ISSN 0919-8822

# JIRCAS Newsletter

## FOR INTERNATIONAL COLLABORATION

NO.7 June 1996

On the way from shopping, Niger
(Photo by T. Terao)

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JIRCAS
JAPAN INTERNATIONAL RESEARCH CENTER FOR AGRICULTURAL SCIENCES

# Development of Sustainable Livestock Production in Developing Regions
## —Current Collaborative Research Programs of the Division—

*Dr. Hirofumi Hayakawa*
*Director, Animal Production and Grassland Division*

There is a rapidly growing demand for livestock commodities worldwide as human population pressure and incomes increase. Livestock are raised all over the world and contribute directly to human nutrition and socio-economic welfare and to the productivity of mixed crop-livestock production systems, national resource management and the security of resource-poor farmers.

Two-thirds of the world's utilized agricultural areas are involved solely in pastoral livestock systems, while livestock are an intrinsic part of mixed farming systems playing a major role in nutrient cycling within the ecosystems.

On the other hand, livestock are responsible for major environmental damages such as overgrazing, methane gas emission and soil erosion. In this regard, sustainable increases in livestock production should be achieved through the improvement of conservation and management of natural resources.

In developing regions, it is essential to produce a stable and constant supply of food to meet the requirements of a growing population. Annual production increases in developing countries are projected at 2.4% for crop products, and 3.4% for livestock products (FAO, 1993).

The developing region accounts for nearly two-thirds of the world's livestock population, while production efficiency is only about a quarter of that of the developed region. There is now an urgent need to increase the efficiency of livestock production by genetic improvement of livestock, efficient utilization of feed resources and control of animal diseases.

To address problems on a large scale such as systems of agriculture or global environmental problems, comprehensive projects are currently being implemented in Thailand (Comprehensive Studies on Sustainable Agricultural Systems in Northeast Thailand) and in Vietnam (Integrated Research on Farming Systems Combining Agriculture, Animal husbandry and Fisheries in the Mekong Delta). The main research subjects of the Division are as follows: 1) identification and evaluation of feed resources, 2) management of forage crops and fodder trees, 3) improvement of livestock production with locally available feed resources, 4) utilization of livestock excreta as energy (biogas), organic fertilizer and feed resources for fish, 5) economic evaluation of prevention of parasitic infections in livestock. The Division also plans to participate in comprehensive studies on the development of sustainable agro-pastoral systems in the subtropical zone of Brazil, starting from this year.

In addition to the comprehensive projects, emphasis is placed on projects for the solution of specific problems pertaining to livestock production in developing countries. Studies on the improvement of raising technology of small livestock in the tropics are currently being undertaken in collaboration with researchers of MARDI (Malaysian Agricultural Research and Development Institute). The Division

is engaged in research collaboration with centers affiliated to the CGIAR: 1) biochemical characterization of membranes of lymphocytes infected with *Theileria parva* schizonts at ILRI (International Livestock Research Institute, Kenya), and 2) eco-physiological studies on the persistency of tropical pasture plants in the savanna of Latin America, at CIAT (Centro Internacional de Agricultura Tropical).

JIRCAS is now planning to initiate research programs in the new areas targeted for collaboration in the temperate and cold zones. The steppe of central Asia, with extensive range systems and agriculturally marginal lands, is subjected to a rapid process of desertification and destruction of the ecosystems. Priorities for research include the development of sustainable systems of grassland management and animal production by conserving and utilizing abundant agricultural resources such as indigenous grasses and animals.

The projects listed above are carried out by the researchers of the Division on long-term assignments, often supported with short-term specialists from other sectors. Research projects on a

*Photo 1: Feeding cattle with molasses blocks as nutrient supplement in Malaysia*

*Photo 2: Sheep grazing on the steppe in Kazakhstan*

short-term basis are also undertaken. Studies on the genetic characteristics of indigenous breeds of cattle and buffaloes in the Philippines are planned this year in collaboration with the researchers of UPLB (University of the Philippines at Los Baños).

In recent years the requests for collaborative research from developing countries have become diversified including the application of biotechnology along with the upgrading of the level of research. As a result, the Division is promoting basic research for overseas at the Tsukuba campus on the following subjects: 1) identification of endophytic fungi in pasture plants in tropical regions and their introduction into plants by biotechnological methods, 2) investigation of the endocrinological responses to heat stress in ruminant animals in relation to milk secretion.

Strengthening of the relations with various national and international organizations will be further promoted to enhance Japan's contribution to the international community, as sustainable food production and the general well-being of mankind remain a common goal for all of us.

# 1995 Annual Meeting for Review and Promotion of Research for International Collaboration

*Dr. Nobuyoshi Maeno*
*Director, Research Planning and Coordination Division*

The 1995 Annual Meeting for the Review and Promotion of Research for International Collaboration was held on February 7, 1996 in the International Conference Room of JIRCAS Headquarters.

A total of 54 participants attended the meeting, including representatives from various institutes affiliated to the Ministry of Agriculture, Forestry and Fisheries along with delegates from the Ministry and from JICA (Japan International Cooperation Agency) as well as the Director General, Directors of Research Divisions and several staff members of JIRCAS.

At first the collaborative activities pursued by JIRCAS during the fiscal year 1995 were reviewed and discussed, including information, research projects, international symposium, workshop, seminars, various meetings, Visiting Research Fellowship Program at Okinawa Subtropical Station of JIRCAS, and also at Tsukuba Headquarters which was initiated from this fiscal year, in addition to the orientation of JICA activities, etc.

During the present meeting, emphasis was placed on the importance of the promotion of research activities aiming at the development of sustainable agriculture systems. In this context, the report on the proceedings of the meeting organized on the previous day for reviewing JIRCAS collaborative research activities which were pursued especially with Asian countries was particularly relevant.

Thereafter, discussions were held on an important topic, namely the strategies for further promoting collaborative activities with the People's Republic of China. China is one of the major countries from the viewpoint of world-wide food supply. Since China contains approximately one-fourth of the world population, the trends of production and consumption of food in China exert a strong impact on the world food situation. Therefore, JIRCAS plans to initiate a new comprehensive research project from 1997 fiscal year.

The general discussion was centered on the support extended by other MAFF institutes to JIRCAS for promoting international collaborative research.

*Photo 1: Discussion at 1995 Annual Meeting*

# Screening of Cowpea Lines for Drought Tolerance and Root Characteristics

*Tomio Terao, Iwao Watanabe, Ryoichi Matsunaga and B. B. Singh**

Cowpea is a leguminous crop particularly important in the savanna area of West Africa. Although it is well adapted to the semi-arid conditions, due to the risk of erratic rainfall and long dry spells, a much higher drought tolerance is required.

Nine hundred cowpea germplasm lines were screened in the field in the 1990-91 dry season. Selected lines were further screened using pots in which the soil moisture content was maintained at 3% (w/wet weight) every day. Drought-tolerant as well as drought-susceptible lines were further evaluated in the field in the dry season. Plants were sown after the last rain and grew only using residual soil moisture. Drought-tolerant lines grew very vigorously and yielded about 1 ton per ha, although traditional and improved varieties usually grown yielded less than 500kg per ha and susceptible lines less than 300kg per ha (Table 1). These tolerant lines are expected to perform well and produce more stable yields in drier areas. However, because seed characters are not appreciated by the local farmers, they are used as parents for drought tolerance breeding.

Since the drought-tolerant lines are usually well adapted to dry conditions, they are likely to show good root characteristics. To investigate the major root characteristics for adaptation to dry conditions, the root distribution patterns of drought-tolerant and susceptible lines of cowpea were compared. Plants were grown in thin root boxes. The size of the box was 56cmW×76cmH×4cmD. Boxes were buried in soil to keep the temperature close to that of the natural soil. After the plants grew from 12 days to 3 weeks, the roots were fixed in a pin board and the soil was washed out gently.

Clear differences were observed in the root distribution in the deeper zone between drought-tolerant and susceptible lines (Photo 1). Drought-tolerant lines displayed a wider distribution of roots in the deeper zone of the root system compared with the drought-susceptible lines in which only the tap root penetrated deeply with less branching in the deeper zone. It is considered that the wider distribution of roots in the deeper zone is important to collect scarce soil solution in deeper soil layers.

Drought tolerance and root characteristics are two important but independent factors complementing each other for adaptation to dry conditions. It is important to combine these factors in cowpea varieties with favorable agricultural attributes. Efforts are being made to combine these factors with early maturation as well as resistance to diseases, insect pests and parasitic weeds for sustainable production of cowpea in the Sahelian area.

* International Institute of Tropical Agriculture

**Table 1. Grain yield of cowpea cultivars grown in the dry season**

| Strains | Grain yield (g/plant) | Grain yield (kg/ha) |
|---|---|---|
| TVU-11979 | 14.32 | 1007.0 |
| TVU-11986 | 15.70 | 921.1 |
| TVU-12348 | 13.60 | 910.9 |
| TVU-12349 | 9.17 | 582.4 |
| Dan Illa | 8.09 | 288.4 |
| Kanannado | 7.61 | 470.6 |
| IT84S-2246-4 | 8.23 | 451.5 |
| TVU-7778 | 4.01 | 267.4 |
| TVU-8256 | 2.36 | 153.9 |
| TVU-9357 | 4.58 | 272.1 |

Upper 4 strains: drought-tolerant lines
Middle 3 strains: Traditional and IITA-released cultivars
Bottom 3 strains: drought-susceptible lines

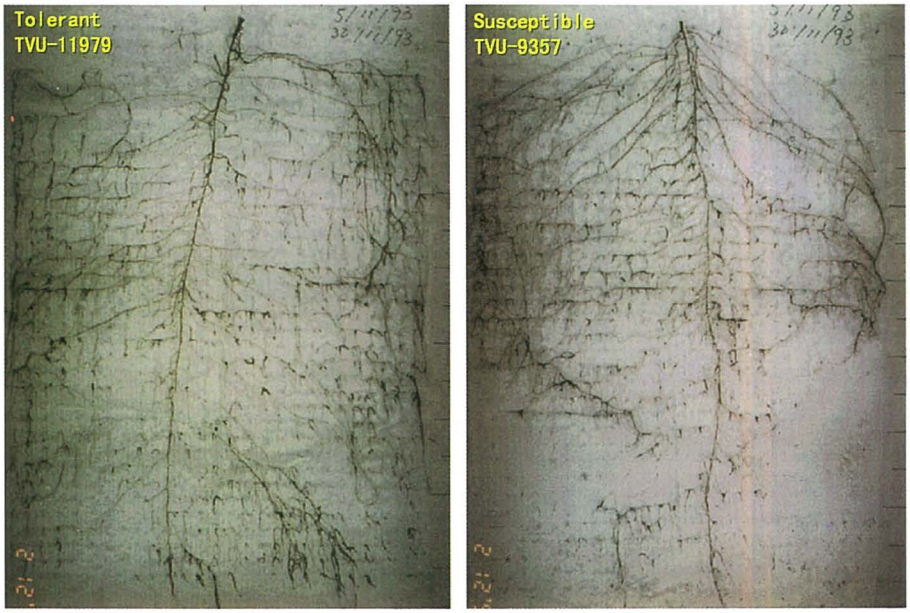


*Photo 1: Root distribution patterns of drought-tolerant and susceptible lines of cowpea*

# Pedological Characterization of Lowland Areas in the Philippines

*Kenzo Miura, Rodrigo B. Badayos* and Angelina M. Briones**

In the Philippines, it is essential to increase rice production to match the rapid population increase which took place in recent years. Thus, it is important to investigate the fertility characteristics of the Philippine lowland soils to identify their real potential for rice production. The prime objective of the present study was to characterize the Philippine lowland soils from pedological viewpoints in reference to factors such as parent material, climate, and topography.

Thirty two major lowland soils from six lowland rice areas were selected for the study. Based on the morphological characteristics, these soils were separated into fifteen irrigation water aquic soils, seven ground water aquic soils, and ten soils which were not or less influenced by irrigation water and ground water. By defining dry months as those with < 100 mm of rainfall, the ground water aquic soils were observed only in relatively humid areas with ≦ 4 dry months per year. In connection with the change in topography from natural levee to back swamp, in Central Luzon which is characterized by > 4 dry months per year, increasing influence of irrigation water was obvious, while in Bicol with < 2 dry months per year, increasing influence of ground water was recognized. Thus, the importance of rainfall and topographic conditions for profile development was verified.

Based on the soil characteristics, Philippine lowland soils showed a high organic matter status, high base status, high clay and high available silica contents, and a large amount of 14 Å minerals, mostly smectite, compared with the other tropical Asian lowland soils. However, there were regional differences: e.g., organic C and total N contents were highest in Bicol, while lowest in Central Luzon, reflecting the difference in rainfall conditions.

The findings of this study indicated that the characteristics of the Philippine lowland soils were essentially controlled by the basic nature of the parent materials. Therefore, it is considered that the Philippine lowland soils have a relatively high potential for rice production among the tropical Asian paddy soils. However, the diversity of the soil characteristics is induced by two conditions, rainfall and topography, which may account for the difference in soil fertility among regions and inside a region, respectively. Thus, it is necessary to develop proper soil management techniques to maintain and enhance the soil capability for sustainable rice cropping, using the knowledge acquired in this study.

* University of the Philippines at Los Baños

*Photo 1: Rice planting in Central Luzon*

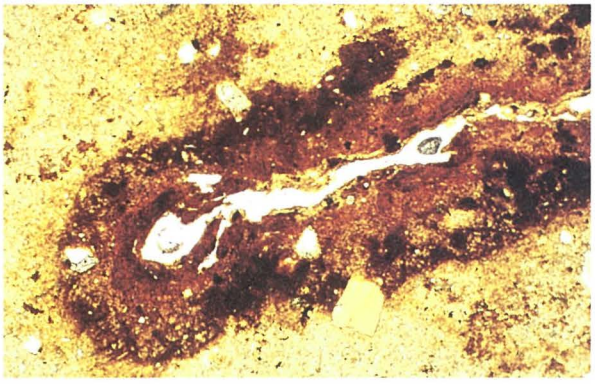

*Photo 2: Photomicrograph of Fe coatings of a root channel (tubular mottles) typical in the ground water aquic soils*

# Reproductive Strategy of the Parasitoid Fly, *Exorista japonica* (Diptera: Tachinidae)
## −Clutch Size Regulation Depending on Host Density −

*Satoshi Nakamura*

Parasitoids are considered to be intermediate organisms between predators and true parasites. The parasitoid larvae develop by feeding on an other organism (often an insect), causing its eventual death. The family Tachinidae of which all members belong to parasitoids is considered to include very important potential biological control agents. However, there have been relatively few studies on the biology of tachinid flies when compared with their parasitoid counterparts, parasitic wasps, since it seems that the culture of tachinids is very difficult. However, it is necessary not only to develop rearing techniques for the insects, but also to conduct fundamental biological studies before using the tachinid flies as biological control agents.

*Exorista japonica* that attacks the common armyworm *Mythimna separata*, is also an important natural enemy of the common cutworm *Spodoptera litura,* and the cabbage armyworm *Mamestra brassicae*. It was reported that *E. japonica* sometimes deposits supernumerary eggs on a single host in the field. Problems such as "what is the optimal clutch size for maximizing reproductive success of a female fly ?" or "can a female fly regulate clutch size in response to host density ?" should be solved before this parasitoid is introduced into fields.

The author developed a procedure for rearing *E. japoni-*

*ca* and predicted that the optimal clutch size of *E. japonica* on a host, last-instar larva of the common armyworm, to gain the maximum fitness was in the range of 1 - 10 in response to the rate of host encounter, host density per unit area (patch) and oviposition ability at the time. To verify this prediction, it is necessary to determine whether the flies actually regulate the clutch size according to the changes of these factors. Therefore, the effect of host encounter rate and host density per patch on the oviposition decision of *E. japonica* females was studied in the laboratory. A female fly increased the clutch size along with the decrease of the rate of host encounter and she also increased the number of ovipositions per patch along with the increase of the host density per patch. The results indicated that *E. japonica* females were able to regulate the clutch size depending on the host density.

*Photo 1:* E. japonica *female ovipositing on* M. separata

*Photo 2: Supernumerary eggs oviposited by* E. japonica *on* M. separata

## Low-Input Hydroponics

*Harushige Sakuma and Katsumi Suzuki*

The area under problem soils such as saline, acid sulphate, sandy soils, is continually increasing in the tropics and subtropics. Hydroponics may thus be a suitable alternative for crop production in such regions, because hydroponic culture enables to avoid problem soils. However, common hydroponic systems in Japan utilize a large quantity of electricity, and their operation is complex, requiring the chemical analysis of nutrients. Systems that enable to analyse and adjust the solution conditions automatically using computers, are expensive and cannot be utilized readily.

We are currently developing and testing hydroponic systems that do not require the consumption of electricity. We constructed a new crop cultivation apparatus (Photo 1). Nutrient solution is placed in the tank located outside. As the tank position is higher than that of the culture bed, nutrient solution flows to the bed automatically by gravity action. The amount of nutrient solution in the canal under the bed is controlled by a floating bulb system. Supply of nutrients to the upper part is achieved through capillary action by using a Liquid-absorbing sheet, root block sheet and polyvinyl alcohol material chips.

We tried to culture melon (cv. Ahle Seine) using this system. Twenty four melons were placed in the culture bed (6m×0.5m). The average temperature was 22.4℃ during the culture period on Ishigaki island. Melons grew normally (Photo 2), requiring 90 days from the seedling stage until harvest. The amount of solution absorbed in one day depended on the weather conditions and it increased on fine days compared with cloudy days. Each melon plant absorbed a total of 60 *l* nutrient solution (composition: N 15g, P 7.2g, K 24.3g, Mg 3g, Mn 3g, B 0.09g, Ca 13.8g, Fe 0.16g). The average yield of melon fruit was 1700g and the sugar content was 14.8%. The yield was comparable to that in standard culture on the ground.

We attempted to culture other crops, for example tomato, Chinese cabbage and sweet potato. Yield of each crop depended on the composition of the solution. In conclusion, optimum conditions of the culture solution shoud be determined for each crop.

*Photo 1: A new apparatus for low-input hydroponics*

*Photo 2: Melons growing normally with the new apparatus*

≪Topics≫

# International Workshop on Paddy Fields
## —Sustainable Agriculture and Control of Greenhouse Gas Emissions—

*Katsuyuki Minami*

International Workshop on Paddy Fields—Sustainable Agriculture and Control of Greenhouse Gas Emissions—sponsored by the Office of Environment Policy Coordination (OEPC), Japan International Research Center for Agricultural Sciences (JIRCAS), MAFF and Mitsubishi Research Institute, Inc. was held at Tsukuba Science City on March 7-8, 1996.

The theme of the workshop covered the current situation and future prospect for the role of rice fields in the promotion of sustainable agriculture and conservation of agro-ecosystems, and for the control of greenhouse gas emissions from rice fields. The topic on the control of greenhouse gas emissions was highly evaluated by related researchers.

The objective of the workshop was to discuss the role of paddy fields in the promotion of sustainable agriculture and the mitigation of methane and nitrous oxide emissions from paddy fields. The workshop consisted of five papers covering the introduction and an overview, eight country reports and twelve case study reports. Mr. S. Tsuge, Director of OEPC and Dr. K. Kainuma, Director General of JIRCAS, gave the opening and welcome address of the workshop, respectively.

The workshop started with the introduction and an overview presented by five researchers as follows:

- The role of paddy fields in the promotion of sustainable agriculture and conservation of agro-ecosystems. K. Minami (Japan)
- Sustainable agriculture and the conservation of agro-ecosystems in Korea. W. G. Bae (Korea)
- Nitrous oxide emission from rice fields. J. R. Freney (Australia)
- A regional analysis of human alteration of nitrogen cycling: The role of agriculture. R. Howarth (USA)
- Agricultural impact on soil consumption of atmospheric methane. A. R. Mosier (USA)

Country reports were presented by delegates of eight countries as follows:

- An option for reducing methane emission from rice fields in China. Z. Cai (China)
- Methane emission from rice fields in India. N. Sethunathan (India)
- Classification of Philippines rice soils according to methane production potential. R. Wassmann (Philippines)
- Preliminary inventory of methane from flooded paddy fields in Malaysia. M. Y. Yusoff (Malaysia)
- Research on methane emission from rice fields in Thailand. P. Chairoj (Thailand)
- Relationships between ambient methane concentration and flux from rice fields as affected by microclimate conditions. Y. A. Husin (Indonesia)
- Measurement of methane emission and mitigation options in Korean rice fields. Y. S. Lee (Korea)
- Possible overestimation occurring in extrapolating methane emission rates from rice paddy fields. K. Yagi (Japan)

Twelve case study reports were presented in another session concerned with methane and nitrous oxide emissions and sink in paddy fields. A data book for sustainable agriculture in paddy fields was distributed to the participants. The contents were as follows: Environmental externalities of paddy field farming, Sustainable agriculture and conservation of the agro-environment in Japan and Climate change and paddy field farming.

*Photo 1: Participants to the International workshop*

### ✧✧✧✧✧✧ JIRCAS News ✧✧✧✧✧✧

**Dr. Minami Won a Scientific Prize**

Dr. Katsuyuki Minami, Director of Environmental Resources Division, JIRCAS was awarded the Prize for Agricultural Sciences in Japan, 1996 and the 33rd Yomiuri Prize for Agricultural Sciences sponsored by the Japan Society of Agricultural Sciences and the Yomiuri Press, respectively for his exhaustive studies on "Agriculture Impact Assessment on Changes in Earth Environment and its Mitigation Strategy" on April 5th, 1996.

≪Research Collaboration≫

# Collaborative Research with ILRI on East Coast Fever

*Yutaka Matsubara*

The International Livestock Research Institute (ILRI), sponsored by the Washington-based Consultative Group on International Agricultural Research (CGIAR), started its operation in January 1995. The Institute incorporates the resources, facilities and major research and outreach programs of two former CGIAR centers — the International Laboratory for Research on Animal Diseases (ILRAD, founded in 1973 in Nairobi, Kenya) and the International Livestock Center of Africa (ILCA, founded in 1974 in Addis Ababa, Ethiopia). The work programs of ILRAD and ILCA have been consolidated, streamlined and reoriented. They now support an expanded, global mandate to conduct research on biological, animal and social sciences to improve livestock productivity in sustainable agricultural systems of developing countries. The new Institute, whose headquarters are in Nairobi, will be directly responsible for about two-thirds of all CGIAR livestock and livestock-related research in developing regions. ILRI will also lead the development of a major CGIAR initiative — the Systemwide Livestock Research Programme (SLP) — and participate in other related inter-center initiatives supported by the CGIAR.

The objectives of ILRI's new global mandate for research are:

1) to improve animal performance through technological research and conservation of animal genetic diversity, 2) to improve and sustain productivity of major livestock and crop-livestock systems, 3) to improve the technical and economic performance of the livestock sector, 4) to develop and transfer technologies to national programs, which will pass these on to client farmers. During 1995, a major task of ILRI was to develop research links and agenda outside sub-Saharan Africa. The keyword for ILRI's future operation is "partnership." The Institute will continue working closely with African national agricultural research systems (NARS) while developing collaborative links with NARS in Asia, which is ILRI's first priority for expanded activities, and with those in Latin America. Six main programs are focused on 1) improving animal health, 2) optimizing livestock production, 3) conserving biodiversity, 4) improving feed utilization, 5) rationalizing national livestock policies, and 6) strengthening the research capacities of NARS.

Researchers at ILRI's Nairobi campus are developing a new vaccine against East Coast Fever (ECF), a deadly disease of cattle caused by a single-celled organism, *Theileria parva*. This parasite, transmitted by ticks, costs farmers in Africa more than US$ 170 million a year in direct losses. The vaccine potential of a protein named p67, found on the surface of the *T. parva* sporozoite form, has been intensely investigated. The p67 gene has been inserted into *Salmonella* bacteria and vaccinia viruses along with a cytokine gene to enhance its effect. Inoculating these harmless recombinant organisms into cattle has demonstrated that some cattle are protected against severe diseases after lethal challenge.

Collaborative research between ILRAD/ILRI Nairobi and the Tropical Agriculture Research Center (TARC)/the Japan International Research Center for Agricultural Sciences (JIRCAS) has been carried out since 1980. The collaboration focused on the characterization of *Theileria* parasites to improve the epidemiological knowledge about the disease, to improve methods of diagnosis, and to develop a "live" vaccine against ECF that is now in use. During this period, TARC/JIRCAS dispatched eight long-term and seven short-term visiting scientists for this program.

The objective of the current cooperative studies is to characterize the inflammatory reaction of the skin of cattle to the bite of the tick, which feeds on cattle blood and infects the animal with *T. parva* parasites. Since early interactions between the parasite and the bovine immune system have considerable bearing on the success of a vaccine based on "neutralizing" sporozoite parasite form, a clear understanding of the environment into which sporozoites are delivered is important for the development of optimal vaccination strategies. A technology to detect parasite and bovine cytokine messenger RNA in the skin using non-radioactive *in situ* hybridization will be developed by the JIRCAS researcher currently engaged in collaborative studies at ILRI. This undertaking should both promote basic knowledge on the immunology of ECF and accelerate ILRI's development of a novel genetically engineered vaccine against ECF.

*Photo 1: Electron micrograph showing antibody binding to the p67 surface molecule of* Theileria parva

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