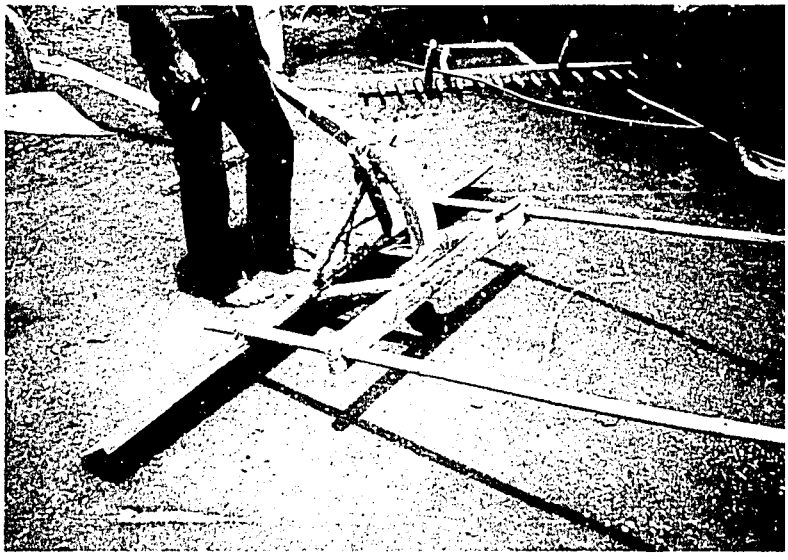
RESULTS / CONCLUSIONS
Three main types of implement were encountered in use in Subang: the wooden mouldboard-type plough (*luku*), a wooden leveller (*garuh*) and a wooden rake/cultivator (*bugis*). Variation in weight and dimensions within these groups was minor. Farmers with single animals used lighter ploughs than those using pairs. However, no significant difference in draught output was recorded (40-60 kg force) between single and paired teams.

APPLICATION/ON-FARM TESTING/ADOPTION/FURTHER RESEARCH
Following this study, ploughs from areas with similar soils are being tested, and modifications are being tested on some ploughs (see *FSR 4*). As variation (and the metal component) of ploughs in E. Java is much higher, there may be scope for trial of some implements from there in W. Java.

INVESTIGATOR(S) INVOLVED Sumanto, Gunawan, Ridwan.



Wooden plough (luku) Subang for use with paired animals.



Leveller (garuh) for wet rice field, set up for use with single animals.

Harrow (bugis) with harness for single animal.

TITLE ***Engineering 5***

Implements for crossbred oxen on heavy clay soils

AIM(S)
To determine the appropriate weight of crossbred oxen for drawing Chinese metal mouldboard ploughs, for effective tillage on heavy clay soils.

ORIGIN OF AIM(S)
Neither the traditional cattle pulling the *maresha* nor tractors can effectively work on local heavy clay soil, especially when wet. Crossbred oxen are already in use in various places of the region, but not with appropriate ploughs. Farmers seem to have understood the inefficiency of using the *maresha* with powerful crossbred oxen. Yet the various metal ploughs did not gain acceptance from farmers. Thus, it was felt important to determine what weight of crossbred oxen would bring about effective tillage on heavy clay soils, when wet, using the Chinese mouldboard plough. It was also intended to evaluate the efficiency of the implements and to make comments for future improvement.

LOCATION
Animal Research Station, Arsi Rural Devclopment Unit, Asella, Ethiopia.

DISCIPLINE(S) INVOLVED Animal scientists.

METHODS / TREATMENTS
A questionnaire for farmers was first prepared to find out more about crossbred oxen and their use for work - but this survey has not been completed. A trial on a research station was then planned, using pairs of animals. Four groups of animals: 200-250 kg; 250-300 kg; 300-350 kg; and 500-600 kg, were used to pull two types of metal Chinese ploughs (one reversible model). Depth and rate of ploughing and feed consumption were measured, on wet, heavy black clay soils, after primary tillage.

RESULTS / CONCLUSIONS
All the first three pairs could not work for more than 15-20 minutes before they tired; neither could they achieve tillage deep enough for planting. The heaviest pairs were able to effectively pull the implements, with sufficient depth for planting. They exhibited better strength, uniform depth and consistent speed without tiring. It was concluded that at least 450 kg animals (in pairs) are required to pull these implements on such a soil, and that the implements need further improvement. Sharper points and edges are needed as well as stronger handles.

A mouldboard plough under test in Ethiopia.

APPLICATION/ON-FARM TESTING/ADOPTION/FURTHER RESEARCH
There are quite a lot of crossbred oxen in the region with no appropriate implements. Thus, the question of making appropriate use of these animals using suitable implements needs further research, involving other disciplines (e.g. agro-engineering, animal nutrition).

INVESTIGATOR(S) INVOLVED Mohammed Y. Kurtu.

DOCUMENTATION

ARSI (1987). Report on trial to determine suitability of crossbred oxen for ploughing. Animal Research Station, Arsi Rural Development Unit, Asella : Ethiopia.

TITLE ***Engineering 6***

Low-cost modifications of the traditional plough for terracing

AIM(S)
To construct terraces on slopes of up to 5% for the conservation of soil and water, using a modification of the *maresha*.

ORIGIN OF AIM(S)
Terraces in the Ethiopian highlands are constructed mainly by manual labour. The use of animals to do this work will enable a larger area to be conserved in a shorter time. The terracing plough is made by replacing the two flat soles of the *maresha* with one wooden mouldboard-shaped wing. The wing can be shifted from one side of the beam to the other by pulling the metal pin that attaches it to the main beam. It is held from detaching by the two metal rings passing through it and the *maresha* handle. The terracing plough is used on areas previously ploughed by the *maresha* and is operated in the same way, with the exception that the wing must be reversed at the end of each pass in order to shift the soil only to the ploughing side.

LOCATION Ethiopian highlands.

DISCIPLINE(S) INVOLVED
Agronomists, Agricultural engineers and Economists.

METHODS / TREATMENTS
Following on-station development and testing of the modified implement, on-farm verification trials were carried out.

RESULTS / CONCLUSIONS
Power requirement for the terracing plough was 80% of that required for the *maresha*. An average of 3.3 passes was sufficient to establish 4 m wide level terraces on a clay-loam field of 8% slope. In monitoring work on 22 terraces (420 m long), it was found that one pair of oxen could prepare about 1 ha in 5 days.

APPLICATION/ON-FARM TESTING/ADOPTION/FURTHER RESEARCH
The terraces reduce soil loss and conserve water by slowing and reducing runoff. More stable crop yields can be expected immediately due to increased water availability, and in the longer term, due to soil and fertility conservation. Some work is being carried out by the Soil Conservation Department of the Ministry of Agriculture in different areas of Ethiopia on testing this approach.

INVESTIGATOR(S) INVOLVED
S. Jutzi, Abiye Astatke, F.M. Anderson, and other members of the ILCA Vertisol team.

A maresha, with a modified wing, for use in terracing, ILCA Debre Zeit Research Station, Debre Zeit, Ethiopia.

DOCUMENTATION

JUTZI, S., ANDERSON, F.M. and ASTATKE, ABIYE (1988). Low-cost modifications of the traditional Ethiopian tine plough for land shaping and surface drainage of heavy clay soils: preliminary results from on-farm verification trials. In: P.H. Starkey and F. N'Diame (eds). Animal Power in Farming Systems. pp.127-132. GATE/GTZ Vieweg & Sohn : Wiesbaden, Germany.

TITLE

Engineering 7

Evaluation and improvement of single animal harnesses

AIM(S)
To select and make available a single animal yoke, suitable for Ethiopia.

ORIGIN OF AIM(S)
The use of oxen in pairs is the most common yoking practice for tillage operations in Ethiopia. However, about 30% of Ethiopian farmers own only one ox, and these farmers face problems in cultivating their land at the proper time because of lack of draught power. The draught requirement of primary tillage implements including the *maresha*, is high and beyond the capacity of an average Ethiopian ox, but secondary tillage and other low draught tasks could be carried out using a single ox. For efficient utilisation of single animals, a low cost, single animal harness and hitching method is needed.

Therefore, an improved version of the inverted V-yoke (used in some countries and tried in Ethiopia by ILCA), and the widely used rigid neck yoke (modified for single animals) were studied. Both harnesses are simple in construction, have low cost and can be made by farmers.

LOCATION AIRIC/IAR, Nazareth Research Centre, Melkassa, Ethiopia.

DISCIPLINE(S) INVOLVED Agricultural engineers.

METHODS / TREATMENTS
This study was carried out on the circular test track of AIRIC, using an hydraulic brake system (loading device) to load the animal, under various work regimes. Trials were also carried out, of the improved inverted V-yoke for transport operations, using the AIRIC single animal cart.

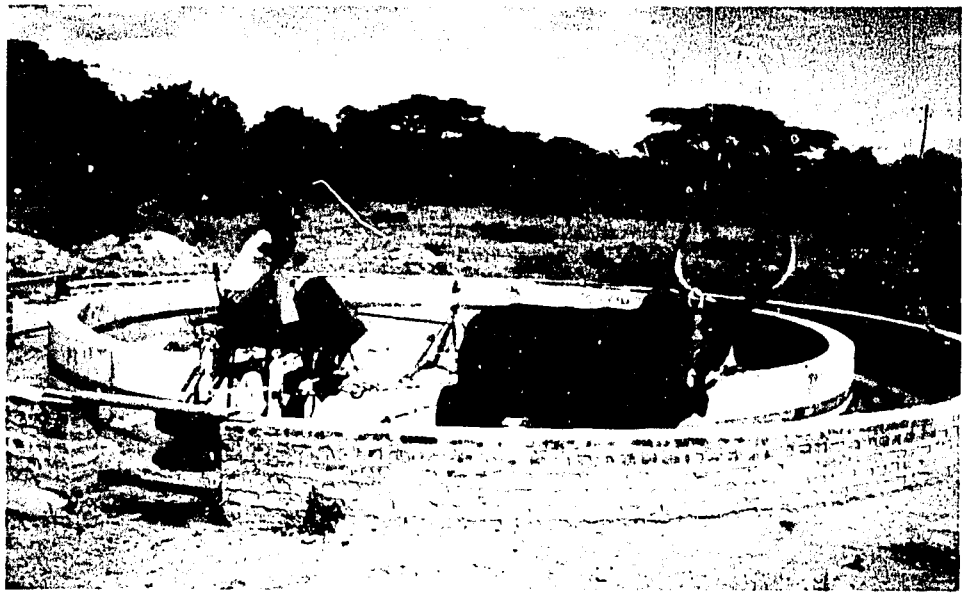
RESULTS / CONCLUSIONS
The inverted V-yoke was found to be more desirable in offering more contact area and "comfort", for efficient utilisation of the animal's strength and longer work duration. It was also superior in terms of minimum rise in body temperature, pulse rate and respiration rate, and slightly higher speed of the ox at 30 kg, 45 kg and 60 kg pull.

The rigid neck yoke is simpler in construction and can be made by local farmers. Achieving stability of this yoke against the animal's neck was observed to be a problem where wooden beams were not of a uniform size.

APPLICATION/ON-FARM TESTING/ADOPTION/FURTHER RESEARCH
Properly constructed wooden yokes could be used with single animals to carry out low draught tasks like secondary tillage, transport, etc., with properly designed implements that match the draught capacity of the animal.

In the trials pulling the cart, an ox, weighing about 300 kg, could pull up to 600 kg of pay load on the oval dirt track of AIRIC for 5 hours/day without showing abnormal signs of fatigue. Use of the harness for secondary tillage operations will be studied in the near future.

INVESTIGATOR(S) INVOLVED Adugna Kebede and Friew Kelemu.



A circular track and load measuring device in use to test the working performance and physiological response of animals at AIRIC/IAR, Nazareth Research Centre, Melkassa, Ethiopia.

TITLE

Feed 1

Effect of light work on intake and digestion in steers fed Rhodes grass supplemented with urea and minerals

AIM(S)
To study the effect of work on feed intake and the movement of feed through the digestive tract.

ORIGIN OF AIM(S)
The work was undertaken as part of the research for an MSc thesis and formed an initial stage of a larger study aimed at improving understanding of the physiology of working animals.

LOCATION
James Cook University of North Queensland, Townsville, Australia.

DISCIPLINE(S) INVOLVED Ruminant nutritionists.

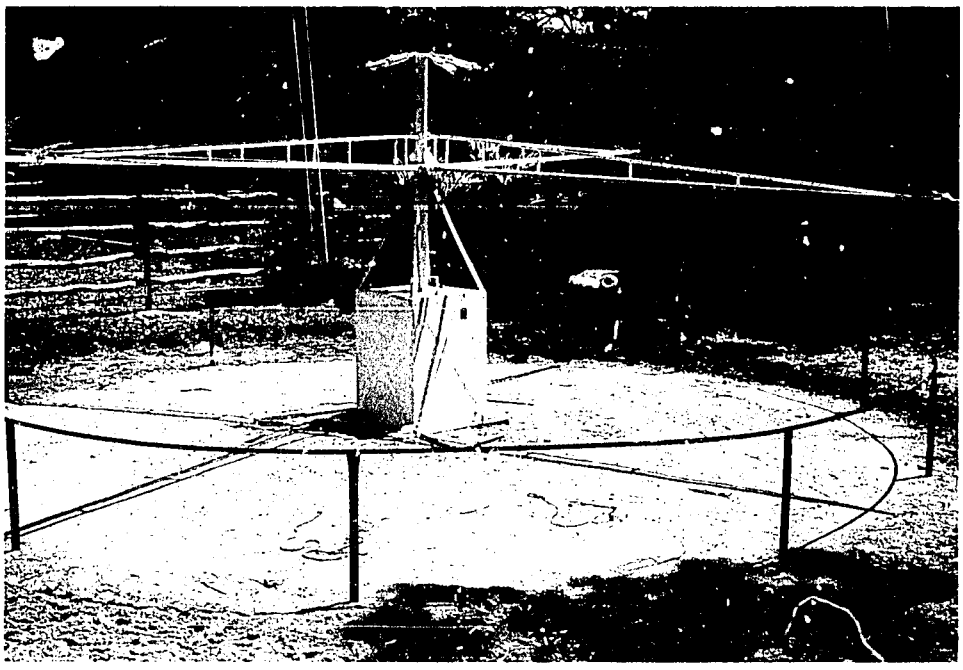
METHODS / TREATMENTS
Six Droughtmaster-cross steers were fed grass hay plus urea and minerals. Three animals were worked for 1 hour per day around a circular track of 22m diameter under a rotary exercise machine at a speed of 4.5 km/hour while carrying a load equivalent to 10% of bodyweight. On Day 8 of the 14 day experiment, Chromium (Cr) and Ytterbiam (Yb) as liquid and particulate markers were dosed through rumen cannulae, after work but before feeding. Rumen digesta and faecal samples were collected for 5 days after dosing.

RESULTS / CONCLUSIONS
1. Organic matter intake was similar in working and non-working steers.
2. Rumen NH_3-N was higher in working steers.
3. Cr was diluted slower in the rumen of working steers.
4. Transit times and faecal retention times were similar in both groups.
5. The dilution of Yb in the rumen was similar in both groups.
6. The level of work did not greatly affect digestive physiology.

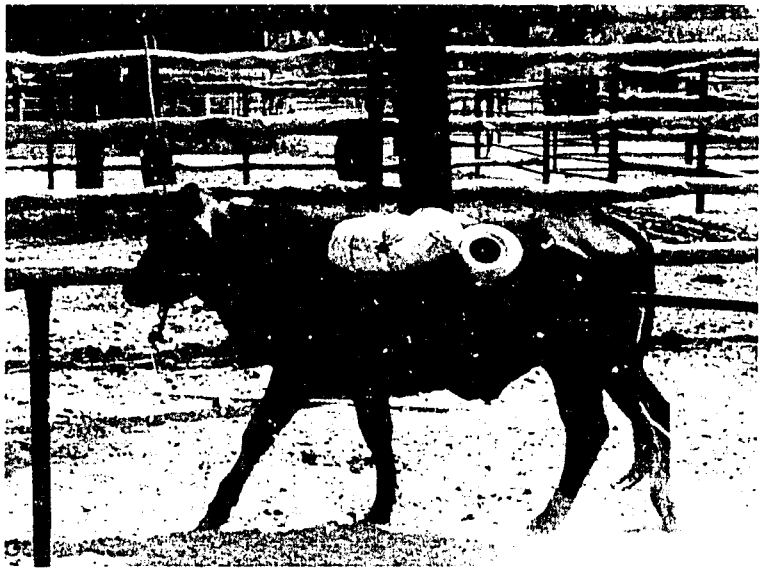
APPLICATION/ON-FARM TESTING/ADOPTION/FURTHER RESEARCH
The results are useful in planning further studies on the efficiency of utilisation of food by working animals. However, the method of loading and working animals was abandoned in favour of carts and treadmills in later experiments.

INVESTIGATOR(S) INVOLVED B. Bakrie, R.M. Murray and J.P. Hogan.

DOCUMENTATION
BAKRIE, B, MURRAY, R.M. and HOGAN, J.P. (1988). The effect of work on intake and rumen fluid volatile fatty acid and NH_3 concentrations, of steers fed Rhodes grass hay. *DAP Project Bulletin*. 7: 9-13.



A rotary exercise machine in use for training animals to work. This machine was later replaced by carts and a treadmill for simulating work in experiments.



A Bos indicus *type steer being trained for work in early experiments.*

TITLE

Feed 2

Effect of diet restriction on working performance and weight loss of local and crossbred oxen

AIM(S)
To determine the effect of diet restriction on work performance and bodyweight loss of local Zebu and Friesian x Boran crossbred oxen.

ORIGIN OF AIM(S)
Oxen are important suppliers of draught power for land development, tillage, threshing and transport in many developing countries. The availability of feed (quantity and quality) is one of the main limiting resources which can affect the performance of oxen.

LOCATION ILCA Debre Zeit Research Station, Debre Zeit, Ethiopia.

DISCIPLINE(S) INVOLVED
Animal nutritionists and Agricultural engineers.

METHODS / TREATMENTS
Ten local zebu and four Friesian x Boran oxen were trained for ploughing singly. Both the local (L) (310 + 40 kg/head) and the crossbred (X) (465 + 40 kg/head) oxen were divided into control (LC and XC) and restricted (LR and XR) groups. The control animals were fed 100% of the estimated metabolisable energy (ME) for maintenance and work while the restricted animals received 75% of the control ration during the first 5 weeks of the trial and 50% during the rest of the trial period. For the local zebu the estimated ME (MJ) requirement for maintenance and work were 19.24 + 0.06 W (where W = liveweight in kg) and 3.85 MJ/hour, respectively; the ME requirements for crossbreds were 29.82 + 0.059 W for maintenance and 6.7 MJ/hour for work.

RESULTS / CONCLUSIONS
Both restricted groups lost weight at the same rate (3.1 kg/week) over the 23 weeks trial period. The LC group lost weight (1.8 kg/week) at twice the rate of the XC group. There was no significant interaction between diet and work performance, and the local animals lost weight at a significantly higher rate than crossbreds on the control diet. Weight loss as a percentage of bodyweight was greater for the restricted groups across breeds, and greater for local oxen across diets. Even though the work performance by the crossbred (XC x XR) was higher than the locals, diet did not have any significant effect on either force or power output.

APPLICATION/ON-FARM TESTING/ADOPTION/FURTHER RESEARCH
A possible strategy would be to let oxen lose weight during working periods and regain condition over the non-working periods. Since it appears that cereal crop residues and grazing on natural pastures cannot meet the energy requirement of oxen during short intensive cultivation periods, farmers are probably already using this strategy.

INVESTIGATOR(S) INVOLVED
Abiye Astatke, J.D. Reed and M.H. Butterworth.

DOCUMENTATION

ASTATKE, A., REED, J.D. and BUTTERWORTH, M.H. (1986). Effect of diet restriction on work performance and weight loss of local zebu and Friesian x Boran crossbred oxen. *ILCA Bulletin*. 23: 11-14.

A local ox, working in a single harness, in a diet restriction trial at ILCA's Debre Zeit Research Station, Debre Zeit, Ethiopia.

TITLE

Feed 3

Effect of work on the utilisation of low protein fibrous diets by swamp buffalo

AIM(S)
To make preliminary measurements on the effect of a traditional level of work on voluntary feed intake and digestion in buffalo.

ORIGIN OF AIM(S)
Following studies of the traditional use of buffalo in tillage of wet ricefields in West Java villages, there is a need for a better understanding of nutrition-work interactions, in order to define more precisely the nutrient requirements of draught buffalo.

LOCATION Balai Penelitian Ternak (BPT), Ciawi, Bogor, Indonesia.

DISCIPLINE(S) INVOLVED Nutrition and Farming Systems scientists.

METHODS / TREATMENTS
Each of 2 groups of 4 non-pregnant female buffalo fed *ad libitum* freshly chopped rice straw and field grasses (1:1) were subjected to a work program, or confined to pens, in a cross-over experimental design with 4 three-week periods of measurement. The work treatment was modelled on existing practices of rice cultivation around Ciawi, in that a draught force of 80 kg was pulled by pairs of animals for 3 hours/day for 5 days/week. Animals under the other treatment were confined to pens and denied access to feed during the work period. Feed intakes, digestibility and rate of passage of digesta were measured in both groups during the third week of each period.

RESULTS / CONCLUSIONS
1. There tended to be an increase in feed intake by working animals (8.81 vs 8.24 kg DM/day).
2. Work increased feed digested by 20%.
3. Apparent DM digestibilities of buffalo in pens and working buffalo were 46.7 and 52.9%, respectively - a significant difference ($P<0.05$).
4. Retention time of digesta tended to be longer in working buffalo.

The work demanded of buffalo during periods of ploughing is likely to be sufficient to increase the efficiency of utilisation of traditional diets.

APPLICATION/ON-FARM TESTING/ADOPTION/FURTHER RESEARCH
The capacity to do work depends on the energy status of the animal, so comparative studies on live weight change between similar working and non-working animals could provide an insight into partitioning of energy for work and other productive purposes. Long-term studies are planned to look at this further, and to examine the effect of work on reproduction.

Paired buffalo pulling sledges in a trial comparing nutrition of working and non-working animals, in Indonesia.

INVESTIGATOR(S) INVOLVED

D. Ffoulkes, A. Bamualim and T. Panggabean.

DOCUMENTATION

FFOULKES, D. and BAMUALIM, A. (1986). A note on the effect of work on the utilisation of low protein fibrous diets by buffaloes. *Buffalo Bulletin*. **5**: 3-5.

TITLE ***Feed 4***

Effect of work on the utilisation of low protein fibrous diets in buffalo fed at different levels of intake

AIM(S)
To study the effect of restricted feeding on the capacity of buffalo to work and on digestive physiology changes in working and non-working animals.

ORIGIN OF AIM(S)
Present understanding of nutrition-work interactions in buffalo is inadequate, to allow the development of suitable production diets and feeding systems, within the framework of traditional draught systems in West Java.

LOCATION Balai Penelitian Ternak, Ciawi, Bogor, Indonesia.

DISCIPLINE(S) INVOLVED Nutrition and Farming Systems scientists.

METHODS / TREATMENTS
Sixteen non-pregnant buffalo cows in a 2x2 factorial design with two levels of feed intake (75% of *ad libitum*, and *ad libitum*) and two levels of activity (no work and work). All animals were individually penned and received a diet of freshly chopped rice straw and field grasses (1:1). The work program was carried out by pairs of buffalo pulling a sledge (80 kg draught force) for 3 hours/day and for 5 days/week. Working animals were doused with cold water at half hourly intervals; however drinking water was withdrawn from all animals during the work period. Over a period of 90 days, measurements were taken of live weight (weekly), feed intake (daily), and digestibility parameters (final 10 days of experiment). Changes in body fat during the experimental period were estimated by marker techniques.

RESULTS / CONCLUSIONS
1. In comparison with their resting counterparts, working buffalo on *ad libitum* feed forfeited more growth (325-80 = 245 g/day) than those with restricted intake (110-(-6) = 116 g/day).
2. Working buffalo were able to maintain weight when consuming 75% of voluntary feed intake which was estimated to provide maintenance requirements for energy.
3. Work had no effect on digestibility but coefficients were poorer when feed was restricted (38 vs 45% DM).
4. Retention time of digesta in the gut was 15% higher in the animals that worked; however there was no relation between retention time and digestibility.
5. Fat reserves were being depleted at a mean daily rate of 130 g in the working buffalo while 90 g/day of fat was being deposited by animals confined to pens.

Under village conditions, buffalo can maintain weight while subject to periods of work, even when feed availability is restricted. Although, theoretically, the capacity to work was increased when animals were fed to appetite, the feed was used less efficiently, probably because the higher intake of digestible energy generated a greater heat load for the animal to dissipate. This has implications for supplementing draught animals with energy concentrates.

APPLICATION/ON-FARM TESTING/ADOPTION/FURTHER RESEARCH
These results have led to research on the efficiency of working buffalo in utilising supplements, and studies on the effect of work on thermoregulatory responses.

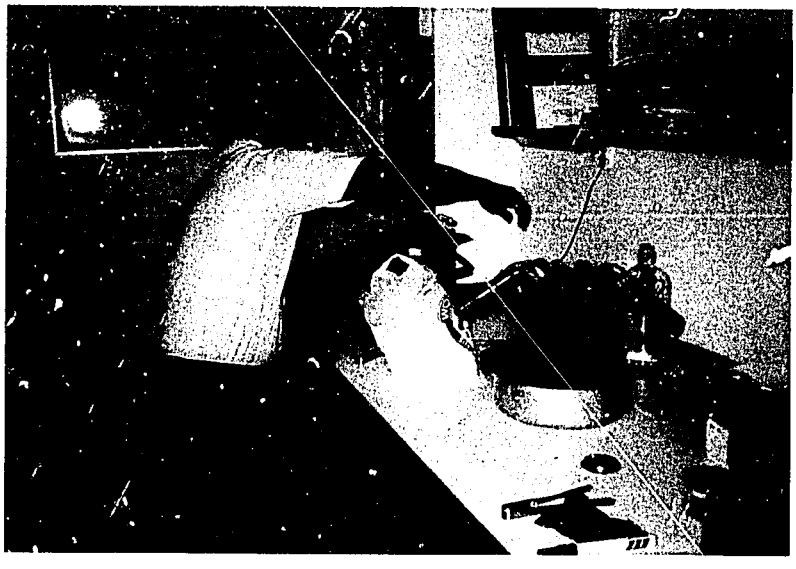
INVESTIGATOR(S) INVOLVED D. Ffoulkes and A. Bamualim.

DOCUMENTATION

BAMUALIM, A. and FFOULKES, D. (1988). Effect of work and level of feed intake on nutritional parameters and bodyweight change of swamp buffalo cows. *DAP Project Bulletin*. 7: 2-8.

FFOULKES, D. (1986). Studies on working buffalo - current research on nutritional aspects. *Draught Animal News*. 6: 7-13.

FFOULKES, D., BAMUALIM, A. and PANGGABEAN, T. (1987). Utilization of fibrous feeds by working buffaloes. In: R.M Dixon (ed), Ruminant Feeding Systems Utilizing Fibrous Agricultural Residues - 1986. Canberra : IDP. 161-169.



Laboratory assay of tritiated water, used to estimate fat composition and water turnover, as part of an experiment on working and non-working animals.

TITLE ***Feed 5***

Effect of rice bran supplementation at different levels on intake, digestibility and growth of buffalo on low protein fibrous diets

AIM(S)
To investigate the effect of rice bran (mainly as energy) supplementation on intake and growth rate of working buffalo.

ORIGIN OF AIM(S)
The research is part of a series of experiments conducted to understand the nutrient requirement of working buffalo, based on traditional feeding systems. The purpose was to gain understanding of the effect of various levels of energy supplementation on feed intake and digestibility, and weight gain in working buffalo.

LOCATION Balai Penelitian Ternak, Ciawi, Bogor, Indonesia.

DISCIPLINE(S) INVOLVED Ruminant nutrition specialists.

METHODS / TREATMENTS
Twenty-four non-pregnant swamp buffalo were divided into six groups with similar bodyweights and placed in individual pens. All animals were fed *ad libitum* with chopped fresh rice straw and field grasses (1:1). The six treatments applied were:

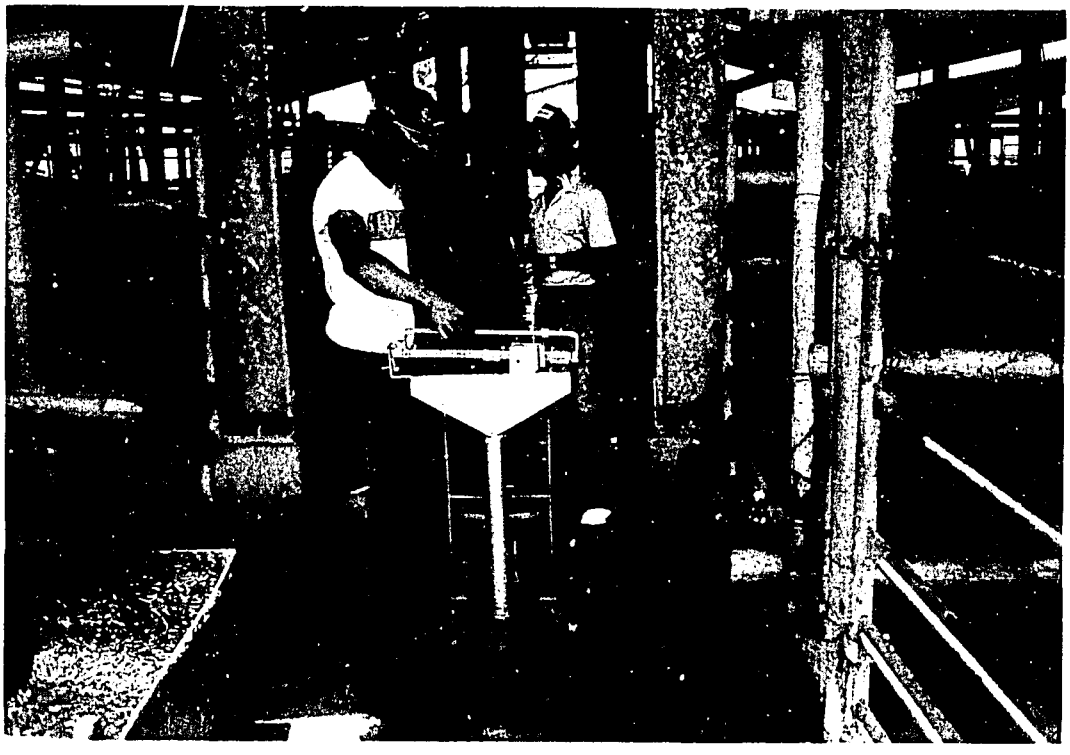
1. Not working (animals confined to pens) and no supplement.
2. Not working plus 0.75 kg rice bran/day.
3. Not working plus 1.50 kg rice bran/day.
4. Working (3 hours/day and 5 days/week) and no supplement.
5. Working plus 0.75 kg rice bran/day.
6. Working plus 1.50 kg rice bran/day.

The experiment lasted for 12 weeks. Measurements were made of daily feed intakes and weekly liveweight changes. Digestibility was measured for 10 days during the middle period of the experiment.

RESULTS / CONCLUSIONS
1. Feed intake increased proportionally with level of rice bran supplement given both in the non-working and working groups, Nos.1-6 above (104, 41, 17, 240, 320 and 315 g/day, respectively).
2. Digestibility was not affected by supplementation except in the group of non-working animals on 1.5 kg rice bran/day, where there was an increase from 40% to 47% DMD for the supplemented group.
3. Supplementation with 0.75 kg rice bran was considered to be adequate to maintain the non-pregnant working buffalo, as the bodyweight changes of animals receiving 1.5 kg and 0.75 kg rice bran were similar.

APPLICATION/ON-FARM TESTING/ADOPTION/FUTURE RESEARCH
The information gained could be useful in advising farmers who wish to feed rice bran to working animals. Future research is planned on supplementation with locally available protein supplements.

INVESTIGATOR(S) INVOLVED
A. Bamualim, D. Ffoulkes, E. Juarini.



Weighing faeces of buffalo in a digestibility trial at Balai Penelitian Ternak, Indonesia.

TITLE

Feed 6

Effect of kapok seed and rice bran supplementation on intake, digestibility and bodyweight change of working buffalo

AIM(S)

To investigate the effect of protein and energy supplement on intake and bodyweight change of non-pregnant working buffalo.

ORIGIN OF AIM(S)

This is part of a series of experiments conducted to improve understanding of nutrient requirements of working buffalo. Following an earlier rice bran supplementation trial, this trial was undertaken to examine the individual and combined effects of energy (rice bran) and protein (kapok seed) supplementation of traditional forage diets in working buffalo cows. Female animals are most commonly used for work in Java, and mixed grasses and fresh rice straw are the most common feeds.

LOCATION Balai Penelitian Ternak, Ciawi, Bogor, Indonesia.

DISCIPLINE(S) INVOLVED Ruminant nutrition specialists.

METHODS / TREATMENTS

Twenty-four non-pregnant swamp buffalo cows were divided into six comparable groups and placed in individual pens. All animals were fed *ad libitum* with equal parts of chopped fresh rice straw and field grasses. The six different treatments applied were as follows:

1. Working (3 hours/day and 5 days/week) without supplement.
2. Working plus 0.75 kg rice bran supplement.
3. Working plus 0.50 kg kapok seed supplement.
4. Working plus 0.75 kg rice bran and 0.50 kg kapok seed supplement.
5. Not-working plus 0.50 kg kapok seed supplement.
6. Not-working plus 0.75 kg rice bran and 0.50 kapok seed supplement.

The experiment was conducted for 12 weeks. Daily feed intakes and weekly liveweight changes were recorded. Digestibility was measured for 10 days in the middle of the experiment. Working animals pulled sledges at a draught force of around 80 kg.

RESULTS / CONCLUSIONS

1. In working animals, the growth rate was highest for rice bran and kapok seed supplement (320 g/day) followed by kapok seed supplement (230 g/day), rice bran supplement (180 g/day) and control (130 g/day). For non-working buffalo, the group supplemented with rice bran and kapok seed gained 370 g/day, whereas the kapok seed group gained 270 g/day.
2. Supplementation did not increase the total DM intake or digestibility for working or non-working animals.

3. Protein was better than energy supplementation in terms of promoting growth rate, and the supplement with both energy and protein performed the best for both working or non-working buffalo.

APPLICATION/ON-FARM TESTING/ADOPTION/FURTHER RESEARCH
The results are useful in planning future studies to find the most efficient nutrients and feedstuffs to be utilised by animals during working periods. However, in Indonesia, where most rearers use their draught animals for only 10-30 days of work per year, the interest in purchasing supplements specifically for work is likely to be limited to special groups of farmers.

INVESTIGATOR(S) INVOLVED
A. Bamualim, D. Ffoulkes, E. Juarini.

Fistulated swamp buffalo pulling a sledge in nutrition trials at Balai Penelitian Ternak, Indonesia.

TITLE ***Feed 7***

Effect of work on intake, digestibility, growth and ovarian activity of buffalo on low protein fibrous diets

AIM(S)
To study the long-term effects of draught work on digestion, productivity and reproduction in buffalo.

ORIGIN OF AIM(S)
To obtain information on nutrition-work interactions of buffalo in traditional draught systems in order to define more precisely their nutrient requirements and improve the efficiency of draught power.

LOCATION Balai Penelitian Ternak, Ciawi, Bogor, Indonesia.

DISCIPLINE(S) INVOLVED
Ruminant nutritionists, Reproduction and Farming Systems scientists.

METHODS / TREATMENTS
Sixteen non-pregnant female swamp buffalo were divided into two groups and housed in individual pens. Each group was allotted one of two treatments:

1. Control (animals confined to pens);
2. Work.

The work program consisted of pairs of buffalo pulling a sledge of 80 kg draught force for 2 hours/day for 5 days/week over a total period of 12 weeks. Daily feed intakes of chopped fresh rice straw and field grasses (1:1) and weekly live weight changes were recorded, and digestibility parameters measured during the last week of the experiment. Blood samples for plasma progesterone assay were taken 3 times per week during the first 4 and the last 4 weeks of the experiment.

RESULTS / CONCLUSIONS
1. Feed intake and digestibility were the same in both groups.
2. Working buffalo grew at half the rate of those that did not work (107 vs 229 g/day), diverting the equivalent of 4.4 MJ ME for production to work.
3. There was a tendency for ovarian activity to decrease in buffalo subjected to work.

This study showed that nutrients absorbed from the digestive tract that would normally be used for tissue growth were instead used as sources of energy for work. Non-pregnant buffalo under this draught system could be maintained on traditional diets but reproductive performance is likely to be impaired.

APPLICATION/ON-FARM TESTING/ADOPTION/FURTHER RESEARCH

Further studies are needed to investigate the effect of poor feed availability on the work capacity of buffalo. This would be more realistic in relation to the situation in many villages.

INVESTIGATOR(S) INVOLVED

A. Bamualim, D. Ffoulkes and I.C. Fletcher.

DOCUMENTATION

BAMUALIM, A. and FFOULKES, D. (1987). Effect of work on intake, digestibility and growth of buffaloes fed a basal diet of rice straw and field grasses. 4th AAAP Animal Science Congress, Hamilton, New Zealand.

BAMUALIM, A., FFOULKES, D. and FLETCHER, I.C. (1987). Preliminary observations on the effect of work on intake, digestibility, growth and ovarian activity of swamp buffalo cows. *DAP Project Bulletin*, 3: 6-10.

Sampling blood of working buffalo, for hormone analysis to determine ovarian activity.

TITLE

Feed 8

Quantity and quality of feed resources utilised by oxen in the Ethiopian highlands

AIM(S)
To document the quantity and nutritional quality of feed resources allocated to oxen on smallholder farms and to determine the relationship between feed intake and work output.

ORIGIN OF AIM(S)
Part of a larger research project designed to better understand current use of animal traction at the traditional level in the Ethiopian highlands.

LOCATION Debre Berhan, Ethiopian highlands.

DISCIPLINE(S) INVOLVED Animal scientists and Animal nutritionists.

METHODS / TREATMENTS
Hay and crop residue straw were sampled bimonthly over 2 years on 24 smallholder farms during the major and minor cropping seasons and their chemical composition determined. Plot weedings and grid cuttings of communal pastures were also collected and analysed. Feed given and refused was weighed for one working and nonworking day weekly for each team of oxen. Energy requirements for maintenance and work were estimated, based on working regimes.

RESULTS / CONCLUSIONS
Apparent digestible dry matter (ADDM) and metabolisable energy (ME) of both hay and crop residue straw averaged 55% and 8 megajoules (MJ)/kg dry matter (DM), respectively for both years. Crude protein (CP) averaged 6-8% for hay and 5% for crop residue straws. Forage sampled from grazing areas at the height of the dry season had 55% ADDM, 6.3% CP and 8.6 MJME/kg DM, with quality increasing to 62% ADDM, 12% CP and 9.7 MJME/kg DM following the minor rains. Teams expended an estimated 7-8 MJ/hour while ploughing, with individual oxen requiring an estimated 80-91 kJME/$W^{0.75}$ for each hour of work. Feed resources adequately met additional energy requirements of oxen for work, except towards the latter part of the major ploughing season.

APPLICATION/ON-FARM TESTING/ADOPTION/FURTHER RESEARCH
Findings indicate that feed resources on smallholder farms are of relatively good nutritional value. Forage quality of grazing areas appears to meet protein requirements necessary to cover deficits that oxen might incur because of low CP levels in stored hay and crop residue straws, except during the height of the dry season. More research is needed to determine whether stored feed

Sampling of hay and crop residues used in the feeding of draught animals on farms in the Ethiopian highlands.

supplies could be better conserved or redistributed to other livestock for milk production or fattening, and if oxen could rely more heavily on grazing to meet their energy needs. Research is also needed to better determine nutritional requirements of working oxen.

INVESTIGATOR(S) INVOLVED M.R. Goe.

DOCUMENTATION

GOE, M.R. (1987). Animal traction on smallholder farms in the Ethiopian highlands. University Microfilms International, 300 N. Zeeb Road, Ann Arbor, Michigan. U.S.A.

TITLE ***Feed 9***

Intake and utilisation of feed by work oxen

AIM(S)

1. To determine the effects of work on intake, digestibility, rumen function, nitrogen retention and weight change in oxen fed poor quality hay and cereal straw.
2. To compare the effects of work on feed utilisation in crossbred and local zebu oxen.

ORIGIN OF AIM(S)

The nutrition of work oxen is poorly understood because of a general lack of experimental data and the complexity of the topic. Farmers in developing countries do not have a large variety of feedstuffs. During the ploughing and dry season feed resources are scarce. Stored crop residues are the major component of feed rations. The intake and digestibility of cereal crop residues have a major effect on the condition of oxen.

Exotic breeds that have been introduced to African countries are often larger than local cattle and therefore can exert more force when ploughing. There are indications however, that *Bos taurus* and their crosses with *Bos indicus* utilize low quality roughages less efficiently than pure *Bos indicus*.

LOCATION ILCA Debre Zeit Research Station, Debre Zeit, Ethiopia.

DISCIPLINE(S) INVOLVED

Animal nutritionists and Agricultural engineers.

METHODS / TREATMENTS

Eight East African Shorthorn Zebu and eight crossbred (Holstein-Friesian x Boran) were used. Each breed group was divided in two, giving four experimental groups assigned to an initial and final non-working period and a high and low level of work. During resting periods oxen were tethered in individual pens. During working periods they left the pens only for exercise. Oxen were fed *ad libitum* on teff straw and offered hay at 30% of the average intake. Urea was fed at 0.7% of intake. Work consisted of pulling sleds loaded with weights. Oxen were worked individually for 5 hours/day over a period of 207 days. Total faeces was collected during 6 periods of 11-13 d, and urine was collected during 5 of these periods. There was one collection during each of the initial and final rest period and two during each of the two work periods.

RESULTS / CONCLUSIONS

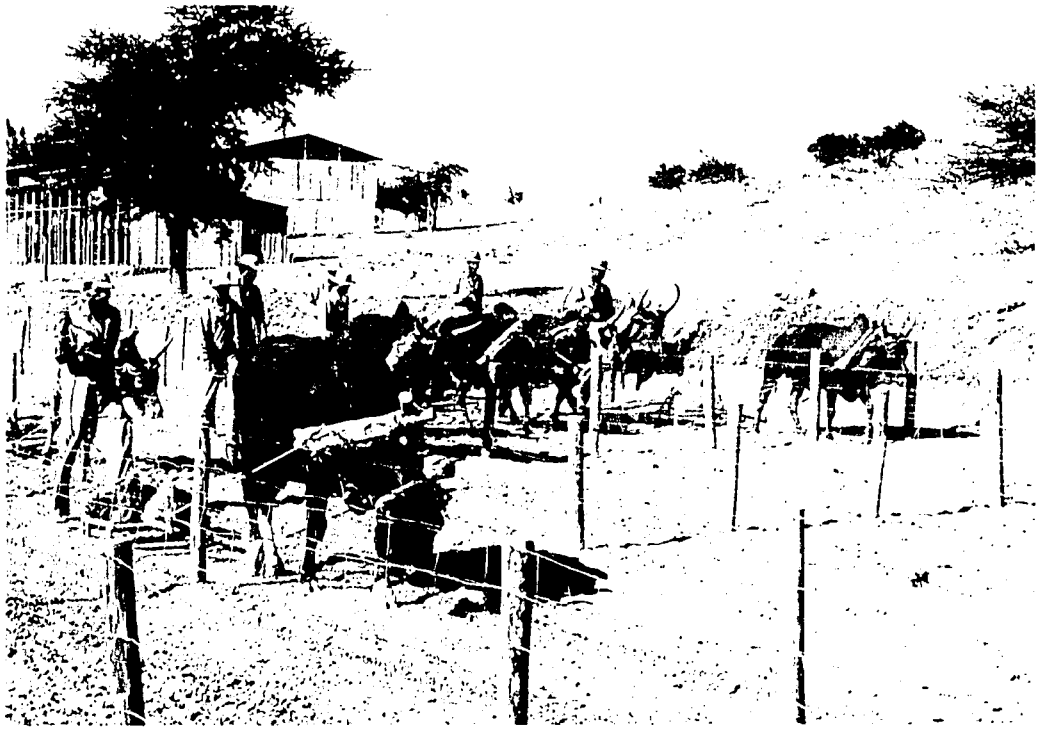
Feed intake was highest in the first rest period and lowest in the last rest period and declined throughout the experiment. Water intake was highest during the working period. Weight increased during the experiment, but rate of gain was lower during working periods. Digestibility was highest during

working periods, but the difference between periods was less than 3 percentage points. Nitrogen (N) digestibility and N retention increased during working periods and was lowest in the first rest period and highest in the last rest period. Dry matter intake per unit of metabolic bodyweight and water intake were higher in crossbred animals. Rate of gain was lower in the Shorthorn Zebu oxen. Oxen did not adapt to increased energy requirements for work by increasing intake of poor quality roughages. The increase in digestibility during work was insufficient to substitute for decreased intake. Results also indicate that differences in efficiency of feed utilisation between *Bos indicus* and *Bos indicus* x *Bos taurus* crossbreds are small.

APPLICATION/ON-FARM TESTING/ADOPTION/FURTHER RESEARCH
Further research is required on the effects of work on intake in relationship to feed quality and energy requirements for oxen under low planes of nutrition and body condition.

INVESTIGATOR(S) INVOLVED H. Soller, J. Reed and M. Butterworth.

DOCUMENTATION
SOLLER, H., REED, J.D. and BUTTERWORTH, M.H. (1986). Intake and utilization of feed by work oxen. *ILCA Newsletter*. 5(2): 5-7.



Local and crossbred oxen working as singles in a feed utilisation trial at ILCA's Debre Zeit Research Station, Debre Zeit, Ethiopia.

TITLE ***FSR 1***

Selection of sites for draught animal power systems research in Indonesia

AIM(S)
To select village sites for farming systems research in the ACIAR Draught Animal Power Project in Indonesia, to satisfy the requirements of policymakers, research administrators, scientists and Project objectives.

ORIGIN OF AIM(S)
The DAP Project is a multidisciplinary study of draught animal systems, designed to identify ways of increasing farmer benefits from draught animal enterprises. As all Project research is to be related to the needs of farmers in major farming systems, and as Project resources are limited, the first task was to select sites for research, at which the major issues in DAP development in Indonesia could be studied.

LOCATION Indonesia.

DISCIPLINE(S) INVOLVED
Animal scientists with training in FSR and Economists.

METHODS / TREATMENTS
The opinion of livestock scientists, administrators and economists was sought on factors that should be considered in siting DAP research. The main criteria suggested were listed in priority order, with the help of administrators and policymakers. Secondary data were then collected to enable the identification of districts which could provide sites to satisfy the most criteria on the above list. In the first district selected in this way, several villages were visited to facilitate selection of initial research sites. The procedure was repeated in each district chosen to represent particular sets of criteria.

RESULTS / CONCLUSIONS
The selection criteria, listed in order of priority were:

1. high importance or potential of draught animals in the farming system (e.g. this excludes areas where tractors have an obvious advantage);
2. accessibility of initial sites, to minimise costs while developing research methods;
3. representation of major agro-climatic zones and farming systems;
4. representation of major livestock species used for draught;
5. facilitation of study of use of both single and paired animals;
6. existence of strong rental markets for DAP;
7. cooperation of officials, farmers and village heads;
8. availability of credit for draught animal purchase by farmers;
9. availability of previous socioeconomic and biological data.

Based on the list of criteria produced, and secondary data on land use, livestock and tractor densities, climate, etc., the initial district selected was Subang in West Java, where both cattle and buffalo are worked as singles and in pairs. Second choice was Pasuruan District, East Java, to represent high density of cattle (Ongole) and drier agroclimate. Third selection was Kupang in West Timor, where the potential for improvement of work performance of Bali cattle seems high. Within each of these priority areas, two or three villages were selected for farming systems research. Although, in transmigration areas, draught animals are extremely important, these areas were given fourth priority because of high costs involved. In future years, when research methods have been further developed, transmigration areas should receive top priority.

APPLICATION/ON-FARM TESTING/ADOPTION/FURTHER RESEARCH

In the first two years, profiles have been produced for two village sites in each of the first 3 priority areas. Farm trials have reached various stages at each site. Research sites in transmigration areas are being selected now that methods of research on DAP have been developed at more accessible sites.

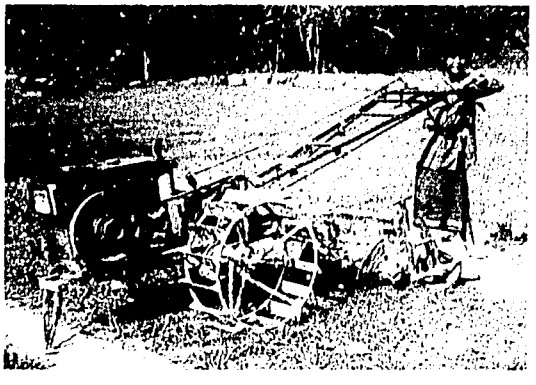
INVESTIGATOR(S) INVOLVED

Santoso, Sumanto, R.J. Petheram, P. Kompiang, C.P. Peacock, J. Perkins and W. Rusastra.

DOCUMENTATION

SUMANTO, SANTOSO, RUSASTRA, W., RIDWAN, PEACOCK, C.P. and PETHERAM, R.J. (1987). Selection of sites for initial research on draught animal power systems in Indonesia. *DAP Project News*. 1: 11-26.

Sites for Farming Systems Research were selected to represent farming systems in which draught animals are important. Areas where tractors are likely to dominate were excluded.



TITLE ***FSR 2***

Draught animal utilisation in Subang, West Java

AIM(S)
To describe the role of draught animal enterprises in farming systems, with a view to improving farmer benefits from draught animal enterprises.

ORIGIN OF AIM(S)
Subang is one area in Indonesia selected for research on DAP by the ACIAR DAP Project, to represent the medium rainfall regions in Java; and cattle and buffalo which are used for work as both singles and as pairs. This study is the initial (descriptive) phase of a FSR approach, which will lead on to designing and testing possible improvements of farms.

LOCATION Subang District, West Java, Indonesia.

DISCIPLINE(S) INVOLVED
Animal scientists and Economists, with assistance from other specialists.

METHODS / TREATMENTS
1. At each of the two village sites selected to represent major sub-systems, rapid surveys were conducted, first on all rearers of draught animals, and later in more detail on 20 rearers and 20 non-rearers, to describe the main biological and socioeconomic features.
2. Monitoring of liveweight, health, reproduction, feeding, labour and animal work for 18 months on 20 cattle and 20 buffalo rearers at each site.
3. Special studies were conducted to collect supplementary data, e.g. on productivity, draught work output, health, implements and feeding.
4. Agroeconomic profiles of each site were developed, including lists of constraints and opportunities for improvement.

RESULTS / CONCLUSIONS
Although only 15% of farmers own draught animals (mainly cows), over 70% use animals to prepare rice fields. Animals work for 10 to 80 days per year. Income from DAP enterprises is most important to a few rearers who have little or no land, but rent out animals. Implements are mainly wooden. Feeding and herding consumes vast amounts of labour. The best prospects for improvement appear to be in development of low cost alternatives, e.g. improved forages and straw preservation, and simple modifications to implements.

APPLICATION/ON-FARM TESTING/ADOPTION/FURTHER RESEARCH
The agroeconomic profiles have been used to design, with the help of specialists, a number of trials on farms, e.g. straw stacking, forage planting, implement modification. Recent trials have been designed to take the form of model units on selected farms, for longer term testing of practicality and farmer opinion.

Interviewing rearers and non-rearers of draught animals, West Java.

A single buffalo preparing land for rice in Padamulya village.

INVESTIGATOR(S) INVOLVED

Santoso, Sumanto, R.J. Petheram, J. Perkins, C. Peacock, and Ridwan.

DOCUMENTATION

SANTOSO, SUMANTO, PERKINS, J. and PETHERAM, R.J. (1987). An agroeconomic profile of Tanjungwangi village, Subang - with emphasis on draught animal rearing. *DAP Project Bulletin*. 2: 4-30.

SUMANTO, SANTOSO, PETHERAM, R.J., PERKINS, J., NANA and RUSASTRA W. (1987). An agroeconomic profile of Padamulya village, Subang - with emphasis on draught animal rearing. *DAP Project Bulletin*. 4: 2-30.

TITLE ***FSR 3***

Farm trials of improved forages in villages in Subang, West Java

AIM(S)
To test the suitability of some easily available, improved forage species for use as feed for draught animal enterprises on farms - with a view to reducing labour demands and increasing farmer benefits from DAP enterprises.

ORIGIN OF AIM(S)
Studies at FSR sites in Subang have shown that rearers of draught animals face a severe decline in forage quantity and quality in the late dry season (Oct, Nov) and a severe labour shortage for collecting forage in the early wet season (Nov, Jan). These shortages result in a reduction in weight gain of stock (as well as stress on family labour resources), and may be a major constraint to increasing the number of animals and of rearers of draught animals. Introducing suitable forages to relieve the labour crisis and improve animal performance is seen as one relatively inexpensive way of overcoming these constraints, which farmers are likely to adopt.

LOCATION Three villages in Subang, West Java.

DISCIPLINE(S) INVOLVED Animal scientists and Forage agronomists.

METHODS / TREATMENTS
Various forage opportunities have been identified with farmers in each village. For each opportunity (e.g. houseyard plot, bank of ricefield, under shade of fruit trees, hedgerows) a few best-bet species are tested on farms. A seed bulking plot is planted in each village. A selected range of cultivars is assessed in terms of survival, farmer adoption and opinion of usefulness, at 3 months, 6 months and 12 months, and thereafter annually for 3 years.

RESULTS / CONCLUSIONS
Initial trials in 1987/88 showed a very low survival rate of grass and legume species. In the second year, after farmers were taken to see forages on farms in Central Java, there was a marked improvement in farmer enthusiasm and also in survival of forage species in farm trials.

APPLICATION/ON-FARM TESTING/ADOPTION/FURTHER RESEARCH
All research is on farms and village land, so practicality and farmer opinion can be immediately assessed. The cultivars chosen are ones that are known to do well under similar conditions elsewhere, and the trials should test survival and value under village management. However, trials are seriously limited by a lack of information on suitable species for clay soils, and by unavailability of the cultivars that are recommended by agronomists.

Planting improved grasses with farmers on banks of their fields.

Farm trials of selected tree legume forages in Java.

INVESTIGATORS A. Thahar, Ridwan, Sumanto, Kuswandi, R.J. Petheram

TITLE ***FSR 4***

Farm trials of a modified traditional wooden plough

AIM(S)
To modify the traditional wooden plough in use by farmers using pairs of animals, with a view to improving the rate of land preparation.

ORIGIN OF AIM(S)
Traditional wooden ploughs are most commonly used for cultivation in Java. A similar plough is pulled by either singles or pairs of animals in Subang. It seems possible that paired animal teams could pull a larger plough, i.e. one that ploughs wider or deeper. Any modification to local ploughing must be cheap and easily made by farmers, with local materials and skills.

LOCATION Subang, Indonesia.

DISCIPLINE(S) INVOLVED Livestock scientists, carpenters and farmers.

METHODS / TREATMENTS
After making a prototype double mouldboard wooden plough with the help of a village carpenter, this was tested and remodified until it functioned in wet soil conditions to farmers' satisfaction. The plough was compared with the traditional single mouldboard plough, pulled by two buffalo on fields of heavy clay soil. Weight of implement, ploughing rate, draught, speed, width and depth of ploughing, and opinion of farmers were recorded.

RESULTS / CONCLUSIONS
The modified plough had a wider cut (39 vs 23 cm) and a higher rate (6.8 vs 4.0 m^2/minute) than the traditional one. Ploughing time was reduced by 26%. Farmers said that quality of cultivation was similar. However, the new plough was heavier (19 vs 14 kg) and this may influence farmers in its adoption. Draught force required to pull the double plough was 40-60 kg, compared to the normal 30-50 kg.

APPLICATION/ON-FARM TESTING/ADOPTION/FURTHER RESEARCH
The plough needs to be evaluated in many soil conditions. The weight should be reduced if possible. Trials indicate that the plough works best in fields with little trash on the surface. Farmers with their own land are interested in trying the plough The new plough may be more readily adopted by farmers who rent out their animals for work, in areas where payment is on a 'per unit area' basis, and not on a 'per day' basis.

INVESTIGATOR(S) INVOLVED Sumanto, Ridwan, carpenter and farmers.

The traditional plough in Subang (left) and the modified version (right) being explained by farmer/carpenter and scientist in Wanareja village.

Although the modified plough is heavier than the original, it can still be carried in the traditional way, as shown here.

TITLE ***FSR 5***

Preservation of rice straw in two villages

AIM(S)
To develop practical methods of preserving rice straw for use by draught animals in medium/high rainfall areas of Java.

ORIGIN OF AIM(S)
In many areas of West Java, the bulk of the rice straw produced is left to rot or is burned after harvest. Yet livestock rearers experience an extreme shortage of forage for their stock in the dry season (Aug-Oct) and of labour for collecting forage in the early wet season (Nov-Dec), when the rice crop is being planted and grazing areas are very restricted. At present in West Java, rice straw is only fed to cattle and buffalo immediately after rice harvest, while the leaves are green. If straw could be preserved with quality similar to that of green straw, from the time of harvest (March or July) until needed in September and/or November, this could be very advantageous to draught animal rearers. The main difficulty is to prevent spoilage of the straw by rainwater and mould.

LOCATION Villages in Subang District, West Java.

DISCIPLINE(S) INVOLVED Nutritionists and FSR scientists.

METHODS / TREATMENTS
Two methods of preservation are being tried on farms:

1. untreated (but properly made) straw stacks;
2. stacks treated with urea and lime and covered.

The untreated stacks are made after carefully turning and drying the green straw, then placing around a central pole, as practised in East Java. The treated stacks are made in layers (with 2% lime and 10% urea), which are well compacted by human trampling. The covers used are made of sewn fertiliser bags. Samples of straw are taken every week for the first 6 weeks and monthly thereafter, for N and fibre determinations. The palatability and feeding value of the straw and farmer opinion is monitored.

RESULTS/ CONCLUSIONS
In the preliminary trials, stacks made were small, because of difficulty in arranging access to the straw (of other farmers). A second difficulty arose when animals would not eat either type of straw, and farmers were not prepared to starve animals to encourage them to eat straw. Animals eat straw of old varieties more readily than the new varieties in use.

Most rice straw in Java is burnt by the landholder, although in the dry season, forage availability and quality is very low in many areas.

A stack made from "green " straw, treated with lime and urea. The straw was taken only from the ricefield seen in the background.

APPLICATION/ON-FARM TESTING/ADOPTION/FURTHER RESEARCH
In the second year, larger stacks and improved techniques are being used. Farmers are now feeding straw, after visiting areas in Central Java where straw is commonly fed. The cost of treated straw is Rp10 per kg, which represents a considerable saving (in labour cost) during times of critical forage or labour shortage.

INVESTIGATOR(S) INVOLVED
M. Winugroho, B. Bakrie, Ridwan, E. Teleni.

TITLE ***FSR 6***

The Subang ploughing contest : species and team size comparisons

AIM(S)

1. To facilitate the comparison of cattle and buffalo, as used in singles and in pairs in Subang villages, in land preparation for wet rice production.
2. To promote an interest in draught animal power and in the skills of draught animal rearing.
3. To demonstrate alternative methods, implements and harnesses.

ORIGIN OF AIM(S)

Although both buffalo and cattle are worked as pairs and as single animals in Subang district, not all the different categories are commonly found in any one village. The contest was organised to bring farmers with different animal and team size combinations together in one village. For the purposes of DAP research and development, it is necessary to promote an interest in DAP, to help raise the status of draught animal rearers, in the face of the strong promotion of tractors that has been dominant in recent years. The venue was also seen as an ideal place to obtain feedback from farmers on possible improvements in draught animal rearing, equipment and use.

LOCATION Padamulya Village, Subang, West Java.

DISCIPLINE(S) INVOLVED

Animal research scientists, Economists and Extension personnel.

METHODS / TREATMENTS

Six farmer/animal teams in each of the four categories, each ploughed plots of land 4 m x 15 m in size. Preliminary matches amongst cattle and then buffalo teams were conducted to select six finalists from each category. In these matches, and in the finals, time to complete tillage of the block was recorded and the plots were judged for four quality criteria (neatness, straightness, inversion and depth). An overall score, based on rate and "quality" of ploughing was used to compare the competing teams.

RESULTS / CONCLUSIONS

Buffalo in the contest (381 kg) were much heavier than cattle (239 kg). Six of the animals involved were bulls and 31 were cows. Both rate and quality of ploughing were higher in paired than single teams, and higher in buffalo than in cattle. However, these results were reversed when performance was calculated as rate (or quality score) per unit of liveweight.

APPLICATION/ON-FARM TRIALS/ADOPTION/FURTHER RESEARCH

Teams in each of the four categories (single buffalo, paired buffalo, single cattle and paired cattle) were placed in the first four positions, based on overall score. This suggests that, with good training and control, even light, single animals can attain high rates and quality of ploughing in wet rice fields.

The results suggest that farmers with greater land area, capital, labour and forage resources, should opt for buffalo and/or paired animals, while the smaller-scale farmers may be advised to use single animals or lighter pairs. The contest generated considerable interest amongst farmers and district dignitaries, which has helped to maintain the momentum of research with farmers. The contest provided a good medium for demonstration of new ideas on DAP, and possibly a boost in the status of animal rearing in the district.

INVESTIGATOR(S) INVOLVED

Santoso, Sumanto, M. Winugroho, Gunawan adn R.J. Petheram.

DOCUMENTATION

PETHERAM, R.J., SANTOSO, SUMANTO, WINUGROHO, M., RINI DI'.RSANA and GUNAWAN (1988). The Subang ploughing contest. *DAP Project Bulletin*. 6: 2-12.

Single and paired teams of working animals competed in the event.

The farmer competitors insisted that the judges be scientists and extension workers from outside of the Subang District.

TITLE

Physiology 1

Effect of work on body temperature regulation in working cattle and buffalo

AIM(S)

To study the physiological response of combined heat stress and work on cattle and buffalo.

ORIGIN OF AIM(S)

The work was undertaken as part of the research for a PhD thesis, and was part of a larger program designed to improve understanding of the physiology of working animals at James Cook University. As far as possible, the work was related to conditions pertaining to working animals in the drier areas of Indonesia, where the University is involved in a Multidisciplinary Study in Draught Animal Power Systems.

LOCATION

James Cook University of North Queensland, Townsville, Australia.

DISCIPLINE(S) INVOLVED

Environmental physiologists and Nutritionists.

METHODS / TREATMENTS

Three pairs of animals, small and large steers and buffalo, pulled a pneumatic-wheeled cart weighing 530 kg around an elliptical track at respective average speeds of 0.74, 0.89 and 0.77 m/sec. Each pair worked on three consecutive days between 0600 and 0900 h. Rectal temperature (RT) and respiration rate (RR) were recorded before work and at 30 minute intervals during the work period and a subsequent two hourly recovery period in the shade. The buffalo were studied with and without access to wallowing. The animals were offered hay in equal portions at 1000 h and 2200 h and feed and work intakes were measured.

RESULTS / CONCLUSIONS

RT and RR reached higher levels following one hour of work by buffalo than after 2 hours' work by steers. Rate of decline during recovery in the shade was similar in both species. However, with wallowing, buffalo were able to reduce both RT and RR to prework levels within one hour.

During work, small steers showed lower RT but higher RR than large steers, but their recovery in RR was more rapid during rest. Daily feed intake of small and large steers and buffalo ($g/W^{.75}$) in the prework period was approximately 140, 173 and 121, respectively. During work, intake declined by an average of 28% with small and large steers, but not in buffalo.

Fistulated cattle pulling a cart during an experiment on the physiology of working cattle and buffalo, James Cook University of North Queensland.

APPLICATION/ON-FARM TESTING/ADOPTION/FURTHER RESEARCH

Under hot conditions, there is a need to allow buffalo to wallow. Cattle are better adapted to working in hot regions than swamp buffalo. A knowledge of physiological symptoms of work stress may have practical application to farmers (see *Physiology 2*).

INVESTIGATOR(S) INVOLVED

B. Bakrie, R.M. Murray, J.P. Hogan and P.M. Kennedy.

DOCUMENTATION

BAKRIE, B. MURRAY, R.M., HOGAN, J.P. and KENNEDY, P.M. (1987). Body temperature regulation in working buffalo and cattle. *DAP Project News*. 1: 9-10.

BAKRIE, B., MURRAY, R.M., HOGAN, J.P. and KENNEDY, P.M. (1987). The effects of wallowing on body temperature regulation in working buffaloes. Proc. 4th AAAP Animal Science Congress. Hamilton, New Zealand. 192.

TITLE

Physiology 2

Studies of the environmental physiology and digestive function of animals at two levels of work

AIM(S)
To compare the physiological response and feed digestion of small and large steers and buffalo at two levels of work.

ORIGIN OF AIM(S)
Research for a PhD thesis, and part of a larger program designed to improve understanding of physiology of animals used for work in S.E. Asia.

LOCATION
James Cook University of North Queensland, Townsville, Australia.

DISCIPLINE(S) INVOLVED
Environmental physiologists and Ruminant nutritionists.

METHODS / TREATMENTS
Three pairs of animals, small steers (SS), large steers(LS) and buffalo (B) were worked by pulling carts of different loads. Comparisons were made between SS and B and SS and LS. Chromium (Cr) and Ytterbium (Yb) markers were used to study the movement of liquid and particulate digesta in the digestive tract. Rectal temperature (RT) and respiration rate (RR) were recorded before work, at 60 minute intervals during 3 hours of work and while resting. Work output was calculated using an ergometer and an oedometer attached to the cart.

RESULTS / CONCLUSIONS
1. All pairs increased their feed intake with increasing work load.
2. Feed digestibility tended to decrease in steers but to increase in buffalo, with work.
3. With light load, the speed of the cart was 0.95, 0.89 and 0.82 m/sec for SS, LS and B respectively. The speeds were slower with heavier load, i.e. 0.79, 0.77 and 0.70 m/sec respectively. The force exerted by the animals pulling the light load, was 0.14, 0.14 and 0.16 kN, and with the heavy load 0.32, 0.30 and 0.36 for SS, LS and B, respectively.
4. RT of SS and LS increased at the same rate during work for both loads, but the rate of decline was slower with the heavier load.
5. RR of SS and LS remained lower with the heavier load during work, but the rate of decline for both groups and loads was similar.
6. Both RT and RR of buffalo reached a higher level after 3 hours of work for both loads compared to SS. These values remained higher during the resting period for buffalo, but the rate of decline was similar.

APPLICATION/ON-FARM TESTING/ADOPTION/FURTHER RESEARCH
Further research is needed to take advantage of the lack of effect of work on digestibility, to improve efficiency of energy utilisation in working animals.

INVESTIGATOR(S) INVOLVED B. Bakrie, R.M. Murray and J.P. Hogan.

A pair of working buffalo used in trials in North Queensland, showing the strain gauge attached between the yoke and beam of the cart (loading vehicle). The wet hessian trunk covers on the buffalo were used to keep animals cool enough to work for 3 hours in the hot conditions. Without the hessian covers, the buffalo would only work for one hour. The cattle were able to work without covers for the full 3 hours, under the same conditions.

TITLE ***Physiology 3***

Effect of diet on energy metabolism of working animals

AIM(S)
To investigate the effect of energy concentration in feed on work output and heat production by working cattle and buffalo.

ORIGIN OF AIM(S)
Research for PhD thesis and part of a larger study designed to improve understanding of physiology of working animals. The purpose of the research was to gain an understanding of the effects of diets of differing heat increment on the heat stress of animals doing work.

LOCATION
James Cook University of North Queensland, Townsville, Australia.

DISCIPLINE(S) INVOLVED Ruminant nutritionists.

METHODS / TREATMENTS
Four cattle and buffalo were fed to achieve the same ME intake per kg bodyweight of two diets, one of high ME concentration. Sorghum hay, urea and minerals provided the low energy diet while the high energy diet consisted of the above, with maize added. The animals were worked on a treadmill for 3 hours/day. Oxygen consumption and CO_2 production was recorded in order to calculate the total heat production. Work output was calculated using an ergometer and oedometer. Rectal temperature (RT) and respiration rate (RR) were recorded before work and while resting after work.

RESULTS / CONCLUSIONS
1. Heat production by cattle and buffaloes were almost similar at 1, 2 or 3 hours of work.
2. There was no effect of diet on the energy expenditure by cattle during work; with buffalo however, the value was higher when given the high fibre diet compared to the low fibre diet.
3. Buffalo had significantly higher rectal temperature during work when given the roughage diet compared to the concentrate diet.
4. The rectal temperature of buffalo on concentrate diet remained lower at all times during work; their respiration rates however, remained higher on this diet compared to the roughage diet.
5. The use of diets of lower heat increment seems to reduce the heat load in the working animals, particularly in the buffalo.

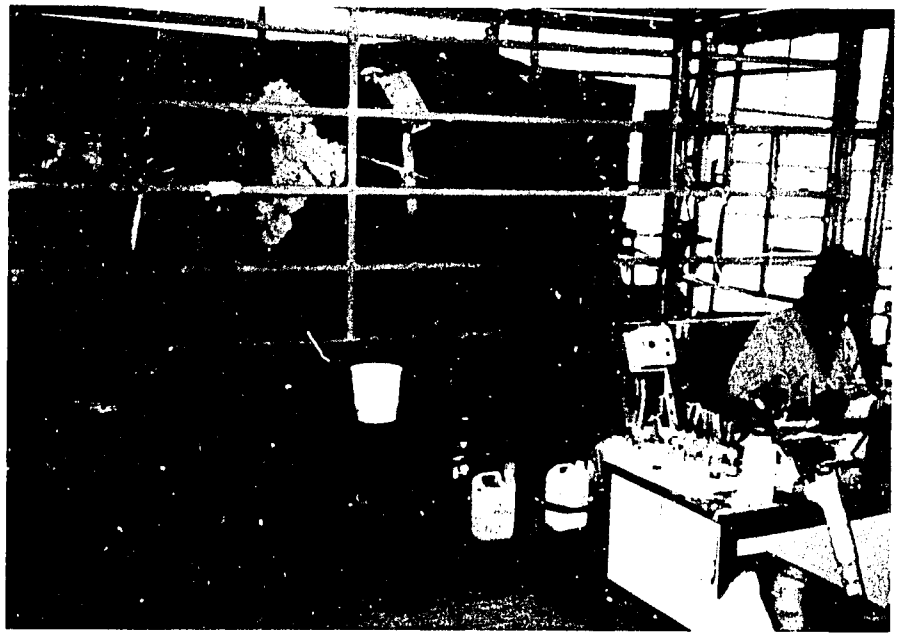
APPLICATION/ON-FARM TESTING/ADOPTION/FURTHER RESEARCH
The results of this experiment further stressed that the choices by farmers to use mainly buffalo in wetter areas and to keep cattle for ploughing in drier climates seem logical, as it takes advantage of characteristics of the different species.

INVESTIGATOR(S) INVOLVED

B. Bakrie, R.M. Murray, J.P. Hogan and E. Teleni.

DOCUMENTATION

TELENI, E., BAKRIE, B., MARTIN, D.G., KARTIARSO. BONIFACE, A.N. and MURRAY, R.M. (1988). Physiological responses and changes in some blood metabolites in working ruminants. Proc. VI World Conference on Animal Production. Helsinki, Finland. 467.



A swamp buffalo working on a treadmill, with mask for collecting expired gas. The speed and angle of the moving floor can be varied, as can the load pulled from the neck yoke and ropes. The pump mounted on the animal's back is used for experiments in which tracers are infused into the bloodstream to measure the uptake of various nutrients by muscles, etc.

TITLE

Physiology 4

A comparative study of body water dynamics in non-working and working swamp buffalo

AIM(S)
To investigate the effect of traditional draught systems on the water requirements of buffalo.

ORIGIN OF AIM(S)
A student project to gain a better understanding of the physiology of working animals in order to improve the efficiency of draught power.

LOCATION Balai Penelitian Ternak, Ciawi, Bogor, Indonesia.

DISCIPLINE(S) INVOLVED
Veterinarians, Nutritionists and Farming Systems scientists.

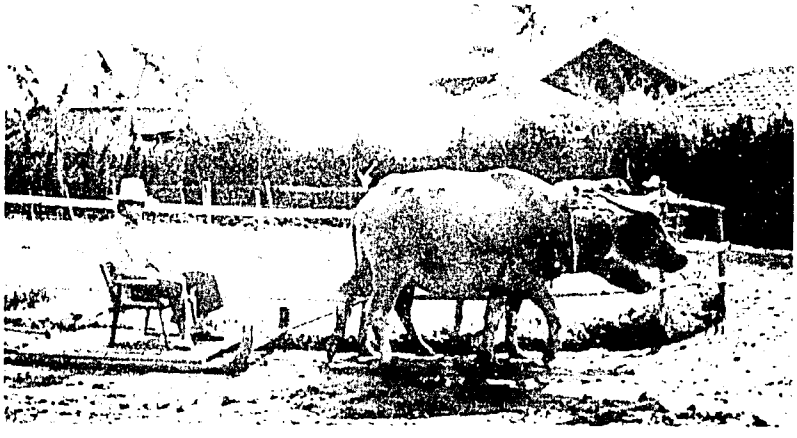
METHODS / TREATMENTS
Eight non-pregnant female buffalo aged 4 to 6 years were housed in covered pens and received chopped fresh rice straw and native grasses (1:1) to appetite. Four animals were worked in pairs by pulling a metal sledge (100 kg draught force) for 3 hours/day. At half-hourly intervals they were hosed down with cool water but not permitted to drink. The other four buffalo were used as control and remained in pens. Their water and feed was withdrawn while work was in progress. Prior to a work period, intra-jugular injections of tritiated water (TOH) were administered to all animals and then a series of blood samples were taken over a 4 day period. Water was extracted from the blood by overnight sublimation and assayed for radioactivity. The dilution of tracer over time was used to estimate water turnover in both non-working and working buffalo.

RESULTS / CONCLUSIONS
Equilibration and subsequent dilution of injected tracer is usually described by a 2-pool system, as was depicted by the curve of specific radioactivity with time in this study. Calculations of water turnover dynamics from tracer dilutions that were assumed to have equilibrated after 6 hours, apparently gave unrealistic values for pool size of working animals, while in non-working animals estimated pool size of body water (269 l) was 75% of bodyweight. Values for the other parameters were similar for each treatment, where T½ was 120 hours and turnover rate was 40 l/day.

Excessive dehydration and rehydration of buffalo during and immediately after working caused greater variation around the dilution curve than in penned animals (0.62 vs 0.83 for R^2).

APPLICATION/ON-FARM TESTING/ADOPTION/FURTHER RESEARCH
This study needs to be repeated with more discrete blood samples being taken, to allow equilibration of marker after each work period over a longer period of time.

INVESTIGATORS INVOLVED
H. Claus, E. Juarini, A. Bamualim and D. Ffoulkes.



Swamp buffalo pulling a loaded sledge in an experiment

Sampling blood for estimation of water turnover and of fat composition (left).

TITLE ***Physiology 5***

Thermoregulatory responses to frequent wetting of working animals with and without trunk covers of hessian sacking

AIM(S)
To test the effectiveness of dampened hessian sacking worn by working buffalo as a means of reducing heat stress, compared with traditional methods.

ORIGIN OF AIM(S)
Buffalo are known to suffer more from heat stress than cattle, which limits their use in hot areas. Farmers in Java relieve heat stress in working buffalo by splashing them with water, as often as possible. A student project to develop new technologies to improve the efficiency of draught animals.

LOCATION Balai Penelitian Ternak, Ciawi, Bogor, Indonesia.

DISCIPLINE(S) INVOLVED Nutritionists and Veterinary scientists.

METHODS / TREATMENTS
Measurements of rectal temperatures (RT), respiration rate (RR) and pulse rate (PR) were made in female buffalo during and after a 3 hour program of work. These indices were measured in animals which were doused with cool water at half-hourly intervals during work, some with and some without hessian over their backs and flanks, and also in uncovered working animals which were not cooled with water.

RESULTS / CONCLUSIONS
1. Thermoregulatory responses increased in all groups during the work period, but increases were greater in uncovered animals (whether or not they were cooled with water) than in those covered with wet sacking.
2. Wet hessian sacking reduced the effect of the climatic variables; ambient temperature, relative humidity and solar radiation.

The evaporative effect of the dampened hessian worn by working buffalo was a more effective means of reducing heat stress than the traditional method of frequently splashing uncovered animals.

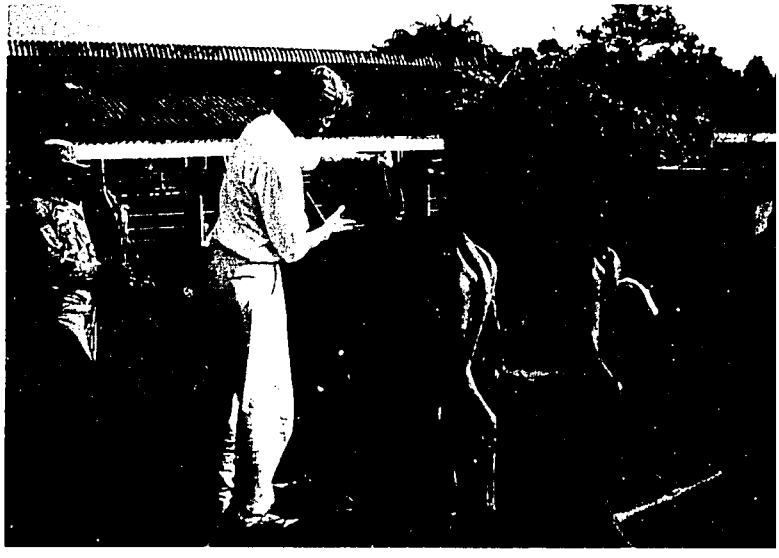
APPLICATION/ON-FARM TESTING/ADOPTION/FURTHER RESEARCH
Needs to be investigated under farm conditions.

INVESTIGATOR(S) INVOLVED R. Pietersen and D. Ffoulkes.

DOCUMENTATION
FFOULKES, D. (1986). Studies on working buffaloes - current research on nutritional aspects. *Draught Animal News*. 6: 7-13.
PIETERSEN, R. and FFOULKES, D. (1988). Thermoregulatory responses in working buffalo with and without covers of wet hessian sacking. *DAP Project Bulletin*. 5: 23-28.

A farmer splashing his working buffalo in Java to keep them cool.

Buffalo with wet hessian trunk covers, working in an experiment at BPT, Indonesia.



Dousing the hessian covers with water.

TITLE ***Physiology 6***

Use of heartgirth to estimate bodyweight of oxen during working and non-working periods

AIM(S)
To determine whether oxen experience substantial bodyweight changes throughout the year and if heartgirth measurements would provide a reliable estimate of such changes.

ORIGIN OF AIM(S)
Part of a larger research project designed to better understand the many facets of current traditional use of animal traction in the Ethiopian highlands.

LOCATION Debre Berhan, Ethiopian highlands.

DISCIPLINE(S) INVOLVED Animal scientists.

METHODS / TREATMENTS
Heartgirth and corresponding bodyweight measurements of 48 oxen belonging to 24 smallholder farmers were recorded for 2 years.

RESULTS / CONCLUSIONS
Monthly mean heartgirth measurements showed little variation, ranging from 152 ± 7 to 155 ± 8 cm. Corresponding bodyweights were 271 ± 33 to 297 ± 42 kg. Fluctuations in oxen bodyweights were minimal across the year, irrespective of working and non-working periods. No significant differences existed between monthly mean weights throughout the year, except in December when animals had not worked for 3 months and in August at the end of the major ploughing season. A single heartgirth equation based on the complete year explained variation in bodyweight almost as well as separate equations applied to each of the two periods in which oxen weights were either above or below the yearly mean. The 95% confidence interval of the predicted weight for an individual ox throughout the year was ± 37 kg. Heartgirth was most reliable when oxen weights were highest.

APPLICATION/ON-FARM TESTING/ADOPTION/FURTHER RESEARCH
Heartgirth provides reliable estimates during periods of the year when animal management is consistent and feed resources relatively constant. During the dry season a weighbridge would be a more accurate method of assessing changes in oxen weights. Use of heartgirth to estimate variables such as force or power output, or feed intake, expressed as a percentage of bodyweight, is not recommended due to inherent variation among individual animals.

INVESTIGATOR(S) INVOLVED M.R. Goe.

Measuring heartgirth of oxen on farms in the Ethiopian highlands.

DOCUMENTATION

GOE, M.R. (1987). Animal traction on smallholder farms in the Ethiopian highlands. University Microfilms International, 300 N. Zeeb Road, Ann Arbor, Michigan. U.S.A.

TITLE

Physiology 7

Effects of work on performance of crossbred cows in the Ethiopian Highlands

AIM(S)
To evaluate the feasibility of using crossbred cows for light work on farms.

ORIGIN OF AIM(S)
Surveys of highland areas showed that farmers depend largely upon oxen for land preparation and threshing. As the supply of oxen is inadequate to meet current draught power requirements, and as many farmers have only one ox or no oxen at all, delays in crop establishment and consequent yield losses are common. There is an obvious need to seek alternative sources of draught power. The use of crossbred cows as work animals was investigated because these are larger than local cows and are being introduced to farmers in an effort to boost milk production.

LOCATION
ILCA Debre Berhan Research Station, Debre Berhan, Ethiopia.

DISCIPLINE(S) INVOLVED
Economists, Animal scientists and Agricultural engineers.

METHODS / TREATMENTS
Thirty-two crossbred cows (Boran x Holstein-Friesian) were split into two groups. One group was used for cultivation and milked, while the other group was only milked. Animals were fed concentrate and hay on an individual basis, according to weight, milk production and work. The following information was recorded for all cows: oestrus, pregnancy detection test, calving date, condition and bodyweight of calf at birth, weight of cow at parturition, weekly bodyweight, daily feed intake, milk yield, lactation length, calving interval, and information on length of work periods, area cultivated, average ploughing depth, force and power output, soil type and moisture, and implement type. Animals worked an average of 21 days during the first lactation and 35 days the second, for a maximum of 4 hours/day.

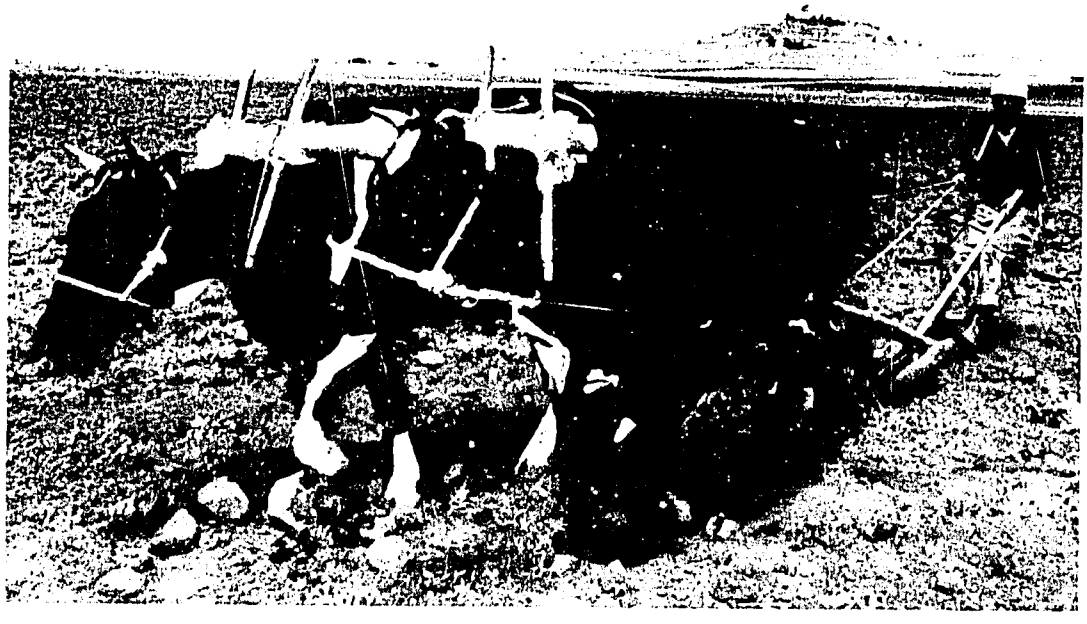
RESULTS / CONCLUSIONS
After the end of the second lactation, no significant differences were found between the worked and non-worked cows, based on the following production indices: milk yield, lactation length, calf birth weight, calving interval, gestation length and number of services per conception. It was concluded that while both groups performed about equally regarding milk yield and reproduction, such results were likely to be confounded by the inadequate amounts of work performed by working cows during the experiment, i.e., treatment levels were not sufficiently dissimilar to allow indices of differences between groups to be detected.

APPLICATION/ON-FARM TESTING/ADOPTION/FURTHER RESEARCH
The findings indicate that at low levels of work and with adequate feeding and proper management, crossbred dairy cows can be employed for draught without adverse effects on milk yield and reproduction. Results could have important application, particularly in areas with severe shortages of oxen. To date, no adoption has yet been observed. Further research is needed to determine the levels at which work might significantly affect milk yield and reproduction. A comparative trial using local animals may be valuable.

INVESTIGATOR(S) INVOLVED
F.M. Anderson, Abiye Astatke and Woldeab Wolde Miriam.

DOCUMENTATION

AGYEMANG, K., ABIYE ASTATKE, ANDERSON, F.M. and WOLDEAB WOLDE MIRIAM (1985). Early indications of effects of work on reproductive and productive performance of cross-bred dairy cows in the Ethiopian highlands. Highlands Programme Working Document. International Livestock Centre for Africa, Addis Ababa.



Crossbred cows drawing the traditional maresha in an ILCA experiment on "cow traction", Debre Berhan, Ethiopia.

TITLE ***Work 1***

Working performance of oxen in the Ethiopian highlands

AIM(S)
To document the working performance of paired oxen used for tillage on smallholder farms in the Ethiopian highlands.

ORIGIN OF AIM(S)
Part of a larger research project to better understand current use of animal traction at the traditional level in the Ethiopian highlands.

LOCATION Debre Berhan, Ethiopian highlands.

DISCIPLINE(S) INVOLVED
Animal scientists and Agricultural engineers.

METHODS / TREATMENTS
An initial baseline survey was conducted amongst farmers to determine the practices and extent of draught animal use during the year. A sample of farmers was then studied during the working season, to measure the performance and work output of their animal teams.

RESULTS / CONCLUSIONS
Oxen were used approximately 50 days/year for tillage activities during the major and minor cropping seasons, and 15 days/year for threshing. Daily ploughing periods averaged 5.5 hours, and were generally not carried out for more than 4 consecutive days. Oxen weighing an average of 280 kg developed an average force output equivalent to 18-23% of bodyweight, depending on length of fallow period and tillage frequency. Animals travelled at speeds of 0.38-0.55 m/sec. Tillage depth was 9-16 cm. Power output of teams averaged 0.5 kW. No significant relationship was found between team weight and force output. Land class and percentage stone cover did not significantly affect force output; subsequent ploughings in preparing plots accounted for significant variation on force output. However, neither single nor multiple tillage variables adequately predicted force or power output of teams.

The local ard (*maresha*) can be constructed and repaired by the farmer, and is suitable for tillage under a variety of agronomic conditions. Its draught requirement does not exceed the average capabilities of indigenous oxen. The indigenous oxen are capable of providing adequate power for necessary agricultural operations. The traditional plough is technically appropriate for the existing variety of tillage conditions. For this reason, and due to economic constraints, the ard is unlikely to be replaced by another tillage implement.

APPLICATION/ON-FARM TESTING/ADOPTION/FURTHER RESEARCH
Research on the possible introduction of improved tillage implements should include careful consideration of agronomic conditions facing farmers in the highlands, particularly features such as heavy clay soils and stony land, as well as economic inputs for purchase and repair. Use of crossbred oxen to provide additional power for tillage is not justified, given draught requirements of the indigenous plough.

INVESTIGATOR(S) INVOLVED M.R. Goe.

DOCUMENTATION

GOE, M.R. (1987). Animal traction on smallholder farms in the Ethiopian highlands. University Microfilms International, 300 N. Zeeb Road, Ann Arbor, Michigan. U.S.A.

Measuring work performance of animals on farms, in the Ethiopian highlands.

TITLE

Work 2

Evaluation of working performance of different combinations of paired cattle

AIM(S)
To assess the working performance and selected physiological responses of cattle when ploughing and harrowing, in pairs of male/male, male/female and female/female Ongole cattle.

ORIGIN OF AIM(S)
Farmers in Central Java use cattle for work in any of the above combinations (single animals are rarely employed). Research was carried out mainly for academic reasons, i.e. for an MSc Thesis topic.

LOCATION
Jogjakarta District. Gadjah Madah University Research Station.

DISCIPLINE(S) INVOLVED Animal scientists.

METHODS / TREATMENTS
For each sex combination, three pairs were worked for six days in November 1985. The animals were rented from farmers living near the research station. The pairs were worked from 0700 - 1000 hours using the traditional plough and the harrow for 3 days each. The variables measured were speed, force, depth of ploughing, area covered, pulse rate and rectal temperature. Force was measured with spring balances. The average weights of the male/male, male/female and female/female combinations were 686 kg, 679 kg and 605 kg respectively. The fields ploughed were a saturated, heavy clay.

RESULTS / CONCLUSIONS
The power output and work accomplished per day was highest with the male/male pair, followed by the male/female combination. No significant differences were found between the three treatments in pulse rate and rectal temperature.

APPLICATION/ON-FARM TESTING/ADOPTION/FURTHER RESEARCH
The finding that male/male pairs produce most power may have some application on farms. However, the majority of farmers use cows currently because of the added benefits of reproduction and docility (handling of animals). It is intended to extend this work to trials with buffalo.

INVESTIGATOR(S) INVOLVED Sulaeman, Harmadji, Soeparno.

DOCUMENTATION

SULAEMAN (1987). Comparison of work performance of different sizes of paired female buffalo ploughing wet ricefields. MSc Thesis, University of Gadjah Madah, Jogjakarta, Indonesia (in Indonesian).

Pairs of Ongole cattle and buffalo (in background) working in wet ricefields in Central Java, Indonesia.

CHAPTER 3

OBSERVATIONS ON APPROACHES TO RESEARCH ON DRAUGHT ANIMAL POWER

The Extent of Research

The volume of literature on research on DAP is relatively small, compared to that for other areas of (a) animal production, e.g. meat, milk, disease, breeding, or (b) other types of agricultural traction, e.g. tractors and machinery. Most of the information on animal traction in sub-Saharan Africa focuses on historical reviews and case studies, implement design and testing, and socioeconomics, with much less documentation available on the management, nutrition and working performance of draught animals (IEMVT 1980; Goe and Michael Hailu 1983; Bartlett and Gibbon 1984; Marti et al. 1985; Marti and Second 1988). In Asia, research has been concentrated in two main areas: i.e. economics of using draught animals compared to tractors, and the design and testing of implements. A substantial number of studies has also been carried out in India to determine the effects of work on various physiological indices of stress in cattle and buffalo (Goe and Michael Hailu 1983; Marti and Second 1988).

Animal traction is currently receiving considerable attention in many countries in Africa and Asia, with governments, international and bilateral aid agencies, national and international research centres, universities and nongovernmental organisations redirecting their agricultural policies towards greater focus on small-scale farmers and their needs.

Major reasons for the increased interest in DAP have been the high cost of imported machinery, the foreign exchange burden of fossil fuels and the disappointing experience with tractorisation, particularly in Africa, in achieving projected increases in agricultural production. There has been a slow, but gradual change over the past 10 years in the attitudes of policymakers, scientists, extension and training personnel and others involved in agricultural development, concerning the present and potential role of animal traction in farming systems.

Evidence of the recognition of the important contribution of DAP to smallholder agriculture is seen in the number of recent meetings, conferences and workshops that have been held in Africa, Asia, Europe and Australia for the purpose of exchanging information on the use of draught animals and the need for research and development. These have included appropriate technology meetings for eastern, central, southern and western Africa (Commonwealth Secretariat 1977, 1979a, 1979b), a national seminar on DAP in India (IIM 1982), a consultative meeting on draught animals within the Mano River Union countries of West Africa, i.e. Guinea, Liberia, Sierra Leone (MRU 1983), a consultative meeting on animal energy in Africa and Asia (FAO 1984), a workshop on DAP and feeding in eastern and southern

Africa (CIMMYT 1984), a symposium on animal traction in France (Machinisme Agricole Tropical 1985), an international workshop on DAP in Australia (Copland 1985), national workshops on agricultural tools and equipment in Kenya, Sudan and Tanzania (ILO 1986, 1987a, 1987b), three workshops on animal traction in West Africa (Poats et al. 1986; Starkey and N'Diame 1988; Starkey et al. 1989), an international planning conference on animal traction research in Ethiopia (ILCA 1987) and a national seminar on animal energy utilisation in India (O'Neill et al. 1987).

A disturbing feature of the list of Examples of Research Topics in Chapter 2 is the piecemeal nature of the research effort on DAP. Animal traction research has often been carried out without a clear understanding of the biological and socioeconomic constraints facing farmers within different agricultural systems. Preliminary appraisals to determine whether the expanded use or introduction of draught animals would be profitable or identification of factors which might limit its adoption or growth, have frequently been omitted (Starkey and Goe 1984, 1985; Starkey 1986). In Asia, too, there has been a lack of coordination between livestock and mechanisation programs (Pathak 1984).

The direction of national policies relating to the use of DAP in many countries is poorly defined, and this has severely hampered research planning. Frequently, different ministries are responsible for livestock, agricultural engineering, agronomy and socioeconomic development. Such ministries may, in turn, be subdivided into several departments, making it difficult to charge a single authority with establishing and coordinating the various needs for DAP research activities. Cooperation, liaison and information exchange between external donor agencies, nongovernmental organisations and international centres involved in research and development of animal traction in sub-Saharan Africa has been minimal (Starkey and Goe 1984, 1985). In India, where an estimated 100 million animals are kept primarily for draught, national priorities for research on animal power have remained relatively low (Ramaswamy 1987). In Indonesia and most other Southeast Asian countries, there appears to be no government policy specifically related to draught animal power, except in transmigration areas (Kasryno et al. 1989). Draught animals continue to play a vital role, despite active policies supporting tractorisation in many areas.

However, over the past few years, recognition of the important role that draught animals play in agricultural systems and the potential for increasing or improving the use of DAP technology amongst smallholders has, in several African countries, resulted in the formation of national animal traction programs, which are using multidisciplinary teams to carry our research, training and development (Starkey 1988a; Goe 1989). In India, a coordinated program of draught animal research has recently been instituted (Alam 1987).

There has also been recent interest in the establishment of networks related to animal traction research, training and development activities in sub-Saharan Africa (Imboden et al. 1983; Starkey and Goe 1984, 1985; ILO/FAO 1985; Starkey and N'Diame 1988) and in Asia and the Pacific (ESCAP/FAO 1983; Pathak 1984). Such networks should foster a clearer focus for research and development efforts, act as a vehicle for the exchange and dissemination of information, and provide opportunities for training in areas involving the use of animals for work. Newsletters devoted specifically to various aspects of management and research on draught animals are currently being published: *Draught Animal News* (CTVM, University of Edinburgh), *DAP Project Bulletin* (ACIAR DAP Project, James Cook University) and *Animal Traction Research Network Newsletter* (ILCA).

Despite this encouraging stir of interest, draught animal power - a most important area of animal production - remains, as yet, one of the least studied and least understood of all fields of livestock science and economics.

The Range of Disciplines Involved in Research

The examples of individual research topics presented in Chapter 2 provide some indication of the range of disciplines under which research bearing upon draught animal power has been conducted in Indonesia, Ethiopia and Australia. However, the particular set of 36 topics chosen, and their classification under the eight disciplinary headings of **Animal Health, Cropping, Economics, Engineering, Feed, FSR, Physiology** and **Work**, suggest a much greater diversity of research than has actually been the case. In the three countries considered here, and also globally, most of the research on DAP has been conducted in a few specialist areas.

Although the emphasis in research on DAP varies from country to country (and in many countries there has been no DAP research at all), **agricultural engineering** is the discipline under which most DAP-related studies have been conducted. The second most prevalent area of research has been that of animal **physiology**, and this is growing. Physiologists contend that a better understanding of the detailed physiology of work and working animals (e.g Kartiarso et al. 1987) will allow the design of improvements to farmers' existing DAP systems.

In the following sections, each of the disciplinary headings used in the classification of research topics is discussed briefly, in relation mainly to the findings of this study in Indonesia, Ethiopia and Australia.

Research Under Disciplinary Headings

The aim of classifying the research studies in Chapter 2 under disciplinary headings was to place the individual examples into a logical order, for clarity to the reader and for subsequent discussion. However, the allocation of particular cases to the headings chosen was, in some instances, difficult and somewhat arbitrary.

For example, experiments on the physiology of working animals may have components of both *Engineering* and *Physiology*, and have been conducted in institutes of both these disciplines. Trials in which *Feeds* for working animals are studied invariably involve some *Physiology* and sometimes *Engineering* aspects of DAP. The heading *Engineering* could have been split into two or more subheadings in the classification, e.g. **implements and harnessing** and **measurement of work performance**. *Work* output has often been studied in relation to *Farming Systems* or to *Economics*, as well as from an *Engineering* and/or *Physiological* point of view.

Despite these difficulties of categorisation, the discipline headings in Chapter 2 nevertheless provide a useful basis for the following discussion of examples of DAP research. Under each heading, other studies conducted elsewhere in Africa or Asia have been cited, where possible, to provide the reader with additional comparative information on the subject.

Animal health

Research specifically directed towards the health of working animals has been minimal and is scattered in the literature. For the most part, available information either catalogues diseases, in general, of animal species used for work, or describes disease conditions incidentally occurring in draught animals (Wells 1987). Examples of such references include FAO (1972, 1977), Neunhäuser (1977), Wilson (1978), Reh (1982), Coulomb (1984), Partoutomo et al. (1985) and Sowe et al. (1988). Few studies have focused on a specific disease, e.g. trypanosomiasis, and its effect on draught animals (Bourn and Scott 1978; Ravindran 1988; Payne et al. 1989).

Detailed studies of animal health on small-scale farms have seldom been conducted. Such research is extremely time consuming and expensive, as it is essential to locate research assistants in the villages concerned, so as to ensure close contact with farmers and detection of all cases of ill health. Farmers must be discouraged from selling or slaughtering sick animals, without prior notification of the researcher, who must establish a relationship with farmers which is conducive to such communication. Otherwise, it is impossible to estimate mortality rates or to diagnose disease accurately. The testing of remedies should be on farms, so that farmer opinion can be assessed, and remedies should be locally available and inexpensive (Starkey and N'Diame 1988). Such village-based studies require the backing of sound veterinary advice and diagnostic and research facilities, and access to expertise from other disciplines (Hoffmann and Dalgleish 1985).

The types of animal ill-health most important to farmers are not always obvious: nor are they those most attractive to research veterinarians for study. For example, in parts of West Java, both farmer surveys and subsequent studies have identified skin burns as a more serious problem in rearing draught animals than harness sores caused by work itself (Burton et al. 1988). The burns are caused by animal pens catching alight from fires lit each night to discourage biting insects in the pen. The traditional treatment of skin burns involves many hours of farmer labour per week and the burns may stop animals from working at critical times of year. Simple trials on insect repellents and cheap remedies for burns (and harness sores) are, unfortunately, topics which do not appear to attract the modern research veterinarian, or substantial research funding.

Research on the identification of health constraints in draught animal enterprises is all important, if limited research resources are to be effectively used. *Animal health 1* is an example of a study designed to identify health problems and to test possible preventive measures and remedies that are available to small-scale farmers. Three requirements for this type of study are very close contact with farmers, funding to purchase sick animals that would otherwise be sold by farmers and access to reliable diagnostic facilities.

The second example (*Animal health 2*) represents a different type of health problem that can be associated with draught animal power. It is possible that some diseases, which have little or no effect on growth or reproduction of livestock, may affect animals that are working. Mortality due to Malignant Catarrhal Fever in cattle in parts of Java is thought to be most prevalent in the working season (Daniels et al. 1989). Studies are needed on this and other diseases that might be associated with work in animals.

Cropping

In crop production trials carried out on research stations, mechanised equipment or hand labour are invariably used to prepare, seed, fertilise, weed and harvest the plots. Such methods are considered necessary to maximise experimental control (Ward 1984; ICARDA 1987). Where the target farmer population relies on animal power for tillage and performs all subsequent operations by hand, then it is doubtful whether findings from some such (mechanised) studies will have applicability to smallholder agriculture.

Experiments on crop production in farming systems where draught animals provide a major source of power should include an animal/implement component where appropriate, to determine variation in quality of the seedbed preparation, as affected by animal and implement performance.

A substantial amount of research involving the use of oxen was carried out in semi-arid West Africa comparing yields of rainfed rice, sorghum, maize, millet and groundnuts on ploughed and unploughed plots (Charreau and Nicou 1971). Seedbed preparation studies have been conducted in Botswana (Wi[illegible]ks 1979; Farrington and Riches 1984), in Ethiopia (A[illegible]ive Astatke and Matthews 1982, 1983, 1984; Jutzi et al. 1987) and in India (Alikhani 1981;

Awadhwal and Thierstein 1984). Research on the effect of animal-drawn and other implements on physical properties of soil in wet rice production and on subsequent crop yields, has been carried out by Painuli et al. (1986), Pagliai et al. (1987) and Willatt and Tranggono (1987).

Probably the most publicised use of animal-drawn implements in agronomic and land use trials has been the research carried out for three decades to develop wheeled toolcarriers, i.e. multipurpose implements that can be used for ploughing, seeding, weeding and transport. Yet these implements have been rejected by farmers because of their high cost, heaviness, lack of manoeuvrability, inconvenience in operation, complicated adjustment and for other reasons. Few farmers have used the wheeled tool carriers as multipurpose implements for long except in the single mode, i.e. for ploughing, cultivating or, most often for carting (Starkey 1988b).

Two studies which incorporated draught animals, crops and implements as part of a multidiscipline approach to cropping research are outlined in *Cropping 1* and *2*.

Economics

Studies of the economics of draught animal power have been conducted in many countries in Africa and Asia. Much of the research in Asia has compared the economic benefits of using animal power (cattle and buffalo) with tractors (Mishra et al. 1976; Binswanger 1978; Goyal et al. 1981; Kalla et al. 1986). Findings are frequently discussed in terms of, which power source is the most labour-saving, their cost-benefit ratios and the projected use of available resources, e.g. petroleum products, working animals, feedstuffs.

In Africa, most economic research has compared the use of animal traction with manual labour. Studies have tended to quantify the direct impact of animal traction on crop output via its effects on yield, area, cropping pattern and labour requirements. Most studies have compared farms "with" and "without" animal power (Sargent et al. 1981; Barrett et al. 1982; Delgado and McIntire 1982), but few have examined farms "before" and "after" its introduction. "With/without" comparisons might tend to overestimate the benefits of animal traction in a way that "before/after" studies would not, because the former confound other factors, e.g. family size, cash income from other sources, and land quality, with the impact of animal traction.

The two studies outlined under the heading of Economics are new initiatives in Java, designed to complement the on-farm studies of a farming systems research project, run mainly by biologists. These are not typical of previous economic studies related to DAP in Indonesia, which have been mainly concerned with the relative merits of tractor use versus other forms of land preparation (e.g. Kato et al. 1979).

The need for simple economic studies to assist biologists and engineers in assessing the viability of proposed improvements to DAP systems, is obvious. Organisation of the DAP research effort so as to facilitate such collaboration between economists and other disciplines would be mutually beneficial.

Engineering

In many countries, animal traction research programs are entrusted to agricultural engineering departments, and this is often the case also within international organisations involved in animal traction research or development. Thus, in both Africa and Asia, agricultural engineers have been more active in research related to draught animal power than have scientists from any other discipline. Their research has fallen mainly under one or more of the following subheadings:

- implement description and evaluation;
- implement design;
- development of loading devices;
- development of measuring devices for draught force;
- measurement of draught force, using various animal/implement combinations;
- measurement of animal work and power output;
- measurement of animal physiological responses to work under different environmental conditions;
- ergonomics (concerning the comfort of working people and animals).

In Chapter 2, examples of research in the last two categories listed above are included under the disciplinary headings of *Work* and *Physiology*, respectively. No ergonomics studies were encountered in the three countries dealt with.

Engineering research on draught animal power has concentrated on the design and evaluation of implements, mainly ploughs. However, poor linkage between the designer, manufacturer, animal scientist, agronomist and farmer has frequently resulted in the development, production and even distribution of implements, which have been unsuitable for prevailing agronomic conditions. Often, they have required more power than the animals could produce, they have failed to structurally withstand various tillage conditions, or they could not be afforded, maintained or repaired by farmers or local artisans.

An area of research which is receiving increasingly more attention is the development of equipment, instrumentation systems and methods to measure the working performance of draught animals (e.g. force and power output, heart and respiration rates, body temperature and stepping rate, angle of hitch) in an effort to better quantify energy requirements of working animals (Lawrence and Pearson 1985; Kemp 1987; O'Neill et al. 1987; Pondey and Bohva 1987; ILCA 1988).

While there is a need for such studies, institutes planning to embark on research in these areas, should consider the financial and human expenditure involved in such studies, in relation to the immediate needs of the animal

users. In this context, it would be worth examining the history of DAP in Europe, the United States and Australia (e.g. Goe and McDowell 1980; Goe and Michael Hailu 1983) to determine how many of the advances made were achieved through simple trials and development of implements on farms, versus detailed studies of draught performance and the mechanics and physiology of work.

Depending on the objectives of the research, it may be that certain performance parameters, e.g. draught and power output and implement testing, can be adequately measured using simpler methods (Premi 1979; Goe 1987; Matthews 1987).

Engineering research has tended to be single-discipline in approach. Yet the need for animal expertise in engineering institutes and for engineering advice in livestock research is all too obvious. One example of a multidisciplinary approach by engineers is outlined in *Engineering 3*, in which engineers, soil scientists, economists and administrators combined to study and develop a system of building ponds for water supplies, using farmers' existing cattle and a simple dam scoop. Another such example is seen in *Engineering 6*, but such collaborative studies have been the exception rather than the rule in most countries and institutions.

Feed

The feedstuffs available to small-scale farmers during working seasons are often very limited, so an improved understanding of feed requirements for work is generally considered to warrant priority research (e.g. Copland 1985; Kartiarso et al. 1987; Reed et al. 1988). However, in most farming systems where draught animals are used, the farmers have evolved feeding systems which utilise cheap or communal forage resources for most of the year and also the body reserves of animals during work seasons. Such feeding practices are difficult to improve on, within the farmer's limited resources, except where animals are worked for long periods of the year. Unless farmers can see a clear return in income from proposed changes, they are unlikely to adopt new animal feeding practices.

Examples of experiments designed to improve understanding of the utilisation of nutrients by working animals are outlined under *Feed 1* to *4*. This research is closely related to some of the experiments described in *Physiology*. Examples of studies on the effects of feeding various locally available feedstuffs as supplements for working animals are described in *Feed 5* and *6* of Chapter 2.

One area of research receiving limited attention by animal nutritionists is the description of the existing diets of ruminants on small farms. Examples of such studies are outlined under *Feed 8* and *9*. The difficulties of conducting these studies are increased where animals obtain a varying part of their feed from grazing and from hand feeding to a varying degree (Zulbardi and Bamualim 1989).

Farming systems research (FSR)
The role of draught animals within different farming systems has recently begun to receive attention, with a view to defining more relevant crop-livestock research activities (Fine and Lattimore 1982; CIMMYT 1984; Poats et al. 1986; Starkey and Apetofia 1986; FSRI/ARFSN 1986; CAAS/ARFSN 1987; Starkey and N'Diame 1988).

The examples of research listed under the heading of *FSR* in Chapter 2 include a range of types of study at various stages of a classical FSR procedure (e.g. Norman 1978; Plucknett et al. 1986), from selection of sites (*FSR 1*) to site description (*FSR 2*), and farm trials (*FSR 3-6*). Some of the examples listed under headings other than FSR, also arose from a typically FSR approach, and may be termed "special constraint-oriented studies", e.g. *Animal Health 1*, *Engineering 1* and *5*, *Feed 8* and *9*, and *Work 1* and *2*.

In FSR there has sometimes been a tendency for description of the system to become an end unto itself. It is important to keep the descriptive phase in FSR to a minimum, in order to save resources and to embark on on-farm trials of possible improvements as early as possible. There must also be a progression from researcher-managed trials to farmer-managed ones, as it is only through farmer participation in trials that the socioeconomic effects and farmer opinion of a technological innovation can be evaluated (Spencer 1988).

Even "failed" on-farm trials can yield valuable information on the most critical factors affecting DAP development, i.e. farmers' attitudes and motivation. Results of many FSR studies strongly support the concept of farmer participation in research as a most fruitful means of achieving improvements to systems, which are acceptable to farmers (Farrington 1988; Sagar and Farrington 1988).

Where FSR scientists have the motivation and communication skills to draw into the FSR process, farmers, specialists and administrators, the prospects for improvement of the contribution of DAP are encouraging (e.g. see *Cropping 2*, *Engineering 3* and *FSR 3* and *6*). This requires, however, a far greater understanding of FSR amongst administrators and specialists than exists at present in most countries. Training in the concepts of FSR at all levels (i.e. administrators, scientists and technicians) is therefore a serious need, if this approach is to have an impact (Petheram 1985).

Physiology
As stated earlier, research on the physiology of DAP is often closely related to that on feeding and on work. The simplest type of experimentation under this heading involves the measurement of the effect of various levels and intensities of work on the physiology of working animals, e.g. body temperature, heart rate, breathing rate and oxygen uptake. One justification for such studies has been to determine reliable indicators of stress in working animals (e.g. Upadhyay 1987; Martin and Teleni 1989). Another aim has been to develop ways of preventing or reducing stress (e.g. in *Physiology 1* and *5* in Chapter 2). A substantial amount of research has been carried out in Asia,

particularly India, to determine changes in various physiological responses in indigenous and crossbred oxen and buffalo performing work under tropical conditions (Goe 1983, 1987).

The physiology of digestion in working ruminants has been another area of research (e.g. *Physiology 2* and *3*). There is conflicting evidence on the subject of whether intake and digestibility (and other digestive functions) are enhanced or reduced by work at various levels. Studies in this field have led on to experiments to examine the effects of low levels of nutrition and of high levels of work stress on animal growth and reproduction rates (e.g. Abiye Astatke et al. 1986; Soller et al. 1986; Winugroho et al. 1988).

In the study of rumen physiology of relatively less well known livestock species (e.g. swamp buffalo), physiologists have found it necessary to embark on studies of the digestive physiology of non-working animals, so that results of studies of these animals while working can be properly interpreted (Kennedy 1987; Kennedy et al. 1987).

Animals working on treadmills (or in similarly controlled conditions), isotope labelling, infusion and analyses for metabolic substrates (see *Physiology 3*), and instrumentation for the measurement of physical and physiological variables in working animals, are some of the techniques used in physiological research on DAP (Lawrence and Pearson 1985; O'Neill et al. 1987). A currently popular topic amongst animal physiologists is the study of the metabolic pathways of various substrates in the blood and tissues of working animals (e.g. Teleni et al. 1988).

At this stage, the rewards to be gained from such studies are unknown. Findings (e.g. about the role of fats and other energy substrates in providing energy for work) will need to be verified under field conditions, and then practical and economic means of introducing improvements to farmer practices will have to be sought. In the planning of physiological studies of draught animals, it is therefore important to link experiments in the laboratory, with observations of actual DAP systems on farms (Pearson 1985) and to carefully assess the relative costs and likely benefits of field and laboratory research.

Work

The two examples of research included in Chapter 2 under the heading of *Work* may have been better placed under other headings. However, they were categorised here as examples of types of field studies which are becoming increasingly common in DAP research projects.

The aim of research such as that included under *Work 1*, is to describe the approximate level of work output of animals under existing farming practices. Simple methods were used to estimate draught force, after conducting surveys of farmers to determine the average period of work per year and per day. The second study (*Work 2*) is an example of a trial in which force was not

measured at all, but in which "area ploughed" was used as an index of work output by different types of animal team.

Both types of study outlined under *Work*, and others in village-based programs, are useful in describing DAP Farming system in general terms. However, the infinite variation in soil and other factors between sites renders the use of data from such studies of limited value in comparisons of work output between different farming systems, or different animal species.

Modular, electronic instrumentation systems developed recently (e.g. Lawrence and Pearson 1985; O'Neill et al. 1987) have made field recording of work output (and of physiological variables) much more practical than in the past, although this work has been, for the most part, limited to on-station studies.

Research applications for this equipment are numerous, but at the current price of about US$30,000 per unit, most DAP research projects have to consider carefully the opportunity cost of expenditure on such items, especially in areas where little is yet known about the DAP systems, e.g. rearing and working practices, feeding, animal and land ownership, and periods worked per year and per day.

Disciplines Omitted

While covering a fairly broad spectrum, Chapter 2 does not pretend to be fully comprehensive as regards disciplines under which research on DAP has been conducted in other countries. One omission is **Animal Breeding** research, which is becoming a popular topic globally, especially in attempts to improve local animals through cross-breeding.

Another research discipline not specifically covered in Chapter 2 is that of the **Sociology** of DAP use. However, sociological information about the rearers and rearing of draught animals is one of the basic requirements in data collection in Farming Systems Research, such as that described under *FSR 2*. Many DAP research programs could benefit from the advice and methods of sociologists in the planning of research and application of results.

Research under **Animal Reproduction**, while not specifically categorised in Chapter 2, is mentioned in some studies conducted under other disciplines, e.g. *Physiology 7*. Experiments on **animal-drawn carts** or on **animal training** on the other hand, are not covered at all, as none was encountered in the three countries studied.

Within certain disciplines, there are several specialist fields that are not covered by the example topics in Chapter 2, and some of these are mentioned in the preceding sections. In the disciplines of **Engineering** and **Economics**, in particular, there have been many more types of, and approaches to, DAP research than are covered here.

Approaches to Research Encountered

Aims of research topics

The aims stated for individual research topics reported in Chapter 2 varied markedly in the degree of location specificity. In cases where there was no reference to a location or region of interest or application, the stated aim was usually related to obtaining a better understanding of some disciplinary area of draught animal power, e.g. better understanding of the nutrition or physiology of working animals, or characterisation of implements used by draught animal rearers. Such generally stated aims were most common in single disciplinary institutions, and were usually associated with the overall aim of the institute.

On the other hand, many researchers interviewed stated their aims very deliberately in terms of a region, a particular species of livestock, a class of soil or climate, or a defined farming system. Where institutes have adopted a multidisciplinary approach, or have had a farming systems orientation, the aims claimed in DAP research tended to be more clearly related to defined farming systems or farmer domains.

In some cases, where research was designed for a particular agroclimatic zone, it was not clear which farmer groups the research results were intended to benefit within that zone. The importance of defining **recommendation domains** (Siriluk et al. 1987) has not been sufficiently recognised in DAP research. The results of attempting to conduct research across too wide a range of farmer domains (e.g. from the poorest to the richest farmers) can be failure to produce acceptable technology for any particular group, or benefits for one group (usually the richest) at the expense of others.

Origin of aims

Obtaining a statement of the *origin* of a research aim from investigators was often surprisingly difficult. This was especially the case in academic institutions where the investigators were students, conducting the research as part of a thesis, or of a larger institutional program.

The aims, as claimed by investigators, could be categorised broadly into those originating from:

- surveys of DAP, livestock or cropping systems;
- published literature;
- institutional objectives;
- assumed knowledge of national research needs;
- miscellaneous thesis topics.

Because of the small number of examples dealt with, it would be invalid to examine whether particular disciplines tended to be more or less careful in the derivation of their research objectives. It was very evident, however, that within any one discipline, some individuals were much more systematic than others in the way in which they sought and justified the aims of their research programs. While some scientists teams related all their research to the needs of a particular farming system or farmer domain (determined by some objective means), other investigators tended to be influenced more strongly by such factors as:

- the academic standing of the topic;
- the ease of conducting the research;
- the ease of publishing results.

There is little doubt that the proliferation of certain types of research on DAP in recent years has been stimulated by the availability and ease of use of particular types of equipment, which make research results appear more scientific and acceptable for publication by professional journals, than is the case in other approaches to DAP research.

As previously intimated, the essentiality of striking a balance in research between expenditure on sophisticated equipment for measuring draught and/or physiological variables, and expenditure on applied research involving participation by farmers and their DAP enterprises, is the major dilemma facing planners in DAP research programs today.

Multidisciplinary research

The degree to which different disciplines combine in research on DAP is influenced by the type of institute, and also by the approach of the individual scientists involved. In some institutes (and locations) it is apparently very difficult to conduct multi- or interdisciplinary research, while in other institutions, collaborative research is actively promoted. The latter (multidisciplinary) types tend to be more development-oriented than research-oriented organisations.

Although the complications of combining disciplines in research make this approach more difficult to organise, the field of draught animal power is so inherently multidisciplinary that the need for scientists from different fields to work together cannot be too strongly emphasised. Many individuals who had previously been involved in some specialist area of research on DAP mentioned the need to combine their skills with other specialists in future studies.

Multidisciplinary research is conducted in various ways. As multidisciplinary teams are considered difficult to finance, some FSR groups prefer to work mainly as biologists, calling in advice from others (e.g. economists and engineers) wherever needed. In this way, it appears to be feasible for scientists from one sphere to build up a working knowledge of other disciplines needed in their particular field of DAP research, so that the requirement for advice

from other specialists becomes less with time. An example of this is seen where animal scientists use sound engineering approaches to measure draught and work. The dangers of conducting poorly designed experiments in such circumstances are, however, very real. A small and close-knit multidisciplinary team, working with the same aims at the same sites, is undoubtedly an ideal worth striving for in the organisation of DAP research.

Results and their dissemination

To date, the results of research on DAP in Indonesia, Ethiopia and Australia have started to provide an understanding of:

- how working animals are used in various farming systems;
- the effect of work on intake and digestion;
- how various metabolites are used during work;
- how work affects body condition and reproductive cycling;
- how to interest farmers in participating in DAP research;
- ideas that might be worth testing on farms, to improve farmer returns;
- promising areas for future experimentation on research stations.

In general, in Indonesia, the dissemination of the results of research on DAP has been relatively ineffective to date, amongst administrators, extension workers and farmers. This failure may be associated with such factors as:

- the short history of research on DAP, and consequently,
- a lack of research results that have been thoroughly tested on farms;
- the deeply rooted traditional practices in draught animal use;
- the stigma attached to animal traction as a source of power amongst some scientists, administrators and extension workers;
- the large injection of funds into promoting tractorisation in many areas;
- a need for infrastructural support for many of the new technologies that have been tested on farms and found to be acceptable to farmers (e.g. credit for animals and implements; seed sources for improved forages; farmer training in DAP use).

In the third year of research on DAP in Indonesia, farmer response to ideas generated for improvement of DAP enterprises has markedly improved. The highest levels of acceptance by farmers have been in areas where research scientists are actively involved with farmers and extension agents in testing ideas on farms. Farmer visits, video films, ploughing competitions and other methods of stimulating farmer interest have been an essential part of the research process. Controlled experimentation on stations has also begun to yield promising results, which now need testing and verification on farms in the village sites where strong farmer contact has been established.

In Ethiopia, the longer history of DAP research and the soundly based farmer-orientation of research has already led to some successful cases of adoption and some promising areas of current research. Long-term research programs and **strong links with farmers** appear to be essential requirements for progress.

It is clear that both the trial and the transfer of DAP research results require methods with strong impact. Video films have been used in Java. Scientists have become enthusiastic and competent at video filming, as this helps to keep a record and to publicise their work. However, they have been less willing to spend time collating and editing material for the production of video films and manuals on DAP for use by extension agents.

Application of results
Over half the scientists interviewed in connection with this study on DAP research did not feel that their results had direct application on farms. When asked about their plans for application of their research, most investigators mentioned first, the need for "further studies" on their main topic of interest.

In contrast to this general finding, some research workers claimed very direct and clear applications for the results of their research. This difference in approach points to the dichotomy in the field of DAP research, between scientists conducting research for the sake of research and publication, and those oriented towards solving farmers' problems. Perhaps both approaches are needed, and the main requirement is for a well coordinated DAP research strategy, to link the work of the academic with that of applied scientists.

On-farm testing
The traditional model of research scientists conducting their experiments on research stations and relying on extension agents to verify and disseminate the results, seems particularly inappropriate in the field of draught animal power. The contrast between conditions on experiment stations and those on farms, is so great that there seems no option but for researchers to test their findings on farms, using farmers' labour, animals, fields, feeds and implements, before there can be any certainty of the applicability of their results. To expect extension agents to take on this work (i.e. **the most difficult part of the research process**) alone, is unrealistic.

In many areas, where tractors have been strongly promoted, the status of draught animal rearing has been seriously undermined, even though DAP may still have a vital role for certain land types and tasks. In these circumstances, scientists have to work with other agricultural development agents to build up the status of DAP, before new ideas on draught animal use are likely to be willingly tried, or accepted by farmers. The ploughing competition described under *FSR 6* in Chapter 2 is an example of farm research designed to simultaneously enhance the status of animal rearing, demonstrate new ideas in DAP and provide useful statistical information on animal work performance.

A basic requirement for farm testing of new ideas in DAP is demonstration. Many trials on farms serve the joint function of demonstrating to farmers (and researchers and extension agents) that a new idea has merit, as well as obtaining data on animal performance or crop production for the new method. In such trials, however, the most important aim is often to gather information on farmer opinion of the new idea, and on whether (and how) this could be

adapted to their particular conditions (Sumberg and Okali 1988). Statistical testing here is not only inappropriate, but clearly unnecessary.

Farmer-participatory research is time consuming and demands a high level of commitment by researchers to improving the benefits to farmers, in this context from their DAP enterprises. Research scientists in many institutional settings feel that they cannot become involved in such "unscientific" activities as farm trials because they:

- receive little credit for research results that are not at the forefront of science in their particular discipline;
- find difficulty in publishing the results of on-farm research;
- have no funds to travel to, and stay in, villages;
- can achieve much more eloquent and publishable results by spending the same amount of time working on research stations;
- have no confidence or training in farmer communication.

These constraints to the conduct of on-farm research are prevalent in all disciplines, but appear to be particularly marked in some areas essential to DAP research. The result has been the development of a profusion of overdesigned implements which are too heavy or too expensive for farmers to adopt. In the conditions of declining land size and livestock ownership prevailing in most countries, and the trend towards the use of cows (Matthewman 1987) and smaller or single animals (Burton 1988), there would appear to be an increasing need for smaller, more efficient implements and inexpensive modifications to traditional tools, rather than for expensive new equipment. Research to these ends cannot be conducted on stations alone, but requires, in addition, on-farm studies by committed mechanics and carpenters, with the help of farmers.

Much of the research of the ILCA Animal Traction Thrust involves scientists working both on stations and on farms. Some studies (e.g. *Engineering 3* and *6*) have progressed from trials on research stations, to farmer field days, then on-farm trials, followed by the involvement of government organisations in promoting the new technology through provision of strategic inputs in rural areas. Creating suitable institutional conditions for scientists to remain involved in such programs seems to be critical to the success of DAP research and development.

Further needs in research

Many of the comments made in earlier sections of this chapter have referred to general differences in approach to research. However, the major problems affecting DAP development are often related to the **management of research** within research institutes or other research organisations.

A major issue observed in the organisation of research on DAP was that of striking a realistic balance between research on stations and research on farms, or at least oriented towards farmers. Where the aim of research is to address the real needs of farmers using draught animals, it appears that the following conditions need to be met in research institutes:

- recognition given to scientists for working with farmers;
- training given to scientists in communication and working with farmers;
- means of communicating with and involving other disciplines in research, as demanded by the needs of particular DAP systems;
- an institutionalised method of involving extension workers in testing and demonstrating results of research with research scientists;
- effective means of communication of results to scientists and extension workers who are already working with farmers;
- effective means of communicating farm tested technology and other research results to policymakers (e.g. the need for credit schemes).

Apart from the requirements for improving the approach to research on DAP within institutes, there is a marked need for coherent national policies on animal traction and on DAP research. The "All India Coordinated Research Project on Utilization of Animal Energy" (Alam 1987) is a model that may be worth consideration for other countries attempting to achieve a more coordinated approach to DAP research.

Certain areas of research on DAP that were not encountered in Indonesia, Ethiopia or Australia should be mentioned. The first of these is **animal training**. Research on methods of training, and on the effect of training methods on work output, seem very relevant in the context of the decreasing size of animals being used and also the declining farmer resources in so many countries.

Another topic receiving attention in some countries is that of **alternative uses** of draught animal power. Water lifting devices, harvesting machines and other animal-powered devices have played an important part in the history of many countries (Löwe 1986). Perhaps it is valid to study the situations in which these machines became useful, and were later abandoned. However, it is obvious that today's conditions of reducing farm size and increasing poverty in developing countries do not parallel the conditions under which most of the animal-powered machines developed in Europe, the United States and Australia. There is a need in studies of alternative applications of DAP to determine whether animals and farmers would be prepared or able to take on further work, and the effect of additional animal work on growth and reproduction of draught animals.

A great challenge in farming systems development is research into cooperative activities by farmers, for the purpose of developing communal resources. One good example is that of farmers cooperating to build earth ponds with oxen and scoops in Ethiopia (*Engineering 3* in Chapter 2).

The achievement of such collaborative efforts between researchers and administrators and farmers, is encouraging to others endeavouring to improve the utilisation of draught animal power. Furthermore, it points to the need for DAP research scientists to become more people-oriented and to realise that collaboration with policymakers is vital to the successful development and application of their research.

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